REAL CORP 2022

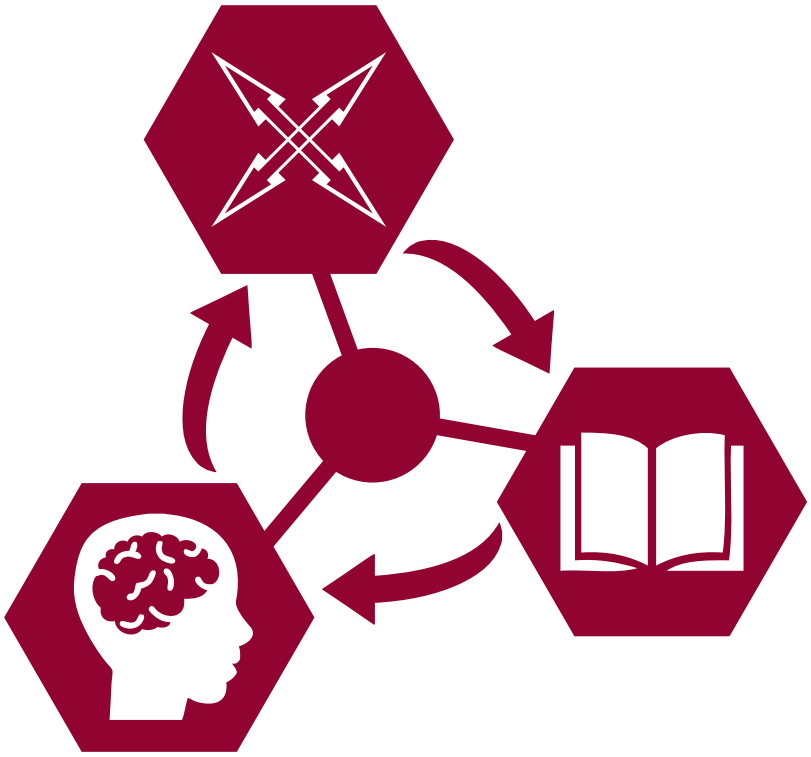
Manfred SCHRENK, Vasily V. POPOVICH, Peter ZEILE,
Pietro ELISEI, Clemens BEYER, Judith RYSER (Eds.)

ISBN 978-3-9504945-1-8 ISSN 2521-3938

PROCEEDINGS

of the 27th International Conference on Urban Planning, Regional Development and Information Society

TAGUNGSBAND



MOBILITY, KNOWLEDGE AND INNOVATION HUBS IN URBAN AND REGIONAL DEVELOPMENT

A co-operation of

CORP
Kompetenzzentrum für Stadtplanung und Regionalentwicklung
Competence Center of Urban and Regional Planning | www.corp.at

ISOCARP
Knowledge for Better Cities

AirportCity SPACE

14-16 NOVEMBER 2021
AIRPORTCITY SPACE
TOWERSTRASSE 3, 1300 VIENNA AIRPORT, AUSTRIA

www.corp.at

REAL CORP 2022:
Mobility, Knowledge and Innovation Hubs in Urban and Regional Development

Proceedings of

27th International Conference on Urban Planning, Regional Development and Information Society

Beiträge zur

27. internationalen Konferenz zu Stadtplanung, Regionalentwicklung und Informationsgesellschaft

Edited by

Manfred SCHRENK, Vasily V. POPOVICH, Peter ZEILE,
Pietro ELISEI, Clemens BEYER, Judith RYSER

Vienna, 2022

ISBN: 978-3-9504945-1-8

ISSN 2521-3938 (Online), **ISSN** 2521-392X (Print)

Im Selbstverlag des Vereins

CORP – Competence Center of Urban and Regional Planning

Kompetenzzentrum für Stadtplanung und Regionalentwicklung

Klosterneuburger Straße 121/36, 1200 Wien, Österreich

office@corp.at, https://www.corp.at

TEAM

Manfred SCHRENK
Clemens BEYER
Peter ZEILE
Wolfgang W. WASSERBURGER
Judith RYSER

PREFACE

Manfred SCHRENK,

Conference Director,
President CORP – Competence Center of Urban and Regional Planning

WELCOME to REAL CORP 2022, the
27th International Conference on Urban & Regional Development and Spatial Planning in the Information Society at Airport City Space in Vienna!

The overall topic of this year's conference is "Mobility, Knowledge and Innovation Hubs in Urban and Regional Development".

Mobility hubs are far from being limited to their function as transport hubs. They are multifunctional and versatile places of encounter. In places where many people come together, information and knowledge are exchanged and new ideas are developed. Since mankind has become sedentary, such hubs have formed where the exchange of people, goods, but also ideas and knowledge takes place. With the rise of cities, this process has intensified and today, when almost 60 % of the world's population lives in cities, dealing with this centre function is more important than ever.

New challenges keep emerging that keep us busy maintaining and developing the functions of such hubs:

- Societal transformation and changes in population and ageing structures require adjustments to both urban structures and rural areas.
- The climate crisis simply does not allow us to continue as before. Ecological footprint, energy performance certificate and climate governance are not mere buzzwords, but important fields of action to steer future developments.
- The increasingly easy access to all forms of mobility on land, water and in the air is not only changing our settlement and social structure. The construction and operation of mobility infrastructure is often resource-intensive.
- Above all this hovers the sphere of digitisation. Much is already possible without having to physically move for it – data, information and knowledge move instead.
- In recent years, the pandemic has shown how quickly our structures can be shaken to their foundations even without "conventional" natural disasters. The diverse reactions and the struggle to return to normality, which continues to this day, have produced some remarkable results.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

REAL CORP 2022 addresses the links between society‘s innovative achievements and the confronting demands of our environment, cities and settlements. In order to achieve acceptable sustainable development, spatial planning and related disciplines need to carefully address current trends and influence them with appropriate governance mechanisms to maintain and improve the quality of life, but also to decisively address the concerns of our ecosystem. We therefore invite contributions from all disciplines involved in urban development in order to analyse the challenges for the future of urban spaces in a holistic manner. In addition to science-based contributions, we also welcome practice-based reports on short-term measures and/or long-term strategies for urban and regional development.

This year we brought together some 200 participants from more than 30 countries worldwide. The main goal of the REAL CORP conference series is to bring together leading experts in the field of spatial planning, geoinformation and related disciplines to exchange their knowledge, share their ideas, discuss current developments and get together for face to face networking leading to the development of new thoughts, partnerships and projects.

The success of the REAL CORP conferences is – clearly without doubt – the result of the efforts of participants, reviewers, and the conference organising team. We would like to acknowledge the Reviewer Team and Programme Committee members for their valueable voluntary help with the review process. Our thanks go to all participants and authors of the submitted papers as well. The proceedings of this year’s conference contain around 120 scientific papers; some 90 of them were selected after a double-blind, double-stage (for both abstracts and full papers) peer-review process for publication and presentation at REAL CORP 2022. The non-reviewed papers were accepted by the programme committee after a double-blind abstract review.

Welcome to Vienna! Have a great conference!

Manfred SCHRENK, Clemens BEYER & the REAL CORP Team

Editors – Herausgeber:
DI Manfred SCHRENK, President CORP – Competence Center of Urban and Regional Planning, Vienna, Austria
Prof. Dr. Vasily V. POPOVICH, SPIIRAS, St. Petersburg, Russia
Dr.-Ing. Peter ZEILE, TU Kaiserslautern, Kaiserslautern, Germany
Dr.-Ing. Pietro ELISEI, URBASOFIA, Bucharest, Romania
Dipl.-Ing. Clemens BEYER, CORP – Competence Center of Urban and Regional Planning, Vienna, Austria
Arch. Judith RYSER, City Scope Europe, London, UK

Publisher – Medieninhaber und Verleger:
CORP – Competence Center of Urban and Regional Planning
Kompetenzzentrum für Stadtplanung und Regionalentwicklung
Klosterneuburger Straße 121/36, 1200 Vienna, Austria
office@corp.at, https://www.corp.at

ISBN 978-3-9504945-1-8
ISSN 2521-3938 (Online), **ISSN** 2521-392X (Print)

Table of contents – Inhaltsverzeichnis:

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Keynote: Metropolitan Integrated Planning Co-Construction of the Meta-Logistics District

Antonella Contin, Valentina Galiulo

(Assistant Prof. Antonella Contin, Department of Architecture and Urban Studies, Politecnico di Milano, via Bonardi, 3 20133 Milano, antonella.contin@polimi.it)
(PhD candidate Valentina Galiulo, Universidad de Sevilla, av. Reina Mercedes 2, 41012, v.gal@us.es, valentinagaliulo@polimi.it)

1 ABSTRACT

Accelerating the ecological transition and access to sustainable mobility through a partnership between metropolises, cities and districts fostering the dialogue on science, technology and innovation to contribute to a global strategy tackling climate change problems is fundamental. In the contemporary city, due to the conflict of scales, we must understand how to relate metropolitan scale to the local one. Starting from the metropolitan dynamics connected to the logistics sector, one of the main territory negative impact makers, the paper introduces the Metropolitan Cartography tool to obtain a meta-project necessary to achieve sustainable development by dealing with SDGs applications and bringing together different disciplinary knowledge. The research field of action is two transects of metropolitan landscape, which identify two possible logistics *meta-districts*. The first is in the Città Metropolitana di Milano a West-East transect from Milan to Melzo, which is intersected by the second, South-North, which starts in the Piacenza, Emilia Romagna Region intermediate city. The research project first aim is to produce a cartography tool able to define the circumstances of sustainable plan and design of the entire logistics meta-district transects studying the mobility's impacts. The second research's aim argues about the necessary condition to produce a sustainable local archipelago system's design project linked to the logistics meta-district's transect "last mile" that can be directly managed by the local communities. Nevertheless, it must be designed to be connected to the metropolitan grid.

Keywords: metropolitan grid, meta-district, sustainability, logistics, integrated planning

2 THE DIFFERENT SCALES OF INTERVENTION

2.1 Metropolitan approach to complexity's perspectives

If sustainable mobility is considered only a technical fact for economy or law (laws and decrees), the disciplinary field concerned will be very narrow. Our metropolitan approach to complexity also induces the perspective of the physical and geographical components of the territory and the city.

To be able to think of a project on the use of sustainable mobility as a regional and metropolitan process up to the archipelago scale of local net-grids, we must reflect upon the relationship between metropolitan cities, medium, small towns and neighbourhoods. Moreover, the research deals with how to go down from the regional and metropolitan scale to the hyper-local scale. We imagine an integrated system of sustainable mobility, pinned in precise hinge points working in synergy at the different scales, up to the definition of the smart grid for the urban-rurban-rural-natural linkage patterns.

The issues we can/should cover with our studies are many:

1) Innovation is one of the keys to enabling the development of local communities. Existing innovative solutions and technologies grown for big city markets must be adapted and proven effective for Italy and Europe's multifaceted context to bring economic, environmental, and health benefits. Can we think of evolutionary innovation? That is, a systemisation of technologies that today in the country work not in unison.

2) The proposal will be concerned with demonstrating innovative climate adaptation, mitigation and sustainable energy solutions in the social, economic and environmental spheres. In addition, the project will have to explain the benefits of the proposed solutions with particular regard to Sustainable Development Goals 4, 5, 7, 8, 11, 12, 13 through the use and implementation of local Metropolitan Cartography data (Contin, Giordano, and Nacke, 2021). The significant engagement of civil society in implementing research proposals is also key to the success of possible technological solutions. Attracting private investors to sustainable mobility solutions will contribute to sustainable economic development for the benefit of the metropolitan area, intermediate cities and neighbourhoods.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

3) R&I policies must be coupled with capacity building and appropriate financing solutions to facilitate market uptake and technology diffusion. Sustainable local economic development should also include identifying the workforce's technical, professional and educational needs and proposing relevant training and qualification activities for policymakers. In our proposals, we have developed capacity building and tools teaching the approach to metropolitan complexity in its four components: physical, social, economic and governance from policymakers, civil servants, and local leaders to practitioners.

4) Demonstrations of the value of these solutions are still needed by observing the impacts of the proposed solutions on the environment, climate change objectives and the social and economic dimensions. Monitoring the results at the different scales through a set of indicators and the open-source Metropolitan Cartography maps will be an essential outcome of the proposal.

5) Developing and implementing a customised and local approach to the sustainability process from manufacturing to education and recreation capable of improving a value chain at different scales and identifying the most harmonious relationships based on the local context, the local material supply chain, the local workforce, the green economy but also the new horizons of online commerce. The goal is to ensure sustainable local economic development through sustainable mobility. The value chain applies at different scales, and what is variable at the local scale becomes invariable at the global scale.

2.2 Specific Local Scale Project Issues

In the intermediate areas between logistics and the urban fabric, entire areas often remain abandoned and cannot find an opportunity for conversion to new uses. On the other hand, a large amount of land is urbanised and intended for parking lots and areas dedicated to loading/unloading and storage. In many cases, these areas are used only for a few hours of the day, while for the remaining time, they remain deserted. These areas are completely devoid of common and public spaces, often protected by gates and walls that do not allow any exchange with the city. Still, that produces degradation at their borders, also generating in the citizens a sense of insecurity and hostility towards this productive function of the city, highly polluting, not resolved by the promise of new employment possibilities threatened by the increasingly intensive use of the automation of the logistics activities in the future.

2.2.1 Metropolitan Urbanity and Public Realm

Moreover, the Covid-19 pandemic is a catalyst to reflect on the public space' structures, organisations and habits. It provides an opportunity to create sustainable and positive change in our cities with an impact that will be felt well beyond the crisis.

The specific project's research question is how to maintain the quality of life in metropolitan areas and address climate change and eco-problems by implementing precisely in these areas where the impact on citizens due to metropolitan infrastructural projects is most perceptible. It aims to produce a pattern model together with the practices it allows to interconnect the two city fabrics generating a new urban-industrial-rural ecosystem. At the same time, the location of production units can be the basis for social innovation policies integrated with district regeneration policies (Gouverneur, 2014).

The local space design project, first, must introduce the metropolitan urbanity perspective arguing about what will be the role of sustainable mobility in the construction of the metropolitan city culture.

This fact is strictly related to the perspective of the governance question. We are all aware of the need to change our mentality. Still, at the same time, local governments are not implementing any tools for designing sustainable mobility' structural plan along the entire transect and, in very few cases, at the last mile scale. Moreover, involving the different authorities to work together in synergy is a crucial result. It will be a co-construction between the Academy and other metropolitan agents to formulate legislation that can strengthen this vision and technology, moving from decrees on experimentation to regulating actual city transformation.

Then, we must introduce the data perspective to manage the mobility data production fostering a good city lifestyle. Moreover, the data governance that allows local communities to be masters of their data is fundamental.

The finance perspective deals with the physical infrastructural investment that the project requires forcing us to consider how a project can be used to leverage other assets for the city. Considering existing projects future implementation by investing part of the budget introduces the technological issue perspective and the

proposal replicability perspective. The proposal is about technology, planning , design and policy, which can give a more systemic angle to the project, looking at the enabling environment (the conditions) for achieving sustainability today; and considering the morphological, regulatory, institutional, governance and community engagement aspect. Nevertheless, the sustainable mobility perspective demonstrates that the transition to clean energy has begun: it is planned for 2040 in France, Germany in 2030, and Norway in 2025. However, it is uncertain in Italy. Suppose we want to have a green and digital transitions' impact that means a transformation. In that case, we must consider a project as a resource to build shareholders capital research (Nasi, 2021) to achieve its realisation on the ground.

2.3 General Metropolitan Project issues

The metropolitan architecture project aims to determine an inter-scalar pattern of urban-rurban-rural-natural linkage deriving local strategy from a metropolitan reading.

The project's field of action is where the vast logistics area meets the residential city fabric and the peri-urban agricultural field, determining the risk of abandonment in the first urban crown. The spread of large logistics areas is becoming significant in many cities, which must rapidly learn how to order their territory facing metropolitan dynamics. Large portions of agricultural land are occupied in logistics areas, from buildings destined for freight warehouses and distribution centres. The impact of road handling of goods is also highly polluting for air and water and perceived as a threat by citizens, generating conflict.

2.3.1 The Logistics Meta-District

The issue of poor coordination between transport and spatial planning is explored not only at the local level in each individual country but is also a problem at the central level and thus at the level of the European Union – even going so far as to challenge the fact that some metropolitan agency's decisions lack this vision. Metropolitan planning is a needed keyword and intends to highlight the complementarity and the need to integrate logistics planning with the metropolitan and regional territory. The proposal is to build quality indicators through a data platform capable of defining a spatial quality gradient of places from the perspective of sustainability at different scales. Looking at planning differently involves what we can now call a Logistics Meta-District (OECD, 2006) that poses a series of challenges typical of planning. In theory, the definition of transect linked to the Logistics Meta-District goes beyond the administrative boundaries of municipalities, provinces, regions, and states. The Logistics Meta-District thus becomes a territorial entity to which no administrative entity of reference corresponds. So, the idea is to develop a planning and governance model and a project decision-making tool.

3 THE RESEARCH'S PRODUCT

3.1 A decision support system oriented to the public administration

It is a decision support system oriented to the public administration or public entities to govern the Meta-district transect. It could also be a platform offered to private parties to calculate possible mitigation actions (white certificates). Therefore, it is a question of implementing a tool called Metropolitan Cartography that, through keywords and critical concepts tuned to the principles and targets of the SDGs, can provide a decision-making tool through quality indicators for planning metropolitan logistics caring territories and landscapes. Our proposal envisages the production of Metropolitan Cartography open-source maps able to produce a platform that allows decisions on the entire logistics chain about the planning of the logistics meta-district as metropolitan landscape. Instead of existing software products, which only control the last mile' sustainability, the proposal aims to monitor the impact of logistics on the entire transect and then use quality indicators to plan and design a sustainable territory (Contin, Galiulo, Sánchez Fuentes, 2022). That assesses the land use's inferences through environmental impact data and delivers to policymakers and administrators the tool for the policies' conceptual operators to become territorial operations. Policymakers and administrators can use these maps and then the software to obtain white certificates, first, decide, then, which policies to implement and in which sectors to plan and design a sustainable territory.

3.1.1 The twin transition option

The project interprets the theme of digitisation required by the EU twin transition mission in two ways:

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

a) Prototype technology digitisation. This vision should involve the development of a new software studying the Logistics Meta-District sustainability;

b) Digitization as an enabling technology. In this sense, we can understand digitisation as the identification of opportunities of existing digital tools that impact the planning of the Logistics Meta-District. In this case, the technological component of the project is less disruptive; therefore, we would have a project contained in the transport planning part of the optimisation.

3.1.2 Co-construction of interaction areas toward integrated planning

The issue is that logistical activities are rapidly developing along the transect and need to be observed to monitor their impact. Often, this observation is impossible due to a lack of data, and producing the platform mapping tool's contents that must be fed with the data is unthinkable. Then, the governance project can be developed according to two approaches that can encourage the involvement of the actors in the transect to make data available:

a) A participatory approach that relies on pricing leverage sees logistics players entering the ecosystem of this platform by inserting the data in their possession and participating in planning decisions. It is a question of devising an objective incentive that monetises the sharing of data (3% discount on IRAP or permission to enter the TL zone without paying);

b) A coercive carrot-and-stick approach.

In second hypothesis, observation takes place without the involvement of data producers. In this case, the project would produce data using, for example, trajectories only.

The proposal should provide also a platform that observations of passive data and operational data provided by companies can feed.

3.1.3 The need for a metropolitan scale vision and the dimension of the landscape boundary. The areas of interaction

The transect of the Logistics Meta-District is a strip of land with variable width. Concerning this strip, the sustainability of logistics is based on the CO_2 emission, which has to be evaluated in its impact according to the bio-potentiality of the area. The platform allowing the co-construction of planning rules for the logistics district considers how transport (grey infrastructure) can also be an element of territorial conservation. It helps the policymakers identify the most sustainable trajectory, allowing them to make decisions about environmental and social policies (for example, reforestation is needed where there is a need to absorb CO_2). The issue of logistics landscapes, perhaps one of the most impactful on the territory, must be placed in a metropolitan dimension. The metropolitan vision is crucial as it allows for decisions on environmental and social operations at a large scale, which becomes necessary precisely through observation and collaboration with the logistics transport sector. The issue of logistics is essential on a metropolitan scale because it concerns the whole point of large-scale transnational projects.

Metropolitan areas have become distribution nodes for global supply chains. As the distances involved in sustaining global supply chains have increased, the distribution function has taken on new significance, particularly with the creation of extensive terminal facilities such as ports, airports, rail yards and distribution centres. These facilities handle movements coming from, going to, or simply passing through a metropolitan area, an interface for the global distribution of goods. With containerisation as the tool that supports most international trade, intermodal terminals have become notable features of metropolitan landscapes at different scales. The theme of the scale of the intervention leads us to define the physical, social, economics and governance's dimensions of the boundary, so the project is necessarily multidisciplinary.

4 THE METROPOLITAN PROJECT

4.1 The macroscopic level

Thinking about logistics, in theory, means looking at supply chain techniques. Therefore, there is a macroscopic level of metropolitan planning, i.e. a level that needs to be understood because, in the logic of the decision support system, it is necessary to provide information to enable the public decision-maker to modify the behaviour of the actors involved. According to a definition typical of the discipline of transport, it

is necessary to reproduce the playing field in which logistics actors play. Therefore, it is essential to have a territory that, case by case, is organised according to the structure of the distribution networks serving that region. Moreover, though, reaching the sustainability what is vital to observe are the strategic geographical positions where the facilities of the distribution networks are located and, therefore, where warehouses and distribution centres serving metropolitan areas are located. In the case of Milan, for example, today, warehouses are almost at the city's gates.

4.2 The microscopic level

Today, it is possible in very central areas of the city to see the location of large logistics distribution centres, which should also be part of a definition of geographical and not just supply chain support points.

In the light of the SDGs principles of sustainability (UN-Habitat, 2022), it is necessary to find a point of synthesis between the geographical and economic vision. The mediation point can be related to the micro-level.

According to the Italian Law: n.84-1994, and AC 1259 of 2020 (Parlamento Italiano, 2020), the strategic system planning document presents the definition of the inter-port and city interaction areas saying the municipalities in which they are located have planning sovereignty over their territory, and the inter-port system authority has planning sovereignty over the logistics domain. However, if there are areas where the two planning systems overlap, the two authorities must confront each other and agree on their objectives, which are often very different. That has historically never been the case, however.

If carried forward, this reasoning of the interaction areas between inter-port and city needs a tool that allows the co-construction of decisions on the planning of logistics forecasts starting from a macro metropolitan dimension. At that scale, the list of supply chains indicates how broad the analysis must be because the local flows are part of large over regional flows system. Still, when we enter the microscopic, it is fundamental to define the question of the logistics-city interaction.

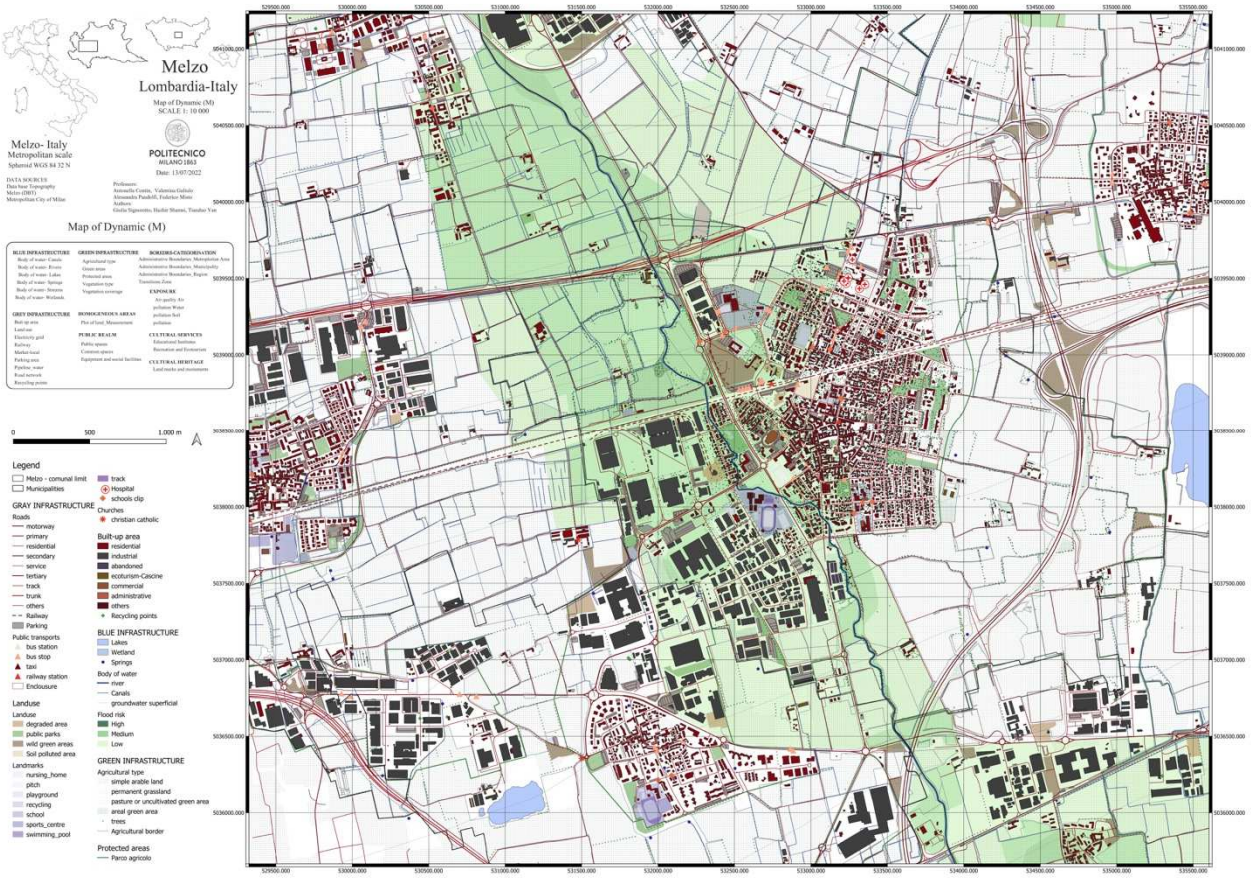


Fig. 1: Map of dynamic in Melzo Case study according to Metropolitan Cartography Methodology.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

5 THE CARTOGRAPHY TOOL

5.1 Metropolitan Cartography and Quality of Metro-Space indicators

The proposal is to experiment with an implementation of the tool called Metropolitan Cartography generated from a Glossary (TELLme MGIP Software Glossary http://www.tellme.polimi.it/tellme_apps/tellme/login) that allows us to create connections between concepts and keywords (the structural elements of the metropolitan territory) creating a new taxonomy from their relationship. The relations between concepts and keywords harmonised concerning the principles and targets of the SDGs allow us to navigate through the complexity of the data in a controlled manner according to the Metropolitan Discipline. The Glossary, together with the Metropolitan Cartography, serves to help us in the data mining phase to select precisely those data that in the representation between the different scales can help us represent an impact condition on the existing state of territory. The tool conceived by the Tellme co-financed European project has allowed us to generate a set of maps called Protocol Maps, in which information (data) and concepts are packaged through a structure that declines on different scales and themes. These maps are not thematic but synthetic because we have tried to cross-reference data that are not only data relating to the city, i.e. the urban core, but also large-scale spatial data and economic and social data. So, in addition to the global open-source data, we have selected Istat statistical information that we have tried to refine concerning the needs of the Glossary. The maps give us the possibility to understand the structure of the territory. However, our data have not been generated to remain only in a paper space; they can determine Maps of Dynamics within an IT Hub (TELLme Hub http://tellmehub.get-it.it/). The project tests how open source data can also have visualisation and validity at the local scale.

The idea is to systemise the open-source data that structure the Protocol Maps through inter-scalar spatial applications that already give a planning vision as a reaction to the metropolitan dynamics that cause the territory's vulnerability. The metropolitan dynamics map allow us to analyse the impact phenomena on the metropolitan transects of the Logistics Meta-District. We thus investigate the spatial, social and economical components that determine degrees of Rural Neglection due to the expansion of unconnected logistics centres. It is a qualitative indicator of Urban-Rural Linkage that interprets the state of care of a rural space that can no longer be described only as such. Rural Neglection is an indicator of the quality of the urban-rural landscape between the interstitial spaces of infrastructured rurality, i.e. areas contained in the system of infrastructural networks between small and medium-sized cities, dependent on the Metropolis for the flows of economic and social capital and territorial regulation. It is an analytical device to establish progressions of spatial quality through Metropolitan Cartography. It is an indicator constructed through the interpolation of open-source data, the same used to build the Protocol maps, aimed at determining and reporting a scale of synthetic values to analyse spatial relations between the multiple physical components of the rural-rurban-urban space under study. The Rural Neglection Indicator is necessary to handle care conditions in metropolitan rural landscapes. The Rural Neglection Indicator aims to determine a value gradient of neglect, abandonment, disorder and lack of care of the place of original agricultural vocation that is now subject to new metropolitan metabolic dynamics and projects.

This indicator is then linked to a second indicator, the Green-Grey Continuity Breakdown, which indicates the break in the continuity of the metropolitan structure constituted by the green-grey infrastructure that does not correspond to generic ecological corridors but also relates to mobility, the existing infrastructure system and the public realm. It is a tool to determine structural sensitivity in specific urban-rurban-rural locations in the metropolitan city at the urban scale. The continuity of the Green-Grey Infrastructure (Contin, Giordano, Nacke, 2021) has not yet been achieved and determined at the project scale. Green-Grey Infrastructure Breakdown is a qualitative indicator that allows representing the fragmented character of metropolitan landscapes, in specific urban-rurban-rural contexts, through a design reading aimed at marking forms of discontinuity, heterogeneity and structural hybridisation between the spatial categories belonging to Green Infrastructure (London City Hall, 2018) and those belonging to Grey Infrastructure. These are places where the existing architecture and urban fabric often do not cooperate with the formal matrix of the metropolitan landscape units to determine unitary interventions that intend to give new shape and new meaning to the places of the city.

Quality indicators are capable of defining a range of quality gradations at different scales, which, starting from the open-source data, will make it possible to systemise and interpolate the various concepts and thus

the multiple levels of information which we deduce from the Protocol Maps (Contin, Galiulo, Sanchez, 2021). To create quality indicators, the study from the macro metropolitan scale focuses on specific landscape units determining a research frame capable of identifying a unit of action within the broader field of action of the Metropolitan territory. Seeking and often constructing data at a shallow scale that is always open and related to the Metropolitan Green and Grey infrastructure means not considering transport planning as unrelated to achieving sustainability. We have a geographical base determined by a blue infrastructure and a green infrastructure and precisely logistics issues whose relationships are conceptualised through the choice of some Key Words and Related Concepts integrated with information levels contained in the semantic packages of our Glossary.

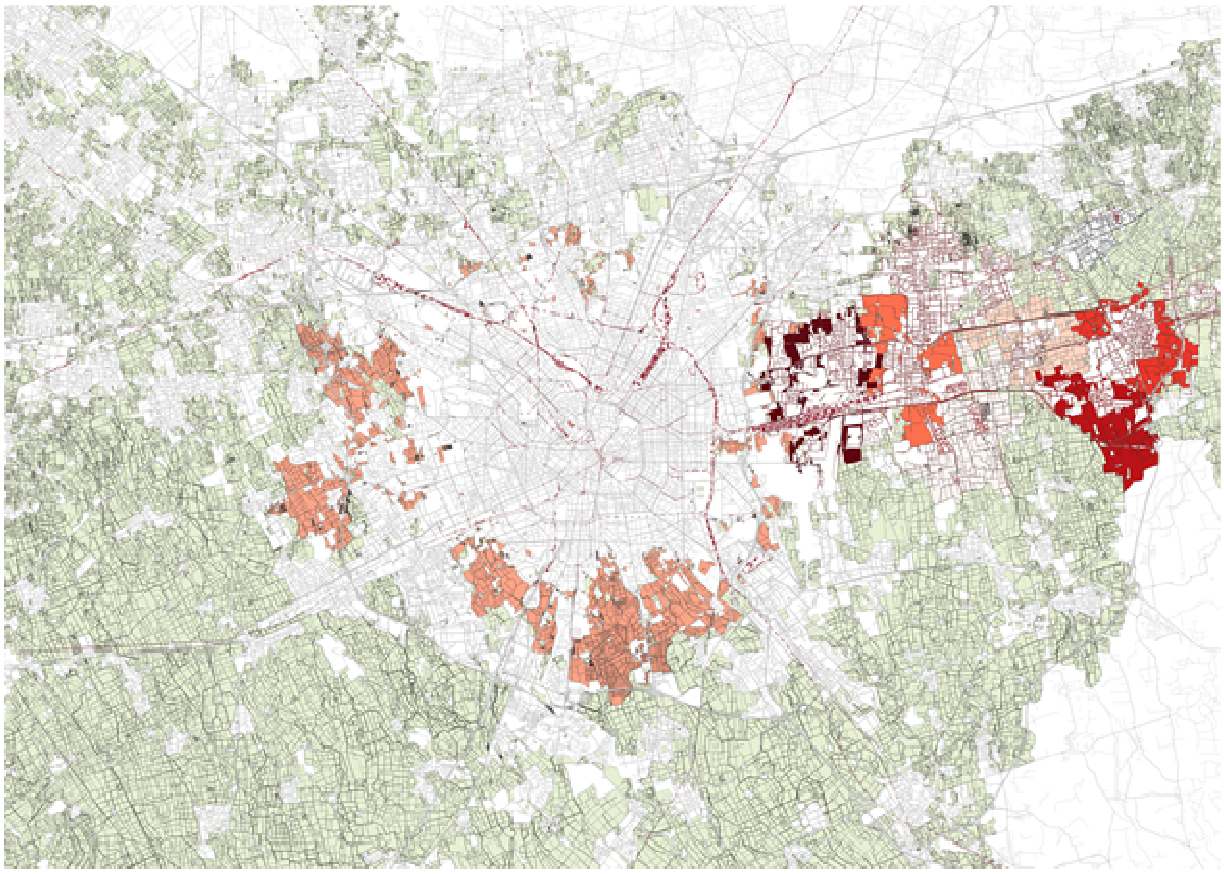


Fig. 2: Metropolitan Area of Milan. Rural Neglection is a qualitative indicator related to Urban-Rural Landscapes in between the interstitial spaces of infrastructured rurality. They are spaces of interdependence from the main Metropolis for flows of productive, ecosystem and social-economic services. Rural Neglection indicates gradients of eco-tonality to establish progressions of spatial quality, through the Metropolitan Cartography's maps.

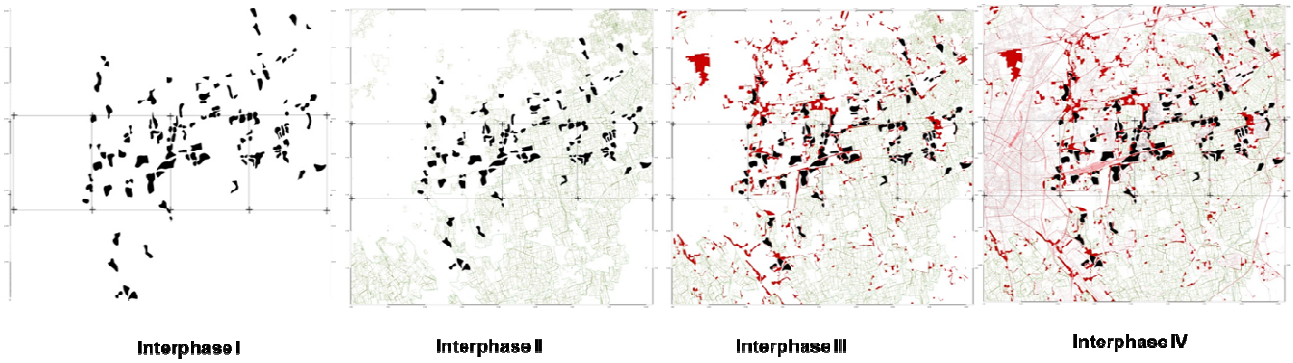


Fig. 3: The urban-rural interphase, in the metropolitan city, is a morphological space, linked to the structural and formal conditions of the land according to Green-Grey Continuity Breakdown

The idea is to systemise the data of the landscape units set on specific quadrants (relative to strategic geographical support points for the project), bounding boxes (micro-action units) and particular field of action (macro-action field) specific to the case study to determine, through our Maps, Meta-projects as plan

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

for the shareholders' negotiations. We want to stress that it is not only the issue of the impact that interests us (which has already been explored) but also the possibility of generating meta-project maps that can guide administrations' decisions toward priority sectoral policies.

6 THE CASE STUDIES

6.1 Piacenza_Melzo Logistic Living Laboratories. The Logistics Meta-District: Linkage Territory-City-Logistics Pattern

The Metropolitan Architecture Project concerns two areas in the cities of Piacenza in the Emilia Romagna Region and Melzo in the Milan Metropolitan area. The adoption and dissemination of innovative mobility solutions based on best practices, replicable data and planning in the neighbourhood involved in the proposal as a living laboratory contribute to the achievement of the priorities of the European Green Deal (EU Commision, 2019), which stresses that "transport should become drastically less polluting, especially in cities".

The first case of Piacenza objectives of the project along via Emilia presents the development of the general theme of the optimal distribution of the land use mix both in the urban centres and in the suburbs, looking for the rationalities of the plan to achieve the best combination of residential, commercial, leisure and industrial spaces to reach the most sustainable mobility patterns (integrated mobility) according to the available and future transport demand and supply. Moreover, we want to emphasise the need to determine new patterns of linkage between the territory, the city and the productive areas. This is not only to solve the structural lack of a connection avoiding the fragmentation of areas and the consequent services inaccessibility for the most fragile populations but also, to create a public realm capable of constituting the new idea of inclusive and democratic urbanity at the metropolitan scale.

Obviously, to assess the value of using integrated sustainable mobility at the local scale, it is necessary to understand better the impact of the interconnectedness of HGV freight transport and the burden of e-commerce on unsustainable delivery patterns, such as "just in time" deliveries producing longer journeys with more and more empty light-duty vehicles (LDVs), potentially leading to increased congestion, pollution, greenhouse gas (GHG) emissions and accidents along the transect, right down to the definition of the physical location where the interchange must take place.

The proposal intends to optimise the potential mix of strategically located land owned by public authorities (unused railway tracks and marshalling yards, real estate, car parks) or logistics service providers in urban areas to develop a comprehensive policy strategy and projects on the entire landscape section that integrates transport, logistics and land use returned as common and public space to the community.

Improving spatial management and urban planning by focusing on the "new normal" after the Covid-19 pandemic, considering how cities are optimising space planning and allocation, also means thinking about shared transport facilities for passengers and goods. For example, train/highway/light rail/active mobility interchanges could provide space for bus parking during the day and local delivery centres at night, including integrating transport centres in commercial and office buildings, shortening last-mile delivery distances and providing accessibility for passengers.

Starting from a definition consistent with the sustainability principles expressed by the SDGs, it is possible to demonstrate the viability of economically feasible and design sustainable solutions driven by relevant technologies (e.g. real-time traffic information, space management, electric car data) and the identification of governance/regulatory models that can influence the affordability of sustainable mobility consolidation, unswerving the need for full planning of loading and unloading spaces, to provide services and goods, moving towards a scenario where there is no double parking or no unsafe situations for cyclists and pedestrians in cities that cause congestion and road risk.

The final objective is to rethink the city's structure that integrates its different functions through a linkage pattern based on the definition of the green-grey infrastructure as a tool of interscalarity between urban parts and of a precise landscape image construction defining a new idea of the public realm.

This vision is based on the conviction that the physical dimension of the city determines the implementation of governance (Dente, Bobbio, Fareri, Morisi, 1990) from form to norm. It thus allows a sharing of appropriate principles by the main shareholders (municipality, floating and settled citizens, logistic operators,

couriers, and private institutions) for the development of sustainable and safe practices that determine a sense of metropolitan urbanity capable of connecting the different scales of the city. Addressing the issues of low-emission zone design by employing reliable data leads to the consolidation and management of space by establishing a dialogue with shareholders to define sustainable urban logistics plans and environmentally friendly e-commerce solutions that can also determine new morphologies, functions and new metropolitan urban morphotypes (Contin, Galiulo, 2020).

The case of Melzo is paradigmatic too. The design of the new passenger station connected to the cargo hub must be considered a driver of change for the entire buffer area between the historical city and the new logistics. It must thus connect transversally by giving quality and vertically by generating a public realm that holds together the historic Cascina Triulzia building with its garden and the school complex to the north by rethinking the use of the remaining intermediate agricultural fragments bringing them back to public use.

7 CONCLUSION

Assessing how urban space is used and allocated for the distribution of goods and parking would allow for mitigating impacts on congestion, noise, road hazards, air quality, greenhouse gas emissions and liveability. Still, it would also allow for the return to the city of significant portions of land currently neglected, assessing the impact on the existing and planned sustainable mobility model. The proposal should address the dynamic reallocation of space for the integration of urban freight transport at the local level, the impacts of use on urban and public space, and the optimal mix of space distribution and land use. Project proposals address the potential of strategically positioned urban (or peri-urban) spaces to develop and implement a pilot demonstration integrated with parks, trees or other green recreational areas. The objective is to reduce the impact of freight transport and logistics on the urban fabric through integrated mobility and quality of the public space. Projects could consider the involvement of real estate companies, logistics service providers, together with municipalities and citizens to develop sustainable planning models and spaces designed for open and clean consolidation hubs/spaces in cities (e.g. the use/sharing of existing private locations and other potential areas available in the city), for the dynamic reallocation of spaces building a new pattern of urban, rurban, rural, and natural linkage patterns.

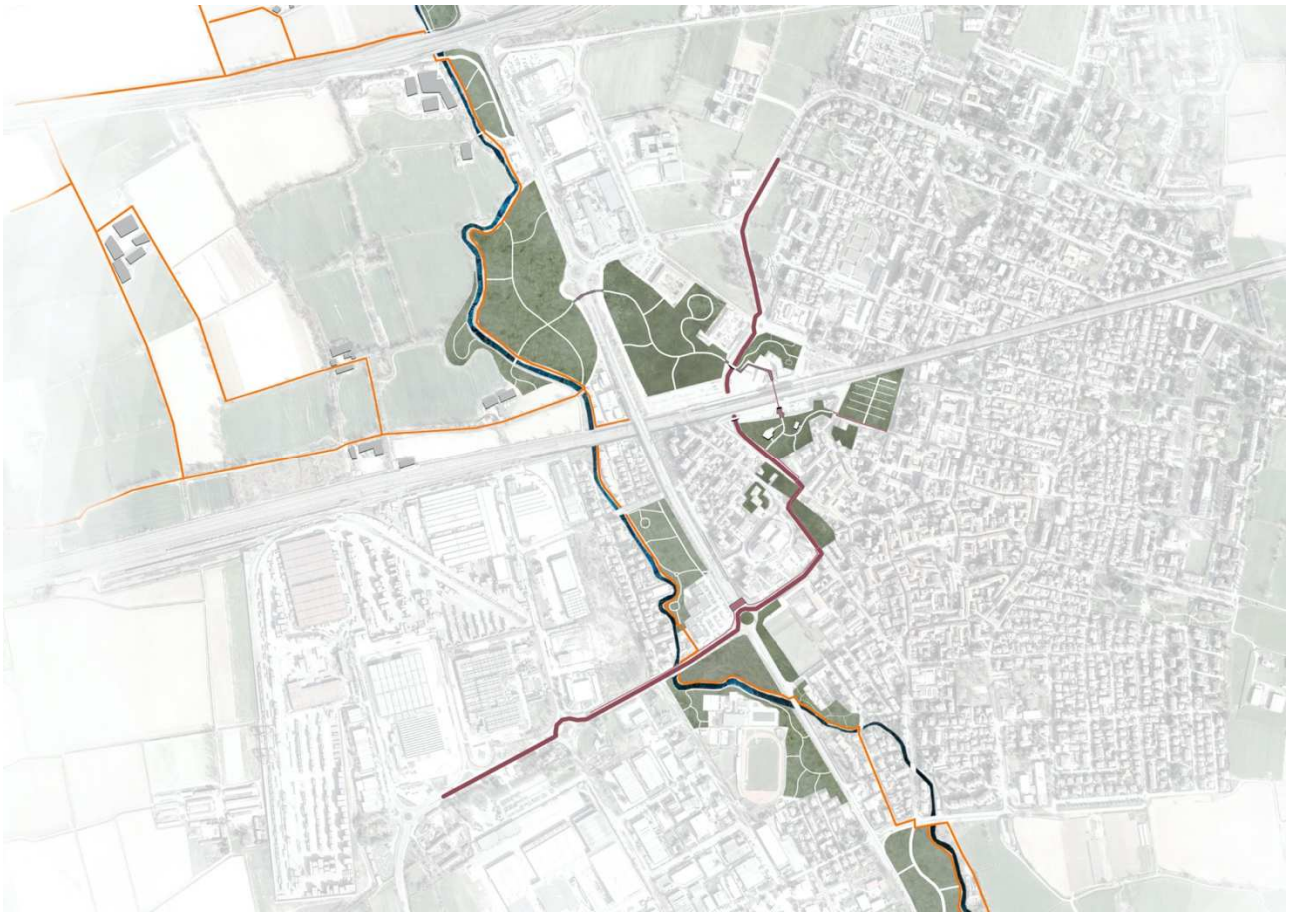


Fig. 4: Strategic Plan for Melzo in Metropolitan Logistic Meta-District of Milan

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

8 REFERENCES

CONTIN, Antonella, GALIULO, Valentina, SANCHEZ, Domingo: Tellme Metro-Dology: Metropolitan Cartography Como Herramienta Metodológica De La Sostenibilidad. Proceedings ITESO. 3er Congreso Internacional Sobre Sustentabilidad En Los Hàbitad, 4-5-6 November, ITESO Universidad Jesuita de Guadalajara. Guadalajara, 2021.

CONTIN, Antonella, GALIULO, Valentina:What is the quality of the space?, Proceedings ISOCARP 56th virtual World Planning Congress, Nov. 08, 2020-Feb04, 2021.

CONTIN, Antonella, GALIULO, Valentina, SÁNCHEZ FUENTES, Domingo:Metropolitan Cartography: An Inventive Practice Tool for Caring Metropolitan Landscapes, In ARCC-EAAE 2022 International Conference Resilient City: Physical, Social, and Economic Perspectives. Miami, US, Florida International University. Miami, 2022.

CONTIN, Antonella, GIORDANO, Patrizia, NACKE, Melina: Training for education, learning and leadership towards a new metropolitan discipline. Inaugural book, CIPPEC. Buenos Aires. 2021. https://www.cippec.org/publicacion/tellme-inaugural-book/

EU Commission: Communication from the commission to the European Parliament, the European council, the council, the European economic and social committee, and the European green deal committee of the regions. Com/2019/640 final. Bruxelles. 2019. https://eur-lex.europa.eu/legalcontent/EN/TXT/?qid=1576150542719&uri=COM%3A2019%3A640%3AFIN

DENTE, Bruno, BOBBIO, Luigi, FARERI, Paolo and MORISI, Massimo (eds.): Metropoli per progetti: Attori e processi di trasformazione urbana a Firenze, Torino, Milano, Il Mulino. Bologna, 1990.

GREATER LONDON AUTHORITY: London Environmental Strategy, Greater London Authority, London, 2018.

GOUVERNEUR, David, Planning and Design for Future Informal Settlements, Routledge. London, 2014.

OECD: Territorial Reviews: Milan, Italy, OECD Publishing, Paris, 2006. https://books.google.it/books?id=p_nkIC7iWKIC&pg=PA94&lpg=PA94&dq=metadistrict&source=bl&ots=ZSzyH729HT&sig=ACfU3U2qzT8F_nVK8MGlcHBvd7GhYWg0Rw&hl=en&sa=X#v=onepage&q=metadistrict&f=false

NASI, Francesco: Tecnologia, politica e capitalismo all'alba dei furiosi anni Venti. Intervista a Alec Ross, in Globalizzazione a pezzi? Pandora Rivista N°2/2022, pp. 16-25. Tempora Editore, Bologna, 2022.

UN-Habitat, Integrating the SDGs in Urban Project Design Recommendations from the Global Future Cities Programme. Un-Habitat: Nairobi, 2022. www.unhabitat.org

TELLme.Training for Education, Learning and Leadership towards a new MEtropolitan discipline. ERASMUS+ PROGRAMME 2014-2020 KA2 – Strategic Partnership for Higher Education. Retrieved from: https://ec.europa.eu/programmes/erasmus-plus/project-result-content/4030d44c-a715-40ee-80a9-d32a6908e194/TELLme%20O2%20Metropolitan%20Glossary.pdf

TELLme.Training for Education, Learning and Leadership towards a new MEtropolitan discipline. ERASMUS+ PROGRAMME 2014-2020 KA2 – Strategic Partnership for Higher Education. Retrieved from: TELLme Hub http://tellmehub.get-it.it/.

PARLAMENTO ITALIANO. CAMERA DEI DEPUTATI. Legge quadro in materia di interporti https://temi.camera.it/leg18/dossier/OCD18-13977/legge-quadro-materia-interporti.html. Roma, 2020

🏆 *reviewed paper*

A Mannheim Best Smart City Case: New Measuring System for the Complex Analysis of Spatially Distributed Environmental Data

Danny Westphal , Gamze Ünsal-Peter, Matthias Rädle, Hans Rüdiger Kaufmann, Thomas Walch

(Danny Westphal, Hochschule Mannheim; Mannheim, DE, d.westphal@hs-mannheim.de)
(Gamze Ünsal-Peter, Hochschule Mannheim; Mannheim, DE, g.uensal-peter@hs-mannheim.de)
(Matthias Rädle, Hochschule Mannheim; Mannheim, DE, m.raedle@hs-mannheim.de)
(Hans Rüdiger Kaufmann, Hochschule der Wirtschaft für Management; Mannheim, DE, hans-ruediger.kaufmann@hdwm.org)
(Thomas Walch, Nevoox; Mannheim, DE, thomas.walch@nevoox-europe.de)

1 ABSTRACT

Serving Smart City (SC) and societal objectives (i.e. contributing to better air quality and combat the Corona virus), a novel measuring device is presented as the latest offspring of the SC Ecosystem Mannheim. In this paper – based on the description of the concerted activities of the various players of the Mannheim SC ecosystem – we aim to present the findings of our study of the distribution of gases and particles and their impact on the health of SC citizens of all ages and the ecological balance. Furthermore, the relationship between CO2 and liquid aerosols is discussed. In particular, the questions of how corona-relevant droplets spread and how quickly they evaporate are investigated. A broad portfolio of possible applications suggested by Nevoox rounds off the article. The practical case is interlinked with the results of the DevOps Competences for Smart Cities project with competences being the common denominator. The case reflects necessary transversal (such as creative, innovative, entrepreneurial, networking) and technical competences (i.e. related to coding, data architechture, big data, cloud computing or AI) to exist in an ecosystem aiming for sustainable innovation.

Keywords: health, ProxiCube, ecosystem, Smart City, DevOps

2 INTRODUCTION

The intensive SC engagement, positioning and branding of the City of Mannheim (Smart City Mission Statement 2030; Bitcom Award for Administration; Approved Role Model Project Smart Cities; future-proof city quarter development ‘Franklin’; Urban thinker campuses) sets the stage for the product’s current international success. The Mannheim Smart Production network is a nexus between manufacturing companies, research institutions and B2B solution providers. Here, the idea of the cube-shaped multi-sensor system was created during the development of the next generation of Industrie 4.0 manufacturing. Furthermore, the Wirtschaftsförderung Mannheim (Promotion of the Economy) provides know-how on location, real estate, financial promotion opportunities, recruitment of qualified staff or company contacts. Mafinex is Mannheim’s technology center for startups. Last but not least Mannheim’s universities propel the town’s SC movement. The University of Mannheim scientifically accompanies the SC Model project and investigates, for example, the influence of SC on social imbalances. The University of Applied Management Studies Mannheim was a partner of the EU supported project on DevOps competences for SC having created the globally first MOOC program in this emerging knowledge stream. To provide some theoretical underpinning, this paper revisits two previous RealCorps Conference presentations on DevOps competences and Urban Management (Kaufmann et al., 2020; Kaufmann et al., 2021). Last but not least, the University of Applied Sciences Mannheim: the device development was led by Dr. Thomas Schäfer from the Institute CeMOS of the University of Applied Sciences Mannheim. The industrial production readiness of the final product was achieved by ProxiVision GmbH/Bensheim, and the responsible sales partner is Nevoox GmbH/Mannheim.

As a competitive advantage, the novel low cost device allows a much more structured and small scale environmental monitoring than was possible before its development and mass production. Suggestions for further research refer to the possibility to keep dozens of measuring cubes in operation in parallel. With this information, smart cities can be optimized by measuring environmental conditions in existing urban quarters or districts aiming to counteract detrimental consequences, thereby benefitting the health of the citizens of all ages and the ecological balance.

For this reason, the following experiments, application examples and possibilities focus on these aspects. Furthermore, the relationship between CO2 and liquid aerosols is discussed. In particular, the questions of how corona-relevant droplets spread and how quickly they evaporate are investigated.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

3 MATERIAL AND MEASUREMENTS

The device, dubbed ProxiCube, is a cube-shaped multi-sensor system with an edge length of 8 cm (Fig 1), lead-developed by Dr. Thomas Schäfer from the CeMOS competence centre at Mannheim University of Applied Sciences. It measures distributed environmental data such as CO2, TVOC, temperature, pressure, humidity, luminous intensity, loudness, but also fine dust and liquid aerosols. More values, such as position, speed, acoustic frequency ranges, CO and much more can be provided as add-on sensors.

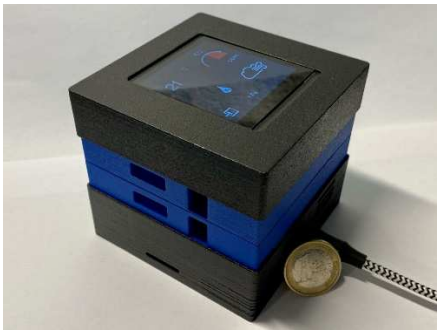


Fig. 1: ProxiCube NX3 series with digital display

All data are transmited to the cloud via radio can be retrieved, displayed, and further processed from the database worldwide via authorization certificates – also retroactively via mobile phone or PC or control centre.

Based on simultaneously measuring and storing all the aforementioned data via sensors, AI algorithms can be applied such as correlation clusters to be used for urban planning and management. The device categorizes dry particulate matter in different size classes and enables the exact identification of the respirable load and of the amount of dust trapped in the mouths and throats of citizens. The same applies to liquid aerosols, which are measured separately from dry particulate matter. Fluid droplets are also distinguished between respirable and non-respirable ones. As to liquid aerosol measurement, the standard integration of separately measured liquid aerosols which this environmental sensor makes this device worldwide unique. For the basic idea of the separate measurement of total aerosols and the liquid part, a patent has been applied for.

3.1 Outdoor and indoor air quality monitoring

The small and inexpensive sensor can generate the same measured values as highly complex reference devices as it was confirmed by recent publication (Westphal et al., 2021) and additional comparative measurements.

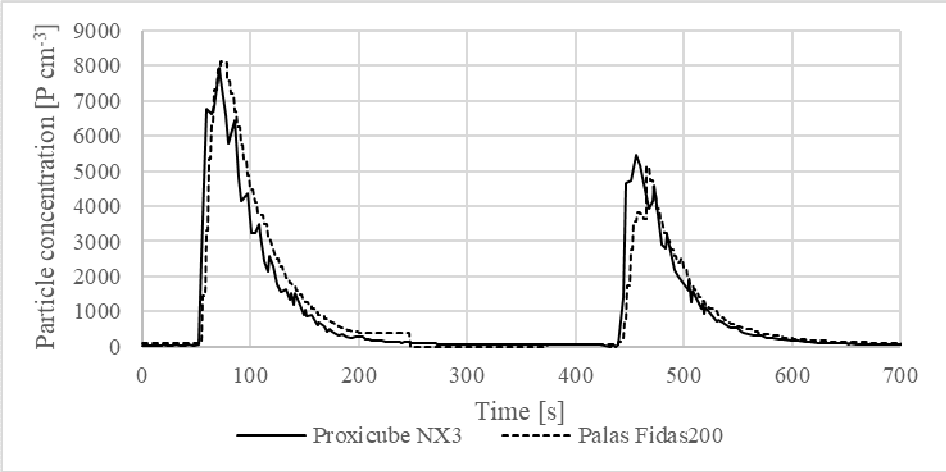


Fig. 2: Calibration of ProxiCube NX3 with Palas Fidas 200 with room dust

In Figure 2 the measurement of smoking candels in an exclosed chamber is shown. As you can see both Proxicube and the reference measurement device Fidas 200 show similar particulate matter concentration. Due to the inexpensive nature of the cube, for the first time, urban planners are now able to use a variety of measuring cubes not only to monitor particulate matter in a simplified way at neuralgic points in cities, but

also to quantify its local distribution. They can, for example, investigate the question of how far the dust on the main road travels into the side streets, or up to which floor of a high-rise building it rises.

In addition to monitoring indoor air quality, the influence of outdoor air on indoor air quality can now also be studied and, based on this, measures to improve indoor air quality can be taken. To illustrate this, indoor air measurements were carried out in the kitchen of an institute.

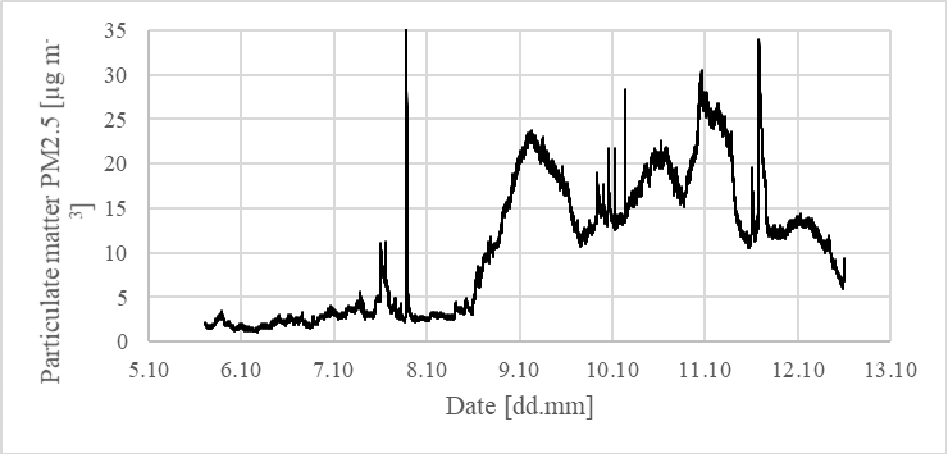


Fig. 3: Particle load in the kitchen of an institute (CeMOS, Mannheim, John Deere Str. 81A, diameter below 2,5 µm

Fig. 3 shows the respirable fraction (< 2.5 µm) of dry particles over the course of several days. In addition to short-term fluctuations, which can be attributed to the frequency of use of the kitchen, a connection with weather events and the resulting fluctuations in fine dust pollution can be identified (Fig. 4). At the start of the measurements it was raining outside. Therefore, the particulate matter concentration is relatively low. During the following dry days between 06.10.21 to 10.10.21, fine dust entered the kitchen through the open windows. This can be seen in the increasing background fine dust load. Towards the end of the measurements, it began to rain again. This is clearly shown by the falling fine dust loads. This makes it possible to localize the causes of fine dust and to initiate targeted countermeasures.

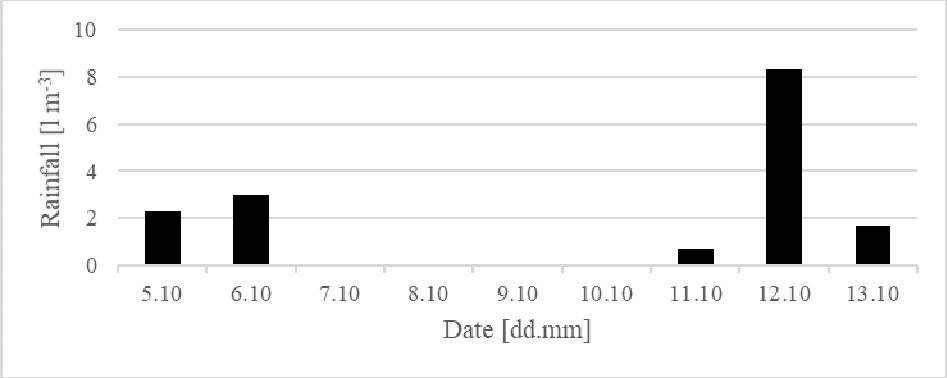


Fig. 4: Weather data recorded during the measurement period

In addition to monitoring particulate matter concentrations, the measurement of $CO_2$and TVOC shows correlations between various environmental impacts.

Figure 5 shows the increase and decrease of CO_2 and TVOC in the kitchen of an intitute during one working day. The institute's daily routine starts at 7am and ends at 6pm. Due to closed windows the CO_2concentration rises continuously until 6pm. There is a fairly obvious peak during lunchtime. The TVOC measured values show a similar behavior. There is a steep rise in TVOC level at the beginning, a peak during lunchtime and a steep fall at the end of the working day. Compared to the CO_2values, the TVOC value does not increase over time, but shows a relatively constant value.

One can also notice that the progression of organic air pollutants, which also have causes other than humans, is not fully correlated. The TVOC sensor in this case is non-specific and cannot distinguish between solvent vapors or outgassing of fresh rolls from the bakery. However, specific sensors are available and could be integrated if required by the city optimizer.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

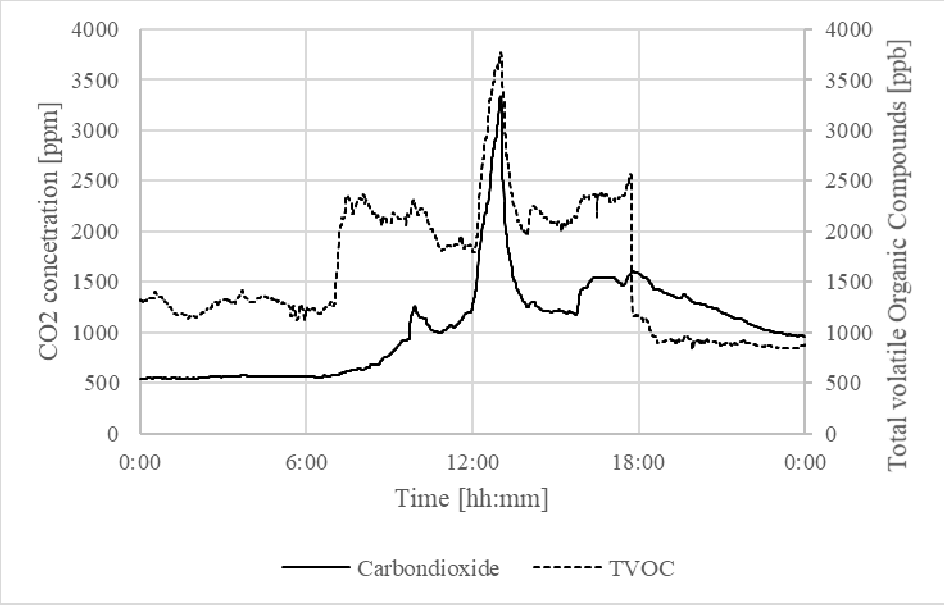


Fig. 5: Air quality measurement in an institute kitchen: CO_2 and TVOC concentrations

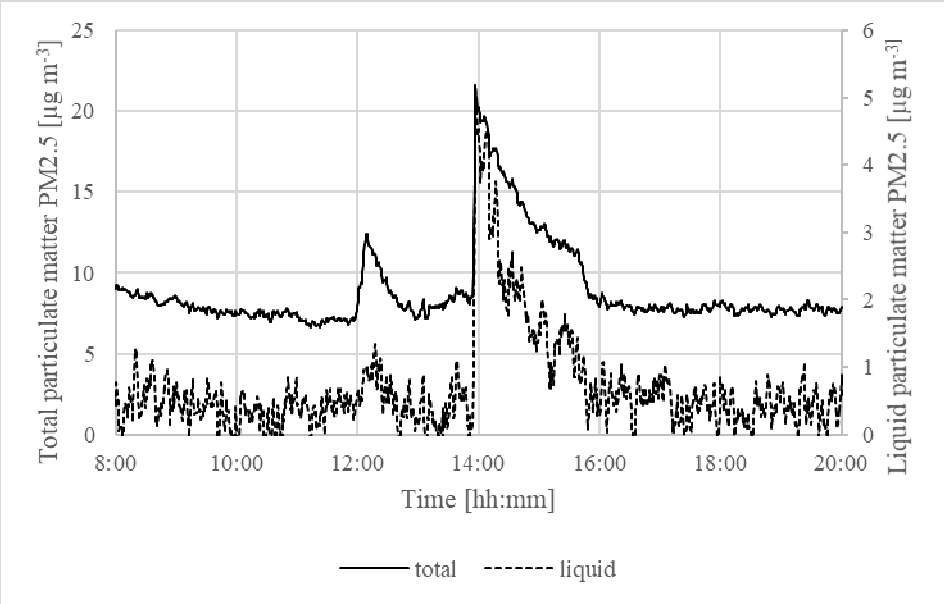


Fig. 6: Air quality control: fluid part of particles/droplets, < 2,5 µm

Figure 6 shows the course of particles in general (solid plus liquid) in one curve and in a second curve only the liquid droplets exhaled by humans during the same measurement as mentioned above. Both, solid particles (fine dust) and liquid droplets are correctly referred to as aerosols. The fraction of aerosols exhaled by humans should be referred to as liquid aerosols (Asbach et al., 2021). These liquid aerosols only occur when a minimum human exposure is exceeded. In well-ventilated rooms, no liquid aerosols can be found because they evaporate near instantaneously.

As it can be seen there are two distinctive peaks, for both general and liquid aerosols. The first, smaller peak during luchtime and a second bigger peak at 2pm. If we compare the course of the aerosols with the measurement curve for CO_2, we see that the aerosol load does not correlate directly with the CO_2curve. The high CO_2load during the lunch break corresponds to the lower aerosol load and vice versa. The reason for this could be that during the coffee break at 2 p.m. there were fewer people in the room than at lunchtime (thus less CO_2), but these people talked more to each other and thus more aerosols were produced. Overall, this suggests that measuring CO_2alone is not useful.

3.2 Examination of temporarily heavily polluted parts of buildings: Airlock in a public building

Another series of measurements shows values recorded over two hours in an entrance area of one of the main buildings on the campus of Mannheim University of Applied Sciences. The area is located between a door that opens to the outside and one that opens to the inside of the building.

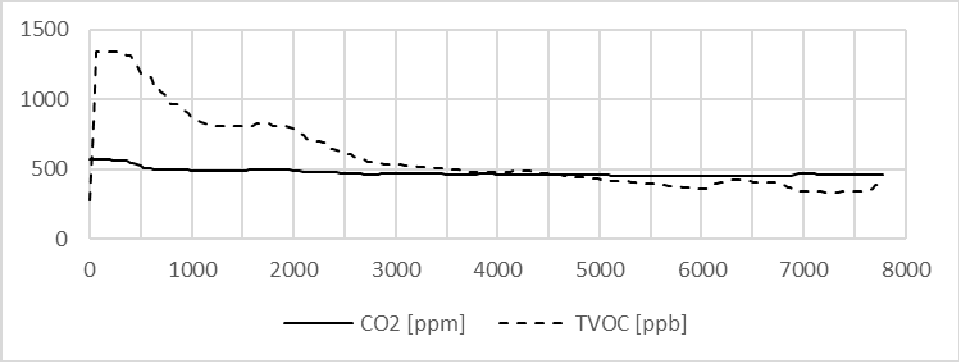


Fig. 8: CO_2 and TVOC measurement curves in the entrance area during the lunch break

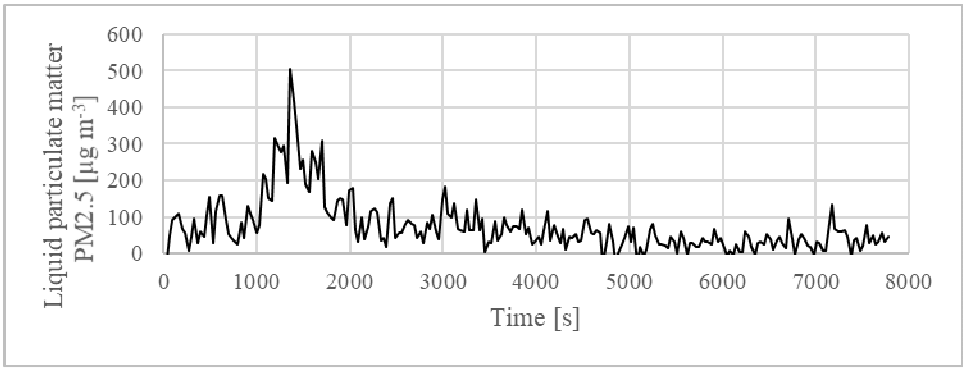


Fig. 9: Liquid particle measurement course in the entrance area during the lunch break

Approximately five minutes after the end of the lectures, an increase can be observed in both TVOC readings and particle readings as several students walk through the airlock (see figures 8 and 9). The CO_2 reading over the entire measurement period is 500 ppm due to the high frequency of door opening. The comparison of the measurement courses of CO_2, particle and TVOC measurements clearly shows that particle pollution lasting for several minutes does not correlate with CO_2 measurements.

3.3 Measurements compared to visualized fogging

A person enters a closed room with a volume of 7 m³ at the beginning of the measurement. After 20 minutes, the person exhales the smoke of an e-cigarette. The dissipation course of the exhaled cloud, a mixture of solid and liquid particles of different sizes and respiratory gases, is recorded as shown in Fig. 10 Within two seconds, the cloud passes over the measuring box in visible swirls and appears to become more transparent due to the distribution.

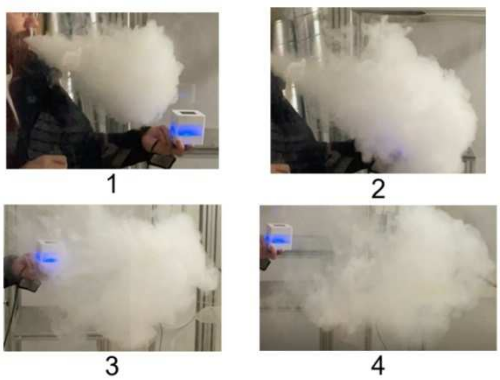


Fig. 10: Experiments in a closed room with e-cigarette: distribution of the cloud in the room.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

The first five vertical lines in Fig. 11 indicate the exhalation times. At the sixth line the person leaves the room and from the seventh line the ventilation is switched on. The NX3 sensor records a liquid particle count of 28601 per cm³, which corresponds to aerosol exhalation in the selected particle size. A CO2 concentration of 2105 ppm is displayed by this unit as a peak after 50 seconds (see figure 11).

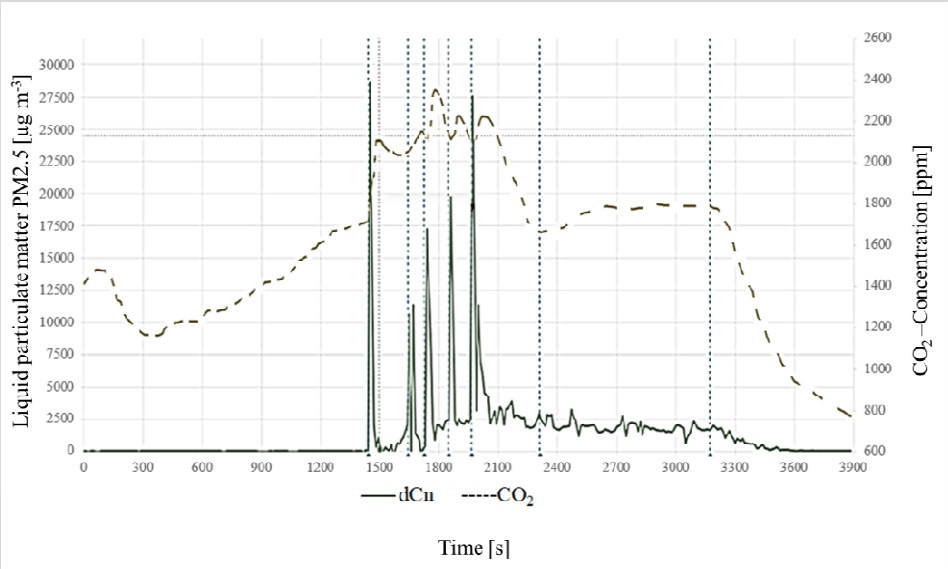


Fig. 11: Experiments in a closed room with e-cigarette: comparison of CO_2 and liquid particle readings directly at the source

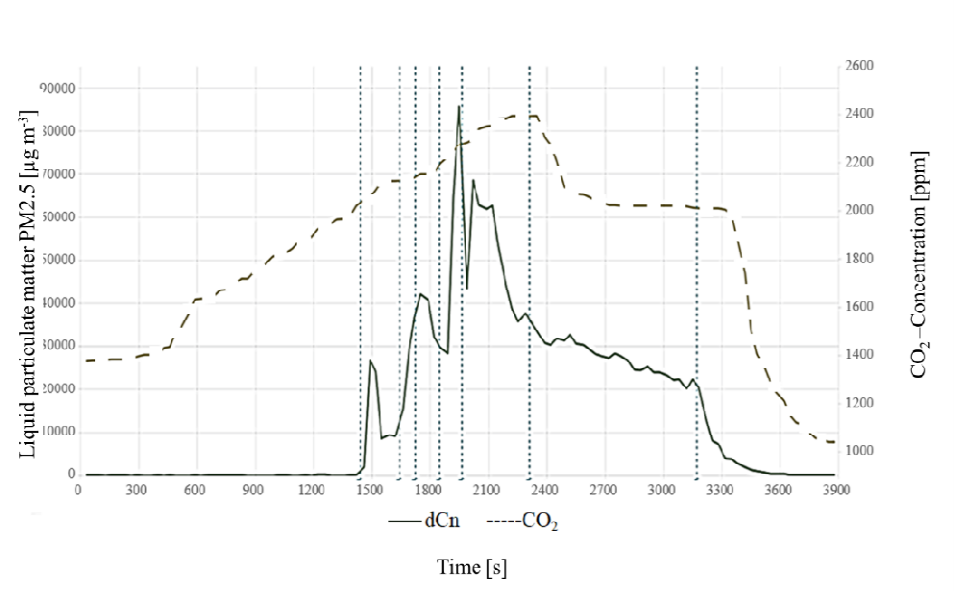


Fig. 12: Experiments in a closed room with e-cigarette: comparison of CO_2 and liquid particle readings approx. 2 m from the source

Another sensor is placed on the floor approx. 2 m away from the experimental setup (see figure 12). The peaks are only recognizable as individual peaks when looking at the dCn curves. Here, a CO_2 increase up to 2400 ppm is registered after the first exhalation. The aerosol measurement shows about 12000 liquid particles with a broader peak curve.

3.4 Current and future applications of the Cube

This highly precise patent-pending technology for indoor air quality and TVOC value measurement with wireless communication via WLAN, Matter, Bluetooth, LoRaWAN or more can be envisaged to be potentially useful for the following manifold settings (without being exclusive): offices and meeting rooms, restaurant and hotels, sports studios and clubs, private apartments and houses, medical practices, hospitals and clinics, nursing and old people homes, schools, kindergardens and day care centers, or hairdressing salons and cosmetic studios. The cube can be customized as to OEM's requirements, colors, configurations or logos.

As already indicated, in the smart city context, this product is intended to be further developed for smart building management and smart homes further exploiting AI opportunities and networks such as Matter, an IP based communication standard, or the Definics or LON network technology. In this vein, future applications might utilize intelligent sensing needed, for example, for motion and presence detection, sleep monitoring (i.e. for babies and kids), or fall detection (i.e. elderly). In addition, relating to climate and pollution issues, and as stated before, urban planners can use a variety of measuring cubes in a simplified way at neuralgic points in cities and, additionally, can quantify its local distribution.

On retrospect, the sequential and diverse processes applied in this case might serve as a blueprint for urban management to initiate, plan and co-ordinate similar innovative cases in the future. The following section of the paper will show that this process of effective urban management requires to decide on desired and citizen driven SC ecosystem achievements and outcomes. On this basis, the priorities in relation with the conditional competences must be assessed and provided and, finally, implemented by an effective collaboration of all SC ecosystem stakeholders.

4 REVISITING THE DEVOPS COMPETENCES FOR SMART CITIES PROJECT IN RELATION TO THE CASE

This paper revisits previous REAL CORP conference presentations (Kaufmann et al. 2021 and Kaufmann et al., 2022) having provided the findings of the project ‚DevOps competences for Smart Cities' supported by ERASMUS + Sector Skills Alliances with the mission to support Smart City administrators as well as co-operating companies and partners in competence development. The project identified the core competences (digital, transferable, Smart City specific and DevOps specific) and future job profiles of city employees. The project's methodology was based on a critical realist reseach philosopy and a triangulated qualitative and quantitative empirical research approach in four countries (Cyprus, Germany, Greece and Italy). A wideranging literature review and documentary analysis had been conducted as to elicit market demands and supply. The research was analysed using content analysis, as well as descriptive and explanatory methods such as cross tabulation, correlation analysis and PLS-SEM analysis. The project resulted in the first global MOOCs Course on DevOps competences for smart cities differentiated by administrative job profiles (smart city planners, IT heads, and IT officers). A sustainable network of International Best Practice was created.

4.1 Competences reflected by the cube case

This paper contributes to the discussion on the prioritization of technical, citizen and people driven Smart City philosophies. The cube applications refer to the people driven one due to focusing on health implications and their implicit solutions for citizens. It draws on the literature on data, technologies and infrastructure provided and points to the need for multidisciplinary literature in smart city themes exemplified by aerosol research in the SARS-CoV-2 context and by technical related literature to identify liquid and solid particles in ambient air. Developing intelligent measurement devices is certainly not the task of city administrators, but, due to the significant contributions of the cube applications to smart city objectives, the paper suggests enhanced understanding of the mutual competences required by all smart city ecosystem actors involved in a team based development approach. This is also underlined by that the data created by the measurement device will become part of the information decision support system of the smart city planner.

The integration of the paramount importance of measurement devices is suggested to be stressed and further integrated into longitudinal studies such as that of Tratz-Ryan and Finnerty, 2018, in Kaufmann et al., 2021) displaying the IT response to dynamic changes in Smart Cities via a Hype Cycle for Smart City Technologies and Solutions such as artificial general intelligence, smart building, data market place, city operation center, sustainability and COP21, smart monitoring for public infrastructures, IoT platform and Internet of Things, smart city framework, connected home, or intelligent building automation systems.

The experiment results of this paper support the qualitative findings of the project in that measurement devices might be regarded as the very basis to generate key success factors and competences for awarded smart cities (see figure 13): a smart city infrastructure and a strategy for digital transformation (see 3.2. in the following); as already mentioned, the findings of the experiments in this paper put the citizens in general and their health in particular at the centre of attention; the existence of necessary skills such as research, IT related, manufacturing and local and global marketing skills are confirmed as well as the implicit smart city

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

education and knowledge transfer (i.e. from the research experiment laboratory to the schools and universites) to follow suit the market implementation of the product; last but not least, an idiosyncratic smart city identity positioning can be achieved exemplified by health orientation or innovation in this case.

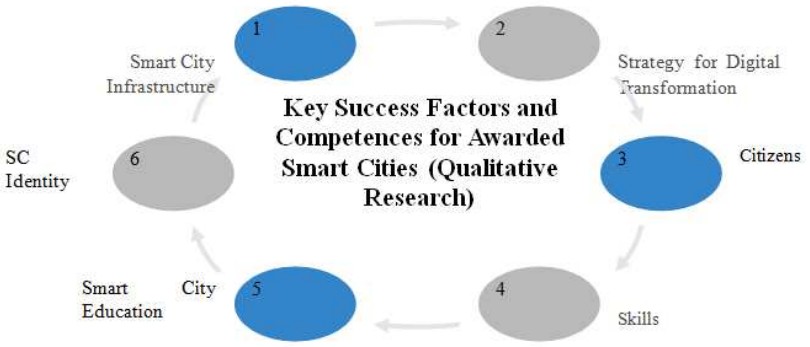


Fig. 13: Key Success Factors and Competences for Awarded Smart Cities (Qualitative Research)

Referring to the required typologies of DevOps competences for smart cities, this paper holds that - in terms of transversal skills - creativity, entrepreneurial thinking, the ability to work in a team, strategic vision & strategy development (including switching from operational to strategic competences, project and process management, design thinking, decision making, problem solving (& conflict solving), Leadership and Management Skills (including change management, new thinking), stakeholder management, sustainable development and advanced presentation skills have been required to develop and launch the product. All of these transversal competences have been confirmed unanimously by smart city planners, IT heads and IT officers to belong to the most important mandatory ones.

Referring to IT Management related competences the experiments provided in this paper confirm the relevance of knowledge on software development lifecycles, introduction to cloud computing and internet of things, system and software architechture, data analytics or risk management mandatory mainly for IT heads and to a lesser extent for smart city planners and IT officers.

Referring to smart city related competences, this paper confirms the relevance of smart city platforms, smart city business models, smart city operating procedures, smart city sustainability, smart city resilience, urban management, smart city services with a special focus on health due to corona crisis and citizen driven/citizen orientation/user experience design to be most important mandatory ones for smart city planners and IT heads.

Additionally, this cube case very well informs on the most needed competences in the field of responsibility of smart city planners as investigated by the DevOps project: Teamwork (i.e. regarding the nexus between research, manufacturing and marketing), urban innovation (i.e. reflected in the unique selling propositions of the cube in terms of reduced size and implicit scalability and private application and health movements as well as multi-sensoring features of the cube) and user experience (reflected, for example, in the readable display of the measurement for the users). With further and ongoing development of applications, this cube case provided might also give good practice insight into technical skills to switch from operational to strategic tasks, IoT specific knowledge as well as machine learning and deep learning, three competences in which the highest training demands exist according to the DevOps project‘s findings. In this wave, DevOps competences are highly recommended for further software development associated with the services of this cube, an additional high training demand assessed by the project.

Interestingly, the DevOps project revealed that the competences in which training is mostly needed, did not overlap with those competence developments for which co-operation with external partners is chosen such as mobile development, IT/cyber security or artificial intelligence. The project researchers concluded that these needed competences are rated as very important, so that these should be trained and be existent in-house instead of relying on external partners. This cube case, which was very much a teamwork success of several partners, however, either suggests to reflect on and revert this conviction or it might imply the perception that the members of the smart city ecosystem are not regarded as external partners by city administrators. However, external knowledge co-operation, most preferably- according to the DevOps project- with consultants and online and distance learning will still be required, especially in those competences in which fewer demands for training have been identified. The project revealed a strong positive and significant

relationship between integrating DevOps competences into the own team and the co-operation with external DevOps teams with this co-operation having a strong adding value to cities in the future (indicating high perceived importance of DevOps and that DevOps competences in the own team (at least partially) is regarded a precondition for collaborating with external partners. Besides the already mentioned future potentially very successful cube application in the health service, this measurement device might have a crucial future role to play in smart building/smart home city services. The DevOps project elicited a significant relationship (0.01 level) between the competence perception in this field and its current and future importance for the city.

Based on the development of the cube case, the authors of this paper conclude to widen the perception of the ‚internal team' to a holistic smart city ecosystem represented by the quintable helix innovation framework (Kaufmann et al., 2022) with the five sub-systems of universities, industry, government (city administration), the public (citizens) and environment. Regarding the smart city movement, the cititzens are regarded the driving force. In the case of the City of Mannheim, the interaction of these ‚five players' is illustrated as follows.

4.2 Mannheim's Smart City Ecosystem

The intensive global, European, national and local engagement, positioning and branding of the City of Mannheim sets the stage for the product's current international success.

The Mannheim Smart Production network, initiated by the Mannheim Wirtschaftsförderung (economy promotion) in 2016 is a nexus between manufacturing companies, research institutions and B2B solution providers. Here, the idea for the basic shape of the cube was created during the development of the next generation of Industrie 4.0 manufacturing. The network is „Germany wide the only communally driven platform for digitalization of production. It unites ca. 50 innovative startups, Mittelstand companies, global players and scientific institutions from IT and production to a both, effective and efficient innnovation cluster in the Metropol- Region Rhine-Neckar and propels digitalisation in the region" (translated from https://smartproduction.de).

Furthermore, the Wirtschaftsförderung Mannheim (Promotion of the Economy) aims to support Mannheim's entrepreneurs to be successful and provides know-how on location, real estate, financial promotion opportunities, recruitment of qualified staff or company contacts (https://www.mannheim.de).

Being the home of more than 60 tech-orientated startups, the technology center Mafinex is a „hotspot of Innovation" providing access to communication and exchange, a treasure of past experience, digital know how, and potential for possible co-operation and synergy between community management, startups and investors. In the meantime, more than 170 startups were successfully supported for their market entry (https://mafinex.next-mannheim.de).

The City of Mannheim positions itself as a digital, open, accessible and transparent City of the Future'. In terms of digital administration, the Digital Association Bitcom awarded the city with the Smart City Award 2019 for the category of Digital Administration on the occasiom of the Smart Country Convention in Berlin. The award is based on the Smart City Index, a digital ranking of 81 big German cities.

In the Vision statement on ‚how we would like to live', emphasis is placed on putting the human being in the very center of ‚smart' and ‚sustainable' ideas developed together with and for all citizens, associations, public institutions, startups or traditional companies for a city which is worth living in. Digital and intelligently connected technologies shall be used to make life easier. Climate neutrality, resource efficiency, simplification of life and an ever stronger sense of community are the city's objectives.

For the strategy development the city follows an overarching roadmap:

- Developing a Mission Statement 2030 ratified by the city's council (Gemeinderat)
- Decision on the digititalization strategy with 40 measures and projects ratified by the city's council
- Workshops with participants from central resorts, city-owned companies and communal enterprises
- Application and Award for the governmental program on model project Smart Cities

Together with other 31cities, the German government (Ministry of the Interior, Construction and Homeland, BMI) granted the model project called ‚sMArt roots (with MA being the city's abbreviation) to the city. The

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

model project‘s Smart Cities are promoted by KfW (Kreditanstalt für Wiederaufbau - credit institute for reconstruction). In addition, the BMI launched a co-ordination and transfer center consisting of DLR (Deutsches Zentrum für Luft- und Raumfahrt- German Aerospace Center-, Fraunhofer, Difu (Deutsches Institut für Urbanistik- German Institute for Urbanistics, Creative Climate Cities, Prognos and other partners, as a precondition to expand knowledge to a wider group of communities. The University of Mannheim scientifically accompanies the Smart City Model project and investigates, for example, the influence of Smart Cities on social imbalances. The focus of this project is to utilize digitization to improve life quality, upgrade public space, becoming more citizen centered and efficient, especially in the fields of energy, traffic and resources based on a validated, interconnected and sector transcending smart city strategy and agile processes. The results of this project should have a role modelling character.

- The sMArt City Mannheim GmbH (Society with limited liability) was founded, a Joint Venture of the city with the energy enterprise MVV Energy AG to expand on recycable energies, for example, based on a photovoltaic initiative aiming to make electricity consumption of city owned establishments totally climate neutral by 2027. The city has been selected by the EU mission 100 climate neutral cities by 2030.
- Finalising the Smart City strategy in September 2022
- Consultation and decision on the strategy in the main committee of the city’s council (Gemeinderat) in autumn 2022.
- Launching the Bundesgartenschau 23 (BUGA- National Garden Show) in Mannheim

The Smart strategy, furthermore, is informed by the results of the innovative open exchange platform for Urban Thinkers Campus, an initiative of the World Urban Campaign of the UN Habitat program aiming to promote sustainability in cities. Here, urban representatives and local and international experts provide input to societal developments on a global level. „To date, Mannheim ist the only German city to have organized this innovative format“ (https://www.mannheim.de). Since, 2016, this event takes place on a yearly re-occurring basis.

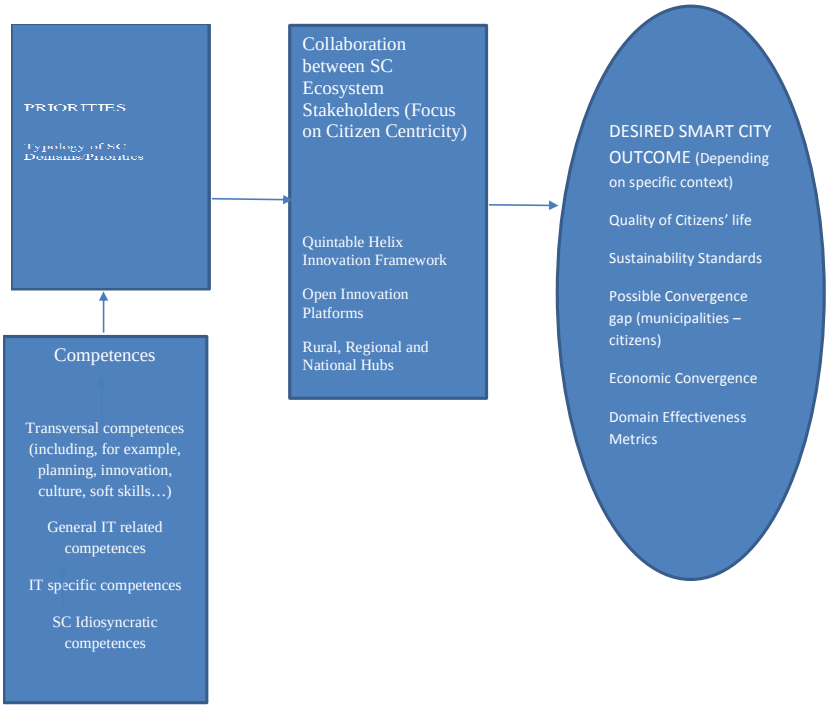
Both, social (socially mixed district) and ecological sustainability objectives are pursued by the development of the Franklin village, a future-proof city quarter to be completed by 2025, the former largest barracks site of the US Armed Forces in Germany, consisting of five largely mixed-used neighborhoods on an area of 94 ha (https://sdg21.eu). Existing buildings will be energetically renovated and new ones constructed entailing ca. 40% of the total area dedicated to a mostly green public open space. The mobility concept allocates equal importance to all transport users, and „public transport is complemented by innovative, low-emission mobility offers of the sharing economy (rental bike, rental car system, establishment and operation of an e-vehicle fleet“ (https://sdg21.eu). „In the Square project, GBG – Mannheimer Wohnungsbaugesellschaft - public utility housing enterprise- is developing two existing buildings into ecological model houses…The sustainability of the methods will be measured and compared by means of a 3-year monitoring of the measure after completion of construction“ (https//sdg21.eu).

Last but not least Mannheim’s universities propel the town’s Smart City movement. Besides the aforementioned involvement of the University of Mannheim in the ‚sMArt roots project‘, the contribution of other Mannheim universities, in particular that of the University of Applied Management Studies Mannheim, i.e. by developing the cube case at hand, and the University of Applied Management Studies Mannheim (HdWM) participating in the DevOps Competences for Smart Cities project have already been described before in detail.

5 CONCLUSION

Referring to the first part of the paper, the experiments confirm that a small and inexpensive sensor can generate the same measured values as highly complex reference devices in a more simplified and decentralized and even private manner. Besides the possible correlation between different environmental impacts, indoor conditions can be correlated with outdoor conditions enabling the design of targeted counteracting measures to improve the respective situation. The experiments showed that CO_2 measures should be supplemented by factors relating to human exposure and ventilation.

Referring to the second part of the paper, the described activities of the various stakeholders mirror the relevance of urban management model suggested in a previous paper (Kaufmann et al., 2022) in terms of the collaboration between the diverse players and the desired Smart City outcomes (see figure 14). The authors of this paper suggest to base the Smart City strategy on existing or newly created competences and increasingly on measurement devices, as this – as the DevOps project has shown- will determine the priorities and collaboration.



Source: developed from the authors based on Agbali et al. (2017) Allam (2019), Appio et al. (2019), Charalabidis et al. (2020), Cukusic et al. (2019), Garg, Mittal and Sharma (2017), Kaufmann et al. (2020), Lytras and Serban (2020), Ojasalo and Kauppinen (2016), Umar (2018)

Fig. 14: Urban Management Model

6 REFERENCES

Asbach, C., Held, A., Kiendler-Scharr, A., Scheuch, G., Schmid, H.-J., Schmitt, S., . . . Weinzierl, B. (2021). Position Paper of the Gesellschaft für Aerosolforschung on understanding the role of aerosol particles in SARS-CoV-2 infection. Köln: Association for Aerosol Research.

Kaufmann, H.R., Sanchez Bengoa, D., Sandbrink, C., Kokkinaki, A., Kameas, A., Iatrellis, O. (2020). DevOps Competences for Smart City Administrators. Real Corp 2020 Proceedings. https://www.corp.at. ISBN 978-3-9504173-8-8 (CD). Editors: Schrenk, M., Popovich, V.V., Zeile, P., Elisei, P., Beyer, C., Ryser, J., Reicher, C., Celik, C.

Kaufmann, H.R., Sanchez Bengoa, D., Tirrel, H., Ali Khan Panni, M.F. (2021). Competences for Smart City

Planners: the Alpha and Omega. Real Corp 2021 Proceedings. ISBN 978-3-9504945-0-1. Editors: Schrenk, M., Popovich, V.V., Zeile, P., Elisei, P., Beyer, C., Ryser, J., Stöglehner, G.

Springer Berlin; Grundlagen der Strömungsmechanik. Eine Einführung in die Theorie der Strömung von

Fluiden. Berlin, Heidelberg: Springer Berlin Heidelberg, 2006. Springer eBook Collection. ISBN 3-540-31323-0.

Westphal, D., Teumer, T., Schäfer, T., Ahlers, R.-J., & Rädle, M. (October 2021). Detection and

Differentiation of Liquid and Solid Particles in Ambient Air. Chemie Ingenieur Technik, S. 1636-1642.

Internet sources:

https://smartproduction.de

https://www.mannheim.de

https://mafinex.next-mannheim.de

https://sdg21.eu

🏆 *reviewed paper*

African Cities in the Post-COVID-19 World: Interrogating the "Forgotten Priorities" of the Pandemic in the Informal Sector in Bulawayo Metropolis

Buhle Dube, Trynos Gumbo

(Buhle Dube, PhD Candidate, Department of Urban and Regional Planning, Faculty of Engineering and the Built Environment, University of Johannesburg, bdube2013@yahoo.com)
(Trynos Gumbo, Associate Professor and Head; Department of Urban and Regional Planning, Faculty of Engineering and the Built Environment, University of Johannesburg; tgumbo@uj.ac.za)

1 ABSTRACT

The impact of the COVID-19 pandemic has reached every corner of the world despite being essentially an urban crisis. The combined effect of weaker urban systems, a plethora of perennial urban problems, and the sprouting informality have exacerbated the scourge of coronavirus impact in most African cities. The introduction of restrictive measures to restrain the spread of the virus had brought about dramatic changes herein referred to as the new world order emanating from the assertion that with coronavirus impact, cities will never be the same again. Very little has been studied and documented about this mantra. This paper interrogates the revival of the "old order" within the informal sector (street trading) by evaluating the changes in implementing the COVID-19 control measures during the peak and off-peak periods. The study adopted a case study research design. A mixed methods approach was applied to gather qualitative and quantitative data through interviews with traders and critical informants in Bulawayo. Triangulated quasi-longitudinal survey data, desktop review data, and geospatial data were analysed using content analysis to create themes on the changes that have been experienced. The results reveal that for the majority of city residents, most of whom are struggling to survive economically, livelihoods and survival strategies are a matter of priority compared to concerns about coronavirus dangers. Consequently, the short-term and reactive measures to curb the effects of the COVID-19 pandemic do not feed into the long-term, transformative, structural changes in city systems in most African cities. Urban studies scholars need to explore the pro-poor urban resilience strategies in tandem with the cityscapes that are bedevilled with fierce urban contestations without worsening the residents' socio-economic status. Comparative studies assessing the relationship between the "old order" and the "new order" in the Global North and South contexts are critical.

Keywords: Old order, New order, COVID-19, Transportation, Informal economy

2 INTRODUCTION

The world over, cities are the vanguard and front liners in fighting two major battles: the current global health pandemic and climate change. December 2019 saw the beginning of a highly contagious novel coronavirus in the city of Wuhan in China which later became a global pandemic called COVID-19. The disease generated an international public health emergency. It was declared a world pandemic on March 11, 2020, by the World Health Organisation (WHO) when it was reported to have affected around 5,000,000 people in more than 200 countries around the world (Yazdizadeh et al., 2022). There is no doubt that cities bear the worst effects resulting from global health pandemics. COVID-19 is not the first outbreak to strike cities of the world (Cobbinah et al., 2020; Eltarabily & Elgheznawy, 2020; Matthew & McDonald, 2006; Nakamura et al., 2020) and will not be the last. Throughout history, cities have often been tormented by contagions (Banai, 2020; Cobbinah et al., 2020; Eltarabily & Elgheznawy, 2020; LePan, 2020). The Black Plagues killed one-third of Europe and the Middle East during the 14th century, yet the 1918–1920 Great Flu killed 50 million people worldwide (Florida & Storper, 2021). Over 90% of all reported global coronavirus cases and fatalities have occurred in cities, rendering the pandemic an urban crisis. As a result, the outbreak of the coronavirus disease resulted in severe disruption of the informal sector in many African cities leading to a quick conclusion among scholars and commentators that our cities ought not to be the same again due to the COVID-19 pandemic. This study focuses on the comparative analysis of the COVED-19-induced 'new order' and 'old order' in an African city setup. It seeks to investigate the processes surrounding the restoration of the 'old order' during the peak of COVID-19 in the Bulawayo metropolis.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

2.1 Background and Context of Study

The COVID-19 pandemic is the only one that has taken place at a time when information generation and dissemination have been made accessible by modern technologies and media platforms. So, COVID‑19 is also an 'infodemic' characterised by the bombardment of information (Chakravarti et al., 2020). Even though rapid dissemination of valid and reliable information is indispensable during this period of high uncertainty when everyone is grappling with the question, 'when and how is this pandemic going to end?' (Chakravarti et al., 2020). Amid the significant global battles, such as the fight against climate change and health pandemics, it is crucial that we take stock of our cities and figure out where they are headed. This is so because the urban populations are ever increasing. Over 55% of the world population now resides in cities (United Nations, 2019) and 68% of the world population is projected to live in urban areas by 2050 (UN DESA, 2018). Likewise, Africa is currently the fastest urbanising continent in the world (Lall et al., 2017; Pharoah, 2016), whose growth rate stands at 3.2% per year (Helena, 2020; The Brookings Institution, 2021).

Consequentially, the outbreak and the resultant effects of the COVID-19 pandemic have ignited the debate around the effectiveness of city planning practice in Africa in general and in Zimbabwe in particular. While the pandemic brought about so many negatives to human life, engagements that seek to reflect on how urban planning protocols can promote the public health agenda in Africa as a continent should be taken as an opportunity (Cobbinah et al., 2021). Notwithstanding that the COVID-19 epidemic has reached its peak, there is still a need for more knowledge generation around the subject. Identifying knowledge gaps for research prioritisation in the realm of health pandemics in cities is crucial (Yazdizadeh et al., 2022).

Central and local governments rely on COVID-19-induced trends to guide urban transformation toward sustainable cities (Aki-Sawyerr et al., 2021). Based on obtaining trends (both peak and off-peak) of the COVID-19 pandemic, there are varying standpoints about the world's future. Critical decisions have been made too. From various perspectives, researchers and commentators made exciting inferences about the pandemic and the future of our cities. When superimposed on the African cities' set-up and complexities, the most connotative COVID-19-induced hypotheses of the stereotype fashion include but are not limited to the following: 'Our cities may never look the same again after the pandemic' (Holland, 2020); 'There is compelling evidence that cities will never be the same again'; 'The COVID-19 pandemic has changed the face of the world' (Global Cities, 2021); 'Cities cannot be the same after COVID-19' (Barcelona City, n.d.); 'Our cities may never look the same again after the pandemic' (Cable News Network, 2022); '…the old life is gone forever' (Wilson, 2021); 'Covid-19 on top of climate change – a state of permanent crisis' (Larsson, 2021); and 'The pandemic is transforming urban life' (Florida et al., 2020). These inferences are a stereotype in that they paint all the cities with one brush, i.e., that of COVID-19-induced permanent change, hence the 'our cities will never be the same' mantra- which this paper seeks to argue against strongly. Interestingly, not all the temporary changes to city life emanating from the global pandemic outbreaks will permanently alter all the world's cities (Moore et al., 2020). Thus, the above-stated conclusive inferences are a fallacy if not prematurely pronounced.

On critical decisions, governments introduced lockdowns which altered city dwellers' daily habits (Persiani et al., 2021). There was also the adoption and enforcement of public health measures that sought to curtail the contagion spread alongside the provision of treatment for those who fell ill. In most African cities, urban planners quickly adapted cities to lockdown measures rather than the pandemic, perhaps to keep cities functioning during such desperate times. However, the effectiveness of such changes largely depends on the cooperation of urban residents in general and specific risk groups such as the vendors, youths, and transport operators, among others. This leads to the question: '…. will the changes last?' (Holland, 2020). Due to the massive changes in urban systems due to the COVID-19 outbreak and its impacts and a plethora of measures to curb its spread, a 'new world order' buzzword and the assertion that 'with coronavirus impact, cities will never be the same again' have emerged. Very little has been studied and documented about this mantra. Consequently, this paper interrogates the revival of the 'old order' within the public transport and informal (street trading) sectors by evaluating the changes in the implementation of the Covid-19 control measures during the peak and off-peak periods. Consequently, the paper explores in detail the ways/pathways in which the present public transportation and informal sector operators relate to those of the times before and during Covid-19. Despite that cities may survive the Covid-19 pandemic by evolving (Kiger, 2021), there is no compelling evidence that African cities are on the evolution path. There is no sign of change in the

informality space in Zimbabwean towns regardless of the freshness of the impact of the pandemic. It is now business as usual.

3 LITERATURE REVIEW

3.1 Urban Informality and Health Pandemics

Urban informality is not only a Zimbabwean feature. It is also experienced in other countries in Africa, Asia, and Latin America. The prevalence in developed countries is not as high. For the third world, the informal sector amounts to approximately 25% of the economy (Mbiriri, Rutendo, 2010). In Nigeria, the informal sector contributes 75% of the official GDP compared to about 10% in the USA (Ndiweni & Verhoeven, 2013). The informal sector economy accounts for 70% of employment across Africa and remains the biggest employer in Sub-Saharan Africa (UN, 2015). In Zimbabwe, the informal sector economy was 59.4% of the GDP in 2004 (Ndiweni & Verhoeven, 2013), and the sector accounts for 85% of the national workforce . In the 1980s, just after Zimbabwe attained its independence, the informal economy accounted for less than 10% of the workforce (ILO, 2017). Since adopting structural adjustment programmes (SAPs) in the early 1990s, Zimbabwe has developed a very vibrant informal sector. The informal economy's employment grew to 27% in 1991 (ibid). The contributing factors to the growth of Zimbabwe's informal economy include the influx of people into urban areas in anticipation of greener pastures, natural population increase, and employee layoffs due to the closures of companies in the formal sector, which resulted in the rise of unemployment levels from 11% in 1982 to 22% in 1992 then to 30% during the year 1995 (ZimStats, 2014 cited in Sikwila, Karedza, and Mungadza 2016).

The nature of responses to urban informality varies significantly across nations. The outbreak of health pandemics usually exerts pressure on the difficult-to-manage informal sector. The forms of urban informality usually range from street trading, informal settlements, and informal transport (Kamalipour & Peimani, 2021). Urban informality refers to practices and activities that are undertaken beyond what the municipality would define as "normal" and that exist contrary to spatial planning stipulations (Gumbo & Geyer, 2011a; Kamete, 2013; Roy, 2017). Even though integrating the informal sector into the formal economy is inevitable (Chigwenya, 2020; Gumbo & Geyer, 2011b). In most sub-Saharan countries, the spreading speed and severity of health outbreaks such as Covid-19 and cholera are partly shaped by the prevailing economic conditions, especially the informal sector activities (Nguimkeu & Okou, 2021). For instance, the coronavirus outbreak as a world pandemic has significantly altered how daily life plays out in urban public spaces (Kamalipour & Peimani, 2021). The imposed lockdowns and other pandemic spread containment measures have struck a hard blow to the informal sector (Kamalipour & Peimani, 2021; Nguimkeu & Okou, 2021). On the other note, the literature indicates that the cholera health crisis is closely associated with informal housing, population density, and street trading (Penrose et al., 2010). The growth and expansion of urban informality in African cities will be associated with increased risks to human health (ibid). More so, research shows that a higher share of informal labour increases the spread of health contagions (Nguimkeu & Okou, 2021). Ideally, there are two perspectives concerning the role of the informal sector during a health crisis: due to its volatility, informality is the immediate survival option in an emergency; the informal economy suffers a loss, and also informal workers' vulnerability is increased during a crisis (Pitoyo et al., 2020). The informal sector thus serves as a buffer during health outbreaks.

3.2 Theoretical Framework: Substantive-Procedural Theories of Planning Divide

This paper is premised on the substantive versus procedural theories of the planning debate. It uses the substantive-procedural theories of planning divide as the analytical puzzle. Before the aforementioned planning theory dichotomy existed, one mainstream of planning theories, i.e., procedural planning theories. The mainstream planning theories inform planning practice primarily hinged on procedural techniques (Hudson & Kaufman, 1979). The procedural planning theorists subscribe to the planning process. They seek to answer the question of how to plan in a fashion that does not deviate from the stated rules and procedures guiding the planning exercises. However, procedural planning theory has been criticised for its failure to appreciate politico-social contexts (Hibbard & Frank, 2019; Muller, 1987). Critiques have labelled this strand as the one without context and substance.

Context, content, and substance are crucial when dealing with global health pandemics. Substantive planning theories subscribe to content and contexts when planning (Alexander, 2009; Hibbard & Frank, 2019; Hudson

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

& Kaufman, 1979). They seek to answer the question of what to plan. When informed by the substantive planning theories, planners perform their duties the way the situation at hand dictates. One planning approach falling under substantive planning theories that befits an impromptu status such as the Covid-19 outbreak is reactive planning. Due to the high level of uncertainty, planning during the peak of Covid-19 has been an uphill task for city planners. Only the reactive planning paradigm applies to the context of a crisis where there is no ample time, resources, and information to enable a smooth planning process. This approach has no pre-planning ahead of future events (Simmons, 2007). In reactive planning, city planners are presented only with the initial contexts and the much-needed goals (Hibbard & Frank, 2019). This form of planning is equivalent to radicalism. Likewise, in implementing the lockdown measures, governments employed reactive and radical stances to quell the spread of the pandemic.

The reality of an emergency prescribes that instead of producing a plan, city planners make a set of condition-action rules (Simmons, 2007). In principle, a reactive planning system can handle the emergency as well as the uncertain effects, but only if it is possible to provide a reaction rule for every possible situation that may be encountered. Reactive planning strives to restore the previous conditions following an emergence scenario. The approach is about attempts to rewind the clock to the past (Ackoff, 1981). As evidenced by the return to the initial state of affairs in most African cities, former times are preferred over the present-day situation or the anticipated future (Ackoff, 1981; Worth, 2010). Now, the revival of the previous conditions that are characterising the informal sector in Zimbabwe's cities requires the use of substantive planning theories in unpacking the process of this revival and for purposes of confirming why the health outbreaks should be treated as temporary events despite the severity and magnitude of their damage. In long-range planning, lessons will be drawn from the cycles of reactionary and radical planning activity. Over and above, the procedural planning theories should not be rejected. Instead, substantive and procedural planning theories are required when planning for the short term and long term in response to pandemics (Yiftachel, 1989). With the nature of the responses to the pandemic, which are usually impromptu in tandem with the fast spread of the pandemic, it is impossible, if not unnecessary, to refer to the planning blueprints. The reactionary planning approach has become relevant.

4 MATERIALS AND METHODS

A case study design was chosen to enable an in-depth analysis of the research issue in the Bulawayo metropolis case. Many scientific and academic studies have been written based on a case study or using a case study design (Angelstedt, n.d.; Crowe et al., 2011; Hansson, 1981). The execution of this study largely falls under the qualitative research paradigm based on its ability to get into the depth of the inquiry. The quantitative approach was applied to collect data that could easily be converted into numerical form to perform statistical computations and make inferences. The in-depth and informal interviews blended with field observations are the core research methods used by the researchers. The research used longitudinal data about Covid-19 covering 2020 to the present. Longitudinal survey data helps complement data from cross-sectional surveys (Gumbo, 2013).

Regarding the informal trading (vending), a cross-section of Bulawayo city was done where some vending sites were drawn from the city centre. In contrast, some were drawn from the high-density and the low-density suburbs where the interviews with the vendors were conducted. The purpose was to obtain a cross-sectional outlook of the general practice of informal activities during the off-peak times of the Covid-19 pandemic. The consideration of the multiple vending sites brought comparative power research around the subject matter under review. A good design should ensure research findings' reliability, objectivity, validity, and generalisability (Annum, 2019; Butina, 2015; Crowe et al., 2011; Dash, 2017; Golafshani, 2015).

The inquiry performed a rigorous, in-depth, and multi-faceted understanding of a complex (Crowe et al., 2011) subject of health pandemics and informality by further probing into the obtaining responses. The key informants were mainly drawn from the city's department of town planning, environment and health department, and council chambers. Other key stakeholders involved are the representatives of the Zimbabwe Republic Police, Vendors Association, Ministry of Small to Medium Enterprises, and civic organisations. For those with very tight work schedules, the google forms platform was used. To ascertain the informal sector (street trading) spatial reorganisation patterns and changes due to health pandemics, the researchers used a field observation checklist complemented by the cross-checking of facts from the immediate people chosen, based on their convenience and experience. A photographic survey supplemented the observation

method. Survey 123, a mobile phone-based application, was used to gather spatial data for this inquiry. SPSS and Excel packages were used to analyse quantitative (numerical) data that involved descriptive statistics.

4.1 The spatial scope of the study: Bulawayo City

Bulawayo is Zimbabwe's second-largest city. This city is the regional capital of the marginalised Matabeleland region in Zimbabwe (Dube, 2017; Musemwa, 2006). The town has experienced politically motivated or 'man-made' massive deindustrialisation and economic decay since the early 1980s (Musemwa, 2006), which has led to many urban residents joining the informal sector for a livelihood. Water shortage is Bulawayo's central disabling situation for most economic and social activities (Musemwa, 2006). Like any other city in Zimbabwe, and due to their high unemployment rate, Bulawayo urban residents ignored the Covid-19 lockdown as hunger took hold . Bulawayo is regarded as a classic example of the best-run city in Zimbabwe' (The Local Government Investment Conference, 2018) , a trait that 'it (city) has maintained for many decades, stretching right back into the colonial times' (The Herald, 2018), yet it is grappling with informality, especially on street trading and transportation, and that it is the regional centre of the most depressed regions in Zimbabwe (Dube, 2017; Musemwa, 2006).

5 RESEARCH FINDINGS

5.1 An Overview of Covid-19 Cases and responses in Bulawayo Metropolis

In Zimbabwe, like any other place in the world, the outbreak of coronavirus disease and the speed at which it spread called for swift interventions to curtail the spread. The agent's main spreaders are human beings, so the interventions were/are directly targeting human activities. Periodically announced World Health Organisation (WHO) guidelines were used as yardsticks for these interventions. On the basis that, up to now, there is no cure for the Covid-19 disease, almost all the interventionistic measures that the government of Zimbabwe adopted in general and Bulawayo city in particular aimed at addressing the spread of the virus. Before the discovery of the coronavirus vaccine, WHO mainly recommended that the public should maintain social distance, avoid crowded places, sanitise spaces, regularly wash hands and wear masks when in public places. Accordingly, Bulawayo adopted these measures to curtail the spread of Covid-19.

Since the outbreak was of a novel virus, there was a need for intensive information dissemination. Through loudspeakers, the city of Bulawayo's health officials moved around, educating the public about the disease and the measures the city had adopted. Following these measures was the declaration of the national lockdown by the government of Zimbabwe. During the first round of lockdown, projected to last for 21 days starting on Monday, March 30, 2020, the government directed the closures of all informal markets save for the formal markets, which opened daily only for four hours. On Monday, March 23, the country closed its borders. Security forces were deployed to enforce the lockdown. Despite implementing the lockdown and other related measures, the first case of Covid-19 in Bulawayo was recorded on 4 April 2020. By the 1st of July, 2020, 65 coronavirus-positive cases had been recorded in Bulawayo, making the city the second in terms of Covid-19 prevalence in the country [see Figure 1].

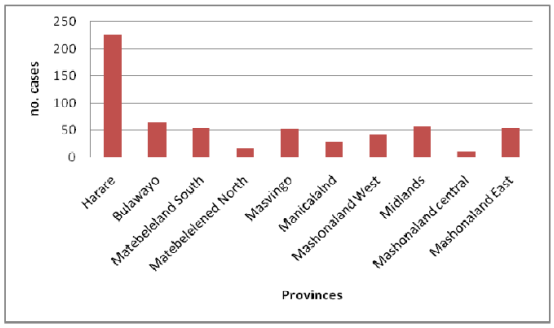


Fig 1: Case of COVID-19 in Zimbabwe. Adapted from the Ministry of Health, Zimbabwe, July 1, 2020

The implementation of the measures mentioned above seriously altered the face of the city of Bulawayo. The informal traders were in a fix. Their livelihood had been taken away from them. Their old way of doing things had varnished. The varnishing of the ancient urban practices represents the new order.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

5.2 The forgotten Covid-19 priorities in the informal sector in Bulawayo

The scare that came with the outbreak of Covid-19 appeared to have instilled an era of permanent structural changes in which governments run their cities worldwide. The government of Zimbabwe generally adopted four sets of measures in response to the Covid-19 pandemic. The steps are strategies to contain the spread of the virus; efforts to improve and enhance health facilities and services to the general populace; measures to support and stimulate the informal economy in a Covid-19 impact context; and direct assistance rendered to vulnerable population groups. The degree of the government of Zimbabwe's commitment to implement the noted measures in fighting the Covid-19 pandemic has been in tandem with the severity of the pandemic itself. As the pandemic drifted from the peak to the off-peak seasons, the commitment to enforce the implementation of these measures responded accordingly. As we found out during the execution of this study, both the government and citizens happen to gradually take a relaxed stance towards the pandemic as the off-peak season looms. Generally speaking, people tend to gradually forget the radical reactive measures they adopted during the peak of an outbreak of a disaster due to the tendency to get used to the outbreak itself and as knowledge about the outbreak floods the public domain. The relaxed stance is herein referred to as the forgotten priorities. In the problem-infested economies dominated by highly volatile informal activity as a survival, such as in the Bulawayo metropolis, those employed in the informal sector are left with minimal choices and are found breaking the restrictive rules to pursue their goals and livelihood despite the government bans and restrictions. Similarly, the government is bound to follow suit the forgotten priorities that the informal sector players involuntarily champion. Below is the assessment of the forgotten Covid-19 priorities in the informal sector that fall into four categories.

5.2.1 Coronavirus spread containment measures

The measures falling within the category of containing the coronavirus spread are the most common and are culpable of delivering a new order in most cities. Such measures included the lockdowns, which involved travel bans accompanied by border closures, night curfews, stay-at-home orders, social distancing, prohibition of public gatherings, and closures of markets, shops, and restaurants. These spread containment measures were generally adhered to by virtually all Zimbabwean cities, albeit to varying degrees. At a national level, Zimbabwe has since eased these restrictions to reopen the national economy. The lifting of these restrictions came at a time when the informal sector players were feeling the pinch as they were either literally not doing any business or illegally selling their stuff, risking arrests and seizures of their goods. Mr. Moyo [pseudo name for an interviewed street vendor] elaborately explained how they eagerly waited for the ending of these Covid-19-induced restrictions:

[…], the thing is, as vendors, we operate our business at a critical point. I mean that if one is absent from the markets to sell their stuff for about three days, this person will struggle to recover the lost days. Let me tell you, in our business, you must work every day, brother. There mustn't be any time lost. So imagine how much time we lost during the lockdown era. For those of us who sell foodstuffs, we ended up eating our stocks.

Transitioning from the old to the new order in Bulawayo

Bulawayo's first approach in responding to the Covid-19 disease eruption was implementing the government's announced lockdown regulations. The lockdown saw all informal sector economic activities being closed down except for government-determined essential services in the sectors of food and medical supplies. Even though, the food supplies in the informal sector were all closed down. If statistics are to go by, the informal sector accounts for 85% of the national workforce, the new order that Covid-19 brought rendered this 85% impoverished. The implementation of the lockdown is generally indiscriminate. The secretary of the Bulawayo Residents Association lamented that while the lockdown was a justified move, the authorities ought to consider some scenarios, such as the disabled who survived by either selling their stuff or operating a private transport business. The new order was even made worse by the government's directive that cities were to destroy all informal activities in the areas of their jurisdiction. This further amplified the unwanted by the necessary new order. Some street traders lamented this new order of the Covid-19 peak times as inhumane, cruel, and somehow unjustified:

[...] my brother, I don't want to recall those days. It was hell on earth. Even though I think Africa was not hit hard by Covid-19. I believe the disease is for cold regions like Europe. But ahhhh [laughing], you may find

out we never had Covid-19 in Zimbabwe, my brother. […] you know our government […] it hates us. They don't was to see people surviving without direct assistance from them. I suspect the lockdown implementation was meant to wipe out city vending businesses. To clean the cities. It's sad. Let's leave it here, bro.

As highlighted in the literature review section, the complete lockdown has been widely believed to deliver a permanent new order in cities potentially. African cities denote a different storyline altogether as the old order in the informal sector has fully reclaimed its initial space. The picture below shows the revived street trading in Bulawayo's CBD. The informal traders view themselves as victims of a failed state and economy. Despite being the mainstay of the urban economies, they claim that authorities give informality in Zimbabwean cities second-class handling. Yet, it is making a considerable contribution to the livelihoods of city dwellers. The informal sector participants are confident they won't fail to provide for their families. One vendor bragged and said:

[…] it is not a secret that we make better money than teachers and police officers, […] I can afford to pay one teacher come month end. […] but look, we need support from the authorities. We are not spreaders of Covid-19. We, too, as vendors, are afraid. They lie and say were' not scared. No. It's not true, brother.

This shows that the informal economy has been steadily growing in Bulawayo to the extent that it is now deeply entrenched. To dismantle it is to declare war. The introduction of the Covid-19-induced lockdown brought life to a standstill. That is the new order. It was a matter of life and death. The government had to be harsh to save life. But surely cities ought not to come out the same again. But the central question is, what new systems have African cities introduced in preparation for future pandemics? It is disheartening to learn that some people are convinced that the lockdown initiative was just there to fix the 'unwanted' business operations. However, the business as usual has come back in full swing without any sign just in 2020-2021that there was gnashing of teeth as Covid-19 was wracking havoc. Although Bulawayo is regarded as an excellent example of being well-managed, the city was not spared from the comprehensive closures. One of the critical informants lamented the blanket approach to Covid-19 by pointing to the fact that:

[…] we were forced to close, restructure and open other spaces to accommodate our traders. Still, as you know, the number has massively grown, we failed to accommodate the majority of them, and it's thus my proposal that we look to other possibilities.

Despite the stern enforcement measures by the government to suppress the spread of coronavirus in cities, the traders would take chances by sneaking into the CBD and selling their goods. As denoted in Figure 2, out of 205 vendors who participated in this study, when asked how they illegally made their way into the CBD to their vending sites during the hype of the lockdown, 67 respondents indicated that they walked into the city centre to do business. One respondent said they bribed the police to find their way into town. Five respondents obtained fake exemption letters to be allowed into the city centre. One vendor used a bicycle to get into town. Statistics from the interviewed sample show that 95 respondents, who constitute the majority of the total sample, ceased their business operations during the peak of lockdown. For survival during tough times, 23 respondents indicated that they operated their business from home.

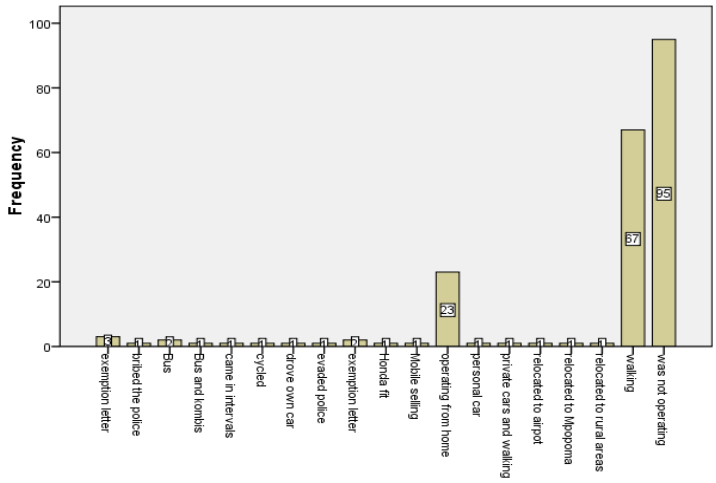


Figure 2: Strategies to survive during the peak of Covid-19. Source: Fieldwork, 2022

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Observation during the survey for this study shows that the old order is fully back into play. Some vending sites have drastically dropped hygiene standards, particularly in the CBD. Some vendors and clients either do not wear masks at all, or they position the masks under their chins [see picture 2]. There is no more social distancing at the vending sites. The researchers observed that in adequately planned sites such as Highlanders, and all the sites in the medium to low-density shopping centres, social distancing is moderate as the vendors only occupy their designated spots. In such scenarios, it is only the clients who get into proximity, especially during the peak hours of the day.

Picture 1: Completely revived street trading in Bulawayo CBD. Source: Fieldwork, 2022

While the government has lifted all the measures to control the spread of the coronavirus, wearing masks remains mandatory in Zimbabwe. In occasional instances, police random arrest those found not putting on or improperly putting on their masks. One vendor believed that the government of Zimbabwe had little capacity to gather verifiable scientific facts about coronavirus. Thus the government solely relied on WHO and the neighbouring countries such as Botswana and South Africa:

[… I don't think the government understood what it was doing…; if you recall how they operated, any measure that was part of the lockdowns that South Africa would announce, these elders would copy and announce. Of the masks, South Africa has lifted the ban, and our authorities are shy to follow suit instantly, but I tell you, very soon, they will follow President Ramaphosa. I doubt if our government had enough clue about the virus. They are just against vendors, my brother.

5.2.2 Health facilities and services improvement

The measures that sought to improve and expand health facilities and services in Bulawayo were not explicitly done to solely cater for vendors. Health facilities and services improvement saw Ekusileni and Thorngrove hospitals designated as the centres handling the Covid-19 disease. The government committed to importing medical equipment and supplies besides hiring healthcare staff. The designation of these two centres would ease pressure on United Bulawayo Hospitals (UBH) which was getting overwhelmed during the pandemic's peak. Interestingly, the opening of Ekusileni hospital brought about a new order which saw the hospital resuming operations more than 15 years after it was closed down. In this category of responses to coronavirus, vendors, like any other Bulawayo resident, were/are bound to benefit. Unfortunately, as the current pandemic stroke, the fragility of Zimbabwe's health system worsened the situation on the ground. The healthcare system was marred by infrastructure dysfunctionality, unavailability of healthcare equipment that includes PPEs, and therapeutic drug shortages. The striking healthcare workers in the hospitals demanding better pay and improved work conditions during the early phase of the Covid-19 pandemic worsened the impact of the pandemic.

5.2.3 The measures focusing on economic development and stimulation

This category focuses on the measures that are meant to stimulate the economy. The section will look at how the government of Zimbabwe manipulated the fiscal and monetary space through its institutions to dampen the economic effect of the health pandemic. After WHO declared Covid-19 as a global pandemic on the 11th of March 2020 (Yazdizadeh et al., 2022), the government of Zimbabwe declared a state of disaster on 20 March 2020. The introduced measures to curb the spread of the pandemic culminated in severe economic disruptions resulting from business closures emanating from lockdowns and the enforcement of curfews. As the financial challenges worsened by the current pandemic, effective from 1 April 2020, the government

introduced the tax-free risk allowances payable to frontline public sector health personnel fighting Covid-19. An economic recovery and stimulus package to the tune of 18 million Zimbabwean dollars was unveiled to revitalise the economy through relief provision to individuals, families, small businesses, and industries impacted by the economic slowdown caused by the Covid-19 pandemic. The government's strategy was to provide liquidity support to all the productive sectors of the economy. Besides offering liquidity support, effective 17 May 2020, registered informal traders, companies and the private sector were to resume operations upon fulfilling certain conditions such as the compulsory wearing of masks and employee testing. 22 July 2020 saw further relaxation of Covid-19 lockdown regulations to steer the economic activity in the country. Business was allowed to operate from 8 am to 3 pm. 08.00 and 15.00.

5.2.4 Direct assistance to the deserving population segments

More so, starting on 1 April 2020, the government introduced a ZW$200 cushioning allowance to vulnerable families per month for three months (KPMG, 2020). Unfortunately, the introduced vulnerable citizens' allowance, which is equivalent to US$12, fell short of the US$1 a day international poverty datum line (Chitungo et al., 2022), even though, not all informal traders fall within the vulnerable person category. The need to assess the effectiveness of these economic measures necessitates the evaluation of the methodology of accessing the beneficiaries. Asked if they ever received any stimulus package from the government, 175 respondents indicated that they never received any handouts from the government. Ten respondents indicated that either they or family members have received a vulnerable citizens allowance. On direct assistance to the deserving population segment, the government of Zimbabwe could not go it alone. According to the 2021 United Nations World Food Programme (WFP), Zimbabwe was given EUR 3 million by the European Union (WFP, 2021). The fund was to support the highly vulnerable urban poor who were failing to meet basic food needs due to the Covid-19 pandemic. Recipients were to be given USD 12 per person per month (ibid). There is a need for research to assess the extent to which the poor informal sector players got covered by this programme of handouts.

6 DISCUSSION

The Covid-19 pandemic interventions implemented by both the central and local government in Bulawayo indicate that the closure of the informal markets results in a temporary ghost city and complete loss of livelihood to the vendors. The temporary closure of the informal players' operating sites means the city's Gross Domestic Product (GDP) disruption. Kamete, (2013) notes that the informal sector constitutes 45% of sub-Saharan Africa's GDP. In Zimbabwe, the informal sector arguably contributes more than 60% of the national GDP (Chigwenya et al., 2021). More so, the fact that the informal sector contributes more than 80% to employment in sub-Saharan Africa (Nguimkeu & Okou, 2021) and is the biggest employer in Zimbabwe (Kumbawa, 2002), severe disruptions such as temporary closure or spatial restructuring of vending activity will result in the interruption of the GDP at a city level. This study's evidence shows an obvious bias toward the formal sector in implementing interventionistic measures to curb the spread of coronavirus. This is based on the common question which emerged after Covid-19 was declared a global pandemic whether urban density and the spread of the pandemic were linked (Wahba, 2020). This was claimed to be so because the pandemic is a contagion. Close social contacts are usually experienced in the informal sector. However, on the contrary, recent studies have shown that density was not the issue, with the case in hand being China's handling of the spread of the coronavirus, where statistics show that the bigger cities which are densely populated did better than the smaller cities which are relatively sparsely populated (ibid).

While it is noble to target this sector, it should be noted that the concerted efforts to control the spread of coronavirus perpetuate negativity about and marginalisation of the informal sector. The implied negativity associated with the informal sector as the super spreader of the contagions becomes the basis for governments to bully the sector despite the full knowledge that the sector is indispensable in most African economies. Noteworthy is the role and importance of the informal sector in Bulawayo city's economy, as the sector occupies an approximation of over 70% of public spaces in the CBD. This shows the importance of this sector where the participants consider their involvement in their business activities as a critical livelihood hence the quick revival of the 'old order' upon the relaxation of the measures meant to stop the spread of the pandemic.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

There is compelling evidence that the city of Bulawayo authorities acknowledges the informal sector's role and enormous contribution to employment creation and the city's economic fabric. The setting up of the committee that the department of town planning steers and a multi-stakeholder representation within this committee show how the city considers the sector. In such a situation, it is difficult, if not impossible, to introduce structural changes in the informal sector operations. Thus, restoring the sector to the initial status implies that the informal sector is a self-regulating system that is difficult to change even in the event of a considerable disturbance such as Covid-19. The imposed changes are treated with contempt, and the rules introduced will be broken. In some way, Bulawayo can't plan its local economy without urban informality taking centre stage because informality has grown to be a permanent feature of an African city. This explains the quickened forgetting of the Covid-19 protocols within the informal sector. The complete integration of the informal sector in all city development plans becomes critical (Chigwenya et al., 2021). City authorities in African cities should not be surprised by how the informal sector activities got restored to their initial situations. This is because the acknowledgment and recognition of urban informality in the planning and management of the cities, especially in the Global South, are tantamount to accepting the realities prevailing in these cities.

Because of the complexities associated with the informal sector activities, situational planning space becomes crucial. Situational planning space falls within the substantive planning theories that advocate reactive planning based on the prevailing situation. Reactive planning is an active attempt to turn back the clock to the past (Ackoff, 1981). The effort to turn back the clock to the past is in tandem with the practice of the informal sector activities taking place in Bulawayo city. Thus, the revival of the usual ways of life within the informal sector confirms that the outbreak of pandemics should be treated with temporary and contextual responses since pandemics will come and go. The context of pandemics is a situation of urgency. In a position of urgency, applying procedural planning theories is impossible. The problem of poverty which is a feature of most African cities, further complicates the planning space during the outbreak of pandemics. More so, poverty and high levels of unemployment explain the swift restoration of the 'old order' in defiance of the assertion that 'cities will never be the same again with Covid-19. As cited in (Chigwenya et al., 2021), Roy (2005) advocates for developing a new urban planning theory that recognises urban poverty as a feature that perpetuates urban informality. Even though, procedural planning theories should not be abandoned entirely but should be adapted to the situational and substantive planning spaces. With the nature of the responses to the Covid-19 pandemic, which were as impromptu as the virus spread itself, it is impossible if not necessary to refer to the planning blueprints and be guided by the procedural statutes which are full bureaucracy and red tape.

The quick forgetting of the Covid-19-induced regulations and protocols herein referred to as 'forgotten priorities' implies the need to fully include the informal sector players in planning for city development and crafting policy instruments. Full recognition and inclusion of the informal sector players in determining the development path of cities give birth to sustainable cities besides providing a livelihood to the informal sector players (UN-Habitat, 2005). This therefore means that 21st-century city planning should embrace diversity by moving away from the traditional ways of planning our cities and their systems. Thus, there is a need for a paradigm shift in urban planning to adopt inclusive planning approaches that seek to include the diverse range of urban societies (ibid). The reality that the informal sector obtained in the city of Bulawayo is a huge statement that urban informality is a permanent feature of African cities that should be handled with care to avoid the blitz that usually comes with the interventionistic strategies to control the informal activities in cities. The fact that over 70% of the interviewed informal sector players are registered with the city of Bulawayo means that the sector is willing to be fully incorporated into the city systems.

7 CONCLUSIONS AND RECOMMENDATIONS

The impact of the Covid-19 pandemic was felt differently in different places. The informal sector players were quick to feel the pinch of lockdown, hence their swift speed to revive the old lifestyles despite the pandemic's menace. In many African cities where poverty has driven a significant number of urban residents into informal businesses, it can be concluded that urban informality has become a culture that makes it challenging to unwind even in the context of a disaster of Covid-19 pandemic magnitude. While the informal sector players recognise the dangers and menace of Covid-19, their livelihood is much more important than hiding for life from coronavirus on an empty stomach. There is compelling evidence that the informal sector

felt they were frog marched into lockdowns and temporary business closures. This is confirmed by the speed at which the traders returned to the city to resume their business operations or the illegal sneaking into the CBD by many street traders during the very peak of Covid-19. Even so, the Covid-19 pandemic is transforming urban space planning in African cities in a significant way, with the city planning authorities still seeking to adapt their planning systems for future pandemics. With the attitude of resistance of the informal sector players, many African countries are likely to be hit harder should similar pandemics erupt. Even if awareness campaigns about the current pandemic are intensified, poverty-driven resistance and hesitancy to abide by the prescribed protocol will remain a permanent feature of many African cities. Critical questions such as how African cities should be planned for better resilience against future shocks remain unanswered in such a scenario. Therefore, it is crucial to look at the fundamentals that lead to the situation of resistance despite looming dangers such as that of the Covid-19 pandemic. Uprooting urban poverty is the most fundamental step that can drive a paradigm shift in the urban planning systems and their reception in the context of a disaster. Authorities should forge contingent livelihood options for the urban poor. In an African set-up, where over 90% of urban citizens are bound to fall within the bracket of the urban poor, it may be difficult to amply fend for them during disasters due to fragile economic fabrics.

Thus, the weaker economic fabrics characterising sub-Saharan Africa result in the inability of cities to adopt responsive stimulus packages should a pandemic strike, a situation which has created fertile ground for urban informality to flourish in African cities. Because of differing economic conditions between the Global North and South, where solid formal economics characterises the former rather than the latter which is characterised by weaker economies that cannot sustain the contingent plans in case of global pandemics, it is a fallacy to say 'African cities will never be the same again' as a result of Covid-19. Comparative studies assessing the relationship between the 'old order' and the 'new order' in the Global North and South contexts are critical. The critical assessment of the drivers of the speeds of the restoration of the old order or routine in the developed and the developing world is vital. As experienced in African city contexts, urban informality shows excellent signs of resistance to shocks. Planning to include the informal sector in African city systems is indispensable.

8 REFERENCES

Ackoff, R. (1981). Creating the Corporate Future: Plan or be Planned. John Wiley.

Aki-Sawyerr, Y., Brady, K., Brandes, U., Carter, S., Elkatsha, M., Larson, K., Mäkelä, J., Mancel-Blanchard, C., Merritt, J., Sharif, M. M., Moreira, R., Pinto-Luz, M., Ridouani, M., Rosado, P., Wahba, S., & Tan, K. Y. (2021). As cities recover from COVID-19, trends emerge to guide urban transformation Deloitte Global report Press Release. Deloitte Global.

Alexander, E. R. (2009). Planning Theory. https://doi.org/10.1177/147309520200100303

Angelstedt, A. N. (n.d.). Do writers of case studies focus to much on the angle instead of describing reality ?

Annum, G. (2019). Research Instruments For Data Collection. Research Methodology, 1–6. https://www.academia.edu/36865594/RESEARCH_INSTRUMENTS_FOR_DATA_COLLECTION_Updated_

Banai, R. (2020). Pandemic and the Planning of Resilient Cities and Regions. In Cities (Vol. 106, p. 102929). Elsevier Ltd. https://doi.org/10.1016/j.cities.2020.102929

Barcelona City. (n.d.). Cities cannot be the same after Covid-19 Barcelona Digital City.

Butina, M. (2015). A Narrative Approach to Qualitative Inquiry. American Society for Clinical Laboratory Science, 28(3), 190–196. https://doi.org/10.29074/ascls.28.3.190

Cable News Network. (2022). Our cities may never look the same again after the pandemic.

Chakravarti, A., Upadhyay, S., Bharara, T., & Broor, S. (2020). Current Understanding , Knowledge Gaps and a Perspective on the Future of COVID-19 Infections : A Systematic Review. January. https://doi.org/10.4103/ijmm.IJMM

Chigwenya, A. (2020). Contestations for urban space: informality and institutions of disenfranchisement in Zimbabwe—the case of Masvingo City. GeoJournal, 85(5), 1277–1289. https://doi.org/10.1007/s10708-019-10022-4

Chigwenya, A., Chigara, B., & Simbanegavi, P. (2021). Urban Informality and COVID-19 Responses in Masvingo City , Zimbabwe : International Journal of Real Estate Studies INTREST Urban Informality and COVID-19 Responses in Masvingo City , Zimbabwe : Questioning City Inclusivity. March.

Chitungo, I., Dzinamarira, T., Tungwarara, N., Chimene, M., Mukwenha, S., Kunonga, E., Musuka, G., & Murewanhema, G. (2022). COVID-19 Response in Zimbabwe : The Need for a Paradigm Shift ? 895–906.

Cobbinah, P. B., Adams, E. A., & Erdiaw-Kwasie, M. O. (2020). Can COVID-19 Inspire a New Way of Planning African Cities? https://theconversation.com/can-covid-19-inspire-a-new-way-of-planning-african-cities-145933

Cobbinah, P. B., Erdiaw-Kwasie, M., & Adams, E. A. (2021). COVID-19: can it transform urban planning in Africa? Cities and Health, 5(sup1), S48–S51. https://doi.org/10.1080/23748834.2020.1812329

Crowe, S., Cresswell, K., Robertson, A., Huby, G., Avery, A., & Sheikh, A. (2011). The case study approach. BMC Medical Research Methodology, 11. https://doi.org/10.1186/1471-2288-11-100

Dash, B. (2017). Methods of Data Collection. Essentials of Nursing Research and Biostatistics, July 2016, 175–175. https://doi.org/10.5005/jp/books/13075_10

Dube, B. (2017). Evolution of the Regionalism Debate and its Implications for Spatial Development Planning and Management in Zimbabwe. ZAMBEZIA XXXXIII, 43, 83–105.

Eltarabily, S., & Elgheznawy, D. (2020). Post-Pandemic Cities- The Impact of COVID-19 on Cities and Urban Design. http://article.sapub.org/10.5923.j.arch.20201003.02.html

Florida, R., Glaeser, E., Sharif, M. M., Bedi, K., Campanella, T. J., Chee, C. H., Doctoroff, D., Katz, B., Katz, R., Kotkin, J., Muggah, R., & Sadik-Khan, J. (2020). How Life in Cities Will Change Due to the Coronavirus Pandemic. In Foreign Policy (p. May 13). https://foreignpolicy.com/2020/05/01/future-of-cities-urban-life-after-coronavirus-pandemic/?utm_source=PostUp&utm_medium=email&utm_campaign=24299&utm_term=Master Marketing List&?tpcc=24299

Florida, R., & Storper, M. (2021). Cities in a post-COVID world. https://doi.org/10.1177/00420980211018072

Global Cities. (2021). Post-Pandemic Cities Recovery, Transition, and Renewal.

Golafshani, N. (2015). Understanding Reliability and Validity in Qualitative Research. The Qualitative Report, 8(4), 597–606. https://doi.org/10.46743/2160-3715/2003.1870

Gumbo, T. (2013). On Ideology Change And Spatial And Structural Linkages Between Formal And Informal Economic Sectors In Zimbabwean Cities (1981-2010). March.

Gumbo, T., & Geyer, M. (2011a). 'Picking up the pieces': Reconstructing the informal economic sector in Bulawayo, Zimbabwe. Town and Regional Planning, 59(0), 53–64.

Gumbo, T., & Geyer, M. (2011b). Picking Up the Pieces: Reconstructing the Informal Economic Sector in Bulawayo, Zimbabwe. Town and Regional Planning, 59(0), 53–64.

Hansson, L. (1981). Can Cases Replace Textbooks ? What would be required of the cases , would they require changes ? 1–12.

Helena, C. (2020). Urbanisation in Africa: Creating Greater Access to Customers. https://www.frost.com/frost-perspectives/urbanization-in-africa-where-do-the-opportunities-lie/

Hibbard, M., & Frank, K. I. (2019). Notes for a Substantive Theory of Rural Planning : Evidence from the US Experience Notes for a Substantive Theory of Rural Planning : Evidence from the. Planning Theory & Practice, 00(00), 1–19. https://doi.org/10.1080/14649357.2019.1627572

Holland, O. (2020). Our cities may never look the same again after the pandemic. In Cnn (pp. 1–18). https://edition.cnn.com/style/article/cities-design-coronavirus/index.html

Hudson, B. M., & Kaufman, J. L. (1979). Comparison of Current Planning Theories : Counterparts and Contradictions. October, 387–398.

ILO. (2017). Women in the informal economy in Zimbabwe.

Kamalipour, H., & Peimani, N. (2021). Informal urbanism in the state of uncertainty: forms of informality and urban health emergencies. Urban Design International, 26(2), 122–134. https://doi.org/10.1057/s41289-020-00145-3

Kamete, A. Y. (2013). On Handling Urban Informality In Southern Africa. Geografiska Annaler, Series B: Human Geography, 95(1), 17–31. https://doi.org/10.1111/geob.12007

Kiger, P. J. (2021). The Future of Cities after the Pandemic - Urban Land Magazine. Urban Land Institute. https://urbanland.uli.org/development-business/the-future-of-cities-after-the-pandemic/

KPMG. (2020). Zimbabwe - Measures in response to COVID-19 - KPMG Global. https://home.kpmg/xx/en/home/insights/2020/04/zimbabwe-government-and-institution-measures-in-response-to-covid.html

Kumbawa, D. (2002). Informal sector now Zimbabwe's biggest employer. Financial Gazette.

Lall, S. V., Henderson, J. V., & Venables, A. J. (2017). Africa's Cities: Opening Doors to the World. In Africa's Cities: Opening Doors to the World. Washington, DC: World Bank. https://doi.org/10.1596/978-1-4648-1044-2

Larsson, J. (2021). POST -COVID cities as vectors for change ESIR Focus Paper. https://doi.org/10.2777/123892

LePan, N. (2020). Visualizing the History of Pandemics. https://www.visualcapitalist.com/history-of-pandemics-deadliest/

Matthew, R. A., & McDonald, B. (2006). Cities Under Siege: Urban Planning and the Threat of Infectious Disease. In Journal of the American Planning Association (Vol. 72, Issue 1, pp. 109–117). Taylor & Francis Group. https://doi.org/10.1080/01944360608976728

Mbiriri, Rutendo, P. (2010). Can Zimbabwe Use Its Informal Economy As a Means for Sustainable Development in the Current Reconstruction Process. 1–85.

Moore, R., Sodha, S., McKie, R., Hinsliff, G., Adams, T., & Bell, T. (2020). Life after Covid will our world ever be the same Coronavirus The Guardian.

Muller, J. (1987). PROCEDURAL PLANNING lHEORY : THE SYNTHETIC NECESSITY *. February.

Musemwa, M. (2006). Disciplining a 'Dissident' City: Hydropolitics in the City of Bulawayo, Matabeleland, Zimbabwe, 1980–1994. Journal of Southern African Studies, 32(2), 239–254.

Nakamura, S., Harati, R., Lall, S. V., Dikhanov, Y. M., Hamadeh, N., Oliver, W. V., Rissanen, M. O., & Yamanaka, M. (2020). Comparing Costs of Living across World Cities. World Bank Economic Review, 34, S79–S88. https://doi.org/10.1093/wber/lhz037

Ndiweni, E., & Verhoeven, H. (2013). The rise of informal entrepreneurs in Zimbabwe: evidence of economic growth or failure of economic policies? African J. of Accounting, Auditing and Finance, 2(3), 260. https://doi.org/10.1504/ajaaf.2013.057636

Nguimkeu, P., & Okou, C. (2021). Does informality increase the spread of COVID-19 in Africa? A cross-country examination. Applied Economics Letters, 00(00), 1–5. https://doi.org/10.1080/13504851.2021.1910128

Penrose, K., De Castro, M. C., Werema, J., & Ryan, E. T. (2010). Informal urban settlements and cholera risk in Dar es Salaam, Tanzania. PLoS Neglected Tropical Diseases, 4(3), 1–11. https://doi.org/10.1371/journal.pntd.0000631

Persiani, P., De Meo, D., Giannini, E., Calogero, V., Varsamis, T. S., Cavallo, A. U., Martini, L., Cera, G., Coluzzi, F., & Villani, C. (2021). The aftermath of COVID-19 lockdown on daily life activities in orthopaedic patients. Journal of Pain Research, 14, 575–583. https://doi.org/10.2147/JPR.S285814

Pharoah, R. (2016). Strengthening Urban Resilience in African Cities. 1–44. www.actionaid.org

Pitoyo, A. J., Aditya, B., & Amri, I. (2020). The impacts of COVID-19 pandemic to informal economic sector in Indonesia: Theoretical and empirical comparison. E3S Web of Conferences, 200. https://doi.org/10.1051/e3sconf/202020003014

Roy, A. (2017). Urban informality: Toward an epistemology of planning. Contemporary Movements in Planning Theory: Critical Essays in Planning Theory: Volume 3, 423–434. https://doi.org/10.4324/9781315259451-31

Sikwila, M. N., Karedza, G., & Mungadza, A. (2016). Tax Collection Constraints, and Tax Burden on the Urban Informal Sector Enterprises: Evidence from Bulawayo, Zimbabwe. Mediterranean Journal of Social Sciences, 7(6), 79–86. https://doi.org/10.5901/mjss.2016.v7n6p79

Simmons, R. (2007). Reactive Planning. In Spring (pp. 3–6).

The Brookings Institution. (2021). Figures of the week: Africa's urbanization dynamics. https://www.brookings.edu/blog/africa-in-focus/2020/07/16/figures-of-the-week-africas-urbanization-dynamics/

UN-Habitat. (2005). Urban Policies and the Right to the City Public Debate. International Journal, March, 1–20.

UN. (2015). UNITED NATIONS Contribution to the 2015 United Nations Economic and Social Council (ECOSOC). 1–5.

UN DESA. (2018). UN DESA-United Nations Department of Economic and Social Affairs. https://www.un.org/development/desa/en/news/population/2018-revision-of-world-urbanization-prospects.html

United Nations. (2019). World Urbanization Prospects 2018: Highlights. In World Urbanization Prospects 2018: Highlights. UN. https://doi.org/10.18356/6255ead2-en

Wahba, S. N. (2020). Can cities bounce back better from COVID-19? Reflections from emerging post-pandemic recovery plans and trade-offs. 3.

WFP. (2021). EU provides emergency cash assistance and nutrition support to people facing extreme food insecurity in Zimbabwe. 2021(August), 2020–2021.

Wilson, W. (2021). For Them, NYC Will Never Be The Same - The New York Times.

Worth, R. . (2010). 4 Approaches to Planning (Reactive, Inactive, Preactive, & Proactive). https://www.entarga.com/stratplan/approaches.htm

Yazdizadeh, B., Chimeh, E. E., Zendehdel, K., & Mobinizadeh, M. (2022). Knowledge gaps and national research priorities for COVID‐19 in Iran. 1–14. https://doi.org/10.1186/s12961-021-00805-y

Yiftachel, O. (1989). Towards a new typology of urban planning theories. Environment and Planning B: Planning and Design, 16(1), 23–39.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

🏆 *reviewed paper*

Air-/Seaport Cities: On Metropolitan Territory of Hub Cities

Sanela Pansinger, Lucija Ažman Momirski

(Dr. techn.arch. Sanela Panisnger, adasca e. U., Office for Urban Research & Planning & Design, Hafnerriegel 10, A-8010 Graz, sanela.pansinger@adasca.at)

(Assoc. Prof. Lucija Ažman Momirski, DI Dr.techn.Arch., University of Ljubljana, Faculty of Architecture, Zoisova 12, SI-1000 Ljubljana, lucija.azman@fa.uni-lj.si)

1 ABSTRACT

Increasing urbanization is transforming cities and regions into metropolitan areas facing current environmental, energy, economic, and social challenges. Some of these metropolitan regions include important infrastructure, transport, and spatial corridors. A new and complex type of spatial organization is emerging there, primarily based on logistical, economic, and political decisions. This phenomenon mainly affects cities and regions with seaports and airports as “brainports” (transport and mobility centers, supply structures, such as logistical centers for the transport and distribution of goods, trade centers, industry, commerce, etc.). The functionalisation of spaces in such territories leads to a recognisable spatial pattern with certain characteristics that clearly differ from other spatial structures and causes a hierarchisation of spatial organisation.

These ever-growing structures, which are geared toward function and profitability, consume a lot of space and land, which is considered one of the most important resources when it comes to reducing the carbon footprint and enabling sustainable spatial development. Therefore, there is a special, forward-looking motivation to transform this spatial complexity with many potentials and resources into a sustainable, integrated spatial development for the city, the region and the neighboring communities. This is because these structures are an ideal opportunity to combine thematic principles such as building and spatial planning, climate and energy supply, quality of life, mobility, noise reduction, economic balance with spatial quality, etc. HubCities as a method and strategy show how such structures can become a transparent, networked and resilient place that also focuses on the human scale.

HubCities is a relatively young topic in spatial and urban development, which only developed at the end of the twentieth century (e.g., through the low-cost airline boom since the liberalization of air transport in 1997 and globalized containerization) as a result of complex processes. There is a lack of temporal distance and the associated historical analysis to comprehensively explain, present and strategically use these processes.

The aim of this paper is to use the term Hub Cities to illustrate the significance, impact, approach and potential of airport and seaport locations and their surroundings for spatial development. The questions raised are illustrated using the example of the airport area and logistics center of Graz (Austria, which is part of the NUTS 3 metropolitan region), the seaport of Koper with visionary ideas of a networked passenger airport (Slovenia), and the port city and regional passenger airport city of Trieste (Italy, which is not part of the NUTS 3 metropolitan region, presumably because the broader area is located in two different countries).

HubCities is thus a long-term strategy for airport and seaport locations and their surrounding areas that identifies the problems and potentials of today's urban development and provides a historical account of the phenomenon (e.g., a shift of important urban functions to the surrounding area). HubCities is a transferable mindset that prevents further urban sprawl, protects landscapes, green and open spaces, and promotes an appropriate mix of uses in sensible locations. It is a program that develops and combines smart systems, solutions, and methods that can be transferred to other airport and seaport regions.

Hub cities lead to the loss of familiar forms, but at the same time new spaces, structures and actors emerge. They all require spatial embedding in order to sustainably achieve the desired qualities of a location that is close to its citizens and typical of the region. HubCities can become the cities of the tolerant society of the future and an impetus for resilient spatial development, in which spatial quality is an added value and a resource and, above all, a prerequisite for the sustainable development of the airport (city) and seaport (city) location, the community, the city and the region.

Keywords: Metropolitan Territory, HubCities, Seaport City, Airport City, Urban Development

2 CHALLENGE, GOAL AND POTENTIAL OF HUBCITIES

2.1 Introduction: What are the challenges?

Increasing urbanization is transforming cities and regions into metropolitan areas facing current environmental, energy, economic, and social challenges. Some of these metropolitan regions include important infrastructure, transport, and spatial corridors. A new and complex type of spatial organization is emerging there, primarily based on logistical, economic, and political decisions. This phenomenon mainly affects cities and regions with seaports and airports as “brainports” (transport and mobility centers, supply structures, such as logistical centers for the transport and distribution of goods, trade centers, industry, commerce, etc.). The functionalization of spaces in such territories leads to a recognizable spatial pattern with certain characteristics that is clearly different from other spatial structures and results in a hierarchization of spatial organization (Fig. 1).

Fig. 1: From left to right: Spatial organisation of the HubCities (yellow rectangle) around Graz Airport (AT), around the seaport of Koper (SLO), around Trieste Airport and around the seaport of Trieste (IT). Source: GoogleMaps.

Several challenges arise in these areas (Fig. 2).

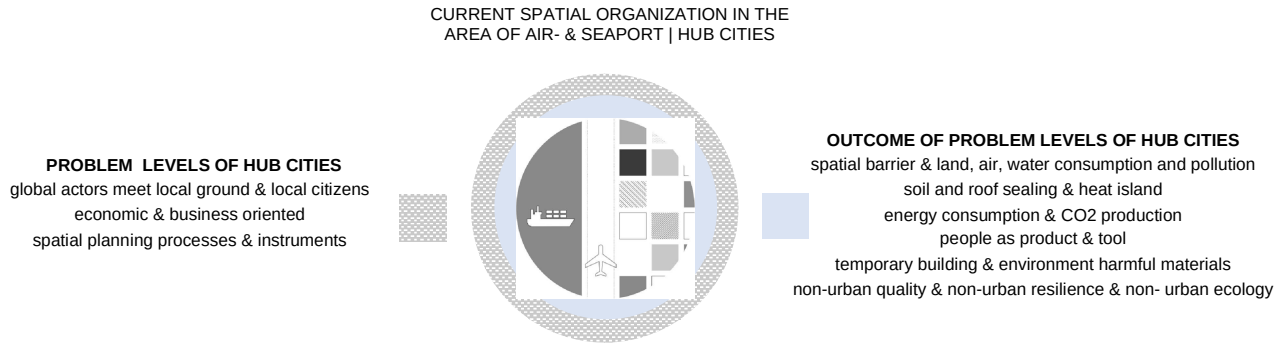


Fig. 2: Problem level and result of the problem level in the field of air and sea ports. Source: S. Pansinger, L. Ažman Momirski.

First and foremost is the conflict of interests: HubCities are both a local and a supra-local place, where global actors with global interests use local spaces while often overriding and ignoring local interests. Global companies have great financial and political power that they use in the spatial expansion of their local territory. Communicating their spatial intentions and decisions to other actors in the surrounding areas does not occur.

Consequently, a second challenge arises: in HubCities conflicting spatial development coexists. Namely, the functionalization of spaces leads to recognizably unbalanced spatial patterns (e.g., large volumes and floor plans of buildings that do not correspond to the human scale, or spatial structures that are clearly different from other spatial structures and cause an abrupt hierarchization of the spatial pattern). Because the actors are oriented toward the (objective) figures of economic growth, these structures often consume all ecological, social, and spatial resources without creating new ones, although they have the potential to do so because of their size and importance. Conflicting functions, physical barriers, spatial interventions, soil consumption, and land uses are not negotiated between actors, leaving spatial development incompatible and in serious disagreement. It also becomes clear that today's planning instruments cannot adequately capture and thus control structural change and its dependence on the interactions between air and seaport locations and the city. This poses the risk of further undesirable developments in terms of capacities or resources, energy supply, noise pollution, land designation or land availability.

The third challenge is the spatial planning process, which makes such spatial development possible. The instrumentarium of spatial development decisions is largely in the hands of the mayors of the local municipalities. They are usually not experts in spatial development, nor are they familiar with contemporary approaches to co-design, negotiation, citizen participation, and citizen science. A top-down approach is still largely used in spatial planning at the local level. This leads to conflicts with citizens (e.g., various types of pollution, ownership of the land, and sale of the land).

2.2 HubCities: a term for airport and seaport territory?

HubCities is a relatively young topic in spatial and urban development, which only developed at the end of the twentieth century (e.g., through the low-cost airline boom since the liberalization of air transport in 1997 and globalized containerization) as a result of complex processes. There is a lack of temporal distance and the associated historical analysis to comprehensively explain, present, and strategically use these processes.

On the other hand, the European air transport sector is one of the strongest parts of the European economy and a world leader. Each year, 900 million passengers travel to, from and within the European Union, representing one-third of the global market. In 2015, Airports Council International estimated the total economic impact of airports and aviation-related activities in the EU at €338 billion. Aviation can act as an "economic multiplier," promoting and generating further economic activity. Geography is not the only factor that determines the location of successful international airports. The availability of suitable infrastructure, labor and tax systems, and historical, cultural and trade links also play a role (Transport EU, 2022).

The presence of seaports in regions is closely linked to the economic development not only of the adjacent cities but also of their territories. Interpreting statistical data in the way that the EU relies on its seaports for trade with the rest of the world (74% of goods imports and exports, 37% of intra-EU trade, and 400 million passengers per year) means that there is adequate hinterland support for seaports and cities in terms of services, infrastructure, labor, etc. (Blue Belt, 2022: Ports, 2017).The European port system created at least 2.5 million jobs (in full-time equivalents) in 2017, both directly and indirectly, i.e. in a broader territorial context. Port cities are consistently among the economically stongest cities (Key figures on Europe, 2017). The European Commission considers ports as "engines of economic development and sources of prosperity" (Ports 2030, 2022). Port cities rank high in human capital indicators (population growth, working age population, entrepreneurship, quality of education, quality of healthcare, etc.) (Fusco Girard, 2013).

Airport cities, seaport cities, and their regions share many characteristics with other industrial and urban areas. Their gateway functions are arguably similar, although the former do not have the same historical embeddedness in their local urban environment as seaports (Konvitz, 2012). These ever-expanding structures, designed for function and economy, consume a lot of space and land, which is considered one of the most important resources when it comes to reducing carbon footprints and enabling sustainable spatial development. There is a special, forward-looking motivation to transform this spatial complexity with many potentials and resources into a sustainable, integrated spatial development for the city, the region and the neighboring communities, because these structures are an ideal opportunity to combine thematic principles such as building and spatial organization, climate and energy supply, quality of life, mobility, noise reduction, economic equilibrium with spatial quality, and so on.

Airports and seaports delimit large industrial and logistics areas within metropolitan regions. Metropolitan regions are characterized by a dense concentration of functions that integrate them into social and economic networks on a supraregional, European and global level. Studies define metropolitan regions according to different criteria. The "administrative" approach to defining a metropolitan region is a management and control tool based on the status of predefined legal or administrative units (OECD, Espon Functional Urban Areas (FUA)), which include cities or densely populated areas, core areas, and less densely populated areas from which people commute to work in the core areas. The "morphological" approach defines metropolitan areas as contiguous urban settlements that reach a certain level of density or urbanization. The "functional" approach is based on the functional relationships or interactions among units in the metropolitan area. The "network" approach refers to the multidirectional and multilevel interactions among actors in a metropolitan area (Vazquez, Morollon, 2012).

HubCities is a specific urban processes of the present in the metropolitan territoriy of airports and seaports. We would like to introduce the morphological approach in the context of HubCities.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

2.3 Goals and potentials of Hub Cities

The primary goal of this paper is to systematically identify and define the HubCity pattern in the area of airports and seaports.

The aim of the paper is also to demonstrate, under the concept of HubCities, the significance, impact, approach and potential of airport and seaport locations and their surroundings for spatial development. The dynamically growing air and seaport territory is an ideal and innovative testing ground for intelligent, networked and integrated solutions, where sustainability requirements can be examined under the given multifactorial conditions. Thus, the goal is not only to integrate the airport and seaport area with its surroundings through ecological, economic, and technological interactions and networking, but also to create a new kind of spatial quality that ensures spatial sustainability (Pansinger, 2017) and thus contains potentials for further urban and regional development. This process requires change and this change demands concepts that generate and bundle new systems, solutions and methods.

It is in this HubCities environment that the complex challenges of our time and new approaches and strategies can be brought together to develop a comprehensive model and gain an edge in knowledge for resilient spatial organization around the airports and seaports of tomorrow. The operation of airports and seaports will not be sustainable for the foreseeable future, as cleaner fuels are still in the development phase. We can't solve this challenge with urban planning, but by developing a sustainable spatial organization around it, we can help improve our footprint. HubCities is a research and implementation project for the future of seaport and airport territories with an international appeal. The basic question is: What can we learn from HubCities for the future?

The questions raised are illustrated using the example of the airport area and logistics center of Graz (Austria, which is part of the NUTS 3 metropolitan region), the seaport of Koper with visionary ideas of a networked passenger airport (Slovenia), and the port city and regional passenger airport city of Trieste (Italy, which is not part of the NUTS 3 metropolitan region, presumably because the broader area is located in two different countries). The impacts between the airport and seaport locations, the city and the landscape are noticeable and visible.

By applying the smart cities criteria and indicators (e.g. smart economy, smart energy, smart mobility, smart environment, smart people, smart housing, smart governance, etc.) to these case studies, the comparative conclusions not only take into account environmental, economic and technological synergies and networks, but also open up perspectives for innovative and resilient spatial quality.

The HubCities approach thus has an important task: to translate condensed and controversial demands into a balanced and sustainable spatial organization of the seaport and airport territory. Historically: If port cities were thriving commercial centers and harbingers of a new, more open society, then today both airport cities and seaport cities can be the cities of the tolerant society of the future (Fig. 3).

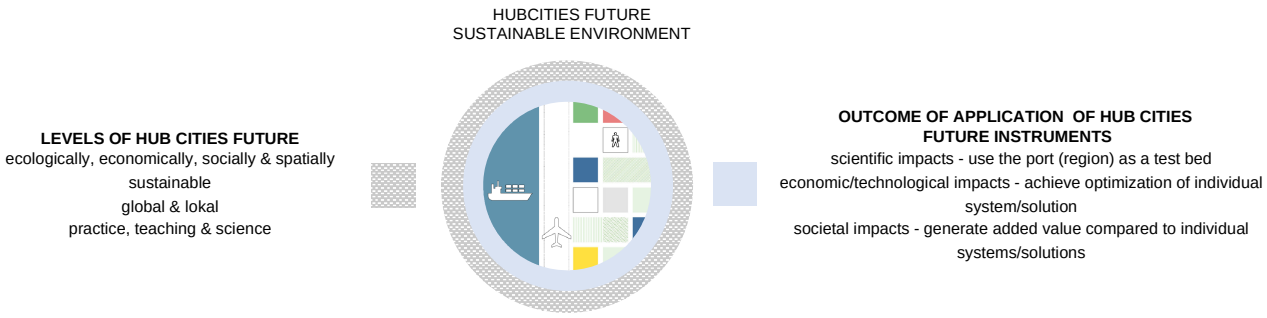


Fig. 3: HubCities Future – new spatial organisation in area of airport and seaport. Source: S. Pansinger, L. Ažman Momirski.

3 METHODOLOGY AND FIELD OF ACTION

3.1 General methodology (Fig. 4)

Step 1: The topic of airports and seaports (brainports) as HubCities is first presented and analyzed on an inter- and transdisciplinary theoretical level and then transferred to the real testbed. The results will provide an explanation for the spatial developments of HubCities, simultaneously supporting them and bringing

together new fields of action in an interdisciplinary and sustainable way. What is required is a readjustment of the spatial planning control options and the implementation of the current challenges in terms of environmental, economic, social and spatial (design) sustainability. This gives the spatial structure of HubCities a new significance for urban and regional development. Graz, Koper and Trieste were selected as test territories.

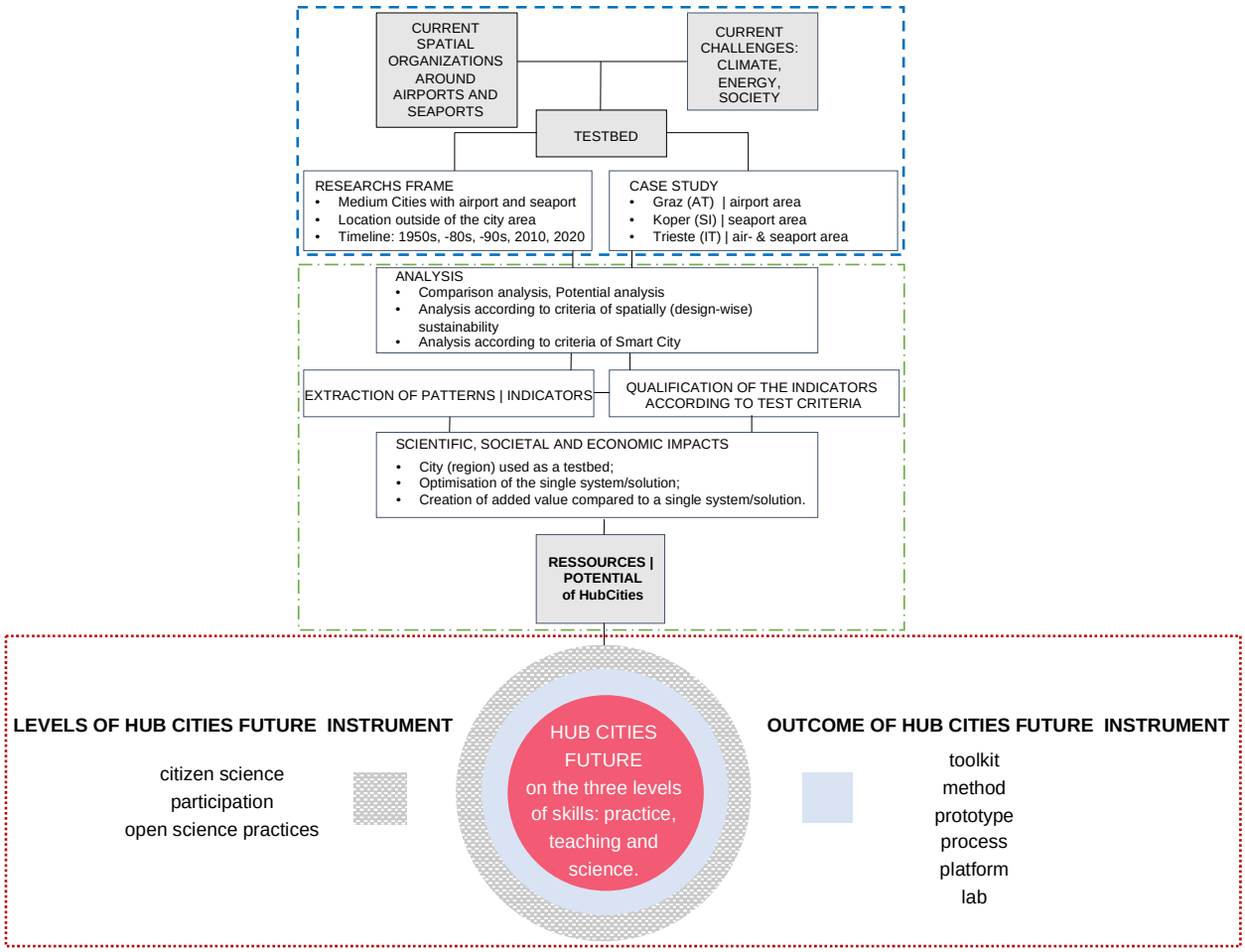


Fig. 4: General methodology and fields of action. Source: S. Pansinger, L. Ažman Momirski.

Step 2: The selected case studies should answer the following questions:

- What different spatial structures can be identified and what is their dependence on the location of airports and seaports?
- Which indicators can be used to systematize and qualify these structures and is there a logic or scheme of their structure to predict future developments?
- According to which criteria are the results of the analysis evaluated and why?

Step 3: Is the last step in the methodology, which is supported by three tools: Citizen Science, Participation, Open Science Practices. The main point is to bring citizen science into the process of spatial planning (biology dominates the topics of citizen science projects and spatial planning is not yet aware of how to use it). Citizens are involved in the design of HubCities, from defining the questions and developing premises to discussing the results and answering new questions. Citizens can also initiate action projects aimed at promoting interventions in local spaces.

RESULTS

3.2 Graz

Where should the area surrounding Graz Airport develop?

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

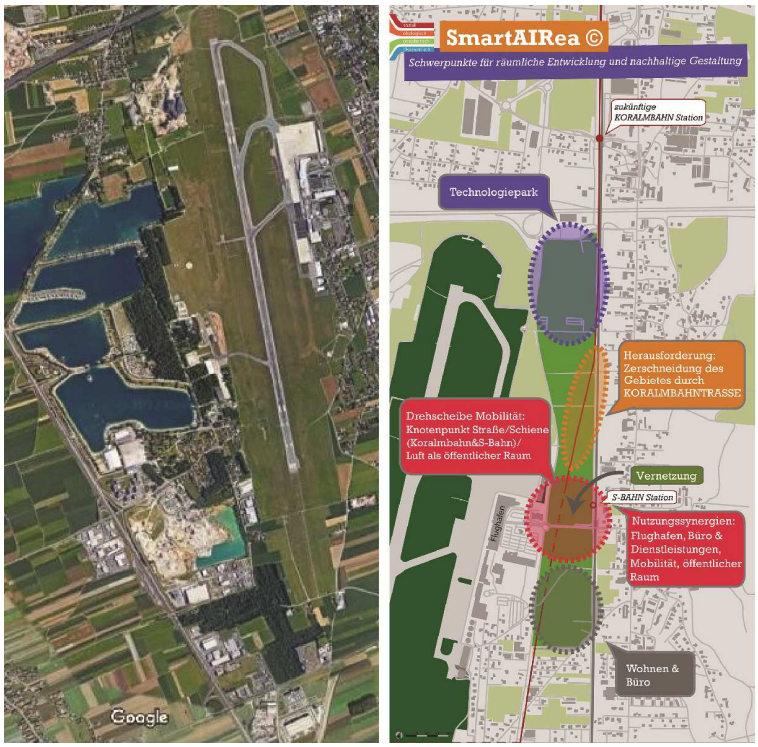


Fig. 5: Current spatial organisation around airport Graz and smartAirea – www.smartairea.eu One of the results shows that a polycentric development or the activation of the individual spatial areas of the airport environment offer the possibility of securing the spatial quality of the airport environment and thus at the same time the airport location in the urban-rural dimension. The challenges lie in a responsible process design that takes into account not only ecological, economic and social aspects, but also design and spatial aspects. Source: S. Pansinger, GoogleMaps.

Step 1: The airport is located in the south of Graz, about 9 km from the city center, mostly in the village of Abtissendorf in the municipality of Feldkirchen and to a lesser extent in the cadastral municipality of Thalerhof in Kalsdorf. The spatial embedding of the Graz airport site in the reference system of settlement, district, municipality, region, country/nation is one of the prerequisites for its positive effect on spatial and urban development. The originally independent areas of the airport surroundings are to grow together through activities (eating and recreation, living and working, traffic and communication) (Fig. 5). This refers to the following points:

- One of the development goals is to create a framework of public spaces and green spaces in the Graz airport area. In the sense of the network principle and in connection with the infrastructure, this area creates a design continuity and thus new social hotspots.
- The airport environment should also be seen as a non-partisan endeavour that transcends spatial boundaries, is planned for the city as a whole and with the involvement of the neighbouring communities, and whose specific development criteria (regional concepts) must be jointly formulated and implemented.
- Involvement of the surrounding communities, which are not in a position to manage possible renewal processes in the airport environment due to their size and importance.
- The airport environment requires variable concepts such as SmartAIRea (Fig. 6) or changes to existing instruments (land use plan, development plan, etc.) due to the long-term unpredictability of the processes taking place there. Economic fluctuations alone can paralyze cohesive planning. The built fabric around the airport should therefore have continuous uses and connectivity to functioning urban areas and be able to respond flexibly to changes.

Step 2: SmartAirea has an interdisciplinary and transdisciplinary structure and impacts on practice, teaching and science at the following levels:

Goal 1. Using the city (region) as a testbed: The area around the airport is used as a testbed for implementation. The proposed scenarios include intelligent, networked and integrated solutions for sustainable spatial organisation and mobility.

Goal 2. Achieve optimisation of individual systems/solutions: Focusing on individual solutions alone was not appropriate to move from the "no progress area to the SmartAIRea". In this project, the following topics were also considered for development: building networks, energy networks, integrated mobility solutions and the involvement of relevant stakeholders and decision makers.

Goal 3. To create added value compared to individual systems/solutions: The involvement of all relevant actors, both as project partners and in the planned workshops, is the basis for creating added value compared to individual solutions. Linking information from the Status Qou determination contributes significantly to its acceptance by stakeholders.

Fig. 6: Digital and analog exhibition and participation process SmartAirea. Source: S. Pansinger.

Step 3: Various measures, means and ways were used to transmit and disseminate the information and project results: Networking activities with the LoI partner and relevant local stakeholders, public events (workshops, kick-off meeting and follow-up meeting), reports in newspapers and on the radio, participation in events and presentations, model making (analog and digital), creation of a homepage (www.smartairea.eu) and integration in university education. At the end of the project an exhibition was displayed at Graz Airport (Fig. 6).

3.3 Koper

Fig. 6: Masterplan of the Port of Koper. Source: L. Ažman Momirski.

Step 1: The port of Koper is the youngest modern port in the Northern Adriatic (Ažman Momirski, 2004) (Fig. 6). Already at the beginning of the development of the port of Koper, an airport was planned. In 1962, the Portorož Airport was built in a landscape park, which is very sensitive to interventions. Therefore, the extension of the runway of Portorož Airport envisaged by the Municipality of Piran is problematic.

Step 2: We examined the possibility of locating the airport near Koper. However, the spheres of influence of four major international airports overlap on the Slovenian coast. Therefore, it does not make sense to build a

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

large airport (with a longer runway) in this area because of the high competition between airports, but it does make sense to locate a medium-sized (regional) airport. The size of such an airport would be smaller than Ronchi or Pula, but larger than the current Portorož airport. The proposed location of the new airport could be in the valley of the Rižana River below Dekani, about 3.5 km east of the port of Koper (Fig. 7). The location is close to the main transportation routes (Ljubljana-Koper highway and Koper-Trst highway). The Koper-Ljubljana regional road and the Ljubljana-Koper railroad line pass by the site. In the coming years, a second railroad line Koper-Divača will be built in the area (Maček, 2016).

A morphological analysis of the area shows that the airport site itself is relatively undeveloped. Along the northwestern boundary of the site, the building fabric is concentrated in the IPLAS industrial area. Such a program is also found along the northern boundary of the site. The airport site also borders the outer edge of the Dekani settlement and, in the southeastern part, the area of the concrete plant. The southwestern edge of the area is adjacent to some residential buildings.

This is a rather large and technically demanding intervention in the space. However, such a project is justified if, in addition to the clear benefits for the coastal economy, one of the main objectives of the task is achieved: the removal of the airport infrastructure from the protected areas on the Slovenian coast.

Step 3: Although some activities involving citizen science have already taken place within the framework of the WeCount project (measurement of traffic volume with low-cost sensors on road sections in the vicinity of Koper), further citizen science actions are in preparation, including the involvement of citizens in the collection of data on living conditions around the port of Koper.

Fig. 7: Proposal for new Koper Airport. Source: Miha Maček.

3.4 Trieste

Fig. 8: Spatial organisation of the seaport of Trieste, and spatial organisation around the airport Ronchi in Trieste. Source: GoogleMaps.

Step 1: The port city of Trieste transformed from an extraordinary and flourishing port city in the nineteenth century to one of the many port cities of the twentieth century on the northern Adriatic (Ažman Momirski, 2021). The golden era of the port city of Trieste was followed by its decline in the twentieth century. Today, the Port of Trieste is striving to adapt to the competitive world of ports. Since 1957, the master plan for the Port of Trieste has been amended twenty-four times. In 2010, a new plan was approved. The Free Port of Trieste currently includes five different free zones. Three of them are reserved for commercial activities (the Old Free Zone, the New Free Zone and the Timber Terminal) and two for industrial activities (the Free Zone for Mineral Oils and the Free Zone for the Zaule Canal). The port of Trieste is located between the city and

the sea, and its quays are long - the port has grown along the coast - but lacks storage and handling areas. Trieste had already used valuable urban space for port activities (Fig. 8).

Ronchi Airport was initially a military airport of the Royal Italian Air Force from 1935. After 1954, with the political decision to give Trieste to Italy, the role of the airport was recognized as fundamental for the development of the northeast of Italy. Commercial traffic began in 1961, and in 2016 the airport was officially renamed Trieste Airport. Currently, it is used as a regional airport for low-cost flights. For Ronchi Airport, the question is whether it is possible to integrate the landscape and airport infrastructure in an environmentally "sustainable" way (Cipriani, 2014). Many airports (but also seaports) are located near ecologically sensitive areas.

Step 2: In 2016, the Port Authority adopted a new regulatory plan (Piano Regolatore del Porto di Trieste - PRP). The functional structure of the port and outlines the main infrastructural developments are redefined. Through direct and indirect impacts, the plan foresees the development and revitalization of the wider port area, including adjacent industrial and logistics facilities and municipalities. Although the redevelopment project is often seen as a compromise to make the planned port expansion more acceptable to the people of Trieste, it requires a shared vision among the main local players in urban development and a collaborative approach to urban and spatial planning to make it a reality.

Step 3: Citizens Science in environmental research is already present in Trieste. MaDCrow, a research and development, involves citizens as data collectors while improving public environmental awareness and participation in scientific research. The goal of the project is to create an innovative technological infrastructure for real-time collection, integration and access to data to generate knowledge about the sea water quality and marine ecosystem of the Gulf of Trieste (Diviaccio et al., 2021). However, a citizens science approach for urban planning at the level of the airport city and seaport city is missing.

4 DISCUSSION

The spatially integrated design of the airport and seaport environment as well as the spatial implementation of multimodal mobility networks from macro to micro infrastructure space, energy systems and supply and the structural-technical coupling of climate protection measures motivate the city and the airport and seaport operators to reduce conflicts and tensions. Thus, the airport and seaport environments develop mutually, but also separately.

The results enable strategic management of the potentials and resources of this spatial organization and make HubCities a driving force of resilient, sustainable spatial development. This is a field of study with great potential that has been little explored in practice. It is the first holistic study of airport and sea port city territories paralely.

The transferability of the results to other HubCities is given and thus also the development of new fields of action. Furthermore, the methodology is not only applicable to HubCities, but wherever the organization of space results from the interplay of different poles or a "in-between" arises. Currently, the following are the main areas where a discourse between global and local interests is taking place: Train station, industrial facilities, etc. They all require spatial embedding in their surroundings in order to achieve certain locational qualities.

The relevance of the Hub Cities project is explained not only by its transferability, but also by the fact that 42% of airport sites are operating at a loss and are therefore at risk of regulatory action and closure. This makes these territories, some of which are already up for disposition, and especially the highly contested surrounding areas, of immediate relevance in terms of urban and regional planning. The pan-European potential through scaling, duplication or even conceptual transfer is thus enormous. Pandemic and current war events also change the role of airports and seaports.

5 CONCLUSION

HubCities develop a new approach for a long-term strategy for airport and seaport locations and their surroundings; the approach is transferable and applicable in practice as well as in science and education; in other HubCities regions. The approach prevents further urban sprawl, safeguards landscapes, green and open spaces, promotes an appropriate mix of uses in sensible locations, generates and combines intelligent systems, solutions and methods.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

HubCities as a method and strategy shows how such structures can become a transparent, connected, and resilient place that also focuses on human scale.

HubCities takes into account and analyzes the transport and spatial corridors that have since emerged, intersecting and settling around the location of the airport and seaport. Each node and territory is a unique mix of uses and opportunities for exchange and change - yet shares architectural and urban design similarities in the form of a specific pattern.

The HubCities approach is forming a new profile of urban planners who will be able to coordinate and use citizen science in conflict situations in urban planning. A long-term outcome will be a first integrative view of the space and environment around airport and seaport cities or HubCities - where local and global interests meet. Through such a new process in spatial planning involving citizen science, the promised paradigm shift in spatial planning, practice, research and education will take place. Spatial planning is a profession, that is too often not based on facts, but on estimates. For providing more reliable scenarios of the spatial development, we need more reliable starting points.

HubCities aims to strengthen the focus on the end user, their tasks, goals and motivation. The requirements of the end user become clearer, and as a result, design teams can better align their decisions with those necesities.

HubCities are thus the missing link between spatial strategies at the micro level and national spatial development plans at the macro level, especially for airport and seaport territories. Hub Cities is thus its umbrella term.

6 REFERENCES

Ažman Momirski, Lučka: The Port of Koper: The Youngest Modern North Adriatic Port. In: Portus 7, 2004, 70–75.

Ažman Momirski, Lučka: The Resilience of the Port Cities of Trieste, Rijeka, and Koper. Journal of Urban History 47 (2), 2021, 293-316, doi:10.1177/0096144220926600.

Blue Belt: https://ec.europa.eu/commission/presscorner/detail/en/MEMO_13_658. EU Commision, 2022.

Cipriani, Laura: Ecological Airport Urbanism. Airports and landscapes in the Italian NorthEast. Aracne editrice, Trento, 2014.

Diviacco, Paolo, Nadali, Antonio, Iurcev, Massimiliano, Carbajales, Rodrigo, Busato, Alessandro, Pavan, Alessandro, Burca, Mihai, Grio, Lorenzo, Nolich, Massimiliano, Molinaro, Andrea, Malfatti, Francesca: MaDCrow, a Citizen Science Infrastructure to Monitor Water Quality in the Gulf of Trieste (North Adriatic Sea). Frontiers in Marine Science 8, 2021, doi: 10.3389/fmars.2021.619898

Fusco Girard, Luigi: Toward a Smart Sustainable Development of Port Cities/Areas: The Role of the “Historic Urban Landscape” Approach. In: Sustainability 2013, 5, 4329-4348; doi:10.3390/su5104329

Key figures on Europe: https://ec.europa.eu/eurostat/documents/3217494/8309812/KS-EI-17-001-EN-N.pdf/b7df53f5-4faf-48a6-aca1-c650d40c9239. EU Commision, 2017.

Konvitz, Joseph. (2012). Contemporary Urban History: What the Study of Port Cities Implies for Evidence, Methodology, and Conceptualization. In: Journal of Urban History, 39(4), 801-806. https://doi.org/10.1177/0096144212470248

Maček, Miha: Novo letališče obalne regije: idejna zasnova letališča v Mestni občini Koper (diplomsko delo). Fakulteta za arhitekturo Univerze v Ljubljani, 2016.

Pansinger, Sanela; Förster, Julia: Airport neighbourhoods as future regional development areas for resource awareness and gestalt sustainability: Smartairea. In: WIT Transactions on Ecology and the Environment 2, September 2018 | https://bit.ly/2PyUuaU

Pansinger, Sanela: EXCESS - flEXible user-Centric Energy poSitive houSes. H2020 in https://positive-energy buildings.eu/news?c=search&uid=RRBprhah, 2020.

Pansinger, Sanela: Gestalt Sustainability - the future field of action to reduce our ecological footprint. In: https://www.derstandard.at/story/2000058692472/wie-man-nicht-orte-in-orte-fuer-menschen-verwandelt, 2017.

Ports: https://transport.ec.europa.eu/transport-modes/maritime/ports_en. EU Commision, 2017.

Ports 2030 : https://ec.europa.eu/transport/infrastructure/tentec/tentec-portal/site/brochures_images/ports2013_brochure_lowres.pdf. EU Commision, 2022.

Transport EU, 2022. https://transport.ec.europa.eu/transport-modes/air/airports_en.

Vazquez, Esteban Fernandez; Morollon, Fernando Rubiera: Defining the Spatial Scale in Modern Regional Analysis New Challenges from Data at Local Level. Springer, 2012.

🏆 *reviewed paper*

Analyses on Stopping-off Points and Destination Selection of Nagoya CBD Visitors by applying Spatial-Temporal Position Data

Yoshimasa Matsumoto, Toshiyuki Kaneda

(Yoshimasa Matsumoto, Nagoya Institute of Technology, Gokiso, Showa, Nagoya, Aichi, Japan, cls15084@ict.nitech.ac.jp)
(Prof. Toshiyuki Kaneda, Nagoya Institute of Technology, Gokiso, Showa, Nagoya, Aichi, Japan, kaneda@nitech.ac.jp)

1 ABSTRACT

In recent years, GPS(Global Positioning System) data and various other data have been provided as information on people's shopping-around behaviors within CBD(Central Business District), allowing people's shopping-around behaviors to be obtained in more detail. In addition to conventional person-trip surveys, these data have the potential to reveal new aspects of people's shopping-around behaviors. Furthermore, through the restaurant API(Application Programming Interface), by combining spatial-temporal position data with restaurant data, it will be possible to clarify people's district visitation factors and downtown selection behavior.

In this study, We defined a 5-minute stop in the area as a stopping off points in the spatial-temporal position data, and aimed to clarify the factors of stopping off points in the Nagoya CBD area by latent factor analysis of PLS(Partial Least Squares) regression, and to estimate individual destination selection behavior by multinomial logistic analysis. The results of the latent factor analysis of the PLS regression revealed that the regression coefficients were high for the number and type of restaurants in the 0-12 time period, but high for entertainment facilities in the 12-18 and 18-24 time periods. Furthermore, multinomial logistic analysis revealed a trade-off between proximity of 3 meters and the utility obtained from one restaurant.

Keywords: Shopping-around behaviour, Stopping-off point, Spatial-Temporal Position Data, Urban analysis, Big data

2 INTRODUCTION, PROBLEM AND OBJECTIVES

In recent years, GPS data and various other data have been provided as information on people's behavior within urban centers, allowing people's behavior to be obtained in greater detail. In addition to conventional person-trip surveys, these data have the potential to reveal new aspects of people's behavior. Furthermore, by combining restaurant API data, it will be possible to clarify people's district visitation factors and downtown selection behavior.

Therefore, in this study, the stopping off point is defined as a 5-minute stay in the area in the spatial-temporal location data, and the purpose of this study is to clarify the factors of the stopping off point in the Nagoya CBD by latent factor analysis of PLS regression and to estimate the individual's district selection behavior by multinomial logit analysis.

3 SETTING AREA AND DATA SOURCE

The target area was the central Nagoya area centered on Nagoya Station and Sakae Station, and was divided into 55 districts according to townships (Fig. 1). Table 1 shows the spatial-temporal position data by sample, restaurant API data, commercial concentration statistics data, and Nagoya City Building Survey data used in this study.

The spatial-temporal position data by sample is based on the PT(Person Trip) survey conducted on October 3, 2011 (weekday) as part of the respondents. The Chukyo area data provided includes the minute-by-minute latitude and longitude coordinates of the trips of 208,543 sample members. The restaurant API data contains restaurant information registered on Gurunavi, a restaurant information service.

Symbol	Data name	Source	Number of data	Year
A	spatial-temporal position data	Tokyo University	208,543	2011
B	restaurant API data	Gurunavi	13,144	2019
C	commercial concentration statistics data	Tokyo University	611,839	2014
D	Nagoya City Building Survey data	Nagoya City	32,925	2011

Table 1: Data source

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

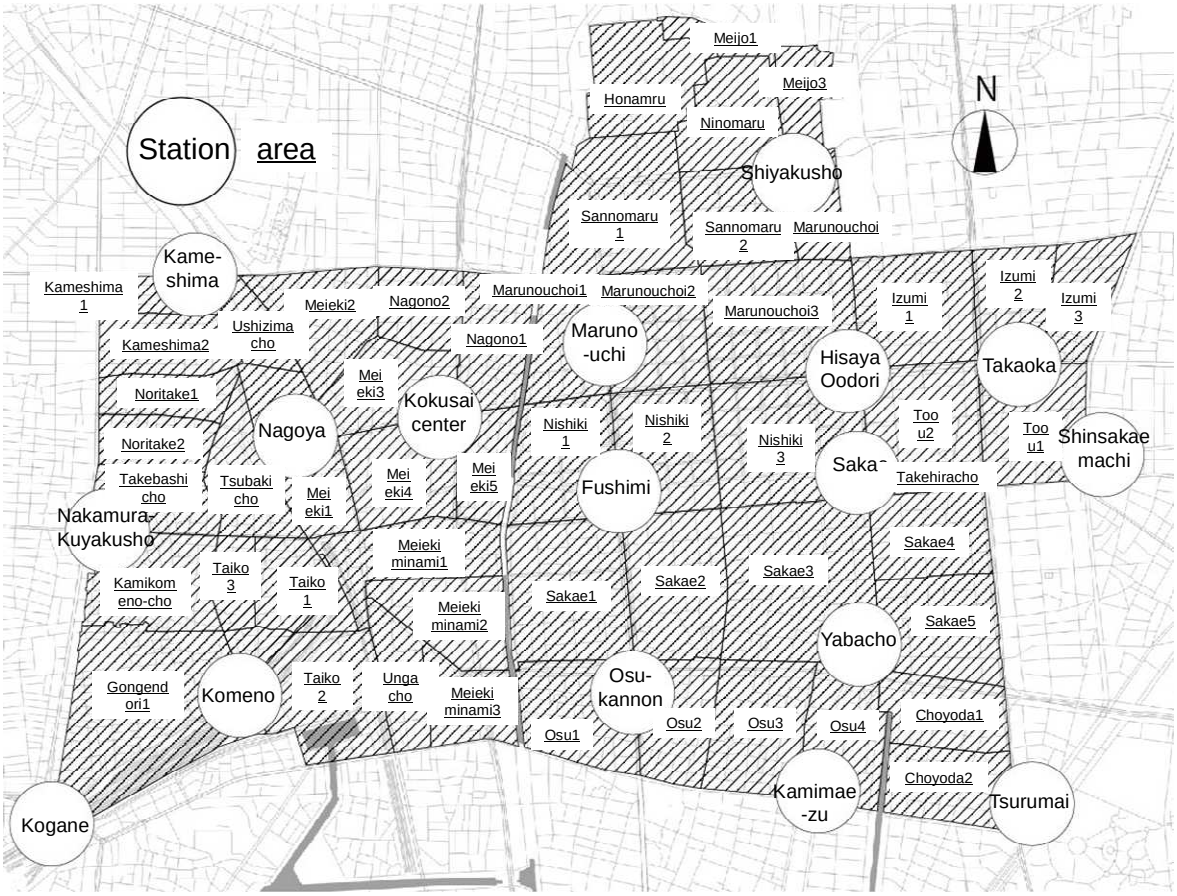


Fig. 1: Targeted Nagoya CBD and area division

4 EXTRACTION OF STOPPING OFF POINTS BY TIME ZONE WITHIN THE CITY CENTER USING SPATIAL-TEMPORAL POSITION DATA

Stopping off points were defined as follows. We extracted the five-minute stay behavior of visitors and defined the five-minute stopping off points as those points (Fig. 2, Table 2). First, visitors who passed through the area were extracted because of the large size of the data (Table 2-ii). If there were five or more points inside the circle, the center point was designated as the five-minute stop point, the beginning point was designated as the start time of the stop, and the number of points was designated as the stop time (Table 2-iii). Next, to determine whether or not the sample was at home, we pseudo-checked whether or not the linear distance between 0:00 and 23:59 was within 25 meter. If it was within 25 meter, the first and last stop points of the sample were deleted as home (Table 2-iii). Finally, based on the time of the start of the stop, the sample was divided into 0-12:00, 12-18:00, and 18-24:00, and divided into stop points at each time of day.

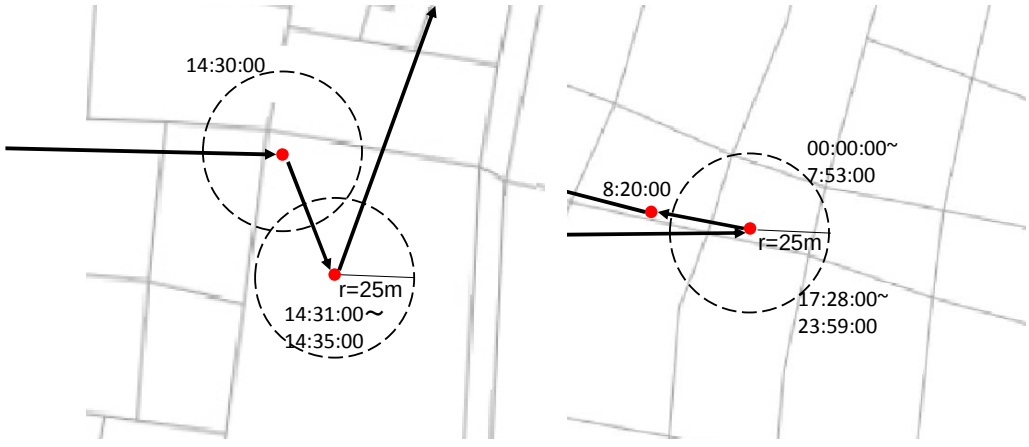


Fig. 2: Determination process:Five-minute stop points definition and decision to go home

Steps		the number of people	Stopping-off points
i	All samples	208,543	
ii	Sample passing through the area	17,445	
Determination process			
iii	Samples of stopping-off in the area	9,910	14,536
iv-1	0:00~12:00 samples		8,775
iv-ii	12:00~18:00 samples		4,220
iv-iii	18:00~24:00 samples		1,514

Table 2: Number of samples in each process

The results of the extraction showed that the spatial-temporal position data had larger values than the results of the PT survey, except for the 8:00 p.m. time slot, suggesting that shorter stop times could be extracted from the data.

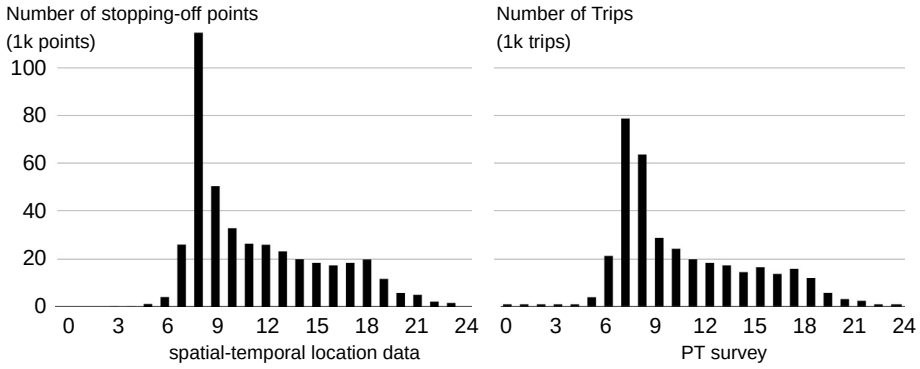


Fig. 3: Comparison of point histograms by time period for PT survey and spatial-temporal location data

Figure 4 shows the spatial distribution of stopping-off points extracted from the patial-temporal position data by sample.

In particular, from 18:00 to 24:00, the distribution is centered on Meieki 1, 3, and 5-chome, Sakae 3-chome, and Nishiki 2 and 3-chome. In addition, it can be seen that many of the stops are for 2 or 3 hours overall.

Fig. 4: Spatial distribution of stopping-off points by stop time (left: 0:00-12:00, middle: 12:00-18:00, right: 18:00-24:00)

Next, a histogram of stop times for each time period (0-12, 12-18, and 18-24 hours) is shown in Figure 5. 60-minute stays are prominent in the 0-12 hour time period, but this is thought to be due to a 5-minute transit stop. The peak at 600 minutes can be interpreted as a stay at the office due to employment.

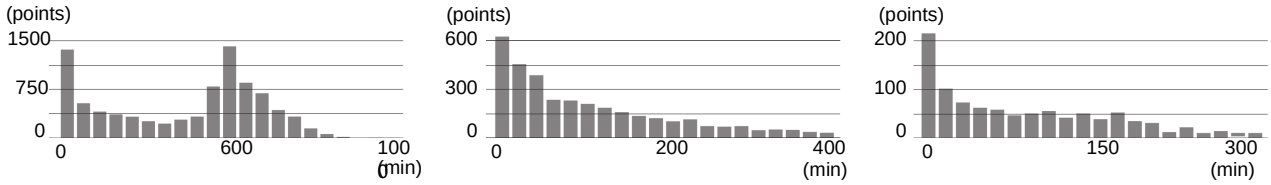


Fig. 5: Histograms of stop times by time zone(left: 0:00-12:00, middle: 12:00-18:00, right: 18:00-24:00)

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

5 CHARACTERISTICS OF INNER-CITY DISTRICTS BASED ON RESTAURANT API

Next, the restaurant API data was used to explore the number of restaurants and restaurant types for each time period.

The restaurant API data was plotted on a map (Figure 6). By time zone, the number of restaurants open between 12 and 6 p.m. increased (2,208), with a particularly marked increase in Osu and Sakae.

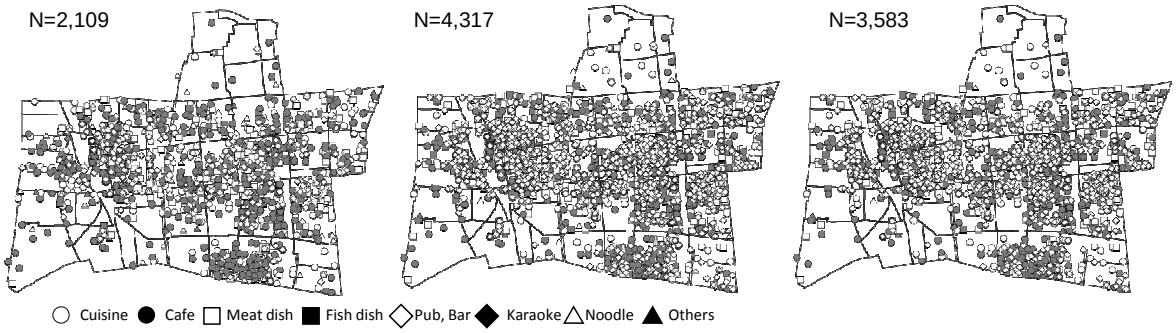


Fig. 6: Space distribution of restaurants by restaurant types (left: 0:00-12:00, middle: 12:00-18:00, right: 18:00-24:00)

Aggregate results by district also show that of the 22 total restaurant types, Meieki 3 and 4 and Sakae 3 and Nishiki 3 have more than 20 restaurants types. (Table 3).

	Right:Restaurants/km2 Left:types							Right:Restaurants/km2 Left:types					
	0~12		12~18		18~24			0~12		12~18		18~24	
Ushijimacho	263	12	338	13	213	10	Ninomaru	10	2	16	3	10	2
Nagono1	253	10	464	16	349	15	Sannomaru1	21	6	37	8	28	7
Nagono2	149	6	191	8	166	6	Sannomaru2	5	1	15	2	15	2
Meieki1	856	19	939	19	714	17	Marunouchi	52	2	73	3	52	2
Meieki2	222	16	475	18	353	16	Marunouchi1	111	10	222	13	185	12
Meieki3	488	17	1515	20	1240	20	Marunouchi2	165	10	266	14	188	12
Meieki4	708	19	1401	20	1057	20	Marunouchi3	126	13	215	17	147	14
Meieki4	247	10	585	17	476	14	Izumi1	231	15	449	17	342	16
Taiko1	57	4	85	5	57	3	Izumi2	175	8	330	14	265	13
Taiko2	0	0	0	0	0	0	Izumi3	96	6	208	12	178	10
Taiko3	72	4	131	7	87	5	Touou1	238	14	363	16	300	16
Takebashicho	55	5	111	7	96	6	Touou2	209	13	489	17	387	15
Tsubakicho	399	16	1231	19	1123	19	Takehiracho	107	4	214	6	150	4
Noritake1	116	5	270	10	250	9	Sakae1	240	15	487	18	389	17
Noritake2	83	4	148	7	138	7	Sakae2	222	15	387	17	260	16
Kamejima1	12	1	113	7	113	7	Sakae3	626	19	1203	21	1077	21
Kamejima2	53	5	99	8	66	7	Sakae4	504	14	1397	20	1282	19
Meiekiminami1	237	14	473	15	340	14	Sakae5	168	13	323	16	261	16
Meiekiminami2	29	4	35	5	17	3	Nishiki1	224	11	385	15	286	14
Meiekiminami3	48	4	56	5	40	4	Nishiki2	292	15	563	19	432	17
Meiekiminami4	9	1	27	3	27	3	Nishiki3	481	18	1737	21	1653	21
Kamikomenocho1	45	7	68	10	36	7	Chiyoda1	12	2	44	5	44	5
Unngacho	118	13	141	14	103	12	Chiyoda2	53	4	124	7	100	6
Gongendori1	18	4	24	6	18	5	Osu1	22	3	50	6	41	6
Makinocho	0	0	0	0	0	0	Osu2	277	9	495	16	448	15
Meijo1	0	0	0	0	0	0	Osu3	411	15	602	19	506	19
Meijo3	20	2	20	2	20	2	Osu4	151	13	244	16	177	13
Honmaru	9	2	19	4	14	3							

Table 3: Number of restaurants and restaurants types by time zone by district

6 ANALYSIS OF STOPS IN NAGOYA CBD USING LATENT FACTORS IN PLS REGRESSION

Next, we get a latent factor analysis of PLS regression, which stands for partial least squares regression, a technique that can be adapted to data with the threat of multicollinearity. PLS regression analysis was used because of the highly correlated combinations found among the variables in this study. With the number of visitors per district area as the objective variable, latent factors are analyzed by time period (0-12, 12-18, and 18-24 hours). The objective and explanatory variables are organized and presented in Table 4. The equation for PLS regression analysis is as follows.

$$X = t_a p_a^T + t_b p_b^T + t_c p_c^T + t_d p_d^T + t_e p_e^T + E$$

$$y = t_a q_a + t_b q_b + t_c q_c + t_d q_d + t_e q_e + f$$

(tn: n-th principal component, pn: n-th loading, E: residual of X, pn: n-th coefficient, f: residual of Y)

	Variables	Source	Note
y	Number of visitors per district area	A	Stopping-off Start Time
a	Number of restaurants per district area	B	Opening time
b	Number of restaurant types per district area	B	Opening time
c	Number of recreational facilities per district area	C+D	
d	Number of cultural facilities per district area	D	
e	Number of retail stores per district area	C	

Table 4: Objective and explanatory variables used in PLS regression analysis by time period

A summary of the analysis results is shown in Table 5, where the number of latent factors with the lowest PressRMSE(Root Mean Squared Error) was selected, resulting in a latent factor number of 2 for all time periods. The regression equation for the relationship between the number of visitors per unit area by district was obtained for these two latent variables.

		0-12	12-18	18-24
Number of components		2	2	2
R2		0.606	0.314	0.109
PressRMSE	first latent variable	0.00052	0.000254	0.000195
	second latent variable	0.00112	0.000433	0.00021
Cumulative contribution rate		72.7	68.4	62.7

Table 5: Summary in PLS regression analysis

Next, we examine the standard partial regression coefficients by time period (Table 6,7,8).

In particular, the absolute values of the number of entertainment facilities (c: 0.448), cultural facilities (d: -0.369), restaurant types (b: 0.213), restaurants (a: 0.157), and retail stores (e: -0.117) were higher between 18 and 24 hours, in that order.

A comparison of the rank order of the standard partial regression coefficients across time periods reveals that the number of restaurants and the number of restaurant types are higher in the 0-12 time period, while the number of entertainment facilities is higher in the 12-18 and 18-24 time periods.

	a	b	c	d	e
Standard Variance Regression Coefficient	0.257	0.429	0.163	-0.083	-0.0028
first latent variable	0.004	89.446	0.012	0.000	0.000
second latent variable	0.222	0.000	0.959	0.005	-0.011

Table 6: Latent variable loadings(0-12)

	a	b	c	d	e
Standard Variance Regression Coefficient	0.152	0.261	0.549	-0.245	-0.028
first latent variable	0.003	40.598	0.007	0.000	0.000
second latent variable	0.184	0.000	0.781	0.005	-0.011

Table 7: Latent variable loadings(12-18)

	a	b	c	d	e
Standard Variance Regression Coefficient	0.157	0.213	0.448	-0.369	-0.117
	0.001	13.478	0.003	0.000	0.000
second latent variable	0.061	0.000	0.305	-0.008	-0.002

Table 8: Latent variable loadings(18-24)

In PLS regression analysis, as in principal component analysis, the latent variables are orthogonal and the axes can be interpreted as an overall indicator of the variables. Therefore, each latent variable is interpreted by looking at the loadings of the latent variables and the distribution of latent factor scores. The spatial distribution of latent factor scores by time period is shown in Figures 7, 8 and 9.

The spatial distribution shows that there is no significant difference between the first and second latent variables by time period. However, looking at the loadings for each latent variable, the first latent variable is

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

0.894 for the number of restaurant types from 0-12:00, 0.406 from 12-18:00, and 0.134 from 18-24:00. Although the loadings decrease as the hours get later, they are higher than the other variables, which can be considered the "axis of restaurant diversity" can be considered.

The second latent variable can be considered as the "urban entertainment axis" since the number of entertainment establishments is 0.959 from 0-12am, 0.781 from 12-18am, and 0.305 from 18-24am, similarly taking higher values than the other variables.

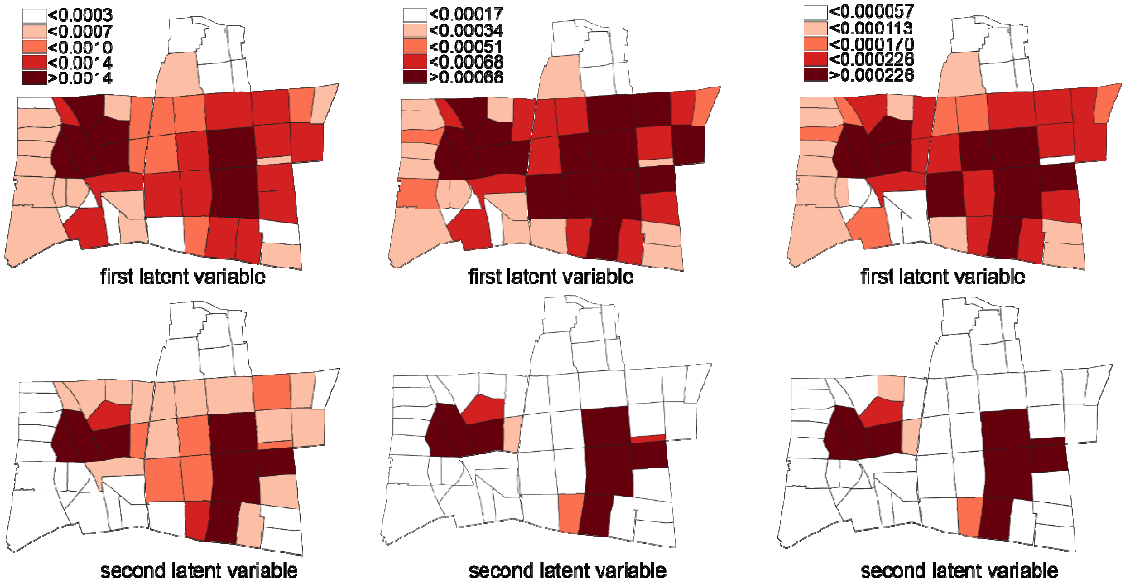


Fig. 7: Spatial distribution of latent factor scores (left: 0:00-12:00, middle: 12:00-18:00, right: 18:00-24:00)

7 ESTIMATING A MODEL OF NIGHTTIME DISTRICT CHOICE BEHAVIOR USING MULTINOMIAL LOGIT ANALYSIS

Next, we consider that there are routine and non-routine free activities in the nighttime after work because of the characteristics of the spatial-temporal location data and the fact that it is a weekday. Therefore, we estimate the district choice probability of visitors to the Nagoya city center area by conducting a multinomial logit analysis, with the presence or absence of individual district choice as the objective variable and the linear distance between the 18-24 pm stop as the explanatory variable in addition to the explanatory variables in the PLS regression analysis. The variables used are shown in Table 9.

	Variables	Source	Note
y	Visitation choice by district	A	Stopping-off Start Time
a	Number of restaurants per district area	B	Opening time
b	Number of restaurant types per district area	B	Opening time
c	Number of recreational facilities per district area	C+D	
d	Number of cultural facilities per district area	D	
e	Number of retail stores per district area	C	
f	Distance between stopping-off points	A	Distance between stopping-off points in 12-18

Table 9: Variables used in multinomial logit analysis

	a	b	c	d	e	f
a	1					
b	-0.139	1				
c	0.047	-0.608	1			
d	-0.047	-0.318	0.296	1		
e	0.467	-0.419	0.362	0.04	1	
f	-0.063	-0.204	0.122	0.083	0.022	1

Table 10: Correlation matrix between variables

Since multinomial logit analysis requires consideration of multicollinearity among explanatory variables, correlation coefficients among each explanatory variable were obtained and variables were selected. As a result, the number of restaurants (a), the number of cultural facilities (d), and the distance between stops (f), which are not subject to multicollinearity, were used in the analysis (Table 10).

The equation for individual utility obtained from the multinomial logit analysis is as follows:

$$\log (y) = 0.606 \log (a) - 0.216 \log (d) - 1.995 \log (f) + 6.151$$

Using the cross-validation method based on the parameters obtained, a high value of 0.984 was obtained for the success rate.

A summary of the analysis results is shown in Table 11. The negative values for the distance between stops indicate that the longer the distance, the smaller the utility an individual can obtain from the district. We also find that the individual's utility increases as the number of restaurants per unit area increases. This suggests that there is a trade-off between the utility gained from one restaurant and the proximity of 3 meters.

	parameter	odds	VIF	p-value	AIC	Success rate
intercept	6.151				6937.4	0.984
a	0.606	1.833	1.024	<0.05		
d	-0.216	0.805	1.011	<0.05		
f	-1.995	0.136	1.019	<0.05		

Table 11: Variables used in multinomial logit analysis

From the obtained model equation, the individual's probability of choice by district is estimated and illustrated in the figure. The estimated probabilities of choice by district are Meieki 1, Nishiki 3, Meieki 4, and Sakae 3, in descending order of probability. In addition, there are two distributions, one centered on Meieki and the other centered on Sakae (Figure 8 left).

Next, using this estimated model equation, we estimate where and how much the number of restaurants and facilities by district should increase to increase the probability of individuals choosing any given point over competing districts. As an example, we selected the Osu 1, 2, 3, and 4 districts and estimated the district-specific selection probabilities for the case in which the number of restaurants was increased tenfold from 1,172.8 to 11,728.3. The results showed an effect of reducing the selection probability of Sakae 3 by one rank and increasing the selection probability of Osu 3 by one rank (Figure 8, right).

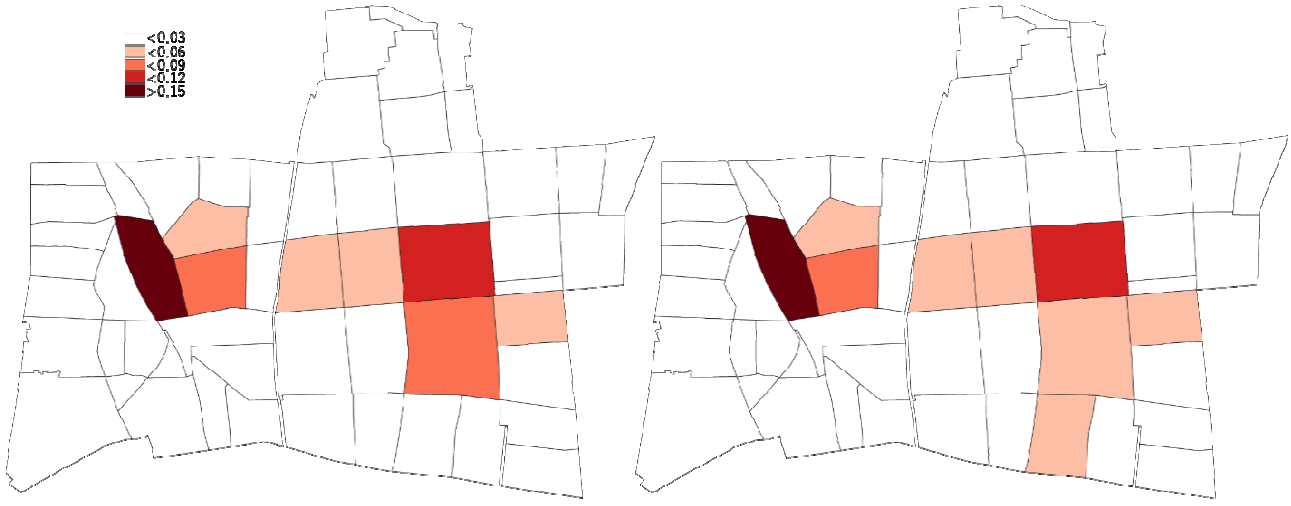


Fig. 8: Estimated probability of selection by district (left: existing state, right: Increase the number of restaurants in Osu area by 10 times)

8 CONCLUSION

This study clarified the factors of stops in the central Nagoya CBD and estimated district-specific selection probabilities based mainly on the spatial-temporal location data and the restaurant API data.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

1) The standard partial regression coefficients of the PLS regression showed that the number and type of restaurants were the top factors during 0-12 hours, while entertainment facilities were the top factors during 12-18 hours and 18-24 hours. Regardless of the time of day, the first latent variable could be interpreted as the restaurant diversity axis and the second latent variable as the urban entertainment axis.

2) A multinomial logit analysis revealed a trade-off between the 3-meter proximity and the utility gained from one restaurant. In Nagoya CBD, the probability of choice is high in Meieki and Sakae, but increasing the number of restaurants in the Osu area increases the probability of choice in the Osu area and decreases the probability of choice in Sakae 3.

9 REFERENCES

Y. Sakurai, S. Miyazaki and A. Fujii, Construction of a Choice Behavior Model for Commercial Areas Using a Multinomial Logit Model and Analysis of Trade Areas, Journal of Urban Planning, 2011, Vol.46, No.3, p.427-432

Suehashi, K., Saito, S., and Kumada, T., Development of an aggregate circulation Lukoff model for predicting sales based on frequency of visits to a commercial district in Komakura, in Proceedings of the City Planning Institute of Japan, 1998, Vol.33, No.3.

Edward L. Glaeser, Hyunjin Kim, Michael Luca, Nowcasting the Local Economy:Using Yelp Data to Measure Economic Activity,Harvard Business School NOM Unit Working Paper No. 18-022

Akihiko Namie, An Attempt of Regional Analysis Using PLS Regression: A Case Study of Garbage Discharge in Fukui Prefecture, Geographical Review, 2007, Vol. 80, No. 4, p.178-191

🏆 *reviewed paper*

Analysing the Causes and Challenges of Urban Spatial Expansion in Windhoek, Namibia: Towards Sustainable Urban Development Strategy

Cyrlius Tjipetekera, Trynos Gumbo, Eric Yankson

(Cyrlius Tjipetekera, Dept of Urban and Regional Planning, University of Johannesburg. Cnr Siemert & Beit Streets, Doornfontein 0184 Johannesburg, South Africa, cyrliustjipetekera@yahoo.com)

(Prof. Trynos Gumbo, Dept of Urban and Regional Planning, University of Johannesburg. Cnr Siemert & Beit Streets, Doornfontein 0184 Johannesburg, South Africa, tgumbo@uj.ac.za)

(Dr. Eric Yankson, Dept of Architecture and Spatial Science, Namibia University of Science & Technology. 13 Storch Street, Windhoek, Namibia, eyankson@nust.na)

1 ABSTRACT

The global population has continued to increase over the past fifty years and many scholars believe that this trend will continue until the year 2050 or beyond. The challenge now lies with the ability of most cities especially those within the global south to develop and provide the most needed infrastructure and services. Namibia, with only 2.5 million people, with Windhoek, the capital city accounting for about 400 000 residents; is battling with the high rates of urbanisation since the influx of the people into Windhoek continues to be soaring. There have been massive spatial expansions as new arrivals settle on the urban fringes, consequently, over the years the city has been failing to keep pace in terms of basic service provision. Though there has been some research that have studied the spatial expansion of the city within its peri-urban areas. There is still a need for extensive research that unpacks the key causes of these urban transformations and the challenges of the uncontrolled urban spatial growth. Thus, this paper explores and unpacks the root causes of these spatial urban transformation. The increase of the urban population has led to urban sprawl which has negatively affected the efforts of the city of Windhoek to provide development infrastructures and services. Moreover, the demand for housing have also increased and those that cannot afford to rent in the formal housing sector are pushed into the informal settlements. Thus, the city of Windhoek faces a daunting task in the provision of basic services to its residents as this is exacerbated by the need to adopt a pro-poor planning approach, which in many instances places financial burden on the city. Thus, to address this challenge there is a need for the formulation and effective implementation of spatial planning tools such as the spatial development framework and policies that will specifically guide the urban spatial transformation in the peri-urban areas of Windhoek. A case study research design was adopted to investigate the uncontrolled urban spatial transformations in the peri-urban areas in city. The research employed qualitative data analysis that involved the extensive review of existing technical documents from the City of Windhoek and peer reviewed journals articles.

Keywords: peri-urban areas, spatial transformation, urban growth, urbanisation, Windhoek

2 INTRODUCTION

The world urban population continues to grow and has put pressure on cities to provide for the necessary infrastructures such as better roads and houses to their residents. In 2021, the total world population was 7.9 billion people, and more than 50 % of these inhabitants live in urban areas (UN-Habitat, 2022). De Vidovich (2022: 238) observed that, peri-urban areas and urban fringes are pivotal places as they offer an understanding of the contemporary urban transformation as most of the world urban population lives in these areas. In Africa as a whole this phenomenon has led to an increase in the number of residents who live in the informal settlements also known as the shanty towns. Visagie and Turok (2020: 351) assert that these massive expansions of the urban areas coupled with the lack of infrastructures or services provision in the informal settlements and peri-urban areas have contributed to urban planning segregation and have disadvantaged mainly the urban poor regarding the key services that should be provided by the city administration for all. A shift of population from the rural areas into the urban areas has led to various challenges, one of them has been the uncontrolled urban spatial transformation in most of these cities, especially those in the global south. In most of the cities this sporadic urban spatial transformation has been happening within the peri-urban areas (UN-Habitat, 2014). In Namibia, a country of 2.5 million people, and in Windhoek which is the capital city and accounts for about 400 000 residents, the effects of urban spatial transformation have been clearly observed. The rapid increase of the population moving from rural to urban

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

areas such as Windhoek has been driven by several factors. The influx of people mainly from the rural areas presents a huge problem to the City of Windhoek and consequently overburdens its efforts in providing the required municipal services. This problem is amplified by the fact that many of the people who migrate to Windhoek find it difficult to get employment opportunities within the formal sectors and hence, they find themselves trapped by poverty within the informal settlements. Therefore, this paper has examined the causes of spatial expansion and the challenges that are associated with this expansion. While, lastly the paper has proposed strategies that could be used as policy intervention in addressing the unsustainable urban spatial expansion.

3 CONCEPTUAL SYNOPSIS

In the case of Windhoek, some scholarly work indicates that some of the primary factors that enticed the rural population to flock to Windhoek can be attributed to the "pull factors" which are perceived by the rural residents as better health services, good education facilities and the prospects of better job opportunities that are found in the urban areas. While on the other hand, lack of better health care and education facilities in rural areas are seen as some of the "push factors." Crush, Nickanor and Kazembe (2019: 3) argues that the vast number of the people who move from therural to the urban areas of Namibia greatly influence the spatial transformation of the peri-urban areas of Windhoek. According to Indongo, Angombe & Nickanor (2013) and Chitekwe-Biti, 2018: 403) one aspect that led to the increased number of residents in Windhoek after independence was the abolishment of the apartheid policy that restricted the movements of residents into Windhoek without the "PASS law". Windhoek has now seen more demand for housing, and this puts enormous pressure on the City of Windhoek to deliver serviced land and road infrastructures. De Vidovich, (2022: 239) and Katumba & Evaratt (2021: 148) argue that another aspect that put many of the post-apartheid African cities such as Windhoek and Johannesburg at disadvantage are its mono-functional design concept which encourages residential sprawl. This concept was borrowed from the Western planning ideals and amplified during the apartheid planning era. Umenne, Stoffberg and Kandjinga (2021: 237) assert that due to impact of this past apartheid policy on planning many of the urban centres such as Windhoek were left with a high level of disparities and uneven spatial development. In trying to respond to some of the challenges the City of Windhoek had to extend its boundary of the town and townland, with the aim of ensuring that there is sufficient land for the ever-increasing demand of land. While the City of Windhoek has been pro-active in extending its boundary there is still a rapid increase of people in the peri-urban areas with some scholars estimating that close to 50% of the residents in Windhoek live in the informal settlements (Crush, Nickanor and Kazembe, 2019: 1). According to Urban Dynamics (2020: 98) this historical expansion of the City of Windhoek municipal boundaries makes it one of the largest in the world. However, this expansion has created several challenges. Many of those who live in the peri-urban areas of Windhoek are still not connected to most of the municipal services.

This now means that a rapid spatial transformation is taking place within the peri-urban areas of Windhoek and due to this continued pressure, there has been sporadic conversion of productive agricultural land into residential areas, which is mainly dominated by informal settlements comprising unserviced land on the fringes of Windhoek. Van Greunen (2021: 4) posits that informal settlements should be viewed as part of the urban production process, especially in many cities of developing countries. This assertion rests on the inability of many cities in the global south to adequately provide key municipal services. However, some scholars have looked at the concept of co-production of urban spaces within the peri-urban areas as a solution to the proliferation of the informal settlements which lack basic services. Delgado, Muller, Mabakeng and Namupala (2020: 176) argue that through co-production different interest groups could find a common ground in terms of how informal areas can best be upgraded and thus the process could benefit from the local knowledge. Concurring with the above assertion, Miltin and Bartlett (2018:356) note that the defining characteristic of co-production is that the community and the state together co-deliver the necessary urban services with the low-incomes groups. From a policy perspective the City of Windhoek has also adopted and approved the preparation of the Windhoek Urban Structure Plan - WUSP. Once fully implemented the WUSP aims to firstly curtail the unsustainable urban growth and spatial patterns of physical development, as well as to serve as a framework that will guide the spatial distribution of municipal services. Furthermore, once approved the WUSP will provide a legal guiding framework that will ensure that urban

land in Windhoek will be used for the highest and best use in line with the existing policy framework (Urban Dynamics, WUSP, 2020).

4 RESEARCH METHODOLOGY

The study has employed a qualitative approach in terms of data collection where various technical documents and scholarly articles were reviewed. The technical documents that were reviewed included the WUSP, informal settlement upgrading approaches. The journals articles reviewed are those that had thematic areas that covered the spatial expansion within the peri- urban areas. For the journals articles only those that were published in the past ten years were selected to provide both the trend and guidance in terms the relevant literature in the domain. This has allowed for an in depth understanding of the key causes of urban spatial expansion within the peri-urban areas of Windhoek. The researcher extensively used different search engines such as Google scholar, SAGE, ELSEVIER, SPRINGER, Google search to obtain the information. O`Connor (2019: 67) asserts that document analysis is a sub-branch of discourse analysis which focuses on the analysis of meaning in words and images.

A case study design approach was adopted with the understanding that this approach would complement the qualitative data collection method by unpacking the drivers of urban spatial transformation within the peri-urban areas of Windhoek. Havana informal settlement was selected as the case study where urban spatial expansion has taken place. Since the City of Windhoek has developed several plans and policy documents, the researcher deemed it necessary to reviews these documents using the document analysis method. For spatial analysis, Google earth application was used to track the physical expansion of Havana informal settlements using a real-life tracking option that allowed the researcher to travel in time and thus view the actual expansion of the informal settlement as it developed over the years.

5 RESULTS AND DISCUSSION

This section will discuss in detail four key factors that were identified to be the primary contributors to the urban spatial transformation within the peri-urban areas of Windhoek. Though from extant literature it is evident that there are many factors that have contributed to the uncontrolled expansion within the peri-urban areas of Windhoek, the section below will discuss four of the causes that were uncovered.

5.1 Causes of urban spatial expansion of the city

The expansion of development within the peri-urban areas of Windhoek is very complex as it is influenced by a range of interconnected factors. Therefore, the paper deemed it necessary to select the main causes as they would offer a better illustration of the problem at hand.

5.1.1 Rapid pace of Urbanisation in Windhoek

Most of the reviewed literate indicates that immediately after Namibia got its independence in 1990 many of the people who were in the rural areas started to move to Windhoek. In 1991, the Namibia Population and Housing Census indicated that the urban population stood at 28%. This population then increased to 33% in 2001 and 42% in 2011 respectively (Namibia Statistics Agency, 2012). Indongo, Angombe and Nickanor (2013:4) observed that “though there has been an overall population increase in Namibia, Windhoek city has actually accounted for 36% of the total share and thus making it the primary focus of urbanisation.” The reasons for these rural-urban migrations are several. However, some studies have identified three main factors that have contributed to this phenomenon. Indongo, Angombe and Nickanor (2013:4) assert that the three main reasons why people move from rural to urban areas are due to better job opportunities, good education facilities, and escaping poverty in rural areas. Further to this, some literature indicates that some of the reasons for moving from rural to urban areas has been tied to economic opportunities and this speaks to the uneven development of, and provision of services in the country with greater bias towards the urban centres. Moreover, empirical evidence from some of the studies conducted in Windhoek indicates that “as the city continues to grow and develop it then automatically attracts more people from rural areas and consequently increases the demand for more services.

In a study that was conducted by Endjala and Botes (2020: 162) within the Northwestern informal areas of Windhoek, it was discovered that one of the main reasons why people were moving to Windhoek was to seek employment, while those who moved with the family was the second reason. However, there was also a

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

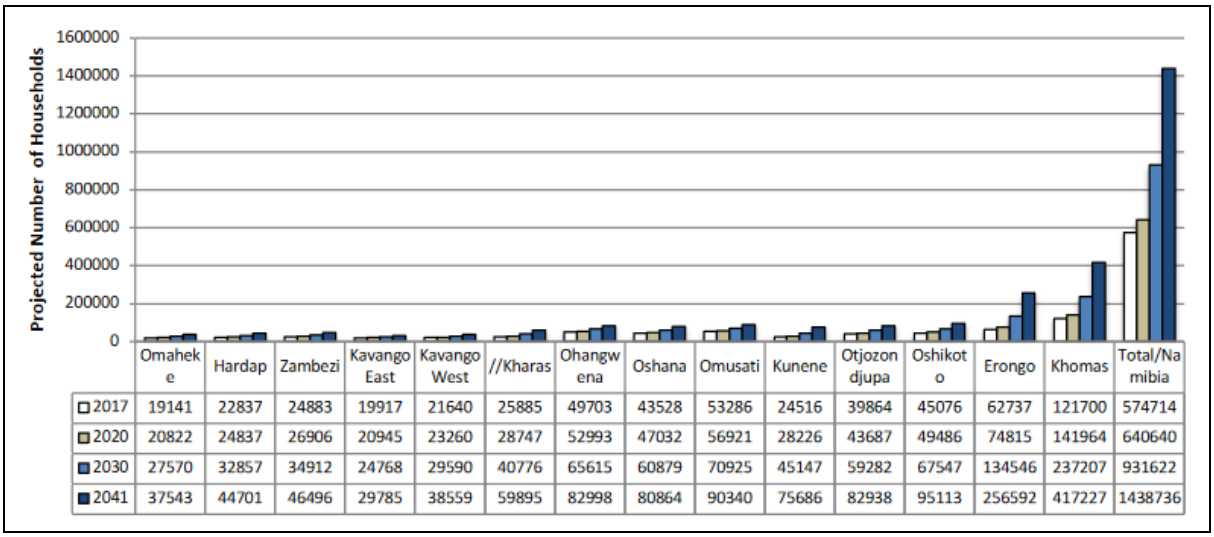
group of those who moved to the city in search of better services such as education. What is important to note is that many of the rural population who migrated to Windhoek in search of better opportunities were not literate and thus they may only find employment within either the informal trading business or at times they find temporary employment.

Reasons for coming to Windhoek	Frequency	Percent
To look for a job	60	57.1
Better services in the city	11	10.5
Tertiary education	8	7.6
Transferred with work	6	5.7
Moved with family	13	12.4
Better Healthcare	2	1.9
Total	105	100

Table 1: Reasons as to why people move to Windhoek: Source: Endjala and Botes (2020)

5.1.2 Increased Demand for Housing, Infrastructure, and Services

As indicated in the previous section the rapid increase of population in Windhoek has put tremendous pressure on the ability of the City of Windhoek to provide for all the necessary services. In most instances people who move to Windhoek are seeking employment opportunities and thus do not have income to rent in the formal housing sector once they arrive in the city. This means that their only alternative is to stay with their relatives in the informal settlement or if they are lucky to occupy unserviced land within these areas.



	Omaheke	Hardap	Zambezi	Kavango East	Kavango West	//Kharas	Ohangwena	Oshana	Omusati	Kunene	Otjozondjupa	Oshikoto	Erongo	Khomas	Total/Namibia
2017	19141	22837	24883	19917	21640	25885	49703	43528	53286	24516	39864	45076	62737	121700	574714
2020	20822	24837	26906	20945	23260	28747	52993	47032	56921	28226	43687	49486	74815	141964	640640
2030	27570	32857	34912	24768	29590	40776	65615	60879	70925	45147	59282	67547	134546	237207	931622
2041	37543	44701	46496	29785	38559	59895	82998	80864	90340	75686	82938	95113	256592	417227	1438736

Table 2: Demand for housing in Windhoek, Khomas region: Source: Asino and Christensen, (2018)

Consequently, the increase of the population in urban areas such as Windhoek put pressure on the provision of properly planned townships which should then be accompanied by road infrastructure. Indongo (2015:4) observed that unless prompt policy interventions are introduced, the great population increase will overburden the municipal infrastructures and services. Moreover, an increase in the Windhoek population requires a municipal planning system that can fast-track and deliver affordable land to the urban residents. Unfortunately, in the case of the City of Windhoek the municipal planning system has not been able to effectively address the housing and infrastructure because the city cannot keep up with the pace and thus it is difficult to provide for all their needs in good time. The Table above indicates the gross national housing demand for all the regions in Namibia. One will observe that the Khomas region were Windhoek is lies has the highest number of demands for housing. However, Asino and Christensen (2018: 24) noted that within the medium period of 2021 to 2030, the demand for housing could drop before it increases again in the long-term period from 2031 to 2041. This means that though the demand of housing units in the formal sector were expected to drop in the medium term, the city still faces a daunting task in providing for municipal services that are key to township establishments, such as road networks, water reticulation systems and

electricity grid in the informal areas and especially those within the urban fringes as they are far from existing municipal infrastructures.

5.1.3 Uncontrolled occupation of unserviced land

The increase of the Windhoek population mainly due to the rural-urban migration has become a time-ticking bomb. In 1946, Windhoek had a population of less than 20, 000 people, in 1975 it had a population of 80,0000 people, while in 2001 the urban population in Windhoek has doubled to 200,000 people. The Namibia Statistics Agency in 2011 indicated that the Windhoek population was 325,800, which was a 50% increase from the previous census. Hence the increase in the population led to the rapid expansion of the physical borders of the City of Windhoek. The city now started to expand into the commercial farms which are privately owned. After the city realised that it was running out of land for its residents, it entered into agreements with these farm owners to purchase land from them though this exercise was later seen to be counterproductive. From the policy perspective the city then applied to the Ministry of Urban and Rural Development to expands its boundaries (Windhoek Urban Structure Plan, 2020).

Figure 1: The footprint of Havana informal settlements in Windhoek in 2004, source: Google earth

After Namibia got its independence many of the segregation laws were abolished and this led to the influx of the people in the capital city. Figure 1 shows that in the year 2004 there was little expansion within the peri-urban areas of Windhoek. These areas which are also known as the North-Western informal areas include the Havana informal settlement. These areas were first developed by the City of Windhoek as the reception centres of the excessive urban population, and the city administration at that point, hoped that these could be temporary areas and once the migrants have established themselves, they should move into the formal residential areas. However, the rural migrants opted to permanently stay in the areas that were established as reception areas. Weber and Mendelsohn (2017: 19) observed that one of the key drivers of informal settlement growth was rural-urban migration and mainly from the Northern of Namibia.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Figure 2: Physical expansion of Windhoek in 2022: Source: Google Earth.

The image above was taken during March this year (2022) and one can clearly see the rapid urban transformation which has led to an increase in the sporadic occupation of unserviced land within the peri-urban areas of Windhoek. Moreover, it is also evident that outside the study area (outside the orange solid line) there has been rapid proliferation of informal housing activities. This continuous pressure has forced the city to be proactive and look for new ideas on how to address these socio-spatial problems that were amplified by urbanisation. The Namibian government, together with its stakeholders such as the City of Windhoek then developed the Flexible Land Tenure Systems Act of 2012 as a tool to address tenure insecurity amongst the low-income groups. Another critical aspect within the flexible land tenure system is the emphasis that it puts on the participatory approach, especially during the in-situ upgrading process of the informal areas. Kohima, Mabakeng and Alexander (2022: 8) noted that the involvement of community members within the informal settlement upgrading allows them to provide inputs into the planning and development of their area.

5.1.4 Sporadic conversion of agricultural into residential land

Since much of the land on the periphery of Windhoek is owned by private individuals or by entities which opt to sporadically convert this agricultural land (small-holdings) into residential areas through new "private townships "that provide their own services to its own residents. However, in principle the development of new "private townships" on the periphery of Windhoek cannot be discouraged as these developments happen on private owned land. The unfortunate thing is that these developments only address the housing needs of middle- and upper-income groups, as many of the private developers who undertake this process are driven by profit maximisation. This means that the City of Windhoek as the local authority is the one that is left with the sole responsibility for providing housing and service needs for the low-income groups.

5.2 Challenges due to the urban spatial expansion of the city

Each of the four causes that were discussed in the section above present a challenge to the proper administration of peri-urban land, as well as the provision of the basic municipal services by the City of Windhoek.

5.2.1 The city can no longer accommodate all its residents due to shortage of land

The biggest challenge that the City of Windhoek will continue to face for may years is the fact that it does not have enough land within its area of jurisdiction which would have enabled it to expand sustainably and at the same time provide the necessary municipal services to its residents. Even if formally the City of Windhoek has extended its boundary which now includes close to 75 farms and small-holdings, technically the city does not own these properties as indicated in the Windhoek Urban Structure Plan report. Therefore, since the only available land is privately own the City of Windhoek has found itself in a difficult position where it cannot accommodate the ever-increasing number of the population due in-migration and natural population growth. What saddens is that some of the residents who opt to occupy the unserviced land find themselves facing a lot of challenges, some of this land is in the river catchment area and hilly topographies. The Flexible Land Tenure Act of 2012 aims to provide secure tenure to the urban poor, through a process that allows for block registration of land rights to which a group of members will have rights to. Lauterbach and De Vries (2021: 1) posit that the key defining attribute of the flexible land tenure system is to provide a land registration system that is less complex and affordable to the urban poor. Thus, the idea is to have a system of registration that is not as complex as the conventional one which has been marred by bureaucracy. However, the flexible land tenure has also been very slow in terms of the implementation process.

5.2.2 Provision of municipal services & infrastructure is costly

The provision of basic municipal services in the peri-urban areas of Windhoek has been observed by many of the urban poor residents as the greatest challenge of all time. Since many of these residents have occupied land that is very far from most of the municipal network in terms of roads, electricity, water, and sewer reticulation systems they are totally disconnected from the formal part of the city. However, the City of Windhoek over the years has introduced communal water points were many of the residents could get water using a “water token” that is purchased from the city offices. However, for other infrastructures such as the roads and sewer system it has been quite difficult for the city to provide them as they require substantial investment which in most cases is based on the cost-recovery approach, which is not feasible in the low-income areas. In their study Demmert and Ndhlovu (2018: 71) observed that the cost of providing bulk services within the formal planning system and the professional fees attached to this process are hampering the provision of serviced land to the low-income groups.

5.2.3 Increased transportation cost to the ultra-low-income groups

The city of Windhoek has a dedicated municipal bus system that is normally used by the urban poor. The unfortunate part of this bus system is that it only operates in the formal part of Windhoek. Thus, within the informal settlement areas many of the urban poor depend heavily on informal transport. such as unregistered taxis and minibuses. This further complicates the livelihood of these residents as they walk long distances in the event of an emergency before they can find a bus stop or taxi rank. Since there are no proper roads, the police and ambulance services struggle to attend to critical matters in the informal areas.

5.2.4 Windhoek lacks spatial governance due to diverse land ownership on its periphery

In recent years the biggest challenge that the city is facing has been the issues of spatial governance. With all the fragmented land development and sporadic land occupation that is taking place on the periphery, the city is faced with the daunting task of proving effective spatial governance. In as much as most of the new townships that are being developed on periphery belongs to private entities, there is a need for the city to provide spatial direction that will sustainably guide the future development of the city. The Windhoek Urban Structure Plan report of 2020 indicates that there is a great possibility that a formal town could be established on the northern edge of the city and along the B1 road which stretches from Windhoek to Okahandja. This assertion is based on the increasing number of privately developed estates/gated communities in this area. This development has been amplified by the upgrading of the B1 national road to a dual carriage way that has significantly decreased the travelling time between Windhoek and Okahandja.

6 TOWARDS A SUSTAINABLE URBAN DEVELOPMENT STRATEGY

Based on the discussion presented above in this paper it is clear that the city administration has several legal instruments that they can use to control and steer development especially within the peri-urban areas, yet this

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

appears not to be the case. This means that there is a contradiction in terms of what the city can legally do and what the city has been able to do, within the armpit of these existing legal instruments.

The paper therefore, recommends the following interventions in solving the burden on the municipal infrastructure caused by the ever-increasing urban population which in turn leads to urban spatial expansion within the peri-urban areas of Windhoek.

- The Status quo Report on the formulation of the Windhoek Urban Structure Plan, advocates for deliberate efforts to be undertaken by the city to encourage sustainable land development approaches that includes infill development; this requires the city to identify all those vacant erven/plots which are linked to the municipal services and encourage investment in these areas through policy formulation and implementation. This paper concurs with this approach which should be done as matter of urgency.
- The Flexible Land Tenure System Act of 2012 and its regulations, provides the necessary registration process that can enhance the provision of the affordable and secure land right for the ultra-low-income groups. However, what is needed is the effective implementation of this legal instrument. Moreover, the City of Windhoek Upgrading and Developmt strategies should be used to complement the Act.
- More importantly, there is a need for the city to look at innovative ideas regarding provision of better housing to alleviate the ever-growing number of substandard houses in the already overcrowded informal settlements. While from a national policy perspective, the Namibia government should as much as possible try to balance the development of infrastructure and provision of social services equitably amongst all urban centres and rural areas. It is hoped that this could deter rural residents from migrating to the urban areas.

7 CONCLUSIONS

The City of Windhoek faces a daunting task in trying to provide basic services to its residents. This is because the provision of basic services such as serviced land, road and water supply require the city to apply pro-poor planning frameworks which in many instances become a financial burden foil the city administration. Moreover, while many of the current residents find it difficult to makes ends meet the city is still seen by those in rural areas as the “the promised land” were there are better job opportunities, good education facilities and an effective health care system. This perception continues to foil the movements of rural populations to urban centres such as Windhoek and thus these centres are continuously required to provide basic services to the urban poor even when the urban centres find themselves in very deep financial distress. However, if correctly understood and implemented both the flexible land tenure system and the WUSP could serve as guiding legal frameworks for a more effective and participatory type of planning, especially for the peri-urban areas of Windhoek. The emphasis now should be on the effective implementation of of these legal instrument.

8 REFERENCES

Asino, K., & Christensen, A. (2018). Assessments of housing needs in Namibia. Windhoek: Integrated Land Management Institute, Namibia University of Science and Technology.

Chitewe-Biti, B. (2018). Co-producing Windhoek: the contribution of the shack dwellers federation of Namibia. Environmenta and Urbanisation, 30(2), 387-406.

City of Windhoek. (2020). City of Windhoek Urban Structure Plan: Status qou report. Windhoek: City of Windhoek.

Crush, J., Nickanor, N., & Kazembe, L. (2019). Informal Food Deserts and Household food insecurity in Windhoek, Namibia. Sustainability, 11(37), 1-15.

De Vidovich, L. (2022). Socio-spatial transformation at the urban fringes of Rome: Unfolding Suburbanisms in Fiano Romano. European Urban and Regional studies, 29(2), 238-254.

Delgado, G., Muller, A., Mabakeng, R., & Namupala, M. (2020). Co-producing land for housing through informal settlement upgrading: Lessons from a Namibia municiplaity. Urbanisation and Environment, 32(1), 175-194.

Endjala, T., & Botes, L. (2020). Surviving like a Bird: Livelihood coping strategies in an informal settlement of Windhoek, Namibia. African Sociological Review, 24(1), 151-173.

Indongo, N. (2015). The effects of Urbanisation on housing conditions in Namibia. International Journal of Humanities, Social sciences and Education, 2(7), 1-8.

Indongo, N., Angombe, S., & Nickanor, N. (2013). Urbanisation in Namibia: views from semi-formal and informal settlement. Windhoek: University of Namibia.

Katumba, S., & Evaratt, D. (2021). urban Sprawl and Land cover in Post-Apartheid Johannesburg and the Gauteng-City Region. Environment and Urbanisation, 12(1), 147-164.

Kohima, J., Mabakeng, R., Alexander, L., Ricardo, P., & Simataa, V. (2022). Reception areas analysing the delivery of land for housing in Namibia. Warsaw, Poland: FIG Congress 2022: Voluteering for the future- Geospatial excellence for better living.

Lauterbach, R., & De Vries, W. T. (2022). Beyond accuracy: Evaluating alternative measurement methods in context of flexible land tenure system in Namibia. Survey Review, 54(385), 281-289.

Miltin, D., & Bartlett, S. (2018). Editorial: Co-production key ideas. Environment & Urbanisation vol 30 (2), 355-366.

O`Connor, J. (2019). Document Analysis. In M. Lambert, Practical Research Methods in Education (pp. 67-75). London: Routledge.

Remmert, D., & Ndhlovu, P. (2018). Housing in Namibia: Rights, challenges and opportunities. Windhoek: Institute for Public Policy Research - IPPR.

Umenne, S., Stoffberg, M., & Kandjinga, L. (2021). Inclusive urban campus development: A case study for Okahandja, Namibia. Journal of Building Construction and Planning Research, 9, 231-250.

UN Habitat. (2014). Intergrating Urbanisation in the CCA and UNDAF: A guide for United Nations country teams. New York: United Nations.

Urban Dynamics Town and Regional Planners. (2020). City of Windhoek Urban Structure Plan: Status quo report. Windhoek: City of Windhoek.

Van Greunen, S. (2021). The city assemblage: A case of Windhoek, Namibia. ELSEVIER, 1-10.

Visagie, J., & Turok, I. (2020). Getting density to work in informal settlements in Africa. Environment and Urbanisation, 32(2), 351-370.

Weber, B., & Mendelsohn, J. (2017). Informal settlements in Namibia their nature and growth: Exploring ways to make Namibia urban development more socially just and inclusive (1st ed.). Windhoek: Namibia Development Workshop.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

🏆 *reviewed paper*

Analysis of Factors for Pedestrians' Spatial Distribution in Sakae District of Nagoya Using Mobile Phone Location Data

Yufan Zhang, Toshiyuki Kaneda, Akira Ota

(Yufan Zhang, Graduate Student, Graduate School of Engineering, Nagaoya Institute of Technology, Gokiso, Showa, Nagoya, Japan, y.zhang.394@stn.nitech.ac.jp)
(Toshiyuki Kaneda, Doctor of Engineering, Graduate School of Engineering, Nagaoya Institute of Technology, Gokiso, Showa, Nagoya, Japan, kaneda@nitech.ac.jp)
(Akira Ota, Doctor of Engineering, Faculty of Urban Life Studies ,Tokyo City University, Tokyo, Japan, otaa@tcu.ac.jp)

1 ABSTRACT

Recently, mobile phone location data containing the activities of different urban residents can be employed for an urban study. Compared with field research, mobile phone location data have a larger volume, wider range, and higher frequency. It can provide fresh data to support urban research. Most analyses of the spatial distribution of pedestrians employ linear or log–log models using least squares, but the drawback is that the number of pedestrians and the number of counts do not always follow a normal distribution and the least-squares method is vulnerable to outlier effects. Thus, the use of generalised linear model (GLM) with maximum likelihood estimation for the analysis of the factors influencing pedestrian distribution makes sense. However, these models lack suitable indicators to rank the factors' strengths. In this study, we employed the Sakae district of Nagoya as the object of the study and divided the factors influencing the spatial distribution of pedestrians into four categories: street attribute factor, land use, space configuration, and transportation accessibility factor. Finally, we employed a GLM to study the factors influencing the pedestrians' distribution. We introduced a mean standardised partial differential value to compare the significance of each variable in the model. The findings showed that the correlation coefficient between forecast and actual values was better for the linear model whereas the mean absolute percent error was better for the negative binomial distribution model. Both models revealed that the integration value generated from the segment angular investigation was substantially correlated with the pedestrian distribution as a space configuration indicator.

Keywords: Mobile Phone Location Data, Pedestrians, Generalized Linear Model, Segment Angular Analysis, Urban Planning

2 INTRODUCTION

The quantitative analysis of the spatial distribution of the number of pedestrians has great significance in the 21st century. Recently, in addition to conventional outdoor survey data, the three cellular carriers in Japan have recently begun commercial services of mobile phone location data in urban areas. Owing to the large scope and volume of mobile phone location data collection, it is predicted that new advances in the quantitative analysis of the pedestrian numbers' spatial distribution will be introduced.

In addition to street attribute factors, facility volume (land use) factors, and transportation accessibility factors, space configuration factors based on the space syntax (SS) theory, quantifying urban form, have received attention as factors influencing the spatial distribution of pedestrian counts. Desyllas et al. (2003), Araya et al. (2005), Ozbil et al. (2015), Shimizu et al. (2019), and Kaneda et al. (2020) confirmed the involvement of the SS theory in the spatial distribution of the number of pedestrians as a factor of urban form.

However, in the above research, when investigating pedestrian count distribution factors, models that compute predictions using the least-squares method, like linear and log–log models, are employed. Although models using the least-squares method have the benefit of simple extraction of the factor structure, they have the drawback that the pedestrians' number, which is the number of counts, is not always normally distributed and is vulnerable to a singular value, making it meaningful to investigate the generalised linear model (GLM) that employs the maximum likelihood method. The study by Stavroulaki et al. (2019) revealed that the negative binomial regression model is better than a linear model when pedestrians are the study's subject.

In this study, mobile phone location data, which are count data, are employed as an indicator of the spatial distribution of the number of pedestrians, and the factors influencing the spatial distribution of pedestrian counts are the street attribute factor, facility quantity factor, traffic accessibility factor, and the integration value obtained from the segment angular analysis in SS theory as the urban area form factor. Model

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

equations are selected by employing a linear model and a negative binomial regression model. The two models will then be compared to investigate the factors contributing to the spatial distribution of the number of pedestrians in the Sakae Station area of Nagoya City and to examine the applicability of the negative binomial regression model.

2.1 Study Area

Nagoya City, with a population of approximately 2.3 million, has two major commercial and business clusters: the Nagoya Station and Sakae Station area. The Sakae Station area as a study target is a 150 ha area, including Nishiki, Izumi, Sakae 3-Chome, and Sakae 4-Chome, based on the "Sakae Area Urban Development Project" of Nagoya City (Fig. 1).

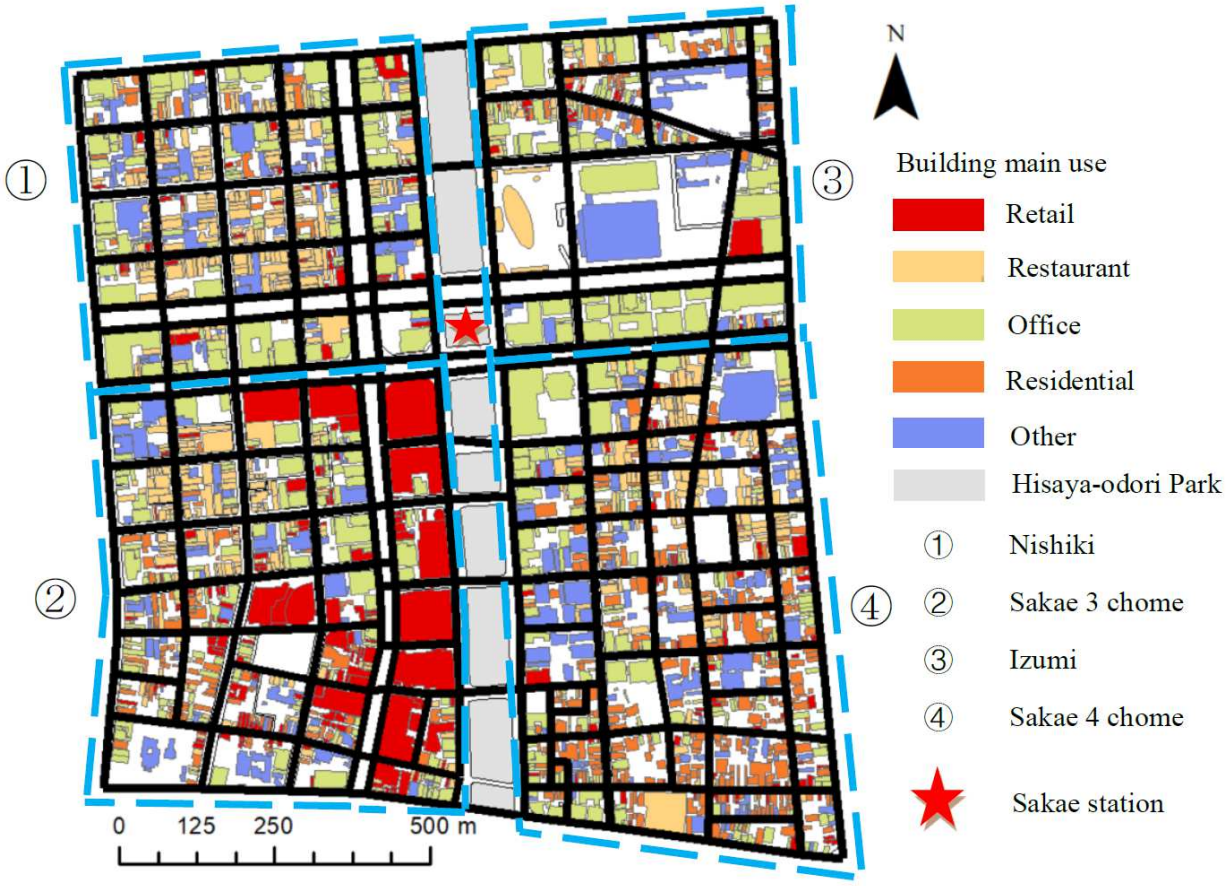


Fig. 1: Distribution of streets and building uses in the Sakae Station area

2.2 Mobile Phone Location Data

In this study, the number of pedestrians was generated from the KDDI Location Analyzer's primary movement line data (KLA). KDDI, a Japanese mobile phone service company, uses GPS location data obtained from its smartphone users to make expanded estimates using the official population statistics. The period from April 1, 2020, to March 31, 2021, was set as the collection period, the data covered the time of day for the aggregation unit from 5:00 to 29:00, the age of users was 20 years or older, and walking was the means of movement.

In the study area, the number of street links with pedestrian number data is 332 because there are some street links where the number of pedestrians cannot be obtained. The average daily value for each weekday is visualised on a map using GIS for the collected data. Looking at the spatial distribution of the number of pedestrians on weekdays and holidays (Fig. 2), the maximum numbers of pedestrians in the street link of Sakae Station on weekdays and holidays are 7090 and 8881, respectively. Furthermore, it can be confirmed that the number of pedestrians in the Nishiki area has decreased on holidays compared to that on a weekday.

The histogram of the number of pedestrians and summary statistics on weekdays and holidays (Fig. 3) indicates that the maximum number of pedestrians is higher on holidays than on weekdays, whereas the

minimum number of pedestrians is higher on weekdays than on holidays. The dispersion is larger on holidays than on weekdays, and it can be discovered that the pedestrians' distribution is more concentrated on holidays than on weekdays.

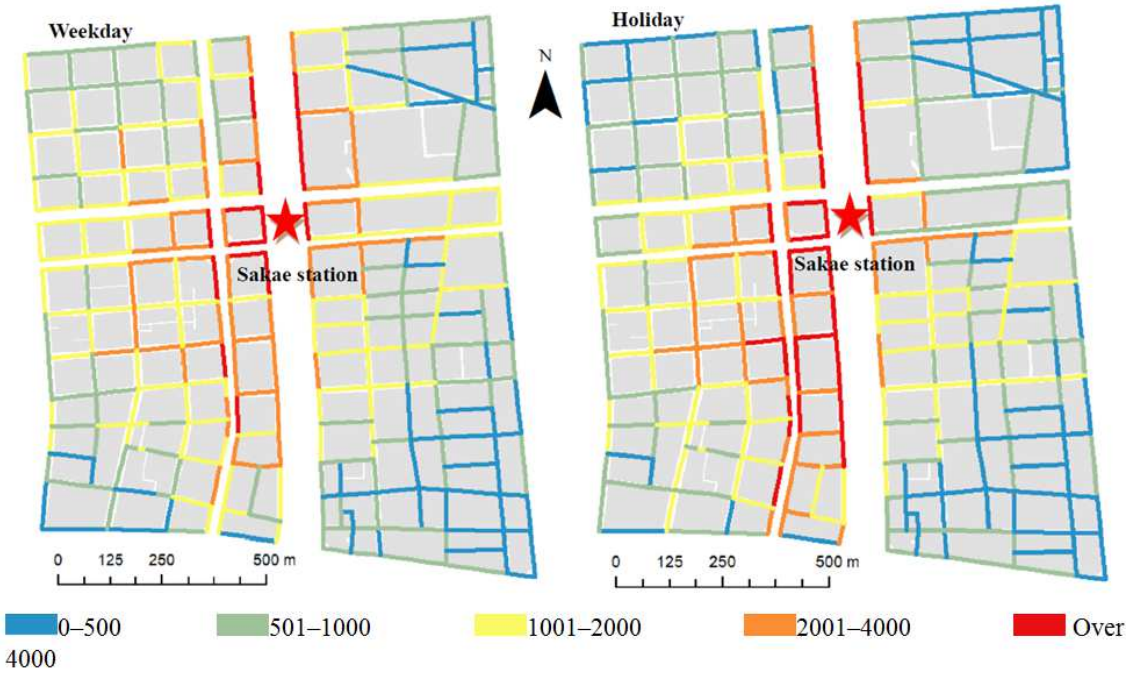
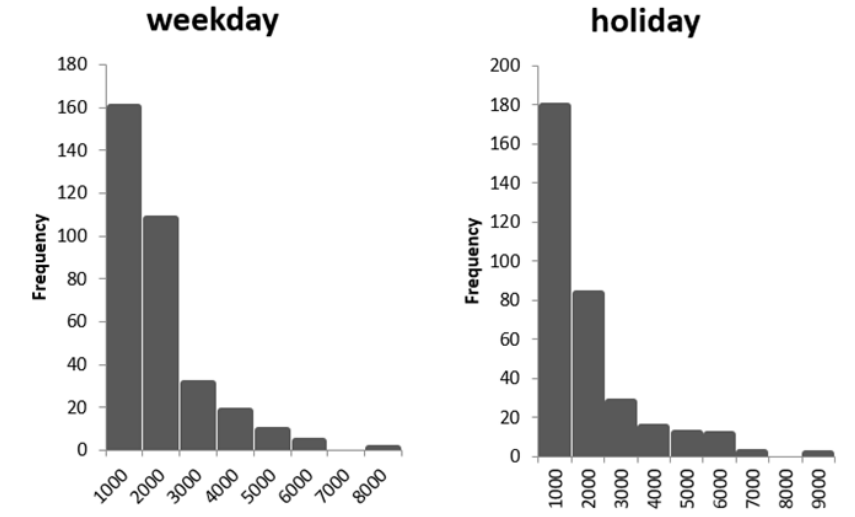


Fig. 2: Spatial distribution of pedestrians (persons/day)



Mean	1362
Sum	452296
variance	1225728
minimun	138
maximun	7090

Mean	1431
Sum	475168
variance	1959837
minimun	117
maximun	8881

Fig. 3: Histogram of the number of pedestrians and summary statistics (persons/day)

3 CANDIDATE EXPLANATORY VARIABLES

In this study, the number of pedestrians was employed as the objective variable, and 13 variables were created as candidate explanatory variables (Table 1). We classified them into four groups of factors: street attribute factor (three variables), facility volume (land use) factor (six variables), space configuration factor (two variables), and transportation accessibility factor (two variables).

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

When computing the floor-area ratio by land use, when a street has a median strip, the floor-area ratio of one adjacent side block of the street is used as usual, and when there is no median strip, the average of the floor-area ratio of both adjacent side blocks of the street is used.

In this study, (D2) distance to Sakae (m) is logarithmically transformed for analysis using the linear regression model and negative binomial regression model.

		sign	Variable name	Overview	Data source
Objective variable		Y1	Number of pedestrians (weekday)	Average daily street pedestrian counts from April 2021 to March 2022	KDDI location analyzer's primary movement line data
		Y4	Number of pedestrians (holiday)		
Candidate factor variables	Street attribute (A)	A1	Sidewalk dummy	Has no sidewalk: 0, Has sidewalk: 1	Nagoya City road certification map
		A2	Street width (m)	Total width of the road	
		A3	Subway entrance dummy	Has no subway entrance: 0, Has subway entrance: 1	Google maps
	Facility volume factors (B)	B1	Floor-area ratio of retail	All-floor area of retail/block area	Nagoya City planning basic survey data
		B2	Floor-area ratio of restaurant	All-floor area of restaurant/block area	
		B3	Floor-area ratio of offices	All-floor area of offices/block area	
		B4	Floor-area ratio of residential	All-floor area of residential/block area	
		B5	Floor-area ratio of first-floor ratio	First-floor area of retail/block area	
		B6	Floor-area ratio of the first-floor restaurant	First-floor area of restaurant/block area	
	Space configuration factors (C)	C1	Integrated value (R = 400 m)	Integrated value by segment angular analysis with a radius of 400 m	Calculation by DepthmapX
		C2	Integrated value (R＝1200 m)	Integrated value by segment angular analysis with a radius of 1200 m	
	Transportation accessibility factors (D)	D1	Distance to the nearest station	Shortest route distance to the nearest station	Calculation by the shortest path of QGIS
		D2	Distance from Sakae Station (m)	Shortest route distance to Sakae Station	

Table 1: Objective variables and candidate factor variables employed in the analysis

3.1 Floor-Area Ratio

We employed data from the Nagoya City Basic Urban Planning Assessment 2016, a survey of current conditions by building use data, to compute the floor-area ratio of the candidate factor variables employed in this research. We extracted data for four categories, namely, retail, restaurant, office, and residential, and computed the floor-area ratio for each use in each block in the Sakae Station area after calculating the floor area for each use.

Fig. 4 reveals that the maximum floor-area ratio for retail is 800% blocks with more than 50% floor-area ratio are concentrated in the Sakae 3-Chome area. The maximum floor-area ratio for the restaurant is 1193%, and blocks with more than 50% floor-area ratio are concentrated in the Nishiki area and northern part of the Sakae 3-Chome and 4-Chome areas. The maximum floor-area ratio for office is 790%, and several blocks have more than 100% floor-area ratio, blocks with high floor-area ratio for office are concentrated near trunk roads. The maximum floor-area ratio for residential is 427%, and blocks with more than 50% floor-area ratio are concentrated in the Sakae 4-Chome area.

Fig. 4: Floor-area ratio by use

3.2 Space Configuration Index Using Segment Angular Analysis

This study employed the integration value obtained from the segment angular analysis of the SS theory as the space configuration index. The SS theory is a spatial analysis approach that focuses on the topological and geometric relationships of space and uses information on the physical shape of space to quantitatively assess spatial connections and their relationship to human perception and behaviour (Hillier et.al. 1993; Hillier 1996).

We established a segment map of the Sakae Station area using base map information from the Geospatial Information Authority of Japan. A buffer zone of over 1200 m was placed around the periphery of the research area when plotting the segment map by considering edge effects. As for the space configuration index, we used the integration value from the UCL depth map's segment angular analysis.

When conducting the segment angular analysis, specifying the analysis area to meet the purpose is possible, and this area is called the radius. In this study, two types of radius were examined: 400 m (neighbourhood) and 1200 m (wide area).

The analysis findings' spatial distribution (Fig. 5) depicts that the integration value of the intersection is high at a radius of 400 m, but this can be ascribed to the short radial streets around the intersection.

At radius = 1200 m, the integration value of streets in the Sakae Station area is substantial, which is because the streets in the Sakae Station area are grid-plan.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

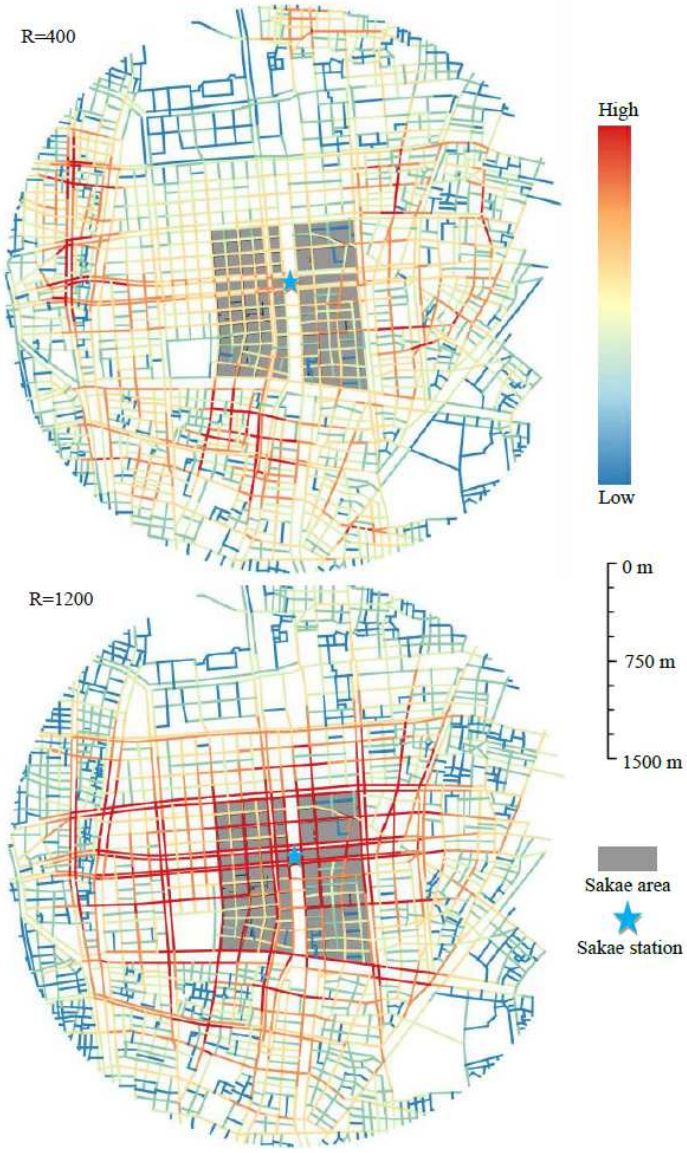


Fig. 5: Integration value by segment angular analysis

4 ANALYSIS OF FACTORS

4.1 Statistical Model

4.1.1 Linear model

The calculation formula for the linear model is the following:

$$Y_1 = \beta_0 + \sum_{j \in A} \beta_j X_{tj} + \sum_{j \in B} \beta_j X_{tj} + \sum_{j \in C} \beta_j X_{tj} + \sum_{j \in D} \beta_j lnX_{tj}$$

In the linear model, the least-squares method, which reduces the sum of squares of the residuals, is used for the solution.

4.1.2 The negative binomial regression model

In this study, the pedestrian data employed were count data. Because count data do not take negative values, they lack normal distribution and do not frequently satisfy homoskedasticity. In this study, a GLM was considered in analyzing count data. As mentioned earlier, the pedestrian counts' variance is greater than the mean on both weekdays and holidays. In this case a negative binomial regression analysis in GLM should be taken.

The objective variable Y_i for streets i (number of pedestrians on the street i) is assumed to have a negative binomial distribution in a negative binomial regression analysis. The calculation formula for the negative binomial regression model is the following:

$$\Pr(Y_i = k) = \frac{\Gamma(k+\theta)}{\Gamma(\theta)\Gamma(k+1)}\left(\frac{\theta}{\mu_i+\theta}\right)^{\theta}\left(\frac{\mu_i}{\mu_i+\theta}\right)^{k}$$

The expected value μ_i is predicted using the following equation:

$$\ln(\mu_i) = \beta_0 + \sum_{I\in A}\beta_I X_{iI} + \sum_{I\in B}\beta_I X_{iI} + \sum_{I\in C}\beta_I X_{iI} + \sum_{I\in D}\beta_I \ln X_{iI}$$

where β_0 denotes a constant, β_I denotes a partial regression coefficient, and X_{ij} denotes a factor variable.

The GLM attempts to maximize the log-likelihood using the maximum likelihood approach.

4.2 Mean Standardized Partial Differential Value

To compare the strength of each factor in the linear model, standard partial regression coefficients are frequently employed. The standard partial regression coefficient is computed using (marginal increase in the z-score of y)/(marginal increase in the z-score of x_i) and is understood as the slope between standardized variables, i.e., the partial differential coefficient. Therefore, the standard partial regression coefficient is employed in the case of the linear model, but in the case of the nonlinear model, the partial derivative of y depends on each x_i, so the case where each x_i is an average value may be illustrated. In this study, the mean standardized partial differential value is used as an indicator to compare the model equations' factor intensities (Kaneda et al. 2022).

Given a linear model $\ln y = \beta_0 + \beta_1 x_1 + \beta_2 \ln x_2$, where y and x_2 are logarithmically transformed, because $y = e^{\beta_0} \cdot e^{\beta_1 x_1} \cdot {x_2}^{\beta_2}$, the partial derivative of y for x_1 is

$$\frac{\partial y}{\partial x_1} = e^{\beta_0} \cdot \left(e^{\beta_1 x_1}\right)' \cdot {x_2}^{\beta_2}$$

$$= \beta_1 \cdot e^{\beta_0} \cdot e^{\beta_1 x_1} \cdot {x_2}^{\beta_2}.$$

Here, the partial differential equation $\left(\frac{SD_{x_1}}{SD_y}\right)\frac{\partial y}{\partial x_1}$ modified using the standard deviation of x_1 and y is called the standardized partial differential equation. Because the value depends on each x_i, the value when the average value is substituted for each is called the x-mean standardized partial differentiation coefficient MSPDV for x_1.

$$\left(\frac{SD_{x_1}}{SD_y}\right)\frac{\partial y}{\partial x_1}\Big|_{x=\overline{x_i}\ for\ all\ i} = \left(\frac{SD_{x_1}}{SD_y}\right) \cdot \beta_1 \cdot e^{\beta_0} \cdot e^{\beta_1 \overline{x_1}} \cdot {\overline{x_2}}^{\beta_2}$$

Note that the MSPDV for x_2 is

$$\left(\frac{SD_{x_2}}{SD_y}\right)\frac{\partial y}{\partial x_2}\Big|_{x=\overline{x_i}\ for\ all\ i} = \left(\frac{SD_{x_2}}{SD_y}\right) \cdot \beta_2 \cdot e^{\beta_0} \cdot e^{\beta_1 \overline{x_1}} \cdot {\overline{x_2}}^{\beta_2 - 1}$$

4.3 Analysis of Results

The correlations between candidate factor variables had an absolute value of 0.7 or above for (B2) floor-area ratio of restaurant and (B6) floor-area ratio of first-floor restaurant (0.714), (C1) integration value (R = 400 m), and (C2) integration value (R = 1200 m) (0.743).

The variance inflation factor (VIF) between each candidate factor variable is computed to investigate multicollinearity. Because combinations of candidate factor variables with a VIF greater than 2 are suspected of multicollinearity, only one of the candidate factor variables is included in the factor analysis.

In the case of (B2) floor-area ratio of restaurant and (B6) floor-area ratio of first-floor restaurant (VIF: 2.037), we used (B6) floor-area ratio of first-floor restaurant and excluded (B2) floor-area ratio of the restaurant because the pedestrians in this study are more likely to be influenced by floor-area ratio of first-floor restaurant than floor-area ratio of the restaurant. Additionally, as for (C1) integration value (R = 400 m) and (C2) integration value (R = 1200 m) (VIF: 2.236), we used (C2) integration value (R = 1200 m) and excluded (C1) integration value (R = 400 m) because the correlation coefficient between (C2) integration

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

value (R = 1200 m) (weekday: 0.525, holiday: 0.414) and pedestrians is greater than (C1) integration value (R = 400 m) (weekday: 0.377, holiday: 0.342).

For each number of pedestrians on weekdays and holidays, linear and negative binomial regression models were analyzed using the candidate factor variables after exclusion. In model selection, the stepwise variable increase and decrease approach was employed to select the model with the minimum AIC.

N = 332	Weekday			Holiday		
	Partial regression coefficient	Standard partial regression coefficient	P value	Partial regression coefficient	Standard partial regression coefficient	P value
Constant	7639.580			7135.664		
(A2) Street width (m)	−10.024	−0.118	0.013	−9.408	0.088	0.096
(A3) Subway entrance dummy	819.531	0.222	0.000	1076.495	0.230	0.000
(B1) Floor-area ratio of retail	1.616	0.247	0.000	3.130	0.379	0.000
(B3) Floor-area ratio of office				−0.927	−0.107	0.011
(C2) Integration value (R = 1200 m)	3.004	0.260	0.000	3.012	0.206	0.000
ln (D2) Distance from Sakae (m)	−1085.455	−0.494	0.000	−997.745	−0.359	0.000
AIC	5257.546			5493.301		
R	0.808			0.743		
MAPE	41.261			64.95		

Table 2: Result of the analysis of factors for the number of pedestrians on weekdays and holidays using a linear model.

N = 332	Weekday			Holiday		
	Partial regression coefficient	Mean standardized partial differential value	P value	Partial regression coefficient	Mean standardized partial differential value	P value
Constant	9.840			8.75		
(A1) Sidewalk dummy	0.199	0.063	0.078	0.333	0.059	0.030
(A2) Street width (m)	−0.012	−0.136	0.000	−0.016	−0.123	0.000
(A3) Subway entrance dummy	0.178	0.048	0.049	0.363	0.088	0.003
(B1) Floor-area ratio of retail	0.001	0.216	0.000	0.002	0.277	0.000
(B3) Floor-area ratio of office	0.000	0.063	0.013			
(B4) Floor-area ratio of residential	−0.001	−0.058	0.028	−0.002	−0.088	0.005
(B6) Floor-area ratio of first-floor restaurant	0.005	0.071	0.005	0.005	0.061	0.033
(C2) Integration value (R = 1200 m)	0.003	0.277	0.000	0.004	0.284	0.000
ln (D2) Distance from Sakae (m)	−0.593	−0.218	0.000	−0.434	−0.144	0.000
AIC	5001.229			5182.148		
R	0.785			0.656		
MAPE	40.915			63.310		

Table 3: Result of the analysis of factors for the number of pedestrians on weekdays and holidays using negative binomial regression.

Therefore, in linear model analysis, a five-variable model for weekdays and a six-variable model for holidays were chosen (Table 2). The variables adopted in the weekday model were on the order of increasing absolute value of the standard partial regression coefficient: ln (D2) distance from Sakae (m) (standard partial regression coefficient: −0.494), (C2) integration value (R = 1200 m) (0.260), (B1) floor-area ratio of retail (0.247), (A3) subway entrance dummy (0.222), and (A2) street width (m) (−0.118).

In the holiday model, the following parameters were used on the order of increasing absolute value of the standard partial regression coefficient: (B1) floor-area ratio of retail (0.379), ln (D2) distance from Sakae (m) (−0.359), (A3) subway entrance dummy (0.230), (C2) integration value (R = 1200 m) (0.206), (B3) floor-area ratio of office (−0.107), and (A2) street width (m) (−0.0880).

Therefore, in negative binomial regression model analysis, a nine-variable model for weekdays and an eight-variable model for holidays was selected (Table 3). The variables used in the weekday model were on the order of increasing absolute value of the mean standardized partial differential value: (C2) integration value (R = 1200 m) (partial derivative: 0.277), ln (D2) distance from Sakae (−0.218), (B1) floor-area ratio of retail (0.216), (A2) street width (m) (−0.136), and (B6) floor-area ratio of first-floor restaurant (0.071).

In the holiday model, the following parameters were used on the order of increasing absolute value of the standardised partial differential value: (C2) integration value (R = 1200 m) (0.284), (B1) floor-area ratio of retail (0.277), ln (D2) distance from Sakae (−0.144), (A2) street width (m) (−0.123), and (B4) floor-area ratio of residential (−0.088).

Both in the linear and negative binomial regression models, (C2) integration value (R = 1200 m) was adopted at 1% importance in both weekday and holiday scenarios, proposing the integration value's effectiveness as a space configuration factor for pedestrians in this study.

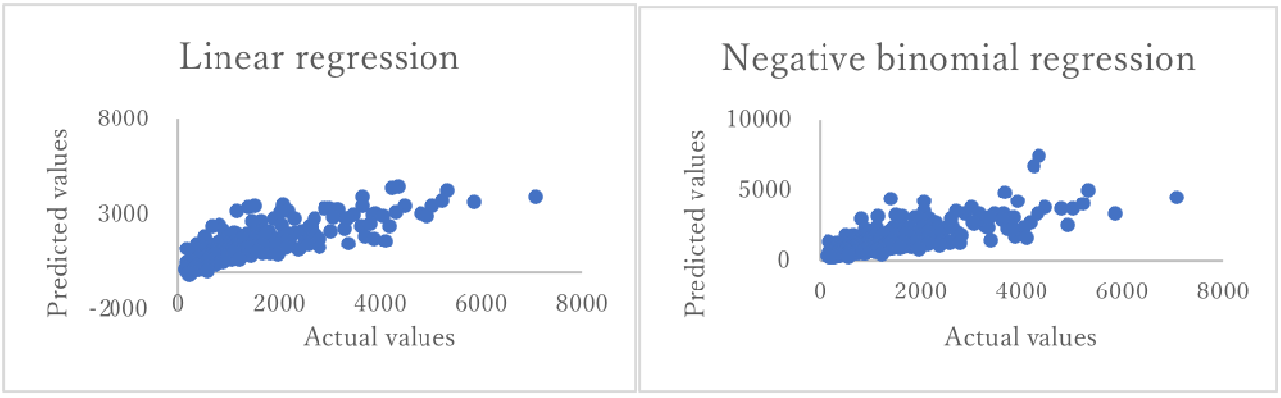


Fig. 6: Scatterplot of the predicted and actual values of the weekday model (R = 0.808, R = 0,785).

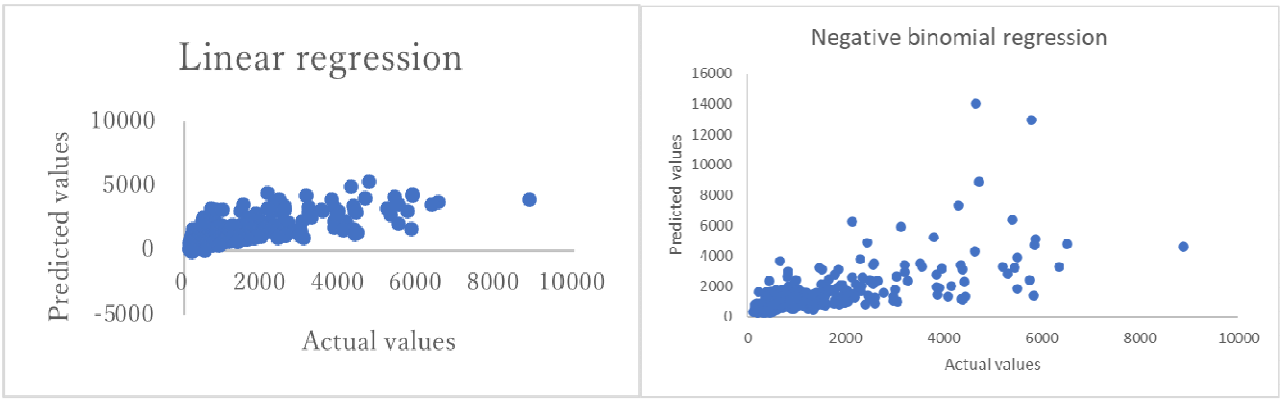


Fig. 7: Scatterplot of the predicted and actual values of the holiday model (R = 0.743, R = 0.656).

Because negative binomial regression cannot compute R^2, we used two indicators for the comparison of the two models: the mean absolute percent error (MAPE) and the correlation coefficient between predicted and actual values.

The calculation formula for MAPE is

$$\mathrm{MAPE} = \frac{100\%}{n} \sum_{i=1}^{n} \left| \frac{Y_i - \hat{Y}_i}{Y_i} \right|$$

By comparing the linear model's findings with those of the negative binomial regression model, we discovered that the correlation coefficient between predicted and actual values was better for the linear model (weekday: 0.808, holiday: 0.743), but the MAPE was better for the negative binomial distribution model (weekday: 40.915, holiday: 63.310). The weekday model outperformed the holiday model, regardless of whether it is a linear model or a negative binomial regression

The scatterplot of the actual and predicted values (Figs. 6 and 7) depicts that although the correlation coefficient of the linear model was better for both normal and holiday, the predicted values of the linear model had negative values. Additionally, when compared with the negative binomial regression model, the linear model had a smaller predicted value, which was due to the least-squares method of minimising the sum of squares of the residuals used to solve the linear model.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

5 CONCLUSION

This study attempted to employ the mobile phone location data in the Sakae Station area as an indicator of the number of pedestrians and to investigate the factors influencing the spatial distribution of the number of pedestrians from four aspects: street attribute factors, facility volume factors, transportation accessibility factors, and space configuration factors. In the analysis, the factor structures of the number of pedestrians on weekdays and holidays were compared using linear and negative binomial regression models, and the following conclusions were obtained:

In the comparison of the AIC minimum model between the linear model and negative binomial regression model in the Sakae Station area, By comparing the distribution of the predicted values and the MAPE, we can see that the negative binomial distribution model is superior. The integration value (R = 1200) generated by segment angular analysis as a city form indicator proposes its validity as a factor for pedestrian counts in both models.

Unlike linear models, to compare factor strengths for each variable, negative binomial regression models cannot use standard partial regression coefficients. In this study, we described with an example that the mean standardised partial difference value using the mean of the standardised partial difference (mean standard partial difference) can be used to compare the strength of each factor variable in a negative binomial regression model.

The mean standardised partial differential value for the factor intensities adopted in the negative binomial regression model indicated that on weekdays, the first factor was the space configuration factor, the second factor was the transportation accessibility factor, and the third factor was the facility volume factor. On weekends and holidays, the first factor was the space configuration factor, the second factor was the facility volume factor, and the third factor was the transportation accessibility factor. However, the findings of the linear model depicted that the ranking of factor intensities was distinct from that of the negative binomial regression model: on weekdays, the first factor was the transportation accessibility factor, the second factor was the space configuration factor, and the third factor was the facility volume factor. On weekends and holidays, the first factor was the facility volume factor, the second factor was the transportation accessibility factor, and the third factor was the street attribute factor.

6 ACKNOWLEDGEMENT

This research is sponsored by Japan Society for the Promotion of Science, KAKENHI Grant Number: 18H03825.

7 REFERENCES

Al-Sayed, Kinda: Space syntax methodology., pp. 75-76. London, UK, 2014.

Desyllas, Jake, et.al.: Pedestrian demand modelling of large cities: an applied example from London, UCL Centre for advanced spatial analysis working papers, 62, 2003.

Hillier, Bill, et.al.: Natural movement: or, configuration and attraction in urban pedestrian movement. In: Environment and Planning B: Planning and Design, Vol. 20, Issue 1, pp. 29-66, 1993.

Hillier, Bill: Cities as movement economies. In: Urban Design International, Vol. 1, Issue 1, pp. 41-60, 1996.

Kaneda, Toshiyuki, et.al.: A study on factor analyses of pedestrians' spatial distribution in Kanayama District, Nagoya. In: Journal of Architecture and Planning, Vol.85, Issue 767, pp. 121-129, 2020.

Kaneda, Toshiyuki, et.al.: Analyses of factors for pedestrian numbers in downtown Nagoya applying space configuration indicators, 13th International Space Syntax Symposium. Bergen, Norway, 2022.

Özbil, Ayşe, et.al.: Modeling walkability: the effects of street design, street-network configuration and land-use on pedestrian movement. In: A|Z ITU Journal of Faculty of Architecture, Vol. 12, Issue 3, pp. 189-207.2015.

Shimizu, Koki, et.al.: Estimation of pedestrian density and speed on street network using smartphone spatio-temporal data. In: 12th International Space Syntax Symposium, Vol. 18, pp.64-71, 2019.

Stavroulaki, Gianna, et.al.: Statistical modelling and analysis of big data on pedestrian movement, 12th International Space Syntax Symposium. Beijing, China, 2019.

Zhang, Yufan, et al.: A transition analyses of Land use from 2006 to 2016 in central Nagoya, Summaries of Technical Papers of Annual Meeting, Architectural Institute of Japan, Vol. 2021, pp. 427-428, 2021.

🏆 *reviewed paper*

Assessing Urban Water Security in the City of Lubumbashi, Democratic Republic of Congo: a Quantitative Analysis

Kalamba Blaise, Trynos Gumbo

(Kalamba Blaise, Department of Urban and Regional Planning, Faculty of Engineering and the Built Environment, University of Johannesburg, blaisekalamba86@gmail.com)
(Trynos Gumbo, Associate Professor and Head, Department of Urban and Regional Planning, Faculty of Engineering and the Built Environment, University of Johannesburg, tgumbo@uj.ac.za)

1 ABSTRACT

Access to urban clean and potable water has been one of the major priorities, as cities pursue and seek to achieve sustainable development goals worldwide. Globally, urban water insecurity is a threat faced by the majority, however, residents of cities in the developing world; particularly low income households are the most affected and are in severe despair. Notwithstanding the abundance of surface and underground fresh water and also efforts by local governments to improve urban water provision, urban clean water accessibility remains a pipe dream for the majority of urban dwellers in the Democratic Republic of Congo (DRC). Currently, very little is documented and known about the levels of water service delivery and coverage in DRC cities. Consequently, this paper assesses water security, specifically focusing on the state of water supply and water management. A case study research design was adopted to investigate the level of water supply in Lubumbashi the second largest city in the DRC. The work also applied a quantitative research approach and questionnaires were administered to gather data on water availability, water accessibility and other variables. A Survey Monkey was applied to gather data from four hundred and eleven participants and the data was analysed using categorical aggregation and content analysis. Findings reveal that inadequate access to clean and potable water is mainly caused by shortages of the hydraulic networks within the population of the city and the inefficient water distribution by the local government. From the study it is also evident that low income households face severe water stress since they totally rely on the municipality water provision and cannot afford to have boreholes. Furthermore, it is clear that households with no pipes in their yards have to walk to their neighbouring houses to have access to clean water. The study also highlights that the city of Lubumbashi is under severe urban water distress and is far from achieving sustainable development goals related to access to clean water for all. In conclusion, it is recommended that an adequate inclusive planning and a methodological approach at the municipality level must be adopted and implemented as a matter of urgency in order to achieve efficient and adequate water provisions to its residents. There is also need to promote awareness in order to improve water security as efforts are made to provide viable suggestions which in turn improve water provision in the city and promote and achieve sustainable urban development in the DRC in the city of Lubumbashi. . The study identified and assessed the undesirable access conditions to clean water by the households.

Keywords: Water Security, Urban Water, Sustainable Development, Lubumbashi, Democratic Republic of Congo.

2 INTRODUCTION

Urban water provision and management has been a very immense and difficult task for governments, particularly local authorities in urban centres of developing countries with limited resources; since accessing safe drinking-water is not only indispensable for people's health but also a basic human right, every local government has to play a key role in the supply and management of drinking (World Health Organization, 2017). Water scarcity the world is experiencing is a serious threat that hinders the human-health development and socio-economic progress (world economic forum, 2019). Even though the matter about the quality, quantity and accessibility of water is now general as it has been argued that about 4 billion of the world population suffer from water shortage (Mekonnen & Hoekstra, 2016); (Kummu, et al., 2016), these issues are to become even tragic because of the rapid increase of urban population, climate change and the ageing and deterioration of the water equipment (Kummu, et al., 2016); (Gosling & Arnell, 2016); (High Level Panel on Water, 2018). Rapid urbanisation worldwide has significant impact on the service delivery as well as on water resources. In this paper the main objective was to examine and assess water security in the city of Lubumbashi, in order to find out whether the city is doing well in terms of water security that demonstrates an implication toward sustainable urban development. To come to this, we have selected a number of factors to assess water security such as water availability, running water frequency, water quality,

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

water accessibility. The study is structured in the following way: Firstly, a summarised background about the subject is presented and we introduce the city of Lubumbashi which is the area of study especially with concern on its availability of water within and its surrounding area at the provincial and national level. Secondly, we give a brief a literature review on water insecurity. Thirdly, we present the method used to collect the data in Lubumbashi and the system we use to analyse the data. Fourth, the results of the survey of the 411 households collected in the study area on water accessibility, water quality, water frequency, water mode of collection are presented. Finally, we discuss the result obtained in the context of water consumption, water accessibility, and water quality and propose some recommendations.

3 CONCEPTUAL SYNOPSIS

Urban water insecurity may be defined as the incapacity to acquire but also to benefit from safe, clean, and sufficient water for a better life and good-health (Jepson, et al., 2017).

The surging concept of water security amplifies the significance of the urban water management narration (Baker, 2012). Water security may be defined as the easy access to good quality and acceptable quantity of drinkable water in order to increase and promote good health, healthy ecosystem and production (Grey & Sadoff, 2007). Water security as part of the Sustainable Development Goals, falls under three major aspects: social, economic and environmental (Giddings, et al., 2002). Each and every aspect of water security is needed to be assessed in order to achieve sustainability and security. For ages water security used to be one of the major rural area threats. However research has shown that it is also a serious issue for urban dwellers as the quality and availability of adequate water is threatened (Maiti & Agrawal, 2005); (Mohan, et al., 2011); (Cook & Bakker, 2012); (Mukherjee, et al., 2021). Hence, our study focuses on urban water security. According to the (United Nations Environment Programme, 2022) report, in Africa, Latin-America and the continent of Asia about one-third of their rivers experience extreme pollution from pathogens; near one-seventh of all their rivers suffer from drastic organic pollution; and salinity pollution ranging from moderate to severe is found in almost one-tenth of their rivers. Yet these are places around the world where people depend directly on rivers for their living and water source. Such polluted rivers put people's health at high risk and make water security in the Global South questionable. The same report argues that worldwide, a significant cause of death and disability is linked to waterborne diseases caused by the contamination of bacteria and viruses. On the other hand, the new and emerging pollutants which are not simple to eliminate from wastewater even when using new treatment technology are aggravating the situation. Worldwide, water demand is expected to escalate as a result of draught, anthropogenic climate change effects of global warming, change in rain fall pattern and intensification of storms (Bhaswati & Rajib, 2019). Despite the fact that many people are going to be affected by the water crisis, the worse affected group will be the marginal populations especially in the Global South because they depend on municipality water provision and also due to their little resources (Habeeb, et al., 2019).

The urban global population was only 30% in the 1950s, this number has increased to 50% by 2007 (UN, 2015). According to the United Nations Department of Economic and Social Affairs, 2019 report on world urbanisation about two third or 62% of the world population will be urbanised by 2050 and developing countries will experience the fastest urbanisation (UN-Habitat, 2020); (Cohen, 2006). Mostly, the rapid urbanisation rate does not correspond to the government's capacity to respond to issues related to inadequate water and sanitation (Narain, et al., 2013); (Varis, et al., 2007). On the other hand, climate change is increasing the already existing pressure on urban water supply, due to the way the rising sea level leads to flooding threat (Hallegatte, et al., 2013); (van Leeuwen, et al., 2012), but also by amplifying and prolonging the draught occurrence (Isler, et al., 2010). Finally one of the major contributions to the water calamity is the unequal distribution of resources and the inadequate water legislation (UNDP, 2006); (UNESCO; World Water Assessment Programme, 2006); (Porcher & Saussier, 2019). This has been predominant in most of the developing countries and the DRC is not spared.

4 RESEARCH METHODOLOGY

4.1 Case Study Research Design

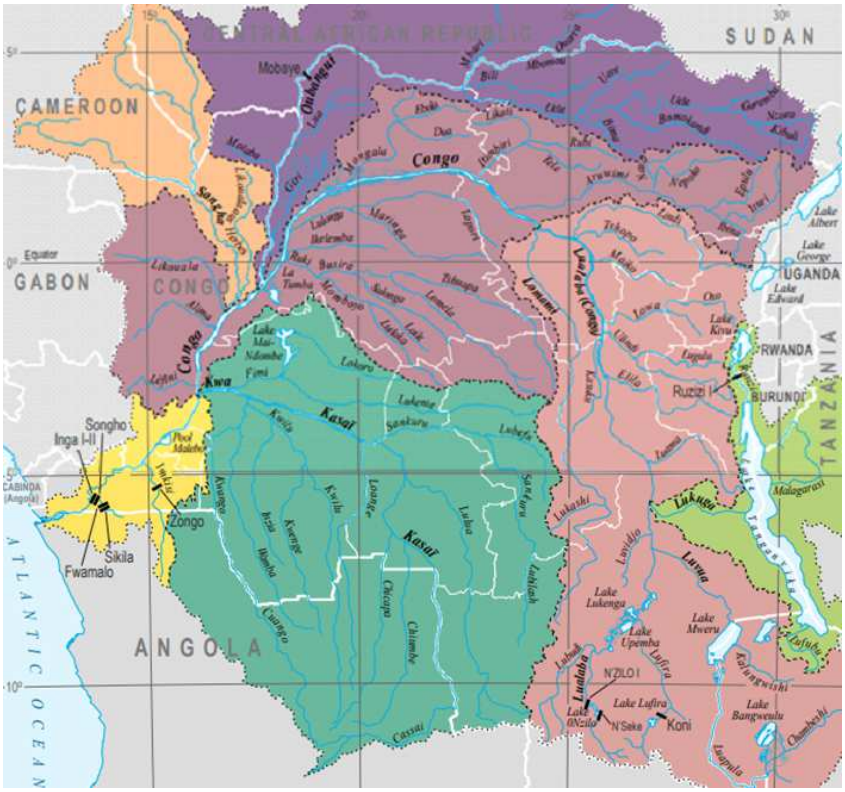
Our methodology is built on two main research strategies. On the one hand, there is the inductive-empirical method based on direct observations, and, on the other hand, there is the hypothetic-deductive method

guiding our survey and inquiry process, from preliminary questionings. As indicated above, our methodology is built around documentary research (consulting works and documents), internet research, quantitative and qualitative surveys; results of the surveys and gathered data processing.

4.2 Area of study

Lubumbashi is the capital of the rich province of High-Katanga, the second largest city in the Democratic Republic of the Congo with 1.7 million inhabitants; Lubumbashi is situated along the mining region of the copper belt. The mining industries have long been the backbones of the local economy.

In fact, the Democratic Republic of Congo is a large country which covers 40% over the 70% of fresh water of the continent of Africa and its 50% of forest in Africa contribute to a significant hydrologic cycle regulation. However, less than 50 % of the Congolese population have access to clean water. This is a paradox for a Congolese citizen who settles in a country with 11 lakes; rivers and sea but suffer from absence of clean water (Martial, 2015).



Map 1: Congo drainage Basin (UNEP, 2011)

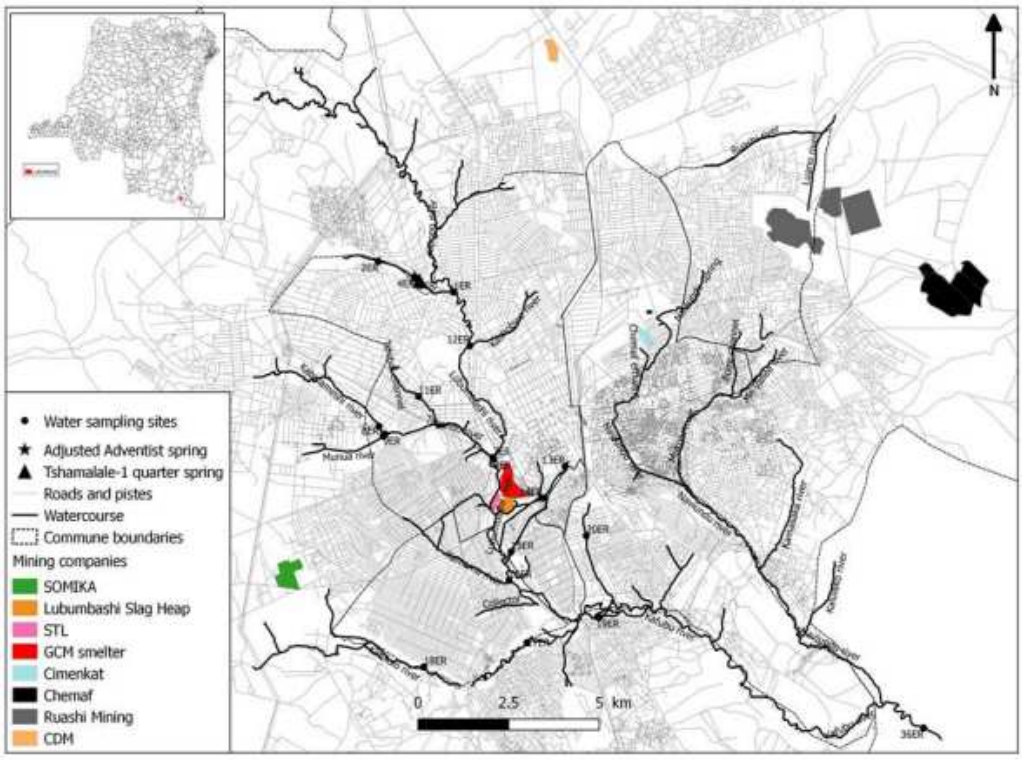
The DRC in general, and the city of Lubumbashi in particular possess an adequate and sufficient hydrographic network that is very dense and well distributed over its territories. The 11 lakes cover about 86080 square Kilometre or 3, 5% of the country's total area. When it comes to its streams, the DRC possesses the longest, powerful Congo River from which its name ''CONGO'' derives. This river is the first in Africa and the second in the world after the Amazon in Brazil in term of its basin area. The Congo River discharges about 40 000 cubic metre per second (m3/ sec.) and its basin occupies about 3 882 000-kilometre square (Martial, 2015). It is also the second in Africa after the Nile in terms of its length which is about 4700 kilometres. Besides the running from the streams, the DRC possesses an important amount of ground water that is used through boreholes. The country has an enormous water reserve; however, it presents a serious difficulty to provide clean and drinkable water to its citizens.

4.3 Field Survey

For this analysis, we have focused on the direct survey, enabling us to understand the city and the diversity in the population water consumptions better. This approach allowed us to discover aspects that were not covered by official investigations and were not found in statistics. These mainly include the spatial distribution of investigations, the relations between them, and the collective and specific water consumption, water distribution, and domestic water collection. Therefore, we resorted to direct observation, interviews

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

and surveys, in order to understand the problem of urban water security in Lubumbashi better, within a sustainable development context.



Map 2: Lubumbashi River Bassin (Muhaya, et al., 2017).

4.4 Size and choice of the sample

The size of the referred sample was basically selected according to the representativeness of indicators and accuracy, while maintaining the investigation within reasonable time limits and our possibilities. Thus, the chosen sample was providing representative indicators for all the municipalities of the city.

In fact, given the real difficulties to proceed and to divide the city into homogeneous sectors, since they do not exist, a simple random method was applied, with a large sample with great dispersion, a method which allowed us to have good household estimators.

By this method, we have chosen a 411-household sample, a number that we could not restrict nor fix since the survey questionnaire was sent to different people which shared it with their relatives. We combed through more than 50 responses per municipality. The concerned households have not been pre-selected. More than this, no preliminary selection criterion has been imagined. We have simply relied on the goodwill and availability but also the internet possession of the respondents since this was an online questionnaire via a link. This has considered the reluctance, even hostility of certain people to respond to our questions. However, we have tried to respect the quota of households to be surveyed by municipality area.

4.5 Data processing

We proceeded at the same time to conceptual as well as to quantitative treatment. The first consisted mainly of the description and location of observed facts and data gathered on the field. The description was built around keywords and previously defined concepts. We wanted this description to be precise and schematic, in order to reach a thorough and methodical explanation of the causes and the effects of phenomena revealed on the field. The latter allowed us to gather the 411-survey household. Thus, our processing concerned 411 surveys. It was carried out by means of a free version of the survey monkey software and the data were processed and analysed with Microsoft Excel.

5 RESULTS PRESENTATIONS AND DISCUSSIONS

The results of the survey are organised and presented next, with the following items: surveyed household distribution over municipalities; household residents analysis (number of people per household); type of

water source per household (tap water, well, boreholes); inside and outside tap water analysis; households serviced per outside tap; distance walked to water source, water consumption per household per day analysis; cost of water analysis, frequency of water and water quality analysis. The following are the findings and results of the 411 surveyed household's data.

Data were collected in all six municipalities of Lubumbashi. Out of the total number of 411 respondents, 21% were from the Lubumbashi Municipality, 19% from the Kamalondo Municipality, 14% from Kenya municipality, 15% from the Katuba Municipality, 13% from Rwashi municipality and 18% from Annexe Municipality. Thus, the data were selected from all around the city.

In terms of the number of people per household, it has been proved that 31% of household in Lubumbashi have 1 to 3 people, 22% have 3 to 5 people, 31% have 4 to 7 people and 13 % have more than 7 people. This data helped to identify and assess the number of litres of water used per household, hence per person per day. It is not an easy endeavour to have adequate average number of people per household since the population is very nomad in the DRC and in Lubumbashi particularly but also due to lack or absent of demographic data (African development fund, 2017).

5.1 Types of water sources

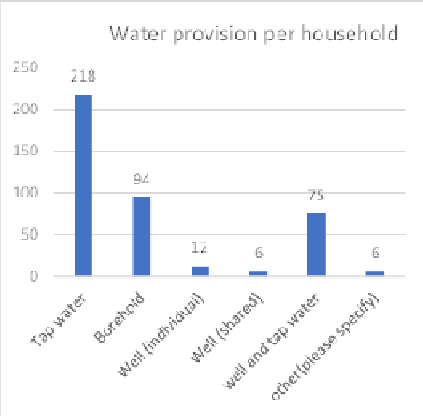


Figure 1.a. type of water source

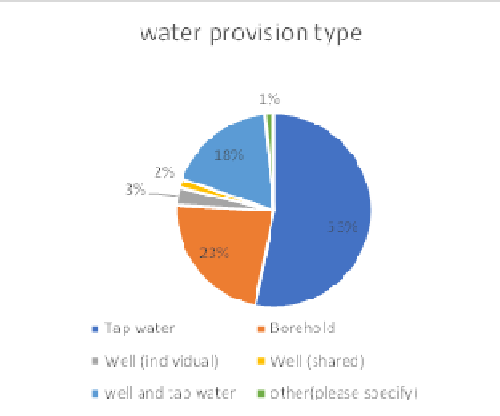


Figure 1. b. water provision type as percentage

From Figure 1.a and 1.b, people in Lubumbashi get their water from different types of sources. 53% of households get their clean water from the Municipality through the only public company that provide water to the city (REGIDESO); 23% of households get their clean water from the boreholes that they have installed in their yards and use big thanks to keep enough water. 3% of households have individual wells in their yards that they use for domestic usage but then get tap water from their neighbours for drinking. 2% have wells in their yards that they share with others, 18% of households have both tap water and a well. This proves that people don't entirely rely on the water provision service from the municipality, so they must find another way of getting water. From all the above, the city doesn't have adequate and reliable water service provision as people have to have boreholes and wells in their yards so that they do not totally depend on the municipality.

5.2 Location of water sources

Figures 2.a and 2.b represent the number of households with water from a piped supply whether from the municipality or from the internal borehole but the tap is installed outside the house. 94% of all households having tap water don't have it necessarily in their houses but just outside and only 6% of households have taps inside their homes. This is to justify that adequate sanitation is jeopardised since water is not running in the house. The households with outside taps have it not just for themselves but also to help the community to get water from them, however, at a certain cost.

It is also found that 60 % of households with outside taps provide water to 1 to 5 other households. 27 % provide water to 6 to 10 households, while 5% provide water to 10 to 15 households, 2% provide water to 15 to 20 households, 1% provide water to 20 to 25 households, and 5% provide water to more than 25 households every day. This is the proof that many households, although claiming that they have tap water, they just have access to tap water from their neighbours.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

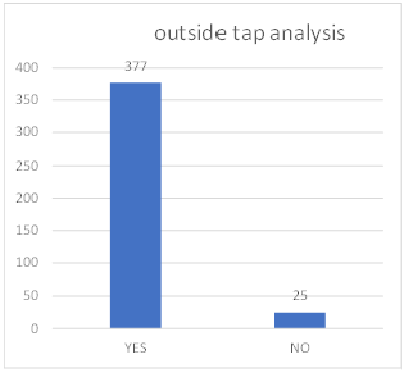


Figure 2.a. Outside-inside tap analysis

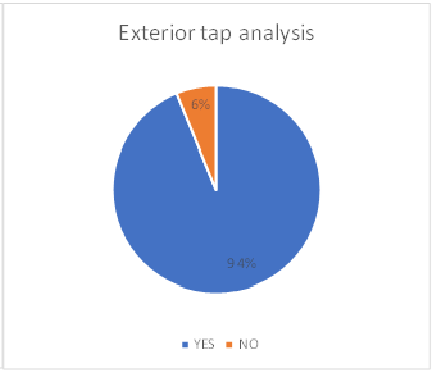


Figure 2.b. % of households with outside and inside tap

5.3 Distance of water sources

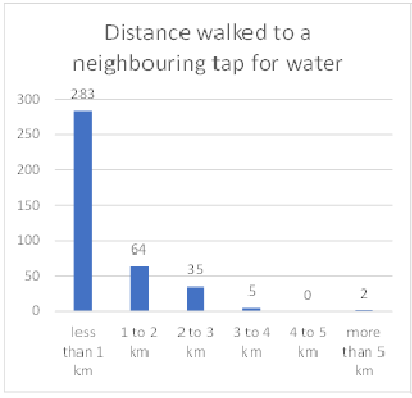


Figure 3. a. distance walked by household to a tap.

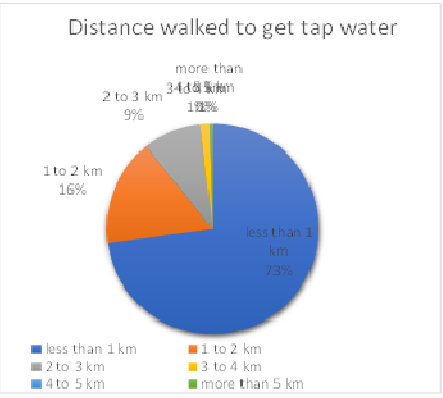


Figure 3. b. percentage of household walk to a tap.

From the above figure, it is shown that about 73% of households surveyed walk a distance less that 1km to get their water from a tap, about 17% walk from 1 to 2 km, 9% walk from 2 to 3 km, 5% walk from 3 to 5km and 0, 5% walk more than 5 km to get their tap water. It can be observed that most household residents are getting their drinking water from outside their yard; this is the proof that they don't have tap water in their yards.

5.4 Water consumption

The above figures show that 19% of the surveyed consume less than 20 liters a day, 36% consume 20 to 40 litres a day, 12% consume 40 to 60 litres, 11% consume 60 to 80 litres a day, 12 % consume 80 to 100 litre a day, 3% consume 100 to 140 litre a day, only 1% consume 140 to 180 litre a day, 4% consume 180 to 200 litre a day and 2% consume more than 200 litres a day. In 2010 the United Nations adopted a resolution to make drinking water, proper sanitation, and hygiene a human right (United Nations, 2010). In addition, the World Health Organisation suggested that adequate water consumption per capita per day should be 50 to 100 litres in order to make certain that fundamental needs will be met (World Health Organization, 2003). The WHO standard seems much higher compared to what is the current consumption in the city of Lubumbashi. By analysing the number of people per household of the respondents, although these results may possibly be carrying some errors. That can be because of the fact that many respondents could not estimate the amount of water they use since they get it outdoor, but it can also be due to the fact that they responded on only how much water they drink instead of how much they use for all their household activities. However, the reality remains true if people do not have water in their house or their plot, their daily consumption will obvious be reduced. Considering a household that the highest water consumption is 200 litres per household per day and that there are 6 people per household, that means the per capita per day usage is less that 50 litres, which is below the standard.

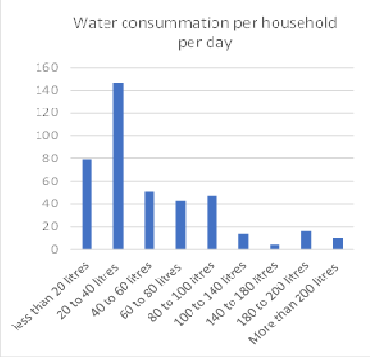


Figure 4. a. water consumption

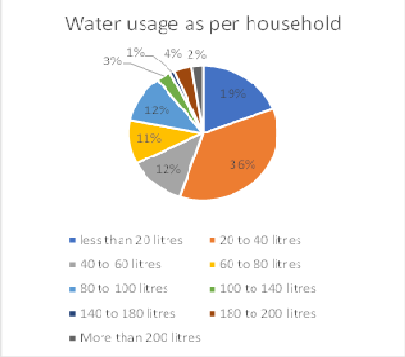


Figure 4. b. percentage of water usage per household.

5.5 Water's cost

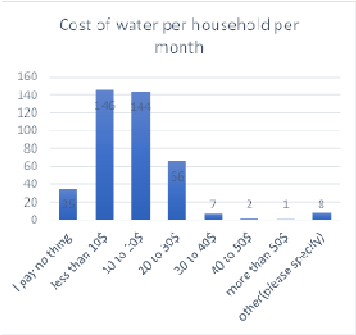


Figure 5 a. water cost per household per month

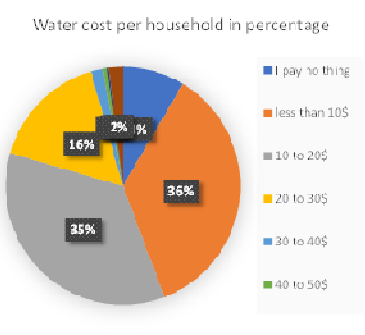


Figure 5. b. percentage of water cost per household

From these figures, it is clearly shown that 36% of the surveyed households pay less than $10 per month for their water consumption, 35% pay 10 to $20, 16% pay 20 to $30, 9% pay nothing for their water consumption and only 4% of households pay more $30. It is better to specify here that these payments are either from the consumer directly to the municipality or from the second consumer to the first consumer who is the client to the municipality; also, the 9% of the surveyed households are probably those with boreholes at their house, since they have disconnected from the municipality pipe connections. However, it can also be seen that the price of water for all the household is reasonable, the current reality may be due to the fact that households that do not have a tap inside their houses will not use so much water, since most of the factors that contribute to water consumption are disconnected from the water pipes (Domene & Sauri, 2016).

5.6 maintenance and reliability

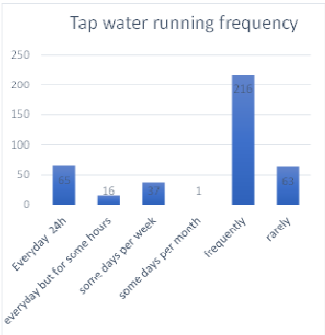


Figure 6. a. running water frequency

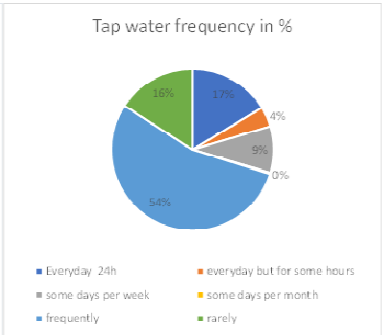


Figure 6.b. running water frequency in percentage

As it can be observed that 54% of the surveyed households in Lubumbashi have their water running frequently but that does not mean every day for 24 hours, 16% have tap running water rarely, only 17% have tap running water every day in their homes, 9% have water only some days a week, 4% have water everyday but at interrupted rate and for some hours in a day. This is a proof of poor water distribution and consumption but also the proof of water insecurity in the city. This is one of the reasons why the citizens of

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

the city of Lubumbashi do not rely on the municipality water distribution, so they find their ways of getting water from unprotected wells they make in their yards.

Further results from the assessment on the quality of water shows that: from the surveyed households, water quality in the city of Lubumbashi should be questionable since only 10% of households consider their water quality good, 36% find it satisfying, 27% use chemicals to have their water purified, it simply means the quality is not good for them, 24% boil their water to make it drinkable, also here they find their water not of good quality. and 4% clearly said the water quality is just bad. The quality of water should be good to satisfy population needs and improve health. According to the definition of water security by Subham, et al., (2022), it should be: the quantity of water that is available and enough, of good quality and always running for improved health, livelihoods, and ecosystem. In this regard, considering the frequency at which water is running in Lubumbashi and the quality of it, the concept of water security is far from being meaningful.

5.7 Issues that are threatening water security

Although some meaningful advancement in several domains of sustainable development in the world are made, meeting the SGDs that relate to water and their targets is still not certain to be successful by 2030 nor to be a reality of long-term sustainability by 2050 (UN-Water, 2021). In order to be on track toward sustainable accomplishments and to reverse the negative tendency, high-priority actions and strong global cooperation are required (UNEP, 2017). About 51 million of the DRC population or almost three quarter has no access to clean, safe, and drinkable water, although over half of the water reserves of the African continent is hold by the DRC (UNEP, 2011).

The city of Lubumbashi (capital of the High-Katanga Province and mostly characterised by mining companies), just as other cities in the country is facing serious urban water poverty even though it is crossed by many rivers. People suffer a lot in terms of urban water availability. According to Martial, (2015) this situation is due to the fact that the company that deals with water in Lubumbashi (REGIESO) is not able to provide the water needs to the population that is growing due to rural-urban migration. This phenomenon is becoming worse due to the ageing of the water pipes and other hydraulic network equipment, and this has been exacerbated by the informal residential area growth and the decay of the urban water infrastructure. Without any doubt these situations have been the cause of the urban water problems in Lubumbashi.

Water usage in the DRC and in Lubumbashi particularly is characterised by domestic consumption which represent about 52% of the total distributed water. This is different if compared to other African countries where a huge quantity of water is first attributed to agriculture usage. In the DRC due to high rainfall and poor irrigation system, the agriculture sector uses only 32% while the industries utilise about 16% (UNEP, 2011).

Before the year 1990, the REGIDESO was considered as one of the most efficient and important public institutions of the country and also one of the best in Sub-Saharan Africa (UNEP, 2012). But nowadays most of these urban water infrastructures are in a very bad condition with no maintenance, not enough funds allocated for their replacement or maintenance, and most of the equipment from the colonial era ageing (UNEP, 2012).

In January 2016, the Congolese Government promulgated a new national law on water which was mainly focused on how best to manage the water resource in the country at the river basin level. This law had truly brought some light to the country reform on the management of water as resource. However, it has not demonstrated an adequate institutional consistency on how well urban water can be improved in order to improve good health and water security for the citizens of the country (UNEP, 2016).

6 MAIN CONTRIBUTIONS – IMPLICATIONS – LESSONS LEARNT

The current study has used a quantity-based methodology of assessment to quantify urban water security in the city of Lubumbashi. The study identifies water-insecure areas in the distribution and consumption of urban water in Lubumbashi. This quantitative approach study will undoubtedly help policy makers from the local and national government to plan well and to take appropriate approaches to provide adequate water service to the citizens; but it would also help different stakeholders to set objectives and milestones to manage the local available water well, and any resources related to social life to achieve sustainable urban water security.

For any future work on water security in Lubumbashi, we would have to focus interest at an individual scale in the collection of data, but also on the difference of households in terms of their social standards and their area of residence.

From this study, we have learned that it is not easy to collect data from households especially when it is done remotely. Secondly, it is easy to have biased data if there is no proper explanation of the questions is given to the respondents. Also, the free versions of data collection and data analysis software are very limited and unable to provide adequate features that are capable to perform large and accurate analysis.

Water management and water usage have an implication on water supply, but it will also have an impact on economic and social activities necessary for people's well-being. In the city of Lubumbashi for example, the local water service provider (regideso) finds itself unable to provide enough water to all the residents of the city because of some unacceptable behaviours of some citizens who sometimes brake pipes in order to get illegal water for 24 hours. This practice affects not only the service provider but also some residents which will not receive water because a lot of water is being wasted somewhere else. Economically speaking, since we cannot separate water usage from economic activities, water scarcity in the city compromises the economic activities of the citizens at large, but the most vulnerable are the poor population. Big companies have lost confidence in the municipality water provision and hence, they have found a way of having water from the boreholds within their premises; however, the small businesses and the lowest income household whose lives depend on small commerce activities such as selling cool water find their businesses hindered due to lake of running water. Social implications are present and visible all over the city. More than 90 percent of residents don't have indoor taps; therefore, sanitation is seriously compromised. This phenomenon is the reason why people are not using their inside toilets but rather use toilets that are built outside their houses at the back of their backyard. These types of toilets don't use any water, they are called direct toilet or pit latrine with no toilet seat but with a hole directly leading to a pit that receives human faeces, which is considered unimproved sanitation. In some cases, people use a very limited quantity of water in a pit latrine with a slab, where they use a container to flush water. These outside pit latrines are all used by more than 3 households with more than 3 residents made up of males, females, and children. This practice is one of the main causes of infectious diseases, especially for females and children. The World Health Organization (2018) argued that inadequate water, sanitation, and hygiene is the cause of diarrhoea deaths which killed 842 000 people in 2012. Moreover, the same source argued that cholera which is another serious water, sanitation and hygiene related disease remains endemics in Africa. In the DRC, more precisely in the east of Katanga Province, about 84% of its population are affected by cholera and diarrhoea. Adequate water, sanitation and hygiene is crucial to prevent cholera, but its achievement remains very long term and expensive in Congo, hence the World Health Organisation (WHO) has introduced the Oral Cholera Vaccine (OCV) in Congo as a quick response to cholera. Since water source is at a certain distance for many residences, drinking water becomes a blue diamond for many households, hence water consumption per day per person is very low which can inevitably lead to many serious health issues; moreover, even the quantity and quality of water for other daily domestic activities such as laundry, dish washing, bathing is affected which can also lead to sanitation problems. To add to this, most of the people going out to look for drinking water are women and children, and this class of population becomes therefore vulnerable to many threats. For example, girls will have to wait until it is late and dark in the queue to get water, hence making them vulnerable for rape or other criminal attacks. In summary, water insecurity in the city of Lubumbashi is related to poverty, hence it is the cause of many sanitation problems and human health issues which deteriorate the well-being of many citizens and put pressure to other services such as the health care service.

7 CONCLUSIONS AND RECOMMENDATIONS

The main purpose of the current study was to conduct a quantitative-based study to assess the urban water security in the city of Lubumbashi. The following conclusion can be drawn from this study: firstly, water provision in the city of Lubumbashi is not secure and adequate, since many factors such as some people not having tap water in their houses and others having to walk far every day to collect water are very present in the city. Secondly, water frequency and water quality are a very serious issue in the city which brings us to conclude that the city of Lubumbashi is experiencing urban water insecurity and this phenomenon may exacerbate due to high urbanisation that the city is facing.

For this reason, the following are the recommendations we can provide:

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

- The city local government needs to consider all human aspects of good living and plan well for adequate provision of safe and healthy water.
- Rational policy, strong political dedication, adequate funds, and profound implication by all the stakeholders are fundamental obligations for successful delivery of drinking water to the citizens of Lubumbashi.
- There is need to improve water supply infrastructure that will help to boost the social well-being of the citizens of the city.
- Green energy from solar panels must be used to provide drinking water using solar water pump for boreholes especially in the area where water and electricity is not yet provided.
- The local government cannot safeguard water security alone, it also needs to work in partnership with the private sector to build a sustainable urban water system and provide adequate service to the citizens.
- There is a need to set up an assessment team of the urban water provision and capable to hold any stakeholder of the service accountable.
- Initiate an awaness compaign to promote water security for the local community is a must.

8 REFERENCES

African development fund, , 2017. semi-urban drinking water supply project, Tunis: OWAS.

Baker, K., 2012. Water Security: Research Challenges and Opportunities. Science, 337(6097), pp. 914-915.

Bhaswati, R. & Rajib, S., 2019. Urban Drought- Emerging Water Challenges in Asia. 3 ed. Fujisawa: Springer.

Cohen, B., 2006. Urbanization in developing countries: Current trends, future projections, and key challenges for sustainability. Technology in Society, 28(1-2), pp. 63-80.

Cook, C. & Bakker, K., 2012. Water security: Debating an emerging paradigm. Global Environmental Change, 22(1), pp. 94-102.

Domene, E. & Sauri, D., 2016. Urbanisation and water consumption: influencing foacotrs in the Metropolitan Region of Barcelona. Urban studies, 43(9), pp. 1606-1623.

Giddings, B., Hopwood, B. & O'Brien, G., 2002. Environment, economy and society: fitting them together into sustainable development. Sustainable Development, 10(6), pp. 187-196.

Gosling, S. N. & Arnell, N. W., 2016. A global assessment of the impact of climate change on water scarcity. Climatic Change, Volume 134, p. 371–385.

Grey, D. & Sadoff, C. W., 2007. Sink or Swim? Water security for growth and development. water policy, 9(6), p. 545–571..

Habeeb, R., Gupta, Y., Chinwan, H. & Barker, E., 2019. Assessing Demographic and Water Sensitivities Arising due to Urban Water Insecurity in Haldwani, Uttarakhand (India):a GIS-Based Spatial Analysis. Journal of Geovisualization and Spatial Analysis, 3(8), pp. 2-19.

Hallegatte, S., Green, C., Nicholls, J. & Morlot, J. C., 2013. Future flood losses in major coastal cities. NatureClimat Change, Volume 3, p. 802–806.

High Level Panel on Water, 2018. Making Every Drop Count: An Agenda for Water Action, NeW York: United Nations.

Isler, P. L., Merson, J. & Roser, D., 2010. Drought Proofing' Australian Cities:Implications for Climate Change Adaptation and Sustainability. International Journal of Social, Behavioral, Educational, Economic, Business and Industrial Engineering, Volume 4, p. 351–359.

Jepson, W. E. et al., 2017. Progress in household water insecurity metrics: a cross-disciplinary approach, s.l.: Wires water.

Kummu, M. et al., 2016. The world's road to water scarcity:. shortage and stress in the 20th century and pathways towards sustainability, 09 December, pp. 1-16.

Maiti, S. & Agrawal, P. K., 2005. Environmental Degradation in the Context of Growing Urbanization: A Focus on the Metropolitan Cities of India. Journal of Human Ecology, 17(4), pp. 277-287.

Martial, M. K., 2015. La preparation d'un code de l'eau: une solution a l'approvionnement en eau potable de la RDC: (Casde la ville de Lubumbashi. KAS African Law Study Library , Volume 1, pp. 109-126..

Mekonnen, M. M. & Hoekstra, A. Y., 2016. Four billion people facing severe water scarcity, New York: Science Advance.

Mohan, M. et al., 2011. Dynamics of Urbanization and Its Impact on Land-Use/Land-Cover: A Case Study of Megacity Delhi. Journal of Environmental Protection, 2(9), pp. 1274-1283.

Muhaya, B. B. et al., 2017. Trace Metal Contamination of Water in the Lubumbashi. Journal of Environmental Science and Engineering, 6(B), pp. 301-311.

Mukherjee, S., Sundberg, T. & Schütt, B., 2021. Issues, Dimensions and Approaches of Assessing Urban Water Security in Developing and Emerging Countries: An Inclusive Perspective. Environmental Management: Issues and Concerns in Developing Countries, 2(1), p. 151–184.

Narain, V. et al., 2013. Urbanization, peri-urban water (in)security and human well-being: a perspective from four South Asian cities. Water International, 38:7(DOI: 10.1080/02508060.2013.851930), pp. 930-940.

Porcher, S. & Saussier, S., 2019. Facing the Challenges of Water Governance, Geneva: Palgrave macmilan.

Subham, M., Trude, S., Pradip, K. S. & Brigitta, S., 2022. An Integrated Quantitative assessment of urban water securityof a megacity in the global south. Frontier in Water, 4(834239), pp. 1-8.

UN, 2015. World Urbanization Prospects: The 2014 Revision, New York: UN.

UNDP, 2006. Beyond Scarcity: Power, Poverty and the Global Water Crisis, New York: UNDP.

UNEP, 2011. program des Nations Unies pour l'environement sur la problematic de l'eau en RDC et opportunites, s.l.: Program des Nations Unies Pour l'environement.
UNEP, 2011. UN news, s.l.: United Nation Environment Program.
UNEP, 2012. Programme des Nations Unies pour l'environnement (PNUE) sur la problématique de l'eau en RDC et opportunités, s.l.: Programme des Nations Unies.
UNEP, 2016. River Partners: Applying Ecosystem-Based Disaster Risk Reduction (Eco-DRR) in Integrated Water Resource Management (IWRM) in the Lukaya Basin, Democratic Republic of the Congo., Nairobi: UNEP.
UNEP, 2017. UN Environment's Freshwater Strategy 2017-2021, Geneva: UNEP.
UNESCO; World Water Assessment Programme, 2006. Water: A Shared Responsibility, New York: (United Nations) Berghahn Books United Nations Educational, Scientific and Cultural Organization.
UN-Habitat, 2020. World Cities Report 2020, The Value of Sustainable Urbanization, Nairobi: UN-Habitat.
United Nations Department of Economic and Social Affairs, 2019. World Urbanization Prospects: The 2018 revision, New York: UN.
United Nations Environment Programme, 2022. Freshwater Strategic Priorities 2022–2025:to implement UNEP's Medium-Term Strategy, New York: UNEP.
United Nations, 2010. The Human Right to Water and Sanitation - the United Nations, New York: United Nations.
UN-Water, 2021. Summary Progress Update 2021 – SDG 6 – water and sanitation for all., Geneva: UN-Water.
van Leeuwen, C. J., Frijns, J., van Wezel, A. & van de Ven, F. H. M., 2012. City Blueprints: 24 Indicators to Assess the Sustainability of the Urban Water Cycle. Water Resour Manage, 26(DOI 10.1007/s11269-012-0009-1), p. 2177–2197.
Varis, O., Biswas, A. K., Tortajada, C. & Lundqvist, J., 2007. Megacities and Water Management,. International Journal of Water Resources Development, 22:2(2), pp. 377-394.
world economic forum, 2019. Global Risks reports 2019 14th edition, Geneva: World Economic Forum.
World Health Organization, 2003. Office of the High Commissioner for Human Rights (OHCHR), Centre on Housing Rights and Evictions (COHRE), Water Aid, Centre on Economic, Social and Cultural Rights. The Right to Water, Geneva: WHO.
World Health Organization, 2017. Guildlines for Drinking water Quality- Fourth edition incorporating the first addendum, Geneva: World Health Organization.
World Health Organization, 2018. WHO Water, Sanitation and Hiegiene Strategy 2018-2022, Geneva: World Hearth Organization.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

🏆 *reviewed paper*

Automated Mobility and Inclusion as Educational Topics for Children and Juveniles and as Tasks and Responsibilities of Mobility Planning: Work-Report on the Project AM4Kids

Nina Hohenecker, Bente Knoll, Christopher Schlembach, Georg Hauger, Gabriela Sammer, Beatrix Schiesser

(Nina Hohenecker, B.Sc, TU Wien, Verkehrssystemplanung, Karlsgasse 11, 1040 Vienna, Austria, nina.hohenecker@tuwien.ac.at)
(Dipl.-Ing. Dr. Bente Knoll, B-NK GmbH, Schönbrunner Straße 59-61/10, 1050 Vienna, Austria, bente.knoll@b-nk.at)
(Dr. Christopher Schlembach, Universität Wien-Institut für Soziologie, Rooseveltplatz 2, 1090 Vienna, Austria, christopher.schlembach@univie.ac.at)
(Prof. Dr. Georg Hauger, TU Wien, Verkehrssystemplanung, Karlsgasse 11, 1040 Vienna, Austria, georg.hauger@tuwien.ac.at)
(Gabriela Sammer, Mag. phil., ZIS+P Verkehrsplanung, Leonhardstraße 12, 8010 Graz, gabriela.sammer@zis-p.at)
(Dipl.-Ing. Beatrix Schiesser, B.Sc BA, B-NK GmbH, Schönbrunner Straße 59-61/10, 1050 Vienna, Austria, schiesser@b-nk.at)

1 ABSTRACT

Automated mobility (AM) involves the increased use of digital information and communication technologies in all areas of traffic and mobility, particularly in the vehicle and mobility sector, in the infrastructure, transportation and the management of mobility-related processes (pre-, on- and post-trip). To ensure that the potentials of AM, like higher efficiency and improving accessibility, meet the demands and mobility patterns of different types of people, especially vulnerable ones like kids and people with disabilities, it is essential to make children and young adults aware of this complex and diverse topic already today. Therefore, planning and development activities in the mobility sector should involve this future generation and consider their ideas and concerns.

Planning and development activities should be considered from a holistic and inclusive perspective, considering a wide variety of traffic participant groups. In this context, the Austrian project AM4Kids[1] creates a direct interface between children and young adults and mobility planning. The scientists and planners take the role of facilitators of knowledge and accompany an inter and transdisciplinary, multi-level exchange between disciplines, such as transport planning, social science, mobility research, and actors from the inclusion sector. In the project, age-appropriate and gender-sensitive workshops, input lectures, and educational materials were developed and implemented by the interdisciplinary consortium of sociologists, transportation planners, landscape architects, civil engineers, software developers, and legal experts for the needs of people with disabilities.

This paper presents the methods applied in the corresponding project phases. Furthermore, a reflection on the achieved results and experiences from the activities in project phases 1 and 2 is provided.

Keywords: role of planning, automated mobility, children, awareness, inclusion

2 INITIAL SITUATION OF THE PROJECT

Today's children and juveniles will be tomorrow's users and decision makers of automated mobility (AM). In the set-up of the project AM4Kids, this coming generation gets in touch with various layers and themes of mobility, especially in the context of AM. The project provides them with an environment in which they can reflect on their mobility patterns and behaviour and learn about mobility demands,needs and situational requirements of various traffic participant groups. The aim is to raise awareness and sensitise children and juveniles on how AM and digitalisation fosters the development of a more and more inclusive traffic system which takes the demands and needs of people with disabilities into account. Furthermore, they shall learn about non-intended and non-anticipated consequences of AM, that is, barriers and gaps in the system for those groups which participation requirements are not appropriately met.

For this purpose, children and juveniles will discover the impact of AM from different perspectives (spatial planning, transport planning, automotive engineering, landscape design, civil engineering, software engineering). The chosen approach enhances cognitive abilities and creative thinking, both being highly relevant in the context of the ongoing digitalisation and automatisation.

[1] Project consortium: B-NK GmbH (lead) and partners TU Wien, Verkehrssystemplanung; Universität Wien, Institut für Soziologie and ZIS+P Verkehrsplanung.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

2.1 Automated mobility: disruptive development with a high potential for a more inclusive mobility system

Some transporation modes like trains or ships are already highly automatised. However, its application to street-based transportation modes like cars is much more complex due to a broad spectrum of different situations, actors and the interaction with other vehicles. The project AM4Kids focuses on the current development of automated vehicles in road traffic. Further studies and projects have dealt with the topic of AM, but mainly in the context of technology development and the necessary road infrastructure. Some studies, such as Heß and Polst (2017), discuss the social impacts of AM by combining different personas' everyday life and mobility patterns with new technological developments such as AM. Research often adresses elderly or disabled people to be significant user groups (Krail 2019; Lenz and Fraedrich 2015).

Designing inclusive AM for different user groups presupposes their active participationin the development process, and taking their mobility behaviour and requirements into account. AM is supposed to be a game changer in the transportation system, which does not only affect situational and infrastructural conditions but also new business models and various ownership models.

2.2 Ensuring equal access to infrastructure cannot be taken for granted

An everyday life understanding often associates modernisation processes with progress in science and technology. From a social science perspective, however, the core of modern society is the emergence of a civil sphere, a kind of community based on citizenship. Using the case of citizenship for the Negroe American, Parsons (1965, p. 1015) argued that inclusion, that is, '[t]he process by which previously excluded groups attain full citizenship or membership in the societal community [...]', constitutes the ongoing modernisation of modern society together with the differentiation of social structures and the pluralisation of forms of life. Technological development, however, is deeply enmeshed with issues of inclusion and exclusion, sometimes in surprising ways. In his provocative paper *Do Artifacts have Politics?*, Winner (1989) pointed to practices of road-building and the social distribution of transportation modes in the 1930s in New York city to show how the poorer Black American population was inhibited from using the generous, modern parkways of Long Island: 'Automobile-owning whites of 'upper' and 'comfortable middle classes', as he [i.e. New York city's town planner Robert Moses] called them, would be free to use the parkways for recreation and commuting. Poor people and blacks, who normally used public transit, were kept off the roads because the twelve-foot tall buses could not get through the overpasses.' (Winner, 1989, p. 123 sq.).

The relationships between technical structures and social inclusion and exclusion are not always intentionally established and so evident as in the case described by Winner. Infrastructure tends to be invisible and to become a taken for granted part of everyday life. This might be one reason why traffic participation is a key arena for expressing issues of inclusion and exclusion.

The challenges associated with digitalisation and automated mobility require a precise analysis and consideration in terms of inclusion. On the one hand, automated mobility promises to open up opportunities for various user groups. On the other hand, there is a risk that new technologies will reinforce social inequalities in terms of the distribution of access to the traffic system.

Often the transport systems lacks inclusive access. For example, a local train that people in wheelchairs can use without steps may satisfy the criteria of accessibility. However, inclusion requirements are not met if wheelchair users do not find the same facilities at the station as passengers who do not use wheelchairs. In practice, wheelchair users often do not have a table like the one available to passengers without disabilities - or the table is smaller, making it impossible to work with a laptop. Inclusion means that people with disabilities have access to use the same transport facilities as those without disabilities. Furthermore, they have the right to travel with their travel companions without disabilities – and not separate from them.

3 AUTOMATED MOBILITY IN THE AM4KIDS PROJECT

Focussing on inclusion and automated mobility, the project AM4Kids deals with transport planning and mobility research of tomorrow. The cooperation grants are aimed at educators who want to work with children and young people on future mobility issues.

Tomorrow's mobility will look different from the one we know today. In recent years, mobility has expanded to include several new mobility options, such as e-scooters, bicycles, hoverboards etc. How should or will mobility, taking self-driving (autonomous) cars into account, develop?

Automated mobility (AM) describes the increased use of information and communication technologies (ICT) not only in the vehicle sector itself but in all areas of transport and mobility, including infrastructure and the handling of mobility-related services (pre-, on- and post-trip). To adress automated mobility adequately, not only autonomous driving itself must be considered, but also issues such as orientation and navigation. This includes searching for the best connection in advance of a trip (pre-trip), the choice of means of transport and orientation on the way (on-trip) and the evaluation of the trip afterwards (post-trip).

To shape a sustainable and inclusive development of automated mobility, it is important to discuss this complex and multifaceted topic with children and young people already today. With the focus on inclusion, the aim is to understand how automation and digitalisation enable and/or restrict mobility of people with disabilities.

To establish an inclusive mobility system for all people, guaranteeing a seamless mobility chain from door to door is key. In reality, many different mobility barriers exist which must be considered in all their various forms to make the mobility system more inclusive. Therefore, the involvement of people with disabilities in the planning and implementation process is essential.

Automated mobility has the potential for independent mobility of people with disabilities, given that its various offers address the concrete and diverse needs of people with disabilities – pre-, on- and post-trip:

- It is essential that the pre-trip activities, e.g., obtaining information about the automated mobility services, the ordering, booking and payment process, and the reservation of any necessary assistance services, can be managed by people with disabilities as independently as possible. The consistent implementation of the multi-sense principle is mandatory.
- Barrier-free access for people with disability has to be ensured at all stages of the journey (on-trip). Starting with leaving one's home, this refers to access to AM services, the (possible) stop, transfer, equipment, information on and around the route, stage or vehicle, the stay in the means of transport itself (quality of stay and equipment) and ends when getting off near the destination as well as when leaving for and arriving at the destination address. This also includes making automated mobility services affordable. Moreover, the appropriate provision of the necessary information, applying the multi-sense principle, during the journey has to be considered due to risks and challenges, such as unplanned stops, and technical breakdowns, that may occur while using the automated mobility system.
- In the post-trip phase, people with disabilities' experiences of using the automated mobility system must be reflected, as well as any complaints to the operating company or, if necessary, parking the vehicle and providing services for the vehicle (e.g., charging the battery, collecting luggage, etc.) have to be considered.
- Ideally, inclusive planning and implementation address a broad variety of user groups (based on 'Design for All' principles). It can be calculated and financed similarly to conventional systems through economies of scale if widely rolled out and standardised. However, suppose particular technologies and requirements result in significantly higher costs for an inclusive mobility offer. In that case, funding from the public sector should be discussed to allocate funding in a socially and fairly balanced way.

4 METHODOLOGY

Having said this, it is important to show children and juveniles the enormous range of effects of automated mobility from the viewpoint of various interrelated perspectives (spatial planning, traffic planning, vehicle construction, landscape architecture, cultural engineering, software engineering, etc.). This also promotes the cognitive ability of networked and creative thinking, which is very important in advancing digitalisation and automation. In addition, the creative potential of children and young people is stimulated in the course of the research project and the interactive methodology (children and young people work with different role models

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

in other settings), so the requirements for a future automated mobility system as well as innovative approaches to solutions for sensible use of technology are developed.

AM4Kids looks at the past, present and future of AM from children's and young people's the points of view. Children and young people investigate how and for whom traffic is – and is not – planned. Together with an interdisciplinary team, they adressesd the following questions: How do children and young people imagine the mobility of tomorrow? What are their wishes and expectations? What ideas do children and juveniles have about automation and digitalisation in the mobility sector? And what should not happen?

If people with disabilities shall obtain the status of full citizenship, they must also be involed in technology-oriented and research-intensive developments. For this reason, six educational institutions (primary and secondary levels 1 and 2 with children in the age group from 5 to 19 years) have been selected by inclusion-related criteria; accordingly, their pupils, children and juveniles, have a broad range of disabilities.

4.1 Knowledge building about mobility and inclusion in school contexts

With the help of role models, including people with disabilities, pupils have gained a first impression of job profiles that are little known, such as transport planning, (rail) vehicle construction, spatial planning, landscape architecture, cultural engineering or software engineering. In addition, children and young people experience inclusion directly: people with disabilities (our role models) are an active part of society and part of the technology-oriented and research-intensive community.

Within AM4Kids, pupils slip into the role of mobility experts. They reflect on their mobilities, think about possible developments in AM, learn about mobility needs and develop scenarios for the future.

The project comprises the following activities (August 2020 – July 2023):

- Introductory activities, such as expert lectures and workshops, shall trigger curiosity about transport planning, mobility research and inclusion.
- By walks and spatial explorations, pupils analyse the structural-spatial and transport infrastructures of their school environment.
- In excursions and workshops, children and young people learn to understand technical objects from a social science perspective. What consequences does the design of infrastructures, software solutions and vehicles have from the perspective of different road user groups?
- Transport planning methods such as surveying, counting, questioning etc. are used.
- In-depth workshops that focus on automated mobility are held.
- Pupils develop visions of the future and scenarios for automated mobility and discuss where the opportunities, risks and consequences lie for themselves and other groups of people.
- In a "Future Council" setting, children and young people will present their work.

4.1.1 Children and juveniles as transportation system planners

"Mobility sniffers" on the move (Part 1):

In the first part of the 'Mobility sniffers' module, we developed activities for primary schools which can be used independently by the teachers. The focus is on concepts: what do terms like mobility or transport mode denote? For this purpose, a mobility picture book and a poster on the characteristics of transport modes were developed.

The pupils learn about different modes of mobility by reflecting on their own and their family's mobility behaviour. Beforehand, the term mobility and the methods to measure mobility are introduced in an age-appropriate way. In addition, mobility is a mediator between the five basic activities: living, working, education, shopping and leisure (Sammer et al. 2019), which can take place at different locations through traffic and mobility. The method is a playful transfer of knowledge on transport and mobility.

"Mobility sniffers" on the move! (Part 2):

The second part of the 'Mobility sniffers'deals with getting acquainted with the school environment by using work tasks and first experiences by using traffic survey methods, traffic observations and traffic system analyses.

Mobility diaries provide group-specific tasks. By developing 'research questions' pupils learned practically that the type of task also requires a specific method for collecting traffic data. Traffic data of the traffic offers and demands of the users are the basis for analysing traffic problems and developing proposals for solutions. According to the questions, the pupils could conduct traffic counts under the supervision of mobility planners, observe certain street sections or public transport stops and take measurements (e.g. pavement widths). In this activity, a first feedback process from research questions to survey methods takes place.

In the school environment, conflicts relevant to traffic safety repeatedly occur due to parents' increasing drop-off and pick-up traffic of pupils. A school environment analysis from the children's point of view can help to raise awareness and increase consideration for the safety needs of children. The daily experiences of the pupils, as well as targeted traffic observations and mobility system analyses, serve as a starting point for a critical examination of the topic of traffic. The way to school is a significant environment for experience, learning and socialisation for pupils. Depending on the age of the children, this experience can be used to make them more aware of many phenomena in the field of traffic and mobility in different ways.

The methods include outdoor explorations, learning to interpret the school environment from a mobility planning perspective, recognising danger spots, and playful knowledge transfer.

4.1.2 Sensitisation workshops for children and young people

The Austrian association 'Hilfsgemeinschaft' [assistance community] offers workshops for children and young people to address the needs and demands of visually impaired and blind people. These workshops are inclusive and can be conducted with all participating educational institutions. Children learn about other disabilities based on the responses to their questions to people with disabilities.

4.1.3 Time travel into the past of mobility

To trigger the pupils' creativity regarding future mobility scenarios, they experience time travel to past visions of the future. The focus is on what ideas people had in the past about today's (their future) mobility and how individual vehicles have changed. The design of contemporary passenger cars, for example, is not much different from earlier carriages. This holds true, e.g., for new Tesla cars, which are considered innovative. The shape of the vehicles has not changed yet (and even in the design of trains, you find a similar carriage character). By working with film clips and texts from about 30 to 60 years ago, we will jointly analyse what was predicted, discussed, actually implemented and established back then for today.

4.2 Reflection of own mobility behaviour as well as recognition of the needs of other people by children and juveniles

In the context of the various activities, pupils reflected on their mobility patterns and possible developments in automated mobility based on adequate knowledge transfer (innovations, research projects, product developments). Moreover, they learned about the needs of other groups of people and developed scenarios for the future of mobility and transportation.

4.2.1 Age-appropriate use of mobility logbooks

As a useful method for identifying and reflecting on mobility needs, the mobility logbook is introduced as an observation, analysis and reflection tool in school classes. Children and juveniles are asked to document their mobility behaviour over several days. In addition to the surveys of trips and stages, pupils worked on further tasks, depending on the school level. To experience mobility from other perspectives within the family, the pupils asked their grown-up relatives at home about mobility in the past, today and tomorrow.

We developed a specific type of logbook for each school level: primary (age group 6 to 10 years), secondary level 1 (age group 10 to 14 years) and secondary level 2 (14 to 20 years). It should be noted that, in consultation with the teacher, we used the following higher-level documents for the workshops, depending on the teacher's discretion. As preparation for filling in the mobility logbook, exploratory walks in the school environment (see mobility-sniffers) are carried out shortly before in the primary and secondary level 1. In secondary level 2, a lecture on mobility behaviour is given as preparation. Direct reference is made to national studies of the Austrian Federal Ministry (BMK, 2016), such as *'Österreich unterwegs'*, ['Austria on the move'] and current mobility topics are explained. This insight into mobility research includes the definition of different terms, the systematics of means of transport, and the core contents and possible results of mobility surveys.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

In primary school, children record their trips from home to school for three days in a row. For this purpose, the day of the week and all modes of transport used for this trip are recorded on the worksheet and the duration of the entire trip in minutes. The second task relates to the routes on three different days in general. Four various destinations are distinguished: home, education/school, errands and leisure. In addition, a reference person for the pupil is asked about his or her trips to compare them.

The third task aims at getting the children to look at the development of modes of transport. For this purpose, children ask adult reference persons about the modes of transport of their childhood to compare them with today's transport modes. Building on the perspective of the past and the present, in task 4, the pupils design an (imagined) mode of transport for the future. In addition, the pupils describe why they would particularly like to travel with this mode of transport in the future. Finally, they chose one of the survey days, and visualise the route to school in a drawing.

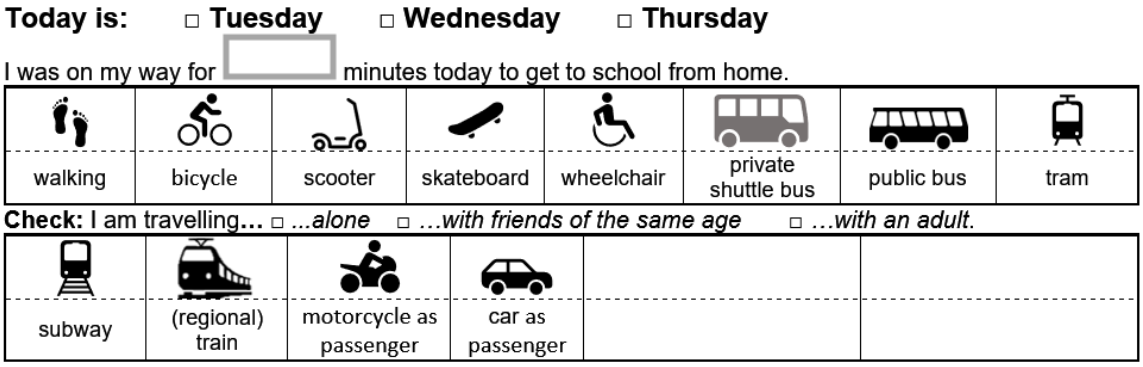


Fig. 1: Excerpt from the primary school mobility logbook

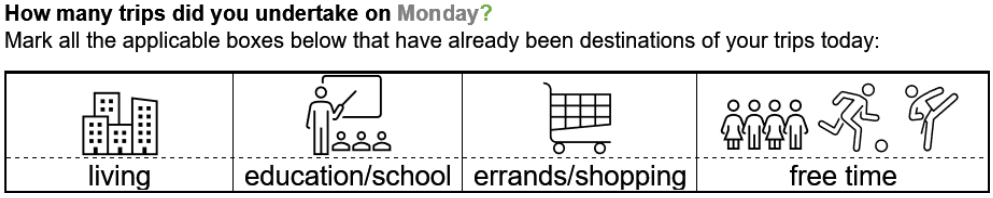


Fig. 2: Excerpt from the primary school trip recording

In secondary level 1, the documentation of the way to school is more finely grained as compared to the primary level. On three days, children record the individual stages of the way to school with exact times and means of transport. Task 2 requires the completion of the same route chain on three different days, whereby a distinction is made between home, education, work, leisure and going on errands.

The third task is to document the way to school in a self-drawn picture, in which challenging places and barriers are located. Moreover, the juveniles should note and explain which sections of the way to school they like. Finally, in task 4, current developments in the mobility sector are reflected together with a reference person. Which modes of transport have changed and which are new? How could people travel in the future? In addition, the children are asked what they would like to change on their way to school if they had the opportunity.

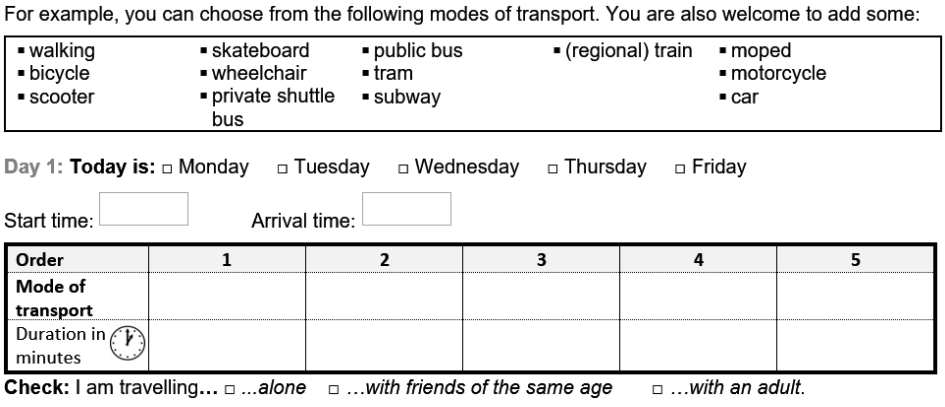


Fig. 3: Excerpt from the secondary level 1 mobility logbook

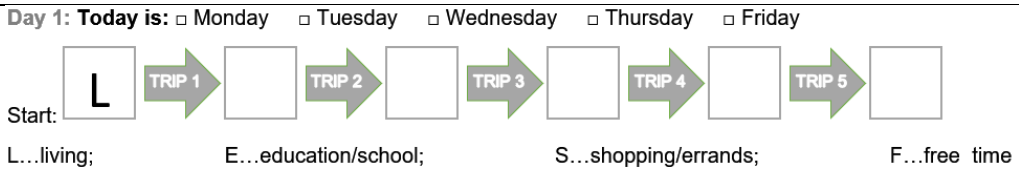


Fig. 4: Excerpt from the secondary level 1 school trip recording

In secondary level 2, the complexity of the enquiry about trips and stages increases significantly. The query is made with a digital PDF form that can be filled out interactively. All paths, including stages and trip chains, are entered in three different days by using a tabular structure.

In the second task, photos of the way to school can be uploaded in the document relating to the categories of general documentation, challenging places and barriers, and particularly positively perceived sections. The third task includes an interview with an adult reference person about their routine routes. This is followed by a comparison of the ways of the past and present from different perspectives. Finally, current developments in the mobility sector are reflected, similar to secondary level 2. Furthermore, ideas for modes of future transport are collected, whereby both writing and drawing can be used. Finally, suggestions to improve the way to school are documented and discussed.

Example for different trips during a day:

L…living; E…education/school; S…shopping/errands; F…free time

weekday / date dd.mm.yyyy	destination		Time recording start & arrival Time	mode of transport 1	mode of transport 2	mode of transport 3	mode of transport 4	mode of transport 5	distance in km (total)	route chain
	start	finish								
monday xx.xx.xxxx	L	E	06:45 / 07:20	walking 5 minutes	public bus 20 minutes	walking 5 minutes			20,0 km	example day 1:
monday xx.xx.xxxx	E	S	15:00 / 15:10	walking 10 minutes					0,7 km	L → E → S → L → →
monday xx.xx.xxxx	S	L	15:30 /16:10	walking 5 minutes	public bus 20 minutes	walking 5 minutes			20,0 km	

Fig. 5: Excerpt of the tabular mobility logbook for schools (secondary level 2)

4.3 Independent development of visions of the future and research questions by children and juveniles

The project's final phase will address the future of automated mobility and has not occurred yet. As already described, the whole process follows a sequence of steps of education that enable the pupils to discuss future developments in age-appropriate ways.

4.3.1 Future workshop on automated mobility

Children and young people will elaborate ideas and perceptions of future mobility in several interactive workshops. Building on the knowledge developed during the project, they tackle questions like: What should my future look like? How do I want to be on the road, for example, to school and travel? What impact do my visions have on co-citizens? How can people with disabilities benefit from this or possibly be negatively affected? The development and complexity of the future scenario will depend on the age group, the educational institution's requirements, and the research questions and conducted surveys. For example, students at an older age will also make links between different factors (environment, industry, economy, society, urban planning, individual groups). The workshop fosters creativity, uses playful approaches and takes advantage of group dynamics to make fun of shaping the future.

4.3.2 Future Council - 'Reality Check of our Future Scenarios'

The Future Council comprises the consortium and the pupils giving them opportunity for appreciative and critical feedback on the developed visions and scenarios. In a discussion on an equal footing, the participating classes discuss how the project ideas are relevant for future development of automated mobility. The Future Council focuses on the enterprising groups that will push innovation in the future: society, politics, industry and users. This means that all projects are considered far beyond being 'good' or 'bad'. Rather, their benefits for a wide range of target groups is evaluated. Getting feedback is essential for creativity and motivation and for dealing with future scenarios. Building on the discussions, children and young people enrich their plans.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

5 DISCUSSION

Within the AM4Kids project, children and juveniles have gained a wide range of knowledge about mobility, environmental conditions, automation, historical developments and different realities of living with disabilities in an age-appropriate way through expert lectures and workshops. Overall feedback from teachers and pupils was positive. The materials developed matched their purpose; the pupils were neither under- nor over-challenged.

In particular, the walks with the pupils in the school neighbourhood opened up discussions between the children and the researchers. Despite using the same materials and taking the same route, experiences varied significantly among school classes. It turned out that the topic of mobility is very present in all age groups. The children not only asked questions during the walk. They also began to think about how street environments could be designed. The groups discussed the advantages and disadvantages of different design elements. Topics initially addressed in a black and white mode of thinking (e.g. trees vs parking lanes for cars) were increasingly treated more reflectively, and different perspectives emerged. For example, one of the pupils said he dislikes pavement cafés because people smoke there, which bothers him. Instead, he would prefer a broader pavement to ride his scooter faster. In the same group, it was discussed that some people find the pavement cafés pleasant places to stay and would not want to miss them. Furthermore, the mobility logbooks are suitable for reflecting on how pupils travel compared to others and why this might be the case.

The teachers' feedback was mainly related to the fact that our interventions enabled children to deal with mobility issues at their own pace. This proved very valuable, especially for children with disabilities, as the street space and the whole environment were explored slowly and with many explanations and interactive tasks. The teachers said that children would not usually take the time to take notice of everyday things in such detail. The possibility to ask questions directly to experts during the workshops was also a great added value for both the children and the teachers.

An essential experience concerns the time factor and the sequence of presenting contents. In the first step, teachers worked with their pupils indenpendently by using documents. In the second step, short lectures before the third step in the form of field work took place (school environment and mobility logbook). In addition, prior knowledge helped a lot to work on the tasks and contents, which made it possible to have more engaged and informed discussions in the field.

At the primary level, among other things, measuring different elements of the street space (e.g. pavement widths, height of the pavement edge, bicycle parking facilities, cars and parking spaces) was top-rated. The teachers combined this task with current teaching content on areas and lengths.

Not only participants but also the researchers had learning experiences during the workshops. The team gathered many new insights on how children perceive street spaces and how different individual perceptions are. Although the focus of this project was purely on raising awareness and knowledge for the children, it can be clearly stated that participation in, e.g., design issues or mobility needs, requires detailed and step-by-step (knowledge) preparation. Direct interaction between researchers and pupils is essential, and a respectful discussion of ideas and visions with the children is indispensable. For example, designs of future modes of transport by primary school pupils show various approaches. However, they have one thing in common: almost all pupils noted that the mode of transport is electric or emits no CO_2. The conscious inclusion of pupils with disabilities and developing teaching materials in cooperation with teachers is highly recommended, as they know their pupils' needs best.

The researchers and planners involved in the project take several roles. They act as role models and experts and offer insight into occupational fields that are hardly known to most participating children. In addition, everyday situations in public spaces are discussed and explored with people with disabilities, making a change of perspective possible at all levels. The research and planning team is a mediator between these levels and simultaneously broadens its own perspectives. Another role of the researcher and planner is to impart knowledge from a technically correct point of view. The contents have to be adapted accordingly depending on the age group. Imparting knowledge and presenting facts as neutrally as possible helped the children to create their perspective on mobility-related topics and to discuss and reflect on them in the group. In the project's final phase, the researchers in the Future Council take a moderating role on the one hand and a feedback-giving role on the other. Thus, visions and ideas can be placed in different contexts.

6 CONCLUSION

Through contact with role models, including people with disabilities, children and juveniles gain a first impression about activities and job profiles of mobility research and planning. In addition, children and juveniles experience inclusion directly in every-day life contexts: people with disabilities are part and parcel of society and shall, therefore, be part of technology-oriented and research-intensive communities. The project sensitised children to mobility in the context of current technical developments and inclusion. Pupils from different educational institutions learn from interaction with research institutions and traffic related organisations. The knowledge thus acquired enables them to experience mobility from different perspectives and allows them to understand some of the implication of scientific concepts. It shows that in the course of pupils' participation processes, the age-appropriate and step-by-step development of knowledge is indispensable to make learning experriences sustainable and valuable.

7 ACKNOWLEDGEMENTS

The Austrian Research Promotion Agency funds this project under the programme "Talente regional", grant number 878694.

8 REFERENCES

BMK, Bundesministerium für Verkehr, Innovation und Technologie (2016): Österreich unterwegs - Ergebnisse der österreichweiten Mobilitätserhebung 2013/2014. Edited by Bundesministerium für Verkehr, Innovation und Technologie. Abteilung II / Infra 2: Infrastrukturplanung (BMVIT). Available online at https://www.bmk.gv.at/themen/verkehrsplanung/statistik/oesterreich_unterwegs/berichte.html, checked on 6/30/2022

Heß, Anne; Polst, Svenja (2017): Mobilität und Digitalisierung: Vier Zukunftsszenarien. Available online at https://www.bertelsmann-stiftung.de/fileadmin/files/BSt/Publikationen/GrauePublikationen/Studie_LK_Mobilitaet-und-Digitalisierung__Vier-Zukunftsszenarien_2017.pdf, 6/30/2022.

Knoll, Bente; Hofleitner, Birgit; Feßler, Anne Katrin; Hauger, Georg; Fian, Tabea; Adensam, Nadine et al. (2021): Automatisierte Mobilität inklusive! Edited by Bundesministerium für Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie (BMK). Available online at https://www.b-nk.at/bericht-automatisierte-mobilitaet-inklusive/, checked on 2/15/2022.

Krail, Michael; Hellekes, Jens; Schneider, Uta; Dütschke, Elisabeth; Schellert, Maximilian; Rüdiger, David et al. (2019): Energie- und Treibhausgaswirkungen des automatisierten und vernetzten Fahrens im Straßenverkehr. Wissenschaftliche Beratung des BMVI zur Mobilitäts- und Kraftstoffstrategie. Hg. v. Fraunhofer-Institut für System und Innovationsforschung (ISI). Karlsruhe. Available online at https://www.iml.fraunhofer.de/content/dam/iml/de/documents/OE%20320/Energie-und_Treibhausgaswirkungen_des_automatisierten_und_vernetzten_Fahrens_im_Stra%C3%9Fenverkehr.pdf, checked on 6/30/2022.

Lenz, Barbara; Fraedrich, Eva (2015): Neue Mobilitätskonzepte und autonomes Fahren: Potenziale der Veränderung. In: Markus Maurer, Christian Gerdes, Barbara Lenz und Hermann Winner (Hg.): Autonomes Fahren. Technische, rechtliche und gesellschaftliche Aspekte, Bd. 39: Springer Vieweg, S. 175–195, zuletzt geprüft am 05.02.2019.

Parsons, Talcott (1965): Full Citizenship for the Negroe American? A Sociological Problem. Daedalus 94(4), S. 1009–1054.

Sammer G., Röschel G., Sammer Gabriela: Mobilitätsverhalten der Grazer Wohnbevölkerung 2018, im Auftrag der Stadt Graz, Graz 2019

Winner, Langdon (1989): Do Artifacts Have Politics? Daedalus 109(1), S. 121–136.

🏆 *reviewed paper*

Automation of Rural Collective Transport: Conceptualising three Alternative Use Cases based on Underexplored Rural Transport Specificities

Alberto Dianin, Michael Gidam, Elisa Ravazzoli, Georg Hauger

(M.A. Alberto Dianin, Faculty of Architecture and Spatial Planning, TU Wien, Karlsgasse 11, A-1040 Vienna, Austria; Eurac Research, Institute for Regional Development, Viale Druso 1, I-39100 Bolzano, Italy alberto.dianin@eurac.edu)
(Dipl.-Ing. Bakk.techn. Michael Gidam, Faculty of Architecture and Spatial Planning, TU Wien, Karlsgasse 11, A-1040 Vienna, Austria, michael.gidam@tuwien.ac.at)
(Dr. Elisa Ravazzoli, Eurac Research, Institute for Regional Development, Viale Druso 1, I-39100 Bolzano, Italy, elisa.ravazzoli@eurac.edu)
(Ao.Univ.Prof. Dr.techn. Dipl.-Ing. Georg Hauger, Faculty of Architecture and Spatial Planning, TU Wien, Karlsgasse 11, A-1040 Vienna, Austria, georg.hauger@tuwien.ac.at)

1 ABSTRACT

Whereas the introduction of autonomous vehicles (AVs) is widely explored in urban contexts, their usage in rural transport services is still understudied. The few works in this field focus on four main use-case typologies, which are only selectively tested. These typologies are mostly concentred on: (a) the type of route and schedules collective AVs could supply (fixed or demand-responsive); and (b) the type of connection AVs are supposed to provide (chain-with-transfers or door-to-door). However, they often neglect a series of rural specificities that the design of AV use cases should comprise, such as the substantial temporal variability of rural collective transport demand or the tendency towards activity chaining of commuters living in rural areas. Based on these underexplored specificities, this study conceptualises three alternative use cases that combine the four reference typologies to complement them. Additionally, the study defines the main characteristics of each use case by referring to a set of shared assets relevant for any application of AVs, such as the schedule, vehicle type, service period, or pricing scheme. Future works may take these conceptual use cases as a starting point to design concrete solutions in specific study areas, quantify their costs for the transport provider and benefits for rural dwellers, and thus enlarge the knowledge on the interplay between AVs and rural collective transport.

Keywords: use cases, rural areas, collective transport, autonomous vehicles, mobility

2 INTRODUCTION

Autonomous Vehicles (AVs) are one of the most discussed innovations of the transport industry (Milakis, 2019). Many studies explore how AVs could be used in transport systems worldwide and what impacts they could have on, e.g. mobility, land use and the environment (Bösch et al., 2016; Meyer et al., 2017). Most of them focus on the urban context, while rural areas are still ancillary (Bernhart et al., 2018; Dianin et al., 2021; Soteropoulos et al., 2019). This condition is linked to various factors. First, rural areas present some technical challenges for the introduction of AVs related to, e.g. the needed internet support and digital 3D mapping of the network (Ort et al., 2018). Second, due to their scattered geographic structure, rural areas are supposed to be less suitable for innovative sharing schemes (e.g. Gelauff et al., 2019). Third, the impacts of AVs on, e.g. mobility, congestion, car occupancy rate or parking space seem to be much more apparent and severe in urban contexts, making rural areas less enjoyable to study (e.g. Thakur et al., 2016).

However, AVs may play an important role also for rural areas and especially for rural collective transport. For example, saved driver costs could lower the dependency on rural public transport (PT) from subsidies (e.g. 40% of operating costs are covered by subsidies in Italian rural areas; Bernhart et al., 2018). Alternatively, such savings could be reinvested to improve the frequency, service period and network extension of rural PT, as well as to introduce more flexible services with the same subsidies as nowadays (Daduna, 2020; Imhof et al., 2020). These improvements would support the goals of the European Network for Rural Development (ENRD) regarding the “Smart and Competitive Rural Areas” (ENRD, 2016). They would contribute to the concept of “smart villages”, which also comprises transport innovations (e.g. SMARTVillages, 2021). Additionally, these collective transport upgrades could mitigate the mobility limitations of some population groups (such as elderly people and pupils; Ranković Plazinić and Jović, 2018) and the risk of social exclusion affecting 23.3% of the European rural dwellers in 2020 (Eurostat, 2022).

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Nevertheless, studies developing and evaluating possible usages of AV in rural collective transport are still lacking (Prioleau et al., 2021, 2020), and most rural studies focus either on the technical barriers to AV introduction, or on their acceptance (Hinderer et al., 2018; Prioleau et al., 2020; Walters et al., 2019). With this article, we want to contribute to this research field by conceptualising a set of systemic use cases for introducing AVs in rural collective transport. In particular, we focus on their topologic and functional side, while not addressing their organisational or financial structures. The proposed use cases steam from a critical analysis of the main use-case typologies developed so far in scientific studies and from identifying some underexplored rural transport-specificities that should be integrated into the design of AV usages. Based on that, we propose three so-called "alternative use cases", describe their key characteristics and explain how they respond to the underexplored rural specificities. These alternative use cases may be considered as a starting point for the future design and evaluation of more specific applications of AVs in concrete rural study areas.

The rest of the article is organised as follows. Section 3 focuses on the existing literature about AV applications to collective rural transport, derives four typical use-case typologies and describes their main characteristics. Drawing on this review and the definition of a series of underexplored rural transport specificities, Section 4 conceptualises three alternative AV use cases and defines their main characteristics. Section 5 concludes the study by explaining how they may be used in future quantitative studies.

3 AVS IN RURAL COLLECTIVE TRANSPORT

3.1 Main use-case typologies derived from literature

The use cases developed in literature may be clustered according to two main criteria: (A) their type of route and schedule, and (B) the type of connection they provide. The former differentiates traditional fixed-route and -schedule services and alternative demand-responsive ones. The latter distinguishes between systems organised either in "trunks and feeders" or in "trunks and branches" (see the definition recalled by Gecchelin and Webb, 2019 and reported in Fig. 1). The first system comprises feeder lines that link settlements to strategic PT hubs where a major trunk line leads to the main centre. The second system includes a series of partially parallel lines (branches), which link different settlements to the same centre through a common route (trunk). By considering criteria (A) and (B) jointly, four main use-case typologies may be recognised in literature: [1] the fixed feeder, [2] the fixed trunk, [3] the demand-responsive feeder, and [4] the demand-responsive trunk with branches. They are schematised in Fig. 1 and described below in detail.

(1) Fixed feeder: AVs operate along minor feeder lines (usually with a fixed route and schedule) to link dispersed rural settlements to major bus or rail nodes. This use case is often introduced to tackle first/last-mile issues (Gühnemann et al., 2019; Rehrl and Zankl, 2018) and is the reference use case of various rural field tests (e.g. Digibus Austria, 2019). Relevant challenges addressed in literature regard, e.g. the development of adequate time schedules (Truden et al., 2021), the forecast of the impacts on transport demand and operator costs (Digibus Austria, 2019; Gühnemann et al., 2019), or the planning of the transfer between the automated feeders and the traditional trunk.

(2) Fixed trunk: AVs are used to improve the performance of major trunk lines linking rural areas to main urban centres (e.g. Daduna, 2020; Mouratidis and Cobeña Serrano, 2021; Rehrl and Zankl, 2018). For instance, AVs allow increasing the frequency of the service (Daduna, 2020), broadening the service period during early morning and late evening, increasing the length of the trunk line or decreasing the fares for passengers (Mouratidis and Cobeña Serrano, 2021). This use case is tested especially along the main rural-urban routes where a significant demand justifies the strengthening of existing PT lines.

(3) Demand-responsive feeder: A fleet of shared AVs replaces existing PT lines and covers a service area shaped by mainly scattered rural settlements. Car- and shuttle-size AVs typically run without predetermined routes or schedules to provide on-demand connections from such settlements to a reference PT hub like a main bus or railway station (Imhof et al., 2020; Johnsen and Meisel, 2022; von Mörner, 2019). Generally, users share rides, but only-vehicle-sharing applications may be tested, especially when the demand is low. This use case is often introduced in areas where the connection from rural settlements to main PT hubs is found to be inefficient by traditional PT.

(4) Demand-responsive trunk with branches: Similarly to the previous case, AVs operate on-demand within a service area. However, they do not have to mandatory take passengers to reference PT hubs. They can also provide direct connections to the final destinations. For instance, they link rural settlements to main urban centres (Schlüter et al., 2021), or offer door-to-door connections to local facilities such as groceries, schools or recreational hubs (Sieber et al., 2020; von Mörner, 2019). This use case is introduced to replace traditional PT when it is found to be unable to properly serve the demand, e.g. because of its spatial dispersion (e.g. Imhof et al., 2020; Sieber et al., 2020).

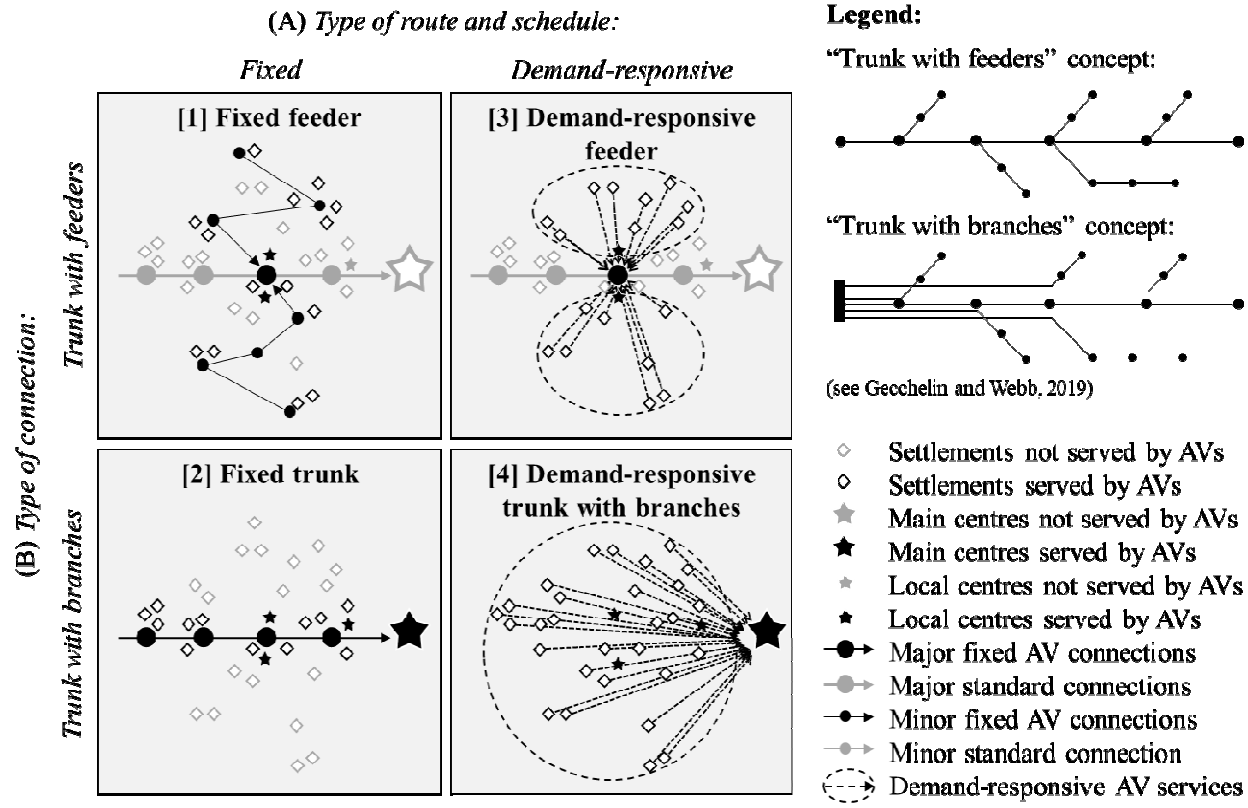


Fig. 1: The four AV use-case typologies for rural collective transport recognised in scientific literature.

3.2 Main characteristics of the use-case typologies

For each use-case typology, it is possible to identify a set of core characteristics. They encompass various assets, such as the schedule and routing/stop principle adopted, the covered service period, the type of vehicle deployed to run the service, or the applied pricing scheme. Table 1 summarises the main characteristics usually associated in literature to each use-case typology by referring to eight assets: Time schedule, Route and stops, Sharing system, Booking system, Vehicle type, User friendliness, Service period and Pricing scheme.

Regarding the Time schedule and the Route and stops, the four use-case typologies usually adopt two different approaches. As current PT services, the fixed feeders and trunk typically work with pre-defined routes, stops and schedule. Therefore, there is no real-time variation based on the demand. Conversely, the demand-responsive feeders, trunk and branches are entirely shaped by the demand, meaning that the routes they follow, the stops they make and their schedule is determined based on actual travel requests. The only exception is the demand-responsive feeder, which offers a hybrid stop scheme since its reference PT hub is a fixed destination.

When designing demand-responsive use cases, the type of Sharing and Booking system is also relevant. AVs may offer both ride-shared and only-vehicle-shared services. The first case is prevalent when dealing with connections that have an appropriate demand potential. In contrast, the second case is suitable when the demand is lacking, and implications for congestion are minor. In both cases, the service booking is mostly assumed to be in real-time, with the travel requests collected and processed to optimise the waiting time for users, the detour degree of vehicles, and their occupancy rate (when dealing with ride-shared systems).

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Other relevant characteristics regard the Vehicle type, the User-friendliness, the Service period and the Pricing scheme. These assets greatly influence AVs' capacity, performance, acceptance and user costs. The type of vehicle used to offer the service may significantly vary by use case typology (see Table 1). Most studies focus on shuttle-like vehicles since they provide an adequate capacity for shared rides. However, even standard buses are considered when dealing with urban-rural connections with high demand(e.g. Apolitical, 2018). The topic of user-friendliness is mainly related to the options at disposal to book and pay for the services, and digital booking, and payment tools are often assumed. Regarding the service period, AVs are often assumed to run the whole day with the same approach (with no change in use cases between peak and off-peak hours). However, aspects such as the AV fleet for demand-responsive services are often dimensioned based on peak demand data (e.g. Kröger et al., 2017). Finally, the fares of these services are usually planned to be distance-based.

Assets	**Use-case characteristics**	**Description**	**Use-cases typologies**			
			[1]	**[2]**	**[3]**	**[4]**
Time schedule	Fixed	The time schedule is predefined by the transport provider and is not subject to changes derived from the demand.	●	●		
	Demand-based	The time schedule is not fixed; rather it depends on the travel requests coming from the demand.			●	●
Route and stops	Fixed	The service departs, arrives and stops in fixed points predefined by the transport provider.	●	●	●	
	Demand-based	The service departs, arrives and stops in flexible points depending on the travel requests.			●	●
Sharing system*	Ride-sharing	Users might share part or the ride if there are more users with similar travel requests.			●	●
	Only-vehicle-sharing	Users share only the vehicle at separated timing but not the ride, which remains individual.			●	●
Booking system*	Real-time	Travel requests are collected and processed almost in real-time. Vehicles are assigned to requests accordingly.			●	●
Vehicle type	Bus-like	Automation is applied to large vehicles similar to standard busses (e.g. 40-60 seats), especially for high-demand lines.		●		
	Shuttle-like	Automation is applied to mini-busses with a lower capacity (e.g. 8-14 seats), especially for medium-demand services.	●		●	●
	Car-like	Automation is applied to standard cars (max 6 seats), especially to offer taxi-like services in low-demand contexts.			●	●
User friendliness	Designed for the digital age	Demand-responsive services are booked only via web and paid via digital methods, while classic tickets/abos work only for PT lines.	●	●	●	●
Service period	Whole day	The service runs the whole day with no interruption or replacement with alternative services.	●	●	●	●
Pricing scheme	Distance-based	The cost of the service for the users is calculated based on the distance travelled or the travel time.	●	●	●	●

Notes:
[1] *Fixed feeder*; **[2]** *Fixed trunk*; **[3]** *Demand-responsive feeder*; **[4]** *Demand-responsive trunk with branches.*
● Characteristics usually associated to each use-case typology in literature.
*****Ride-/only-vehicle sharing and the real-time booking are considered only in demand-responsive use cases.

Table 1: Characteristics typically associated to the four AV use-case typologies.

4 CONCEPTUALISING THREE ALTERNATIVE USE CASES

4.1 Underexplored rural transport specificities

The presented use-case typologies and their characteristics respond to the typical specificities of rural transport, i.e. the lacking and dispersed transport demand and the distinct rural-urban relations shaping commuters´ and students´ mobility (Banister, 1983; Moseley, 1979). However, rural transport presents other

specificities that should be considered when designing AV use cases (Brown and Taylor, 2018; Dianin et al., 2021; Milakis and van Wee, 2020). The following paragraphs and Table 2 summarise them and highlight which use-case characteristics should be designed by considering them. In detail:

Temporal variability of collective transport flows: More than in urban areas, rural zones are shaped by a substantial variation of PT demand between peak and off-peak hours. During the former, several students and commuters travel to workplaces and schools. During the latter, travel demand is low and not concentrated, and mostly generated by people spending a relevant part of their daily life at home (like elderly people, part-time workers or pupils). Existing PT solutions can hardly face this substantial demand variation. They typically serve the peak-hour demand with large-size vehicles and the same vehicles offer an oversized capacity for a few runs during the rest of the day, which are typically low frequented due to their poor time schedule. This condition makes the agency cost efficiency very low and it deteriorates the perception of PT for the uses (Bernhart et al., 2018; Hough and Taleqani, 2018). This suggests the need of differentiating the service design between peak and off-peak hours (especially the time schedule, routing and stops, sharing system and vehicle types), since one single approach hardly fits all the daily phases.

Daily activity chaining: Due to longer distances typically travelled by rural commuters, many daily activities are planned to optimise the daily travel chain (Schwanen, 2008; Talpur et al., 2014). For instance, activities that can be flexibly performed in space and time (e.g. grocery shopping) are performed as stopovers along the routes to and from the locations of daily fixed activities (like work and home place; e.g. Tivers, 1985). This has some impacts on rural transport demand. Rural dwellers tend to rely much more on private cars in order to perform such activity chaining. At the same time, spontaneous unplanned travels are less frequent than in urban areas. To cope with these aspects, the time schedule, route and stops as well as the vehicle design should be planned to ease such activity chaining, as well as the booking system for demand-responsive services could benefit from a more stable planning of individual daily mobility habits.

Spatial distribution of demand: Starting from the general consideration that rural transport demand is spatially dispersed, different conditions apply to e.g. mountain valleys, flat sprawl areas, or polycentric rural settlements. The interplay between these spatial forms and the transport supply should be considered (Dröes and Rietveld, 2015). In particular, the definition of either fixed or on-demand routes and the sharing of either rides or only vehicles might be designed with a stronger consideration of this spatial form. For instance, valleys where all settlements are concentrated along the same route may be more suitable for lines running on pre-defined routes or covering on-demand stops within a band operational area (Nocera and Tsakarestos, 2004). Conversely, sprawl areas may be better served by free-floating taxi services (e.g. Schlüter et al., 2021).

Collective-transport dependency of some user groups: Due to the strong mismatch between private and public transport, rural inhabitants who rely on PT are typically those who cannot access private cars (as people younger than the legal driving age, the elderly, or people unable to afford a private car; Ranković Plazinić and Jović, 2018). This social homogeneity of rural PT users is much higher than in urban centres, where PT is more competitive and even its users are more heterogeneous in their socio-demographic and -economic backgrounds (Rossner and Bullinger, 2020). Starting from this condition, the user friendliness and sharing system of rural AVs should be designed by bearing in mind the characteristics and needs of the typical rural PT users (although the improvements brought by AVs are expected to broaden the range of typical users). For instance, the lower familiarity of older people with new technologies, the higher digital divide experienced by rural dwellers, or the higher perceived vulnerability of young users to safety issues should be integrated.

Affection to private cars of some user groups: More than their urban counterpart, rural inhabitants have the private car as their major if not even only mean to satisfy their mobility needs. This tends to create a strong affection to private cars among rural inhabitants, as well as a lack of habit to share transport means and rides (Mausbach et al., 2019). This is a not-negligible social aspect that should be considered in the design of AV sharing systems. For instance, mixed sharing concepts where users may decide whether to share only the vehicle or even the ride could be a viable solution to cope with this cultural specificity as well as with the lacking demand. This would imply also a deeper discussion on the pricing scheme to introduce (e.g. based on the vehicle occupancy rate in addition to the travel distance).

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Perceived lack of safety: Due to the spatial dispersion and lower presence of people on rural streets, travelling (especially by collective modes) gives more safety concerns to rural users than urban ones. For instance, PT vehicles tend to host less passengers in rural areas, which may lead to negative feelings of unsupervised and unsafe environment. The same applies to the lower presence of pedestrians on the street and the average higher speed of vehicles, which may increase a perceived isolation (e.g. Lu et al., 2014). These aspects should be considered in the design of AV use cases. For instance, vehicles could be designed in a user-friendly way that eases the access of external support services. Additionally, only-vehicle-sharing schemes could be introduced during the timeframes where people are less inclined to share the ride (e.g. late evening).

Underexplored rural specificities	**Use-case characteristics**							
	Time schedule	**Route and stops**	**Sharing system**	**Booking system**	**Vehicle type**	**User friendliness**	**Service period**	**Pricing scheme**
Temporal variability of collective transport flows	●	●	●		●		●	●
Daily activity chaining	●	●		●		●		
Spatial distribution of demand		●	●		●			
Collective-transport dependency of some user groups			●			●		●
Affection to private cars of some user groups			●					●
Perceived lack of safety			●			●		
Notes: ● Underexplored rural transport specificities to be considered for the design of each use-case characteristic								

Table 2: Relation between the underexplored rural specificities and the use-case characteristics.

4.2 Three alternative use cases and their characteristics

To incorporate these rural specificities, we propose three alternative use cases, namely: [1] Fixed trunk with hybrid feeders; [2] Hybrid trunk with demand-responsive feeders; and [3] Hybrid trunk with hybrid branches. The word “hybrid” refers to services mixing fixed and demand-responsive approaches over time. These use cases steam from the four typologies described in Subsection 3.1, which are combined and adjusted differently. Fig. 2 displays them, while Table 3 shows their use-case characteristics.

(1) Fixed trunk with hybrid feeders: A trunk line to the primary reference centre is combined with a series of feeders linked to the trunk nodes. The trunk operates for the whole day with a fixed scheme: fixed schedule and route, high and regular frequency, and bus-like vehicles for increased capacity. The feeders instead change their configuration over time. During peak hours, they run like classic PT lines operated by shuttle-like vehicles. During the off-peak hours, there is no predefined line and stop but service areas covered by taxi-like vehicles. This may be helpful, e.g. for elderly people doing grocery shopping, part-time workers, or kids performing leisure activities during off-peaks. Given the low demand during such timespans, AVs may be shared or not (which is helpful for vulnerable users such as elderly people or kids). This use case may be appropriate to serve, e.g. mountain valleys with a relatively high and stable demand concentration along the trunk line and a series of minor settlements around it always located in an almost linear space.

(2) Hybrid trunk with demand-responsive feeders: The trunk line keeps a fixed-route-and-schedule principle with high-capacity vehicles only during peak hours. During off-peaks, it is operated by shuttle-like vehicles that run along the same route and stops, but their schedule depends on the travel requests from users. The feeder services are always performed on-demand with no predefined route or schedule. However, minor service differences exist between peak and off-peak hours. In particular, during the former, the sharing of the ride is compulsory, while during the latter, the ride can be shared or not. Thanks to this combination, the activity chaining is eased. For instance, users travelling between the urban core and the remote rural settlements may stop by at any local hub, access services like groceries, healthcare facilities, of leisure activities, and then complete the travel up to their remote destination via demand-responsive feeders. In this framework, the local hubs play a crucial role. They have to be planned to adequately host both a reasonable fleet of on-demand AVs as well as the stops of the trunk. Compared to the previous use case, this one is more

suitable e.g. for sprawl areas with a high demand fluctuation along the trunk line and a high spatial widespread of settlements making a line-based system of feeders unviable even during peak hours.

(3) Hybrid trunk with hybrid branches: In this case, all transport services change their configuration between peak and off-peak hours. The trunk runs as a standard bus line, with stops only during peak hours. During off-peaks, the stop system is suspended, and demand-responsive shuttle-like services serve settlements within a walkable distance from the trunk line nodes. The secondary on-demand services act as feeders only during peak hours with mandatory connections to trunk nodes. Conversely, they are configured as branch lines during off-peak hours. This means that during these timespans, they can bring passengers to any desired destination (either local or outer ones). Therefore, during the off-peak hours, the trunk and branches partially run parallel. This configuration has an intrinsic limitation to bear in mind: more collective services run along the same route, generating potential competition and exacerbating possible congestion issues. Therefore, this use case is viable only for low-demand rural areas where congestion is a little concern.

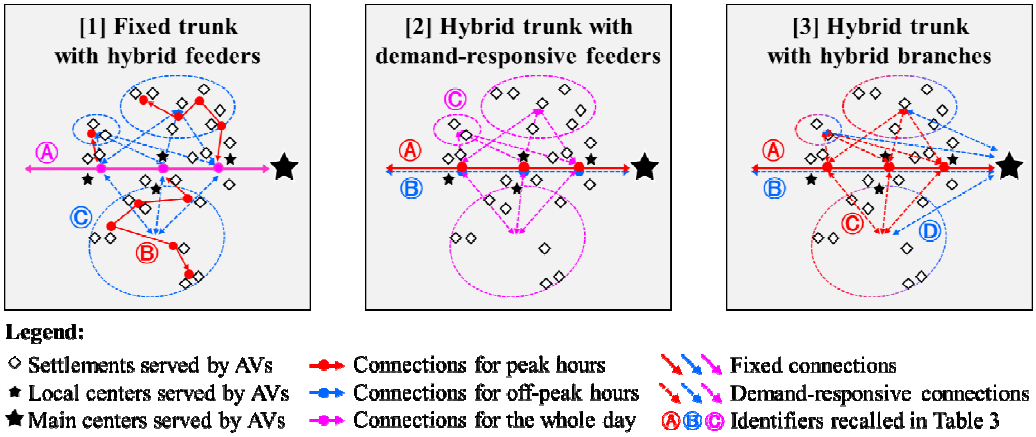


Fig. 2: Alternative use cases for using AVs in rural collective transport.

5 FUTURE WORK AND CONCLUSIONS

These alternative use cases may be a conceptual basis for designing collective AV applications in specific study areas and quantifying their impacts on the rural transport system. Regarding such impacts, what seems still ancillary in the rural AV debate is the quantification of the impacts that different use cases might have on the private-collective transport mismatch. Such mismatch is particularly difficult to solve in many rural contexts and it generates great (accessibility) differences between those who have to rely on collective means of transport and the others accessing private cars (e.g. Carroll et al., 2021). If on the one hand it seems self-evident that AVs will reduce such mismatch, on the other hand it is still unclear how much it will be reduced, as well as where and for whom. Moreover, it is neither straightforward to conclude that such mismatch will be substantially reduced at all, since private cars will also gain important benefits from the automation process (e.g. in terms of perceived travel-time disutility, household sharing of vehicles and parking-related costs; e.g. Dianin and Cavallaro, 2019). These benefits for the private car could keep the private-collective gap still high, hampering any substantial change of transport paradigm for rural dwellers.

Future works may focus on concrete rural study areas, quantify the impacts of collective and private AVs on the generalised cost of transport incurred by users (Ricci, 2011), and compare with the status quo. The generalised cost might be quantified, e.g. for different origin-destination relations (space-based) or the same relation. However, different user types (person-based) and the changes in the collective-private mismatch might be pointed out. This kind of evaluation could be carried out only for those collective use cases that have passed a preliminary check of their transport-provider costs, which should comply with the standards declared by transport providers (e.g. Bösch et al., 2018; Imhof et al., 2020). Figure 3 schematises the process that might be followed to perform such an evaluation of the private-collective transport mismatch in rural areas, starting from the conceptual use cases presented in Figure 2.

Regardless of this possible future research direction, the alternative conceptual use cases developed in this study may be an added value compared to the existing ones: they incorporate a set of rural transport specificities that have been underexplored so far in the literature. According to these specificities, they combine both fixed and demand-responsive services, provided as either trunk lines with feeders or with

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

branches. These services are differently combined during peak and off-peak hours to adequately respond to the high travel demand variation typical of rural contexts. Finally, they have some design features considering the specificities of rural uses. Future studies may use these use cases to explore further the relation between AVs and rural areas, which remains an ancillary but needed research niche.

Assets	**Use-case characteristics**	**Description**	**Alternative use cases**									
			[1]			**[2]**			**[3]**			
			Ⓐ	Ⓑ	Ⓒ	Ⓐ	Ⓑ	Ⓒ	Ⓐ	Ⓑ	Ⓒ	Ⓓ
Time schedule	Fixed	The time schedule is predefined by the transport provider and is not subject to changes.	●	●		●			●			
	Demand-based	The time schedule is not fixed; rather it depends on the travel requests coming from the demand.			●		●	●		●	●	●
Route and stops	Fixed	The service departs, arrives and stops in fixed points predefined by the transport provider.	●	●		●	●		●			
	Demand-based	The service departs, arrives and stops in flexible points depending on the travel requests.			●			●		●	●	●
Sharing system*	Ride-sharing	Users might share part or the whole ride if there are more users with similar travel requests.					●	●			●	
	Mixed-sharing	Users may decide whether to share the ride with other users with compatible travel requests or not.			●			●		●		●
Booking system*	Real-time	Travel requests are collected and processed almost in real-time. Vehicles are assigned accordingly.			●		●	●		●		●
	In advance	Travel requests are collected before the provision of the service to shape it accordingly.						●			●	
Vehicle type	Bus-like	Automation is applied to large vehicles similar to standard busses, especially for high-demand lines.	●			●			●			
	Shuttle-like	Automation is applied to mini-busses with a lower capacity, especially for medium-demand services.		●			●	●			●	
	Car-like	Automation is applied to standard cars, especially to offer taxi-like services in low-demand contexts.			●			●		●		●
User friendliness	Designed for all	Services may be booked via telephone, paid in cash, paper tickets are available, etc.	●	●	●	●	●	●	●	●	●	●
Service period	Peak hours	The service runs only during the peak hours. Other services are provided during the rest of the day.		●		●			●		●	
	Off-peak hours	The service runs only during peak-off hours. Other services are provided during the rest of the day.			●		●			●		●
	Whole day	The service runs the whole day with no interruption or replacement with alternative services.	●					●				
Pricing scheme	Distance-based	The cost of the service for the users is calculated based on the distance travelled.	●	●		●	●	●	●		●	
	Occupancy-based	The cost of the service for the users takes into account the vehicular occupancy rate beside the distance.			●			●		●		●

Notes:

[1] *Fixed trunk with hybrid feeders;* **[2]** *Hybrid trunk with demand-responsive feeders;* **[3]** *Hybrid trunk with hybrid branches.*

ⒶⒷⒸⒹ See the identifiers included in Fig. 2.

● Characteristics associated to each service of the alternative use cases.

***** Ride/only-vehicle sharing and the real-time/in-advance booking are considered only in demand-responsive use cases.

Table 3: The characteristics of the three alternative use cases.

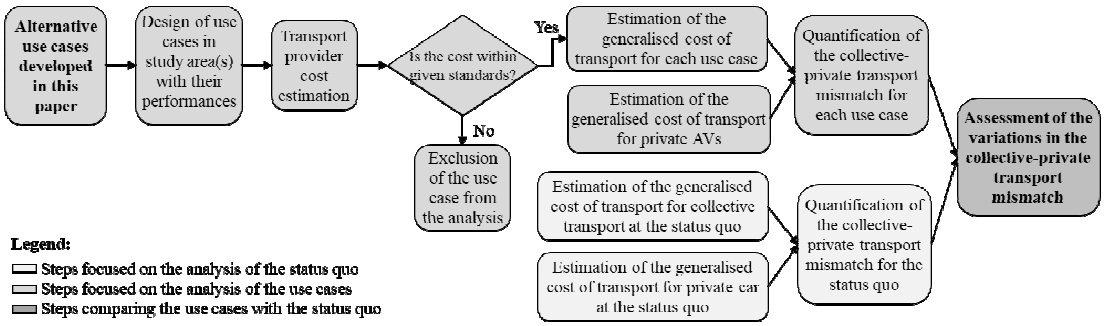


Fig. 3: From the alternative use cases presented in this paper to the analysis of the collective-private transport mismatch.

6 ACKNOWLEDGEMENTS

This research was funded in whole or in part by the Austrian Science Fund (FWF) [I 5224-G Internationale Projekte]. For Open Access, the authors have applied a CC BY public copyright licence to any Author Accepted Manuscript (AAM) version arising from this submission. The research leading to these results has received funding from the Department of Innovation, Research and University of the Autonomous Province of Bozen/Bolzano, within the framework of the FWF Joint Projects between Austria and South Tyrol, under Project number I 5224-G.

7 REFERENCES

Apolitical, 2018. Forget autonomous cars — rural Japan is betting on self-driving buses [WWW Document]. Apolitical. URL https://apolitical.co/solution_article/forget-autonomous-cars-rural-japan-is-betting-on-self-driving-buses/ (accessed 12.25.19).

Banister, D., 1983. Transport needs in rural areas—a review and proposal. Transp. Rev. 3, 35–49. https://doi.org/10.1080/01441648308716514

Bernhart, W., Kaise, H., Ohashi, Y., Schönberg, T., Schilles, L., 2018. Reconnecting the rural: Autonomous driving as a solution for non-urban mobility. ROLAND BERGER GMBH, OpernTurm Bockenheimer Landstraße 2–8 60306 Frankfurt am Main Germany.

Bösch, P.M., Becker, F., Becker, H., Axhausen, K.W., 2018. Cost-based analysis of autonomous mobility services. Transp. Policy 64, 76–91. https://doi.org/10.1016/j.tranpol.2017.09.005

Bösch, P.M., Ciari, F., Axhausen, K.W., 2016. Autonomous Vehicle Fleet Sizes Required to Serve Different Levels of Demand: Transp. Res. Rec. https://doi.org/10.3141/2542-13

Brown, A., Taylor, B.D., 2018. Bridging the Gap between Mobility Haves and Have-Nots, in: Sperling, D. (Ed.), Three Revolutions: Steering Automated, Shared, and Electric Vehicles to a Better Future. Island Press/Center for Resource Economics, Washington, DC, pp. 131–150.

Carroll, P., Benevenuto, R., Caulfield, B., 2021. Identifying hotspots of transport disadvantage and car dependency in rural Ireland. Transp. Policy 101, 46–56. https://doi.org/10.1016/j.tranpol.2020.11.004

Daduna, J.R., 2020. Evolution of Public Transport in Rural Areas - New Technologies and Digitization. Lect. Notes Comput. Sci. Subser. Lect. Notes Artif. Intell. Lect. Notes Bioinforma. 12202 LNCS, 82–99. https://doi.org/10.1007/978-3-030-49757-6_6

Dianin, A., Cavallaro, F., 2019. Automation and urban transport planning: policy recommendations and best practices. WIT Trans. Ecol. Environ. 238, 627–638. https://doi.org/10.2495/SC190541

Dianin, A., Ravazzoli, E., Hauger, G., 2021. Implications of Autonomous Vehicles for Accessibility and Transport Equity: A Framework Based on Literature. Sustainability 13, 4448. https://doi.org/10.3390/su13084448

Digibus Austria, 2019. Simulation of passenger demand and operating cost scenarios for the use of autonomous shuttles in rural public transport.

Dröes, M.I., Rietveld, P., 2015. Rail-based public transport and urban spatial structure: The interplay between network design, congestion and urban form. Transp. Res. Part B Methodol. 81, 421–439. https://doi.org/10.1016/j.trb.2015.07.004

ENRD, 2016. Smart and Competitive Rural Areas [WWW Document]. Eur. Netw. Rural Dev. ENRD - Eur. Comm. URL https://enrd.ec.europa.eu/enrd-thematic-work/smart-and-competitive-rural-areas_en (accessed 5.4.22).

Eurostat, 2022. People at risk of poverty or social exclusion by degree of urbanisation [WWW Document]. URL https://ec.europa.eu/eurostat/databrowser/view/SDG_01_10A/default/table?lang=en&category=sdg.sdg_01 (accessed 5.4.22).

Gecchelin, T., Webb, J., 2019. Modular dynamic ride-sharing transport systems. Econ. Anal. Policy, Special issue on: Future of transport 61, 111–117. https://doi.org/10.1016/j.eap.2018.12.003

Gelauff, G., Ossokina, I., Teulings, C., 2019. Spatial and welfare effects of automated driving: Will cities grow, decline or both? Transp. Res. Part Policy Pract. 121, 277–294. https://doi.org/10.1016/j.tra.2019.01.013

Gühnemann, A., Roider, O., Klementschitz, R., 2019. System Analysis of Use Cases for Autonomous Shuttles to Fill the Rural Transport Supply Gap.

Hinderer, H., Stegmüller, J., Schmidt, J., Sommer, J., Lucke, J., 2018. Acceptance of Autonomous Vehicles in Suburban Public Transport, in: 2018 IEEE International Conference on Engineering, Technology and Innovation (ICE/ITMC). Presented

at the 2018 IEEE International Conference on Engineering, Technology and Innovation (ICE/ITMC), pp. 1–8. https://doi.org/10.1109/ICE.2018.8436261

Hough, J., Taleqani, A.R., 2018. Future of rural transit. J. Public Transp. 21, 31–42. https://doi.org/10.5038/2375-0901.21.1.4

Imhof, S., Frölicher, J., von Arx, W., 2020. Shared Autonomous Vehicles in rural public transportation systems. Res. Transp. Econ. 83. https://doi.org/10.1016/j.retrec.2020.100925

Johnsen, L.C., Meisel, F., 2022. Interrelated trips in the rural dial-a-ride problem with autonomous vehicles. Eur. J. Oper. Res. https://doi.org/10.1016/j.ejor.2022.02.021

Kröger, L., Kickhöfer, B., Kuhnimhof, T., 2017. Autonomous car- and ride-sharing systems: A simulation-based analysis of impacts on travel demand in urban, suburban and rural German regions 4.

Lu, W., McKyer, E.L.J., Lee, C., Goodson, P., Ory, M.G., Wang, S., 2014. Perceived barriers to children's active commuting to school: A systematic review of empirical, methodological and theoretical evidence. Int. J. Behav. Nutr. Phys. Act. 11. https://doi.org/10.1186/s12966-014-0140-x

Mausbach, A.G., Quinlan, D., Johnson, S., Harmer, L., 2019. How to share what we used to own, in: 2019 Fourteenth International Conference on Ecological Vehicles and Renewable Energies (EVER). Presented at the 2019 Fourteenth International Conference on Ecological Vehicles and Renewable Energies (EVER), pp. 1–9. https://doi.org/10.1109/EVER.2019.8813565

Meyer, J., Becker, H., Bösch, P.M., Axhausen, K.W., 2017. Autonomous vehicles: The next jump in accessibilities? Res. Transp. Econ. 62, 80–91. https://doi.org/10.1016/j.retrec.2017.03.005

Milakis, D., 2019. Long-term implications of automated vehicles: an introduction. Transp. Rev. 39, 1–8. https://doi.org/10.1080/01441647.2019.1545286

Milakis, D., van Wee, B., 2020. Chapter 4 - Implications of vehicle automation for accessibility and social inclusion of people on low income, people with physical and sensory disabilities, and older people, in: Antoniou, C., Efthymiou, D., Chaniotakis, E. (Eds.), Demand for Emerging Transportation Systems. Elsevier, pp. 61–73.

Moseley, M.J., 1979. ACCESSIBILITY: THE RURAL CHALLENGE. Publ. Methuen Co. Ltd.

Mouratidis, K., Cobeña Serrano, V., 2021. Autonomous buses: Intentions to use, passenger experiences, and suggestions for improvement. Transp. Res. Part F Traffic Psychol. Behav. 76, 321–335. https://doi.org/10.1016/j.trf.2020.12.007

Nocera, S., Tsakarestos, A., 2004. Demand responsive transport systems for rural areas in Germany. Traffic Eng. Control 45.

Ort, T., Paull, L., Rus, D., 2018. Autonomous Vehicle Navigation in Rural Environments Without Detailed Prior Maps, in: 2018 IEEE International Conference on Robotics and Automation (ICRA). Presented at the 2018 IEEE International Conference on Robotics and Automation (ICRA), pp. 2040–2047. https://doi.org/10.1109/ICRA.2018.8460519

Prioleau, D., Dames, P., Alikhademi, K., Gilbert, J.E., 2021. Autonomous Vehicles in Rural Communities: Is It Feasible? IEEE Technol. Soc. Mag. 40, 28–30. https://doi.org/10.1109/MTS.2021.3104408

Prioleau, D., Dames, P., Alikhademi, K., Gilbert, J.E., 2020. Barriers to the Adoption of Autonomous Vehicles in Rural Communities, in: 2020 IEEE International Symposium on Technology and Society (ISTAS). Presented at the 2020 IEEE International Symposium on Technology and Society (ISTAS), pp. 91–98. https://doi.org/10.1109/ISTAS50296.2020.9462192

Ranković Plazinić, B., Jović, J., 2018. Mobility and transport potential of elderly in differently accessible rural areas. J. Transp. Geogr. 68, 169–180. https://doi.org/10.1016/j.jtrangeo.2018.03.016

Rehrl, K., Zankl, C., 2018. Digibus©: results from the first self-driving shuttle trial on a public road in Austria. Eur. Transp. Res. Rev. 10. https://doi.org/10.1186/s12544-018-0326-4

Ricci, S., 2011. Tecnica ed economia dei trasporti. Hoepli, Milano.

Rossner, P., Bullinger, A.C., 2020. I Care Who and Where You Are – Influence of Type, Position and Quantity of Oncoming Vehicles on Perceived Safety During Automated Driving on Rural Roads, in: Krömker, H. (Ed.), HCI in Mobility, Transport, and Automotive Systems. Driving Behavior, Urban and Smart Mobility. Springer International Publishing, Cham, pp. 61–71. https://doi.org/10.1007/978-3-030-50537-0_6

Schlüter, J., Bossert, A., Rössy, P., Kersting, M., 2021. Impact assessment of autonomous demand responsive transport as a link between urban and rural areas. Res. Transp. Bus. Manag. 39. https://doi.org/10.1016/j.rtbm.2020.100613

Schwanen, T., 2008. Struggling with Time: Investigating Coupling Constraints. Transp. Rev. 28, 337–356. https://doi.org/10.1080/01441640701642363

Sieber, L., Ruch, C., Hörl, S., Axhausen, K.W., Frazzoli, E., 2020. Improved public transportation in rural areas with self-driving cars: A study on the operation of Swiss train lines. Transp. Res. Part Policy Pract. 134, 35–51. https://doi.org/10.1016/j.tra.2020.01.020

SMARTVillages, 2021. Home – Alpine Space: SMARTVillages - Smart digital transformation of villages in the Alpine Space [WWW Document]. URL https://www.alpine-space.org/projects/smartvillages/en/home (accessed 5.4.22).

Soteropoulos, A., Berger, M., Ciari, F., 2019. Impacts of automated vehicles on travel behaviour and land use: an international review of modelling studies. Transp. Rev. 39, 29–49. https://doi.org/10.1080/01441647.2018.1523253

Talpur, M.A.H., Madzlan, N., Irfan, A., Chandio, I.A., Hussain, S., 2014. Time-space geography: A creditable transport accessibility measure for rural dwellers. Appl. Mech. Mater. 567, 763–768. https://doi.org/10.4028/www.scientific.net/AMM.567.763

Thakur, P., Kinghorn, R., Grace, R., 2016. Urban form and function in the autonomous era. Australas. Transp. Res. Forum Proc. 15.

Tivers, J., 1985. Women Attached: The Daily Lives of Women With Young Children, 1st edition. ed. St. Martins Press, New York, NY.

Truden, C., Ruthmair, M., Kollingbaum, M.J., 2021. Analysis of Schedules for Rural First and Last Mile Microtransit Services. Lect. Notes Comput. Sci. Subser. Lect. Notes Artif. Intell. Lect. Notes Bioinforma. 13004 LNCS, 332–346. https://doi.org/10.1007/978-3-030-87672-2_22

von Mörner, M., 2019. Demand-oriented mobility solutions for rural areas using autonomous vehicles, in: Coppola, P., Esztergár-Kiss, D. (Eds.), Autonomous Vehicles and Future Mobility. Elsevier, pp. 43–56.

Walters, J.G., Meng, X., Xu, C., Jing, H., Marsh, S., 2019. Rural positioning challenges for connected and autonomous vehicles. Presented at the ION 2019 International Technical Meeting Proceedings, pp. 828–842. https://doi.org/10.33012/2019.16727

🏆 *reviewed paper*

Awareness about the Relevance of Cascading Effects in Urban Critical Infrastructure Networks under Climate Change – a Participatory Impact Matrix Approach

Markus Groth, Steffen Bender, Peer Seipold, Elisabeth Viktor

(Dr. Markus Groth, Climate Service Center Germany (GERICS) - Helmholtz-Zentrum Hereon, Markus.Groth@hereon.de)
(Apl.-Prof. Dr. Steffen Bender, Climate Service Center Germany (GERICS) - Helmholtz-Zentrum Hereon)
(Dr. Peer Seipold, Climate Service Center Germany (GERICS) - Helmholtz-Zentrum Hereon)
(Elisabeth Viktor, PricewaterhouseCoopers GmbH (pwc))

1 ABSTRACT

Addressing climate change adaptation in urban areas is increasingly urgent. To achieve sustainable and climate-adapted fields of action requires fundamental transformations of supply chains and infrastructures such as transport and mobility, electricity and water supply, or telecommunication as well as an improved understanding of their interactions. Practical experiences show, that in general there is an increasing awareness about this, but for example emergency plans or crisis communication often falls short regarding the indirect impacts of climate change on potential infrastructural failures. Hence, there is also a growing need for applied research and systemic approaches to overcome the current prevailing isolated sectoral view of climate change impacts to gain a holistic understanding of the critical infrastructure networks. Against this background, the paper highlights the relevance of climate change impacts on critical infrastructures, infrastructure interdependencies and potential systemic cascading effects. The analysis uses a participatory approach that has been applied within a case-study for the metropolitan area of Hamburg, Germany. It is based on transdisciplinary research methods, connecting the realms of scientific knowledge about regional climate change with real-world experiences. A strong focus lies on the use of a specific impact matrix approach carried out with key stakeholders from different sectors to identify climate-related drivers causing the most severe failures and losses in the system – either directly in the same sector or indirectly due to breakdowns in other sectors. In sum, the case-study enables a first categorization of the role single key variables play in the infrastructure system. Furthermore, it introduces the topic of adaptation to climate change as a starting point for a better understanding and management of systemic risks in order to build and maintain resilient critical infrastructures and to make urban areas safe, resilient and sustainable.

Keywords: transdisciplinarity, impact matrix, urban areas, critical infrastructure, climate change adaptation

2 INTRODUCTION

Addressing climate change adaptation in cities and urban areas is increasingly urgent as for example nearly 75% of Europeans live in urban areas. This number is expected to grow in the coming years. Moreover, the way cities are planned and constructed often remains unsustainable, like for example the EEA (EEA 2020) points out. The report also highlights, that while many local authorities have realised the importance of becoming resilient to climate change, progress in adaptation planning remains small, whereas the implementation of adaptation measures and the monitoring of their success are even smaller. Measures currently put in place mostly focus on redressing grievances, developing knowledge, awareness raising or policy developments. Technical adaptation solutions have not yet been implemented equally across Europe. At the same time, adaptation of cities is also necessary from an economic perspective. Urban areas are key economic hubs and home of industry and services. Therefore action at all governance levels from EU through national to local is needed to support urban adaptation through improved access to knowledge and funding, political commitment and community engagement, and mainstreaming adaptation into all policy areas (EEA 2020).

This is strongly in line with results from the IPCC special report "Global Warming of 1.5°C". It highlights urgent need for action and shows that even a warming of 1.5°C compared to pre-industrial levels will lead to locally strong impacts of climate change. The overall economic damage up to 2100 can be regionally higher if global warming does not reach 1.5°C but 2°C. In turn, all emission paths for the target of 1.5°C or below require rapid and far-reaching emission reductions as well as system transitions in many socially and economically significant areas. Thereby urban areas are one type of the critical systems that can accelerate and upscale climate action, including both mitigation and adaptation (IPCC 2018). This requires fundamental transformations of central critical infrastructures such as electricity and heat supply, water supply, sewage disposal, transport and mobility or telecommunication as well as an improved understanding and

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

comprehensive consideration of the interactions between critical infrastructure sectors under changing climatic conditions – also taking into account the urban-rural-relations (European Commission 2020a; EEA 2019).

Since the different supply networks are interconnected and dependent on each other, it is mandatory to analyse climate-related concerns with a clear perspective on the entire infrastructure system, including direct and indirect impacts (European Commission 2020a; EEA 2019; Laugé et al. 2014; Eusgeld et al. 2011; Luiijf et al. 2010; BMI 2009; Rinaldi 2001). For instance, if the power supply fails due to extreme weather conditions, serious consequences can follow relating to a number of vital functions in a region (Forzieri et al. 2018; Groth et al. 2018; Mikellidou et al. 2018; Karagiannis et al. 2017): The supply of fresh water can be disrupted, water quality can be compromised and wastewater treatment can be affected. The transportation system can be disturbed, leading to potential failures of evacuation measures. The telecommunication system can break down leading to a halt in transport, mobility and logistics, to name a few examples. In addition, critical infrastructures contain fewer and fewer mechanical redundancies and rely more and more on smart networks and digital information exchange, creating an accumulation of risk and exposing the system to a number of threats.

The exchange of experience with local stakeholders shows, that in general there is an awareness of these interconnections, but for example emergency exercises often fall short regarding the growing indirect impacts of climate change on potential infrastructural failures in the future. Therefore, there is a growing need for practice-oriented research to overcome the still dominating isolated view of single impacts of climate change on selected critical infrastructures (EEA 2020; European Commission 2020a; Lückerath et al. 2020; Groth et al. 2018). An additional challenge is the consideration of the large number of interests from key players such as administration (from local to regional), politics, and companies as well as state of the art scientific knowledge to be considered in the development of strategies and measures.

Against this background, the paper addresses general aspects of the relevance of climate change impacts for critical infrastructures, infrastructure interdependencies and potential cascading effects as well as takes a hands-on deep dive into the topic by introducing the methodology and main results of a case study carried-out with stakeholders in the metropolitan area of Hamburg.

The paper is structured as follows. Section three highlights the overall relevance and need for research regarding the impacts of climate change on critical infrastructure, with a focus on infrastructure interdependencies and cascading effects. The case-study background is described in section four. Based upon this, section five introduces the specific impact matrix approach used as part of a stakeholder workshop within the case-study. The main results are presented and discussed in section six. The paper concludes in section seven.

3 CRITICAL INFRASTRUCTURE, INFRASTRUCTURE INTERDEPENDENCIES AND CASCADING EFFECTS

Critical infrastructures are defined as organisations and facilities of great importance to the state, whereby their failure or impairment would result in serious supply shortages, considerable disruption of public safety, or other dramatic consequences (BBK and BSI 2020).

In this paper, the focus is put on three elements: energy, water and transportation. The aim is to identify the connections and interactions between these sectors and to analyse the underlying dynamics. In doing so, possible weak links and vulnerabilities, leading to cascading effects, can be identified. Specifically with regard to the impact of extreme weather conditions also leverage points for the most effective implementation of adaptation options can be determined. This information forms the basis for the objective to strengthen the resilience of all parts of the critical infrastructure and to reduce vulnerability and risk regarding climate change impacts in the future.

Regarding the specific impacts of climate change in Germany – for instance – the transport and mobility infrastructure are particular expected to be affected by extreme weather events (Hänsel et al. 2019; Nilson et al. 2019). Damages and obstacles caused by floods and landslides – for example – are key challenges for road and rail transport. The navigability of waterways can be impaired especially by exceptionally high or low water levels or by trees falling and blocking the fairway. In addition, especially in combination with strong winds and heavy precipitation, damage can occur to infrastructure elements such as traffic control

systems, overhead lines and power supply systems, as well as inland waterways, ports and maritime facilities. Disturbances of the transport system can cause disruptions in other economic sectors (e.g. producing industry, chemical and pharmaceutical industry) and thus also in other infrastructure services, as observed for example during the period of low water levels in the River Rhine in 2018. Due to low water levels and high water temperatures, there was a lack of cooling water for thermal power plants, which had to be partially throttled. At the same time, the logistics chain for the supply of iron ore, coal and crude oil as well as for the delivery of end products from steel works and the chemical industry on the Upper Rhine was hampered. This resulted in supply bottlenecks for diesel and gasoline (BfG 2019).

Dependencies of critical infrastructure elements in general have already become a growing phenomenon in practice (Lugo 2019; Johansson et al. 2015; Ciscar and Dowling 2014; Moss 2014; Funabashi and Kitazawa 2012; Frantzeskaki and Loorbach 2010; Meusel and Kirch 2005; Rinaldi et al. 2001). The main types of failures describing these interdependencies are i) cascading (manifestation of nth-order-effects), ii) escalating (disruption in one infrastructure causes a larger disruption for another infrastructure) and iii) common cause (disruption in several infrastructures at the same time, e.g. due to geographical interdependencies). In particular, a cascading effect occurs when a disruption in one infrastructure causes the failure of a component in a second infrastructure, which subsequently causes a disruption there, too (Hassel et al. 2014; Rinaldi et al. 2002). In general, critical infrastructure is exposed to various kinds of threats. They are man-made or technical (terrorism, sabotage, software failures etc.) and natural threats. The latter range from geological (landslides, earthquakes etc.) to hydro-meteorological hazards (extreme weather events). Their effects generate a sequence of events in human subsystems that result in physical, social and/or economic disruption. Thus, an initial impact can trigger other incidents that lead to consequences of significant magnitude.

In the EU-project CascEff (Hassel et al., 2014), it is also pointed out, that data collection based on interviews, would be beneficial to analyse these potential system failures, because information about the effects of the conditions under which cascading effects occur is very hard to find. Hassel et al. (2014) therefore suggest holding workshops using contrafactual reasoning ("What if…?" scenarios). This suggestion is taken up in the case-study presented below. Thereby especially physical interdependencies are taken into account, which – if stressed or disrupted – can cause cascading failures for any type of infrastructure, which can lead to safety and security threats or can severely harm economic opportunities and society.

4 CASE-STUDY BACKGROUND

Studying complex systems like critical urban infrastructures means analysing "how parts of a system and their relationships give rise to the collective behaviours of the system, and how the system interrelates with its environment" (Bar-Yam 2002). The crucial determinant of a complex system is its purpose. This is essential to understand the behaviour of the system and to identify influencing factors and leverage points to intervene. A complex system in general is made of stocks, flows and feedback loops. Since a system to a large extent causes its own behaviour, it is helpful to understand which features in the system are the most dominant drivers. How to identify leverage points (active variables) to interfere in the system are described in Meadows (2008).

Against this background, the system dynamics approach helps to understand the non-linear behaviour of complex systems. It was developed by Jay W. Forrester in the 1950s (Forrester 2007a) as a heuristic method to analyse socio-economic systems. Originally, the method was applied to study the impacts of specific business decisions on the behaviour and structure of the business. It allows to go through different options/decisions (i.e. scenarios) and to compare the respective expected reaction of the business (the system) over time (Forrester 2007a; 2007b).

To systematically capture the complex interlinkages of different infrastructure sectors in practice and the impact of future climatic conditions for potential cascading effects, a system dynamics approach has been applied in a project for the metropolitan area of Hamburg. The system under investigation is built from the infrastructural elements of the energy, water and transport sectors. A special focus is placed on the interfaces between these sectors.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

The project is based on transdisciplinary research methods, connecting the realms of scientific knowledge about regional climate change with real-world experiences in sector management. Thereby transdisciplinary research is understood as a deeper and broader form of interdisciplinary research. It is deeper because it transcends disciplines and thereby blurs discipline boundaries. It is broader because it includes not just scientists, but also stakeholders such as citizens and authorities, who should ideally participate in all phases of the research process. Transdisciplinary research represents a unified problem-solving approach in which problems are tackled not only from a disciplinary perspective but grappled with in their entire complexity. Therefore, transdisciplinary research is necessary to solve problems that arise at the intersection of science and society or what is sometimes referred to as the "life-world".

In this context, a participatory approach is applied to identify climate-related drivers causing the most severe failures and losses in the system – either directly in a specific sector, or indirectly affecting a sector due to breakdowns in subsystems.

Starting with identifying key players and identifying the affected and affecting institutions, a stakeholder mapping process (Leventon et al. 2016; Reed et al. 2009) was carried out for the energy, water and transport sector. Based on this, 25 local representatives and experts of the most relevant groups have been contacted. Thereof 13 stakeholders have been interviewed regarding a) their expertise and perception about climate related risks, b) the most vulnerable elements and their dependence on non-climatic influences, especially from the failure of important elements of their own sector or connected sectors, c) their level of preparedness, and d) their institutions adaptive capacity. In a co-design process, cognitive maps were built representing the individual mental models of the interviewees and showing their perspectives of the current local system.

In a next step, connections between the generic terms were defined and combined in one map, based on group model building techniques (Siokou et al. 2014; Bérard 2010; Sterman 2001; Andersen and Richardson 1997; Vennix 1996). This highlights the most frequently mentioned variables of the system and their interlinkages from the stakeholders' perspective. Finally a stakeholder workshop has been carried out, whereby mainly elements of the sensitivity model developed by Vester (1991; 2003) have been applied. This specific approach will be described in more detail in the next chapter.

5 AN IMPACT MATRIX APPROACH AS PART OF A STAKEHOLDER WORKSHOP

One key element of the case-study was a join workshop with the previously already interviewed stakeholders. Thereby it was aimed at distilling those system variables that the stakeholders deemed most relevant, as well as on analysing the impacts these variables have on each other. The participants were split up in three groups for the discussion in order to learn about the individual assessments and to enable each participant to share his/her particular view. Additionally, the workshop provided a possibility for the participants to extend their own cross-sectoral network.

Careful consideration of the process of how to work on the problem at hand is important (Bérard 2010) for a successful workshop in this setting. Different types of cognitive tasks can be applied: i) divergent thinking, done in small groups or by individuals to broaden the space of possibilities to look at the problem (or potential solutions), ii) convergent thinking, often achieved in plenary discussions to concentrate the amount of possibilities to the ones that are deemed most relevant by the group, and iii) evaluation, also mostly done in a plenary setting to evaluate chosen possibilities.

Aside from the group model building techniques discussed in the system dynamics community (e.g. Andersen & Richardson 1997; Andersen et al. 1997, Vennix 1996), it was decided for the workshop to strongly focus on elements developed by Vester (1991; 2003) of working with complex systems.

The sensitivity model was developed to capture the behaviour of non-linear processes and complex systems (Vester 1991). Just like Forrester (2007a; 2007b) and Meadows (2008), Vester considers the understanding and accurate representation of feedback loops as essential. In addition, Vester offers a number of concrete tools that help to set boundary conditions and to prepare for the identification of feedback loops in a structured way (Vester 2003).

The set of variables to be used need to contain information about (Vester 2003):

- Direction of impact (x influencing y, or y influencing x)
- Desired direction of change (increase or decrease, impact of change)
    - Strength of relationship: 0 = No relationship; 1 = Weak relationship; 2 = Medium relationship, proportional; 3 = Strong relationship, disproportionate.

Thereby, it is important to only focus on direct relations. The indirect relations appear automatically when describing the entire system. Based on the variable's description, an impact matrix can be developed as illustrated in figure 1.

Impact of ↓ on →	Influencing factor A	Influencing factor B	Influencing factor C	Influencing factor D
Influencing factor A		1	1	...
Influencing factor B	2		...	2
Influencing factor C	...	0		...
Influencing factor D	3	...	...	

Impact Matrix = basis to define roles of individual influencing factors

Fig. 1: Illustration of the impact matrix (Vester 2003)

An impact index can be calculated with the impact matrix (figure 1) for each factor influencing the system, i.e. each variable. For doing so, the following approach is suggested. After all influencing factors have been evaluated in the impact matrix, the individual values are added row by row to form the active sum of the respective variable. By adding the values column by column, the passive sum of each variable is calculated (Vester 2008; 1991). The active sum allows a statement about how strongly the variables affect the system. Accordingly, the influencing factor with the largest active sum has the greatest influence on the system, whereby this is independent of whether the influencing factor is simultaneously influenced by others. In contrast, the passive sum allows a statement about the strength on how each variable is influenced by other variables in the system. Active and passive sums form the basis for the assignment of the influencing factors to different categories. For each influencing factor, its active sum could then be divided by its passive sum. The influencing factor with the highest quotient is an active variable in the system. Correspondingly, the variable with the smallest q-value is a reactive variable. In a next step, for each influencing factor its active sum is additionally multiplied by its passive sum. The lowest p-value identifies the buffering variable of the system.

Based on these values, each variable can be assigned one of the following five roles in the system (Vester 2003):

- Active: large influence on other variables without being influenced by other variables
- Reactive: small influence on other variables, being influenced strongly by other variables
- Critical: large influence on other variables, being influenced strongly by other variables
- Buffering: small influence on other variables without being influenced by other variables
- Neutral: work well to self-regulate the system.

6 RESULTS

The initial representation based on the interviews already allows certain insights into the structure of the system, e.g. which variables are well connected and can be influenced in many ways, or which variables only have a few outbound connections with an immense impact on others. The workshop results offer an additional multitude of information about the components of the system and the impact of climate change on critical infrastructures and possible following cascading effects.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

The results enable a categorization of the roles that the variables play in the system. In addition, questions about effective levers to initiate change as well as about variables with a stabilising influence can be investigated. Furthermore, variables can be identified that are critical to the system because of their strong interconnectedness, but that can at the same time be a threat due to potential side effects as a result of the high number of links in the system.

Quite striking was the fact that laws, regulations, and especially the Renewable Energy Sources Act (EEG) was discussed a lot, while the variables were only chosen once each (1x “regulation”, 1x “EEG”). Also, a few variables were understood differently. Types of mobility, for instance, were not just understood as the variety of different means of transportation, but also in a much more absolute sense: “is transport/mobility in a crisis situation even still necessary? Who needs to remain mobile, who can stay put at least for a little while?”. The variables chosen by the participants to be the most relevant for their work are shown in table 1.

- Share of electric vehicles (2x) - Specialists - European Network of Transmission System Operators for Electricity (ENTSO-E) - Regulation (e.g. EEG) (2x) - Flood risk	- Road/railway capacity - Road capacity (2x) - Communication - Types of mobility - Grid expansion - Network load	- Grid stability (4x) - Precipitation (2x) - Provision of public services - Volatility of renewable energy (2x) - Wind speed (2x) - Maintenance (2x)

Table 1: Most relevant variables

The results of the impact matrices for the three groups are highlighted in tables 2 to 4 below, whereby each group was named after a colour. In each table the digit “0” represents no impact, digit “1” a weak impact, digit “2” a proportional impact and digit “3” a strong impact.

Impact by ↓ on →	Share of electric vehicles	Network load	Grid expansion	Flood risk	Grid stability	Road capacity	Maintenance	Precipitation
Share of electric vehicles		2	2	0	2	0-1	0-1	0
Network load	-2		0-1	0	-3	0	0	0
Grid expansion	3	-2		0	3	0-1	0	0
Flood risk	0	0	0		0*	0-1	0	0
Grid stability	0	0	0	0		0	0	0
Road capacity	0	0	0	0	0		0	0
Maintenance	0	0	0	0	0	1		0
Precipitation	0	0	0	0-1	0	-2	1	

Table 2: Impact matrix of the "yellow" group

Impact by ↓ on →	Road/railway capacity	Wind speed	Grid stability	Provision of public services	Precipitation	Maintenance	Share of electric vehicles	Volatility of renewable energy	European transmission grid
Road/railway capacity		0	0	2	0	2	0	0	0
Wind speed	3		2	2	0	2	0	3	2
Grid stability	3	0		3	0	2	2	1	2
Public services	2	0	2		2	2	2	0	1
Precipitation	2	0	1	0		2	0	0	0
Maintenance	3	0	3	2	0		2	1	2
Share of electric vehicles	2	0	2	1	0	2		0	1
Volatility of ren. energy	0	0	3	3	0	2	0		3
European transmission	0	0	3	3	0	2	0	2	

Table 3: Impact matrix of the "blue" group

Impact by ↓ on →	Grid stability	Communi-cation	Wind speed	Regulation (e.g. EEG)	Volatility of renewable energy	Specialists	Types of mobility
Grid stability*		3	0	1	0	3/1	3
Communication**	3		0	0	0	3/2	3/2
Wind speed	2	1		1	3[1]	0	2
Regulation (e.g. EEG)	3	2	0		0	2	2
Volatility of renewable energy	3	1	2	2		1	2
Specialists***	3	2	0	2	0		2
Types of mobility****	2	2	0	1	0	3/1	

Table 4: Impact matrix of the "green" group

The fields with two numbers (distinguished with /) first show the intensity of impact during a crisis situation and secondly in a normal situation. *electricity/heat/transport; **using technological devices; ***not just general availability, but also availability at the right time at the right place; ****in a crisis situation, without electricity grid. 1 no sun, no wind (“Dunkelflaute”).

Grid stability is the only variable mentioned in every group. But there are some differences in the results of each group as well. Most differences are linked to the variables grid stability and maintenance. Especially the “blue” and the “yellow” group disagree strongly about their impacts. Whereas the “blue” group was made up by experts of municipal companies, the majority of the participants of the “yellow” group were from the private sector. The “green” group consisted mostly of experts from the areas of administration and associations. For the “blue” group, maintenance and grid stability are crucial elements of a functioning critical infrastructure and therefore impacts many other variables strongly. The “yellow” group represents the users of a solid grid stability and well maintained critical infrastructure. They evaluate the impact on other variables of the system as less strong.

Impact by ↓ on →	Grid stability	Share of electric vehicles	European transmission grid	Specialists	Regulation (e.g. EEG)	Flood risk	Maintenance	Railway capacity	Road capacity	Communication	Types of mobility	Grid expansion	Network load	Precipitation	Public services	Volatility of ren. Energy	Wind speed	**Active sum**
Grid stability		0/2	2	2	1	0	0/2	3	0/3	3	3	0	0	0	3	0/1	0	**7-11**
Share of electric vehicles	2		1	-	-	0	1/2	2	1/2	-	-	2	2	0	1	-/0	-/0	**8**
European transmission grid	3	0		-	-	-	2	0	0	-	-	-	-	0	3	2	0	**4**
Specialists	3	-	-		2	-	-	-	-	2	2	-	-	-	-	0	0	**4**
Regulation (e.g. EEG)	3	-	-	2		-	-	-	-	2	2	-	-	-	-	0	0	**4**
Flood risk	0	0	-	-	-		0	-	1	-	-	0	0	0	-	-	-	**1**
Maintenance	0/3	0/2	2	-	-	0		3	1/3	-	-	0	0	0	2	-/1	-/0	**4-7**
Railway capacity	0	0	0	-	-	-	2			-	-	-	-	0	2	0	0	**2**
Road capacity	0	0	0	-	-	0	0/2			-	-	0	0	0	2	-/0	-/0	**1-2**
Communication	3	-	-	2	0	-	-	-	-		2	-	-	-	-	0	0	**3**
Types of mobility	2	-	-	2	1	-	-	-	-	2		-	-	-	-	0	0	**4**
Grid expansion	3	3	-	-	-	0	0	-	1	-	-		2	0	-	-	-	**4**
Network load	3	2	-	-	-	0	0	-	0	-	-	1		0	-	-	-	**3**
Precipitation	0/1	0	0	-	-	1	1/2	2	2	-	-	0	0		0	-/0	-/0	**4-5**
Public services	2	2	1	-	-	-	2	2	2	-	-	-	-	2		0	0	**7**
Volatility of ren. energy	3	-/0	3	1	2	-	2	0	-/0	1	2	-	-	-/0	3		-/0	**8**
Wind speed	2	-/0	2	0	1	-	-/2	3	-/3	1	2	-	-	-/0	2	3		**8-10**
Passiv sum	**11-13**	**3-5**	**6**	**5**	**6**	**1**	**6-9**	**6**	**6-8**	**6**	**6**	**2**	**2**	**1**	**8**	**2-4**	**0**	

Mentioned one-time
Mentioned two-times
Mentioned three-times

Table 5: Summarizing impact matrix of all groups

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

The role of each of these variables – i) active, ii) reactive, iii) critical, iv) buffering, v) neutral – has been analysed as follows. According to Vester's original approach (Vester 1991; 2003), all participants should have discussed the relevance of all variables together in the workshop, to allow for a summarized evaluation and classification of their relevance in the overall system on the basis of the specific active and passive sums. Against the background of the first-time use of the method in this case study context, however, it was deviated from this in order to be able to implement and test the basic approach as simply and as low-threshold as possible with stakeholders. Depending on the experience with this initial application, it was originally planned to conduct a follow-up workshop in which the approach would be refined with additional stakeholders and applied in accordance with Vesters original approach. However, due to the Corona pandemic and the associated restrictions, this close exchange in the form of further workshops could not be carried out as planned. In order to nevertheless be able to derive initial results and insights into the overall relevance of the variables in the system, the results and assessments of the three subgroups were summarized in a comprehensive impact matrix. On the basis of this overall impact matrix, the specific active and passive sums have been calculated for the individual variables. This impact matrix and the corresponding results are shown in table 5.

Based on this, an allocation of the variables has been carried out in accordance with the five possible roles of the variables in the overall system, as outlined above (Vester 1991). Figure 2 shows this allocation. The difference of opinion concerning the variables maintenance and grid stability between publicly owned companies and private companies are visible again. Also, the two key climate parameters chosen by the workshop participants, wind speed and precipitation, have different roles in the system.

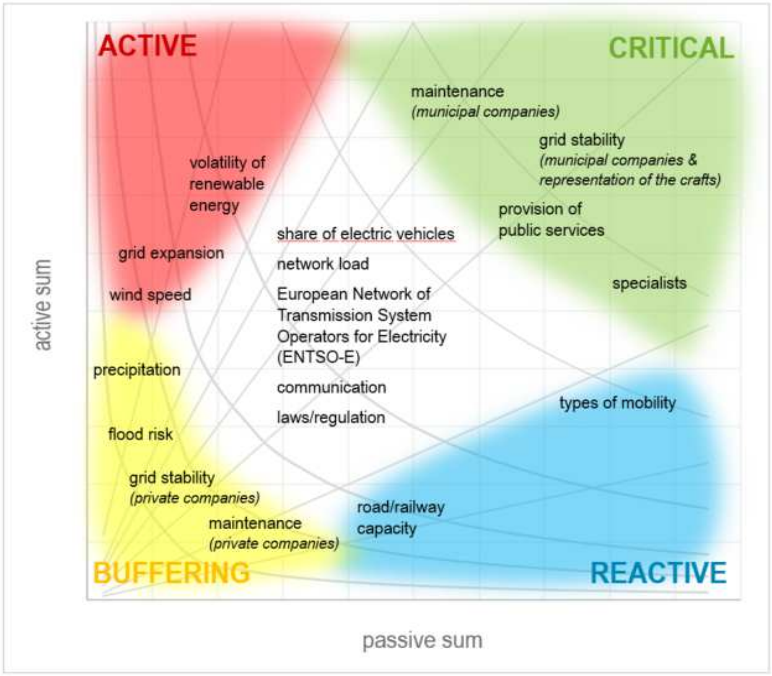


Fig. 2 – Assigned roles for each variable within the case study

Bases on these first results and experiences further need for research can be highlighted. So, for example, the relationships and interconnections between the variables should be investigated in more detail. Since the necessary data for this, might not be easily available, a first step could be to gather the experts' opinion and use a more qualitative approach, e.g. a Likert scale (Likert 1932) as a technique for the measurement of personal attitudes as well as a further development and testing of the paper computer concept by Vester (2003).

7 CONCLUSION

Enabling urban areas to adequately adapt to climate change with a focus on building and maintaining a resilient infrastructure and making cities and settlements safe, resilient and sustainable also requires fundamental transformations of central supply infrastructures as well as an improved understanding and comprehensive consideration of the interactions of these critical infrastructures under changing climatic

conditions. To systematically capture the complex interlinkages of different infrastructure sectors under current and future climatic conditions and to account for potential cascading effects, an impact matrix approach has been applied and presented in this paper.

The results show, that both the interviews as well as the workshop provided valuable insights regarding the specific relevance of cascading effects for the sectors energy, water and transport. However, the applied method also has its limitations, as – for example – at this early stage it was only based on the perspectives of a small group of stakeholders, so that results are specific to their circumstances. Yet, it is expected that the outcome will be at least in parts transferrable to other regions or other infrastructure operators. Secondly, in order to investigate cascading effects, the links between the variables need to be identified and verified. Furthermore, knowledge about the impact level of a certain degree of change in one variable on another and about the time sequence revolving around this change is necessary to interpret and evaluate different scenarios and adaptation measures. This is an essential challenge because of the lack of data for most of the interdependencies in the system.

Furthermore, instead of focusing on the quantification of the non-representative results of the qualitative feedback loops between energy, water and transport in this case-study, it is recommended to also carry out further interactions with stakeholders and to develop the methodological approach. As mentioned, a follow up activity and integration of stakeholders could be a sensible measure to defining the feedback loops more concretely, based on the consensus of all participants, instead of small and rather homogenious groups. This would also be a way to figure out, how a diffent mix of stakeholders could have impacts on the outcome. Also, the development of possible scenarios can be discussed in collaboration with the stakeholders in order to expand and complement those scenarios typical to research with the perspective from practice.

However, even if some limitations remain, the process of interacting with experts was received positively as the stakeholders have been integrated in the process from the beginning. Also, for most of them, it was more or less the first real in-depth approach to deal with the topics adaptation to climate change and climate change related cascading-effects in this context. Therefore, this approach should be seen as a promising methodological starting point and role model for a further integration of stakeholders addressing the growing need to understand and manage systemic risks better regarding critical infrastructures and cascading effects in order to increase resilience to climate change impacts in urban areas.

Thereby key aspects of the “Agenda 2030” (United Nations 2015) – mainly the need to build and maintain a resilient infrastructure (goal 9) and to make cities and settlements safe, resilient and sustainable (goal 11) – are addressed. Furthermore, this overall approach is already in line with the recent 2020 “New Leipzig Charter” (European Commission 2020b). Besides highlighting the need to activate the transformative power of cities, it clearly points out participation and co-creation as key principles of good urban governance in a sense that it requires the involvement of the general public as well as local experts – social, economic and other stakeholders – in order to consider their concerns and knowledge. Furthermore, the “New Leipzig Charter” clearly addresses the cities’ need for steerability and shaping of infrastructure, public services and public welfare. This includes services for health, social care, culture, water and energy supply, waste management, public transport, digital networks, information systems and public spaces as well as green and blue infrastructures (European Commission 2020b).

8 REFERENCES

Andersen DF, Richardson GP (1997): Scripts for group model-building. System Dynamics Review 13 (2): 107-129.

Andersen DF, Richardson GP, Vennix JAM (1997): Group Model-Building: adding more science to the craft. System Dynamics Review 13(2): 187-201.

Bar-Yam Y (2002): General Features of Complex Systems. Encyclopedia of Life Support Systems (EOLSS) Oxford.

BBK and BSI (2020): Schutz Kritischer Infrastrukturen. Gefahren, Strategien und rechtliche Grundlagen, Akteure, Aktivitäten und Projekte zum Schutz Kritischer Infrastrukturen in Deutschland. (BSI). Glossar: Kritische Infrastruktur.

Bérard C (2010): Group model building using system dynamics: an analysis of methodological frameworks. EJBRM 8 (1): 35-46.

BfG (2019): Das Niedrigwasser 2018. Bundesanstalt für Gewässerkunde. Koblenz.

BMI (2009): Nationale Strategie zum Schutz Kritischer Infrastrukturen (KRITIS-Strategie). Bundesministerium des Innern. Berlin.

Ciscar J-C, Dowling P (2014): Integrated assessment of climate impacts and adaptation in the energy sector. Energy Economics 46: 531-538.

EEA (2020): Urban adaptation in Europe: how cities and towns respond to climate change. EEA Report No 12/2020. Kopenhagen.

EEA (2019): Adaptation challenges and opportunities for the European energy system. Building a climate□resilient low□carbon energy system. EEA Report No 1/2019. Kopenhagen.

European Commission (2020a): Proposed Mission: A Climate Resilient Europe: Prepare Europe for climate disruptions and accelerate the transformation to a climate resilient and just Europe by 2030. Report of the Mission Board for Adaptation to Climate Change, including Societal Transformation.

European Commission (2020b): New Leipzig Charter- The transformative power of cities for the common good.

Eusgeld I, Nan C, Dietz S (2011): System-of-systems approach for interdependent critical infrastructures. Reliability Engineering System Safety 96 (6): 679-686.

Forrester JW (2007a): System dynamics—a personal view of the first fifty years. System Dynamics Review Vol. 23, No. 2/3, (Summer/Fall 2007): 345–358.

Forrester JW (2007b): System dynamics—the next fifty years. System Dynamics Review Vol. 23, No. 2/3, (Summer/Fall 2007): 359–370.

Forzieri G et al. (2018): Escalating impacts of climate extremes on critical infrastructures in Europe. Global Environmental Change 48: 97-107.

Frantzeskaki N, Loorbach D (2010): Towards governing infrasystem transitions: Reinforcing lock-in or facilitating change? Technological Forecasting and Social Change 77 (8): 1292-1301. doi:10.1016/j.techfore.2010.05.004.

Funabashi Y, Kitazawa K (2012): Fukushima in review: A complex disaster, a disastrous response. Bulletin of the Atomic Scientists 68 (2): 9-21.

Groth M, Bender S, Cortekar J, Remke T, Stankoweit M (2018): Auswirkungen des Klimawandels auf den Energiesektor in Deutschland. Zeitschrift für Umweltpolitik und Umweltrecht 3: 324-355.

Hänsel S, Herrmann C, Jochumsen K, Klose M, Nilson E, Norpoth M, Patzwahl R, Seiffert R (2019): Verkehr und Infrastruktur an Klimawandel und extreme Wetterereignisse anpassen. Bundesministerium für Verkehr und digitale Infrastruktur (BMVI). Berlin.

Hassel, H., Johansson, J., Cedergren, A., Svegrup, L., Arvidsson, B. (2014): Method to study cascading effects. Deliverable 2.1, Modelling of dependencies and cascading effects for emergency management in crisis situations (CascEff Project).

IPCC (2018): Global warming of 1.5°C. Special Report. IPCC with World Meteorological Organisation (WMO and United Nations Environmental Program (UNEP), 616 S. Geneva (2018).

Johansson J, Svegrup L, Arvidsson B, Jangefelt J, Hassel H, Cedergren A (2015): Review of previous incidents with cascading effects.

Karagiannis GM, Chondrogiannis S, Krausmann E, Turksezer ZI (2017): Power grid recovery after natural hazard impact, JRC Science for Policy Report No EUR 28844 EN. Publications Office of the European Union. Luxembourg. doi:10.2760/87402.

Laugé A, Hernantes J, Sarriegi JM (2015): Critical infrastructure dependencies: A holistic, dynamic and quantitative approach. International Journal of Critical Infrastructure Protection 8: 16-23. doi:10.1016/j.ijcip.2014.12.004.

Leventon J, Fleskens L, Claringbould H, Schwilch G, Hessel R (2016): An applied methodology for stakeholder identification in transdisciplinary research. Sustainability Science 11: 763-775. doi:10.1007/s11625-016-0385-1.

Likert R. (1932): A technique for the measurement of attitudes. Archives of Psychology, 22 140, 55.

Lückerath D, Olfert A, Milde K, Ullrich O, Rome E, Hutter G (2020): Assessment of and tools for improving climate resilience of infrastructures: Towards an ERNCIP Thematic Group. Input Paper.

Lugo AE (2019): Social-Ecological-Technological Effects of Hurricane María on Puerto Rico. Planning for Resilience under Extreme Events. Springer International Publishing. Cham.

Luiijf HAM, Nieuwenhuijs AH, Klaver M, van Eeten MJG, Cruz E (2010): Empirical Findings on European Critical Infrastructure Dependencies. International Journal of System of Systems Engineering 2 (1): 3-18. doi:10.1504/IJSSE.2010.035378.

Meadows, D (2008): Thinking in systems: a primer / Donella H. Meadows; edited by Diana Wright. p. cm. White River Junction, VT, USA: Chelsea Green Publishing.

Meadows DH, Meadows DL, Randers J, Behrens III WW (1972): The Limits to Growth; A Report for the Club of Rome's Project on the Predicament of Mankind. New York: Universe Books. ISBN 0876631650.

Meusel D, Kirch W (2005): Lessons to be Learned from the 2002 Floods in Dresden, Germany. In: Kirch W, Bertollini R, Menne B (Hrsg) Extreme Weather Events and Public Health Responses. Springer. Berlin, Heidelberg, S 175-183.

Mikellidou CV, Shakou LM, Boustras G, Dimopoulos C (2018): Energy critical infrastructures at risk from climate change: A state of the art review. Safety Science 110: 110-120.

Moss T (2014): Socio-technical Change and the Politics of Urban Infrastructure: Managing Energy in Berlin between Dictatorship and Democracy. Urban Studies 51 (7): 1432-1448.

Nilson E, Astor B, Bergmann L, Fischer H, Fleischer C, Haunert G, Helms M, Hillebrand G, Höpp S, Kikillus A, Labadz M, Mannfeld M, Razafimaharo C, Patzwahl R, Rasquin C, Rauthe M, Riedel A, Schröder M, Schulz D, Seiffert R, Stachel H, Wachler B, Winkel N (2019): Beiträge zu einer verkehrsträgerübergreifenden Klimawirkungsanalyse: Wasserstraßenspezifische Wirkungszusammenhänge. Bundesministerium für Verkehr und digitale Infrastruktur (BMVI). Berlin.

Reed MS, Graves A, Dandy N, Posthumus H, Hubacek K, Morris J, Prell C, Quinn CH, Stringer LC (2009): Who's in and why? A typology of stakeholder analysis methods for natural resource management. Journal of Environmental Management 90 (5): 1933-1949.

Rinaldi SM, Peerenboom JP, Kelly T K (2002): 'Identifying, understanding, and analyzing critical infrastructure interdependencies', IEEE Control Systems, 21(6), pp. 11–25.

Siokou C, Morgan R, Shiell A (2014): Group model building: a participatory approach to understanding and acting on systems. Public Health Research and Practice 25 (1): e2511404.

Sterman, JD (2001): System Dynamics Modeling: Tools for Learning in a Complex World. California Management Review, 43(4), 8–25.

United Nations (2015): Transforming our world: the 2030 Agenda for Sustainable Development.

Vennix J (1996): Group model building: facilitating team learning in system dynamics. Hoboken, NJ: John Wiley and Sons Ltd.

Vester F (2003): Die Kunst vernetzt zu denken. Ideen und Werkzeuge für einen neuen Umgang mit Komplexität. Der neue Bericht an den Club of Rome. Munich: dtv. 3rd edition.

Vester F (1991): Material zur Systemuntersuchung: Ausfahrt Zukunft Supplement, München, p. 96.

🏆 *reviewed paper*

„Black Box Babyboomer" – Was kommt auf Kommunen zu? Decision Support System mit Hilfe mathematischer Erreichbarkeitsmodellierung medizinischer Versorgungsstandorte

Marvin Stiewing, Tobias Weber, Kirsten Mangels, Stefan Ruzika, Nicolas Fröhlich, Nils Hausbrandt

(MSc. Marvin Stiewing, Lehrstuhl Regionalentwicklung und Raumordnung, TU Kaiserslautern, Pfaffenbergstraße 95, 67663 Kaiserslautern, marvin.stiewing@ru.uni-kl.de)
(MSc. Tobias Weber, Lehrstuhl Regionalentwicklung und Raumordnung, TU Kaiserslautern, Pfaffenbergstraße 95, 67663 Kaiserslautern, tobias.weber@ru.uni-kl.de
(Dr.-Ing. Kirsten Mangels, Lehrstuhl Regionalentwicklung und Raumordnung, TU Kaiserslautern, Pfaffenbergstraße 95, 67663 Kaiserslautern, kirsten.mangels@ru.uni-kl.de)
(Prof. Dr. Stefan Ruzika, AG Optimierung, TU Kaiserslautern, Paul-Ehrlich-Straße 14, 67663 Kaiserslautern, ruzika@mathematik.uni-kl.de)
(Dr. Nicolas Fröhlich, AG Optimierung, TU Kaiserslautern, Paul-Ehrlich-Straße 14, 67663 Kaiserslautern, fröhlich@mathematik.uni-kl.de)
(MSc. Nils Hausbrandt, AG Optimierung, TU Kaiserslautern, Paul-Ehrlich-Straße 14, 67663 Kaiserslautern, nils.hausbrandt@mathematik.uni-kl.de)

1 ABSTRACT

Lebensqualität in ländlichen Räumen ist insbesondere daran geknüpft, welche Angebote der Daseinsvorsorge vor Ort bestehen oder in angemessener Zeit erreichbar sind. Ein Aspekt gleichwertiger Lebensverhältnisse ist eine gleichwertige Gesundheitsversorgung. Gerade die ambulante medizinische Versorgung nimmt vor dem Hintergrund einer im Zuge des demografischen Wandels älter werdenden Gesellschaft eine Schlüsselrolle ein. Das bevorstehende Rentenalter der Generation der Babyboomer aus den geburtenstarken Jahrgängen 1955 bis 1969 mit jeweils mehr als einer Million Geburten pro Jahr droht in Deutschland je nach lokaler Ausprägung der Bevölkerungsstruktur die Versorgungssituation vor allem in ländlich geprägten Gemeinden zusätzlich zu verschärfen. Die durch Alterungsprozesse steigende Anzahl älterer Menschen führt zu einer entsprechenden Erhöhung der Krankheitslast und einem steigenden Bedarf an medizinischer Versorgung.

Niedergelassene Ärztinnen und Ärzte bilden hierbei das Rückgrat einer bedarfsgerechten flächenhaften Versorgung, von denen wiederum die Hausärztinnen und Hausärzte als Generalisten mit kleinräumiger Verteilungsstruktur erster Ansprechpartner für Patientinnen und Patienten sind. Gleichzeitig gehören viele Ärztinnen und Ärzte heute selber zur Generation der Babyboomer. Trotz angestrebter Gleichwertigkeit verdeutlichen Analysen der Hausarztdichte und der durchschnittlichen Erreichbarkeit von Hausarztpraxen bereits heute große regionale und lokale Disparitäten.[1] Die flächendeckende Sicherstellung der hausärztlichen Versorgung droht damit vor allem in ländlichen Räumen mit niedriger Bevölkerungsdichte zu einer nahezu unlösbaren Herausforderung zu werden. Gleichzeitig setzt eine geringere Bevölkerungsdichte eine gewisse räumliche Größe der Einzugsbereiche von Praxen voraus, um einen wirtschaftlichen Betrieb gewährleisten zu können. Durch Verlängerung der Anfahrtswege, welche im ländlichen Raum ohnehin eine Hürde darstellen, wird der Zugang zu medizinischen Angeboten gerade für mobilitätseingeschränkte Menschen zusätzlich erschwert.

Bisher existiert wenig Datenmaterial zu dem Wohnstandortverhalten der Babyboomer nach ihrer Verrentung. Hier setzt der interdisziplinäre Forschungsansatz des von der Carl-Zeiss-Stiftung geförderten Projektes "Ageing Smart - Räume intelligent gestalten" an.[2] Ein Teilprojekt des Forschungsverbunds beschäftigt sich mit der Gesundheitsversorgung in insgesamt vier ausgewählten Modellkommunen im suburbanen und ruralen Raum und untersucht dort die Erreichbarkeit von Einrichtungen der Gesundheitsversorgung als wichtigen Wohnstandortwahlfaktor. Perspektivisch wird das Teilprojekt über Befragungen auch das künftige Wohnstandortverhalten der Babyboomer sowie die sich daraus ergebende Bedeutung der Erreichbarkeit der Einrichtungen untersuchen. Dieser Beitrag thematisiert die Generierung von Zukunftsszenarien zur Entscheidungsunterstützung mit Hilfe datenbasierter, auf mathematischer Optimierung beruhender Erreichbarkeitsmodelle für oben genannte medizinische Einrichtungen sowie deren konkreten Nutzen wie beispielsweise das Aufzeigen von Lücken innerhalb der derzeitigen Versorgungslandschaft oder eine Resilienzabschätzung der einzelnen Versorgungsstandorte hinsichtlich der zunehmenden Überalterung.

[1] BMI (2020): Deutschlandatlas - Karten zu gleichwertigen Lebensverhältnissen. S.76ff.
[2] siehe auch: Technische Universität Kaiserslautern, Homepage „Ageing Smart – Räume intelligent gestalten" unter https://www.ageing-smart.de/

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Keywords: Babyboomer, Daseinsvorsorge, Gesundheitsversorgung, mathematiches Erreichbarkeitsmodell, Entscheidungsunterstützung

2 BABYBOOMER UND IHRE BEDEUTUNG FÜR DIE SICHERUNG DER GESUNDHEITS-VERSORGUNG

2.1 Forschungsansatz im Carl-Zeiss-Projekt „Ageing Smart – Räume intelligent gestalten"

2.1.1 Aufbau und Zielsetzung des Gesamtprojekts

Das von der Carl-Zeiss-Stiftung und der Technischen Universität Kaiserslautern über einen Zeitraum von fünf Jahren geförderte Forschungsprojekt „Ageing Smart – Räume intelligent gestalten" adressiert die geburtenstarken Jahrgänge 1955 bis 1969 und führt in einem integrierten Ansatz erstmals raumplanerische und versorgungsseitige Ansätze sowie spezifische Bedarfe der „Babyboomer" und Handlungserfordernisse bzw. -möglichkeiten der Kommunen zusammen.

Das interdisziplinäre Forschungsvorhaben, welches im universitären Potentialbereich „Region und Stadt" der Technischen Universität Kaiserslautern angesiedelt ist, gliedert sich in zehn Teilprojekte der Disziplinen Raumplanung, Stadtsoziologie, Klimatologie, Informatik und Mathematik und wird federführend am Fachgebiet Stadtsoziologie unter Prof. Dr. Annette Spellerberg koordiniert. Im Mittelpunkt stehen dabei zunächst drei prägnante Untersuchungsfelder. Diese sind

- Wohnstandorte und damit verbundene Anforderungen an Angebote im Wohnumfeld und die Mobilität,
- das Verhalten hinsichtlich Freizeit- und Erholungsaktivitäten sowie
- die Versorgung mit medizinischen und damit verbunden Gesundheitsinfrastrukturen und Dienstleistungen.

Als Modellkommunen ausgewählt wurden die Landstadt Geisa und die Verbandsgemeinde Kusel-Altenglan (rural), die Gemeinde Remshalden und die Verbandsgemeinde Nieder-Olm (suburban) sowie die Städte Jena, Kaiserslautern und Mannheim (urban) in Baden-Württemberg, Rheinland-Pfalz und Thüringen.

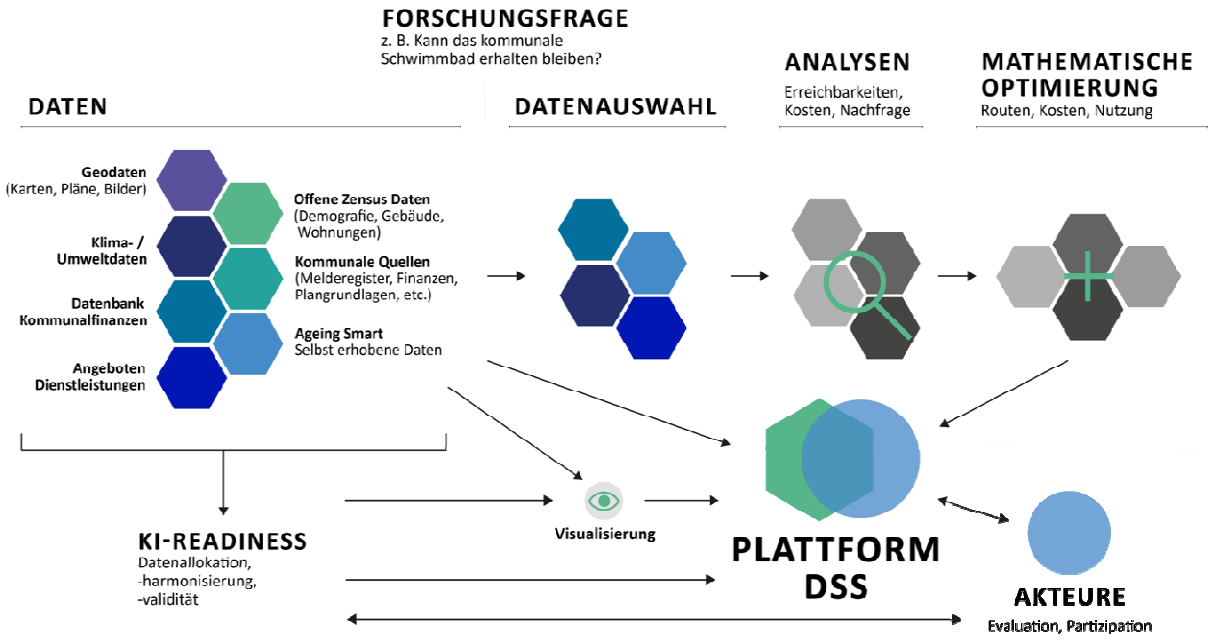


Abb. 1: Methodik und Prozessübersicht des Forschungsprojekts "Ageing Smart – Räume intelligent gestalten".

Langfristiges Ziel des Vorhabens ist die Entwicklung eines daten-, IT- und KI-basierten Systems zur Entscheidungsunterstützung (Decision Support System = DSS, siehe Abb. 1), welches von öffentlichen Akteuren in ihrem Planungs- und Entscheidungsprozess herangezogen werden kann. Infrastrukturen,

Angebote und Dienstleistungen sollen so nachfragegerecht, tragfähig und zukunftsorientiert entwickelt werden können, um die Lebensqualität der Babyboomer und perspektivisch der Gesamtbevölkerung zu sichern und zu fördern.

2.1.2 Forschungsansatz im Teilprojekt "Gesundheitsversorgung"

Als wesentlicher Aspekt der Daseinsvorsorge widmet sich das Teilprojekt „Gesundheitsversorgung", das am Lehrstuhl Regionalentwicklung und Raumordnung unter Leitung von Univ.-Prof. Dr. habil. Gabi Troeger-Weiß und Dr.-Ing. Kirsten Mangels bearbeitet wird, der hausärztlichen, zahnärztlichen sowie allgemeinen fachärztlichen Versorgung in den insgesamt vier ruralen und suburbanen Modellkommunen.

Nach der zu Beginn des Projekts erfolgten Konkretisierung von Untersuchungsfeldern mit Abgrenzung der forschungsleitenden Fragestellungen, einer breiten Literaturrecherche zu den Themen Babyboomern und Gesundheitsversorgung sowie einer internen Strukturanalyse der Modellkommunen stehen

- die aktuelle Wohnsituation und das perspektivische Wohnstandortverhalten der Babyboomer sowie
- deren spezifisches Gesundheitsverhalten und deren Anforderungen an Erreichbarkeit und Ausgestaltung der medizinsichen Versorgung

im Fokus. Ein Baustein zur Generierung neuer Daten ist dabei neben der Befragung relevanter Stakeholder aus dem Gesundheitsbereich die teilstandardisierte Befragung der Babyoomer in den ruralen und suburbanen Modellkommunen Kusel-Altenglan, Geisa, Nieder-Olm und Remshalden. Die Analyse der Wünsche und Bedarfe dient der Beantwortung relevanter Fragestellungen für deren Einspeisung in das projektierte DSS, insbesondere mit Blick auf eine steigende Nachfrage bei gleichzeitig geringerem verfügbaren Angebot. Eine besondere Relevanz gewinnt dabei die Erreichbarkeit der einzelnen medizinischen Standorte, weshalb die Erarbeitung eines dynamischen Erreichbarkeitsmodells als interdisziplinärer Querschnittsansatz aus Raumplanung und Mathematik ein vielversprechender Forschungsansatz darstellt.

2.2 Babyboomer – Kohorte mit Sprengkraft für Infrastrukturen

Planungen und (politische) Entscheidungen mit Auswirkungen auf räumliche Strukturen sind stets abhängig von raumrelevanten Trends und Entwicklungen. Einer der bedeutendsten globalen Transformationsprozesse ist nach wie vor der demografische Wandel. Dieser umfasst im Wesentlichen die Veränderung der Bevölkerung in der Größe, Zusammensetzung und der räumlichen Verteilung mit maßgeblichem Einfluss auf die gesellschaftliche Entwicklung in ökonomischer, sozialer und kultureller Hinsicht. Die Herausforderungen dieser Veränderungen in Deutschland werden in Zukunft erhebliche Abweichungen zwischen Regionen vergleichbarer und unterschiedlicher Größe und Siedlungsstruktur aufweisen und regional angepasste Lösungsansätze fordern.[3] Die Raumplanung ist daher auf allen Ebenen gefordert, auf die Veränderungen der demografischen Situation in Deutschland lokal angepasst zu reagieren.

Eine Besonderheit mit aktueller Relevanz stellt die in diesem Beitrag thematisierte Kohorte der sogenannten „Babyboomer" dar. Diese Alterskohorte umfasst die geburtenstarken Jahrgänge 1955 bis 1969 und wurde zu Zeiten hoher Geburtenraten (dem „Babyboom") während des wirtschaftlichen Aufschwungs nach dem Zweiten Weltkrieg geboren. Diese Generation der heute etwa 52- bis 67-Jährigen ist damit deutlich in der Bevölkerungspyramide Deutschlands zu erkennen und stellt rund ein Viertel der Gesamtbevölkerung. Mit Blick auf die VG Kusel-Altenglan liegt der Anteil der Babyboomer zudem mit insgesamt 26,4% und teils über 30 % deutlich höher (siehe Abb. 2)[4] Durch deren hohe Zahl waren Kommunen bereits in früheren Jahrzehnten gefordert, eine ausreichende Anzahl an Plätzen in Betreuungs- und Bildungseinrichtungen sicherzustellen und anschließend Folgelösungen für die darauffolgenden, zahlenmäßig weit unterlegenen, Alterskohorten zu finden. Aktuell ist die Generation der Babyboomer noch vielfach in gesellschaftlichen Strukturen verankert, etwa bezogen auf Arbeitskraft, Ehrenamt, Politik oder im Gesundheitssystem – sukzessive ist aber deren Ausscheiden durch die Verrentung absehbar, was Kommunen nun erneut vor strukturelle Herausforderungen stellt. Zu nennen ist hier etwa die Schaffung altersgerechter Wohnstandorte

[3] GANS, Paul (2018): Demografischer Wandel, In Akademie für Raumforschung und Landesplanung (Hrsg.) Handwörterbuch der Stadt- und Raumentwicklung. S. 376.

[4] STEFAN, Benjamin/LOEPPKE, Yannick/SPELLERBERG, Annette (2022): Babyboomer in Deutschland – demografische, soziale und räumliche Differenzierungen. Analysen auf Basis des sozioökonomischen Panels 2019. S.1f.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

und Versorgungstrukturen sowie die Schließung entstehender Lücken im Arbeitsmarkt mit entsprechenden Fachkräften. Bezogen auf den Gesundheitsbereich sind die Babyboomer auf der Nachfrage- und der Angebotsseite bisher gleichermaßen stark vertreten, wobei künftig jedoch eine Entwicklung zu Ungunsten der Angebotsseite absehbar ist.

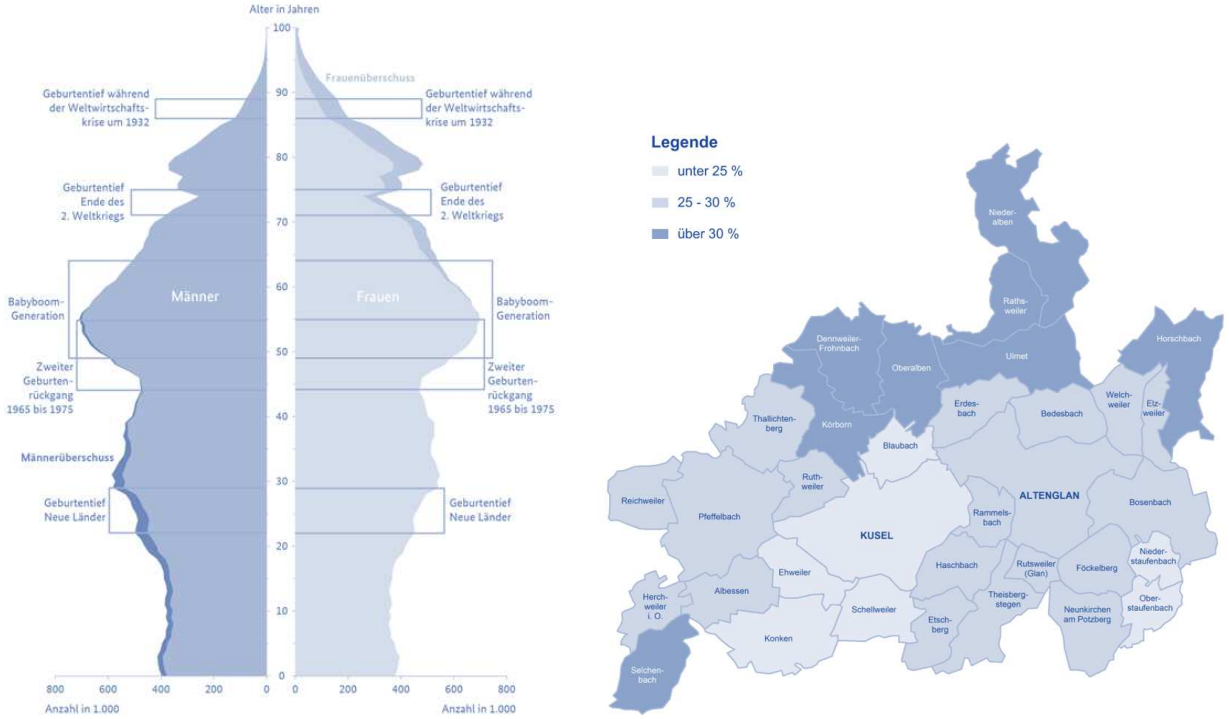


Abb. 2: Altersaufbau der Bevölkerung in Deutschland nach demografischen Ereignissen (links)[5] und Anteil der Babyboomer an der Gesamtbevölkerung in der VG Kusel-Altenglan, Rheinland-Pfalz (rechts).[6]

Sowohl mit Blick auf den Alterungsprozess als auch auf unterschiedliche Lebenslagen, -formen und -stile handelt es sich bei den Babyboomern um eine überaus heterogene Gruppe. Über deren Wohnwünsche und Ansprüche an (Wohn-)Standorte, Mobilität, Einstellungen und Verhaltensweisen ist jedoch bislang vergleichsweise wenig bekannt. Lediglich einige demografische, soziale und räumliche Differenzierungen zur Kohorte der Babyboomer lassen sich durch Analyse des sozio-ökonomischen Panels 2019 vornehmen. Wahrscheinlich ist beispielsweise durch die steigende Lebenserwartung und bessere Gesundheit sowie ein höheres Engagement der Babyboomer, dass große Teile der Kohorte ihren Ruhestand aktiv und kreativ nutzen werden, wodurch auch von einer Veränderung der Wohnbedürfnisse auszugehen ist. Darüber hinaus können die Babyboomer durch deren bessere Bildung und mit Blick auf die zeitlichen Rahmenbedingungen als erste Generation bezeichnet werden, die mit dem raumwirksamen Megatrend Digitalisierung konfrontiert wurde und sich mehr als andere Jahrgänge bei Renteneintritt vergleichsweise digital affin darstellt.[7]

Wenn Kommunen die künftigen Rentnerinnen und Rentner bei der Anpassung ihrer Lebenssituation optimal begleiten wollen, spielen somit vielfältige Aspekte eine Rolle. Mit Blick auf das Teilprojekt ergibt sich ein Fokus auf der klassisch standortgebundenen sowie digitalen und mobilen Gesundheitsversorgung (Angebot und Nachfrage) einerseits und den verkehrlichen Infrastrukturen zur Gewährleistung von individueller Mobilität und Erreichbarkeit der Einrichtungen andererseits. Konkret gilt es, die Bedürfnisse der alternden Menschen, die Raumentwicklung und die Versorgungsmöglichkeiten vor Ort in Einklang zu bringen.

Die Fragen, die die Raumentwicklung in ihrer politikberatenden Rolle, die Politik selbst oder Fachplanungen in Zukunft beschäftigen, beziehen sich dementsprechend auf Standortwahlfaktoren für Wohnstandorte, das Mobilitätsverhalten, Ansprüche und Anforderungen an die Gesundheitsversorgung und Angebote im Wohnumfeld der Babyboomer sowie die jeweiligen Handlungsmöglichkeiten der Politik sowie ihrer Einschätzung und Bewertung: Wie können die Standorte medizinischer Versorgung sinnvoller festgelegt

[5] Eigene Darstellung nach Bundesinstitut für Bevölkerungsforschung (BiB) (o.J.).
[6] Eigene Darstellung nach Statistisches Landesamt Rheinland-Pfalz (o.J.).
[7] STEFAN, Benjamin/LOEPPKE, Yannick/SPELLERBERG, Annette (2022): Babyboomer in Deutschland – demografische, soziale und räumliche Differenzierungen. Analysen auf Basis des sozioökonomischen Panels 2019. S. 3.

werden? Wie können kommunale Finanzen heute für morgen optimal eingesetzt werden? Bleiben die „jungen Alten“ im Ort wohnen? Welche Standortfaktoren sind für welche Akteure relevant? Wie können Erreichbarkeiten gewährleistet und verbessert werden?

2.3 Gesundheitsversorgung und deren künftige Herausforderungen

„Jeder Mensch hat das Recht auf das höchste erreichbare Maß an körperlicher und geistiger Gesundheit.“[8] – So beschreibt Artikel 12 Absatz 1 des UN-Sozialpaktes neben des individuellen gesundheitlichen Anspruchs eines Einzelnen der Auftrag zur Schaffung entsprechender Rahmenbedingungen. Adressat dieses Auftrags sind in erster Linie verantwortliche Akteure aus dem Gesundheitssektor. Mit Blick auf die Raumentwicklung und die damit verbundene Aufgabe zur Sicherung der Daseinsvorsorge[9] adressiert dieser hingegen auch die Raumplanung. Gesundheitsversorgung stellt dabei nicht nur einen Baustein der Daseinsvorsorge dar, welche die Voraussetzung zur Herstellung gleichwertiger Lebensverhältnisse in allen Teilräumen Deutschlands ist. Gleichzeitig ist Gesundheit als ein Teilaspekt der objektiven Lebensverhältnisse unmittelbar an die eigene Lebensqualität geküpft.[10]

Das weitgehend unabhängig von der Raumplanung bestehende Gesundheitssystem in Deutschland teilt sich in einen stationären (insbesondere Kliniken) und ambulanten Versorgungsbereich. Eine besondere Rolle nehmen in diesem System die kassen(zahn)ärztlichen Vereinigungen als übergeordnete Institutionen ein. Neben der Versorgungsforschung stellt dabei die koordinierende Bedarfsplanung, welche die am räumlichen Bedarf orientierte Verteilung der Ärzte regelt, ein wichtiges Instrument dar. Sie orientiert sich am System der zentralen Orte und weist damit einen weiteren Bezug zur Raumordnung auf, die dadurch indirekt auf die Gesundheitsversorgung einwirkt.

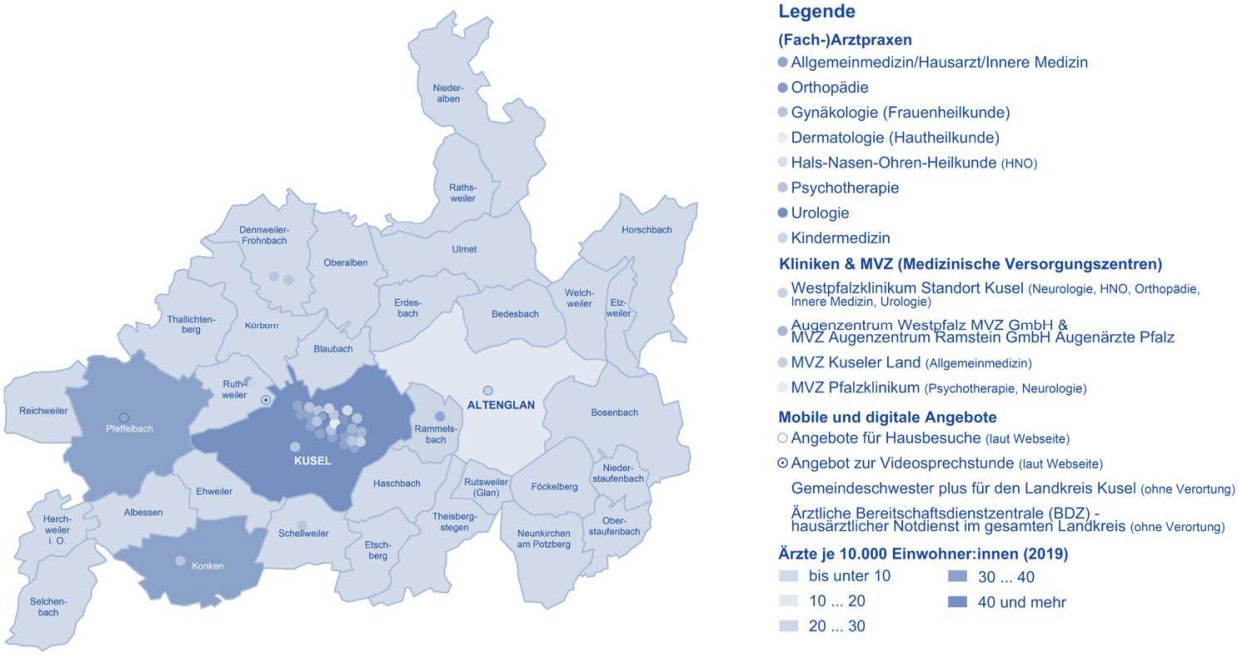


Abb. 3: Ärzte je 10.000 Einwohnerinnen und Einwohner und Ballung medizinischer Einrichtungen innerhalb der VG Kusel-Altenglan.[11]

Im Bereich der ambulanten Versorgung ist insbesondere der Zugang zu Hausärztinnen und Hausärzten von besonderer Relevanz. Mit ihrem engen Vertrauensverhältnis sowie der Funktion als erste Anlaufstelle eines breiten Patientenstamms und allgemeinmedizinischer Allrounder gelten sie daher als Kern des deutschen Gesundheitswesens.[12] Eine ausreichende Zahl der Praxen mit einer räumlichen Verteilung und wohnortnahen

[8] vgl. Art. 12 Abs. 1, Internationaler Pakt über wirtschaftliche, soziale und kulturelle Rechte (ICESCR).
[9] vgl. §2 Abs. 2 Nr. 3 Raumordnungsgesetz (ROG).
[10] vgl. SPELLERBERG, Annette (1996): Soziale Differenzierung durch Lebensstile: Eine empirische Untersuchung zur Lebensqualität in West- und Ostdeutschland. S. 51.
[11] Eigene Darstellung nach Das Örtliche Service- und Marketing GmbH (o.J.) / Google (2022) / BBSR (o.J.) / Kassenärztliche Bundesvereinigung (2022).
[12] BMG (o.J): Hausarztsystem.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

hausärztlichen Versorgung ist dabei unerlässlich für die Gewährleistung der medizinischen Daseinsvorsorge. Hausärztliche Praxen sollen dementsprechend mit einer 15-minütigen Pkw-Erreichbarkeit flächendeckend im Raum erreichbar sein.[13]

Die Analyse der Erreichbarkeit hausärztlicher Praxen zeigt jedoch bereits heute das Bild einer teilräumlichen Unterversorgung – vor allem in ländlichen, suburbanen sowie schrumpfenden Regionen ergeben sich dabei Herausforderungen. In der VG Kusel-Altenglan besteht so heute eine Ballung medizinischer Einrichtungen im Mittelzentrum Kusel während die meisten Ortsgemeinden keine Praxis und damit einen Versorgungsgrad von unter zehn Ärztinnen und Ärzten auf 10.000 Einwohnerinnen und Einwohner aufweisen (siehe Abb. 3).

Allgemein verlaufen Alterungsprozesse in hohem Maße unterschiedlich – während die einen etwa bis ins hohe Alter körperlich wie geistig agil bleiben, benötigen andere zunehmend Unterstützung, um ihren Alltag bewältigen zu können. Von Bedeutung sind hierbei auch gesundheitserhaltende Rahmensetzungen wie die Einbindung in stabile soziale Netzwerke oder die Teilhabe am öffentlichen Leben. Mit zunehmenden Alter steigt aber die Wahrscheinlichkeit für eine Vielzahl von Erkrankungen mit teils chronischem Verlauf sowie das Auftreten neuer Symptome bei länger bestehenden Erkrankungen. [14]

Herausforderungen ergeben sich damit auch durch die Masse der Babyboomer, die mit zunehmendem Alter und entsprechender Verrentung stärker als Patient und weniger als praktizierende Hausärztinnen und Hauärzte auftreten. Folge des erhöhten Behandlungsbedarfs und der gleichzeitigen Verringerung des medizinischen Versorgungs-Angebots ist ein zunehmender Behandlungsdruck auf die verbleibenden Praxen. Ebenso wirken sich eine sukzessive Einschränkung des Aktivitätsradius im Alter und Einschränkungen in der individuellen Mobilität auf die Erreichbarkeit medizinischer Einrichtungen aus. Mit Blick auf die Babyboomer zeigt sich insgesamt, dass sich 22 % große, 57 % einige und 21 % keine Sorgen um die eigene Gesundheit(sversorgung) machen, erstere insbesondere in Ostdeutschland sowie im ländlichen Raum.[15]

Während der demografische Wandel die konventionelle medizinische Versorgungslandschaft in Deutschland damit vor große Herausforderungen stellt, ergeben sich ebenso Chancen durch den digitalen Wandel und die zunehmende Digitalisierung in Wirtschaft und Gesellschaft. Im Bereich der Gesundheitsversorgung sind vor allem digital gestützte Versorgungsstrukturen („E-Health", Telemedizin) sowie mobile Angebotsformen der Beratung und Behandlung zu nennen. In der VG Kusel-Altenglan scheinen gerade digitale Angebote bisher jedoch nur eine untergeordnete Rolle einzunehmen (siehe Abb. 3). Mit Blick auf die Babyboomer ist sowohl über deren Gesundheitszustand als auch über deren Anforderungen an die medizinische Versorgung wenig bekannt. Gleiches gilt für die Aufgeschlossenheit gegenüber digitalen oder mobilen Angebotsformen.

3 MATHEMATISCHE ERREICHBARKEITSMODELLIERUNG ALS FORSCHUNGSANSATZ

3.1 Warum mathematische Erreichbarkeitsmodellierung?

Während Stadt- und Regionalplanerinnen sowie Stadt- und Regionalplaner oft als Generalisten betrachtet werden, denen eine tiefergehende Nähe zur Mathematik meist abgesprochen wird, erscheint die interdisziplinäre Kooperation zwischen Planung und Mathematik schon für sich und gerade mit Blick auf die sich im Projekt ergebenden Fragstellungen vielversprechend. So bietet das mathematische Ereichbarkeitsmodell zum einen ein intuitiv bedienbares Analysetool, mit dem die Erreichbarkeit hausärztlicher, zahnärztlicher und allgemein fachärztlicher Praxen sowie von Krankenhäusern und Apotheken in und aus den einzelnen Ortsgemeinden dargestellt werden können. Dies gilt sowohl für den Status Quo und den zeitlichen Verlauf der letzten (zehn) Jahre als auch für die Vorausberechnung künftiger Erreichbarkeiten auf Basis der zugrundeliegenden Daten. Auf dieser analytischen Grundlage lassen sich dann zum anderen eine Vielzahl planerischer Fragestellungen bearbeiten. Denkbar ist etwa das Aufzeigen bestehender und künftiger Lücken in der Versorgungslandschaft sowie die Abschätzung der Resilienz der Vertragsärztelandschaft gegenüber altersbedingten Problemen bei der Nachbesetzung anhand des Praxistyps.

[13] SUNDMACHER, Leonie/BRECHTEL, Thomas et al. (2018): Gutachten zur Weiterentwicklung der Bedarfsplanung i.S.d. §§ 99 ff. SGB V zur Sicherung der vertragsärztlichen Versorgung

[14] BZGA (2020): 20 Empfehlungen für Gesundheit und Lebensqualität im Alter. S. 1-7 und S. 28-34.

[15] STEFAN, Benjamin/LOEPPKE, Yannick/SPELLERBERG, Annette (2022): Babyboomer in Deutschland – demografische, soziale und räumliche Differenzierungen. Analysen auf Basis des sozioökonomischen Panels 2019. S. 45.

3.2 Methodik und Kooperationsprozess zwischen Raumplanung und Mathematik

Das Erreichbarkeitsmodell geht aus einer Kooperation des Lehrstuhls Regionalentwicklung Raumordnung im Fachbereich Raum- und Umweltplanung sowie der AG Optimierung unter Prof. Dr. Stefan Ruzika am Fachbereich Mathematik der Technischen Universität hervor. Zu Beginn der Arbeit an dem gemeinsamen Modell wurde zunächst die Verbandsgemeinde Kusel-Altenglan als eine der Modellkommunen im Projekt ausgewählt. Die planerische Aufgabe besteht hierbei zum einen in der Beschaffung relevanter Daten (z.B. zur medizinischen Versorgung, Ergebnisse aus der Befragung) sowie der Recherche und Auswahl relevanter Parameter und Rahmenbedingungen. Zum anderen erfolgt aus planerischer Sicht die Definition konkreter Fragestellungen und Darstellungsarten, auch im Hinblick auf die Einspeisung der Ergebnisse in das spätere DSS. Einschlägige Parameter für das mathematische Erreichbarkeitsmodell bestehen in den Bereichen Fußverkehr, (elektrifizierter) Radverkehr, öffentlicher Personennahverkehr mit den Verkehrsträgern Bus und Bahn sowie dem motorisierten Individualverkehr mit dem Pkw. Die Auswahl dieser Parameter stützt sich dabei auf die Abstimmung mit dem Institut für Mobilität und Verkehr (imove) im Fachbereich Bauingenieurswesen der TUK sowie der Auswertung entsprechender Fachliteratur und verkehrsplanerischer Erhebungen (z.B. Richtlinien für integrierte Netzwerkgestaltung RIN, Empfehlungen für Anlagen des öffentlichen Personennahverkehrs EAÖ).[16] Insbesondere herangezogen werden Daten und Richtwerte zu

- differenzierten Geh-, Fahr- und Reisegeschwindigkeiten der einzelnen Verkehrsträger,
- Toleranzen hinsichtlich der jeweils zurückzulegenden Distanzen sowie
- Umsteigezeiten, -widerständen und Takthäufigkeiten im ÖPNV.

Die Mathematik hingegen beschäftigt sich mit der Erarbeitung des dem Ereichbarkeitsmodell zu Grunde liegenden Algorithmus sowie der Aufbereitung der Daten und Verküpfung dieser mit dem Algorithmus. Weiterhin übersetzt die Mathematik die „Wünsche“ und Anforderungen der Planung und speist diese in das Modell ein. Grundlage für die Berechnungen bildet das Straßennetz einschließlich dessen Knotenpunkte.

3.3 Mathematische Modellierung

In diesem Abschnitt wird beschrieben, wie aus der realen Fragestellung und den vorhandenen Daten ein mathematisches Modell entsteht. Dazu erfolgt lediglich die Beschreibung der einschlägigen Konzepte, auf tiefergehende mathematische Details wird an dieser Stelle verzichtet.

Ein *intermodales zeitabhängiges Netzwerk* ist ein gerichteter Multi-Graph $G = (V, E)$ mit nichtleerer Knotenmenge V und Kantenmenge E, wobei jeder Kante $e \in E$ ein Verkehrsmittellabel $l(e) \in \{f, b, c, b\}$ (stellvertretend für „foot“, „bike“, „car“, „bus“) zugeordnet ist. Für einen diskreten Zeithorizont $\{0,1, \dots, T\}$ habe $e \in E$ zum Zeitpunkt $t \in \{0,1, \dots, T\}$ zudem eine nicht-negative Reisezeit von $c(e,t)$.

Die reale Situation wird nun wie folgt in solch ein mathematisches Netzwerk überführt: Existierende Straßenkreuzungen sowie mögliche Wechselstellen von Verkehrsmitteln (z.B. Bushaltestellen) werden zu Knoten im mathematischen Netzwerk. Diese werden nun durch gelabelte gerichtete Kanten sinnhaft verbunden: Kann etwa von einer Kreuzung zur nächsten Kreuzung gelaufen werden, werden die beiden entsprechenden Knoten im Netzwerk durch jeweils eine Kante mit Verkehrsmittellabel f in beide Richtungen verbunden. Handelt es sich darüberhinaus um eine Einbahnstraße, so werden zusätzliche Kanten in Fahrtrichtung für Fahrrad und Auto hinzugefügt. Bei Buslinien werden jeweils zwei aufeinanderfolgende Bushaltestellen durch eine Kante verbunden. Ein Weg im mathematischen Netzwerk (also eine geordnete Abfolge von Kanten) kann also als intermodaler Weg in der realen Welt interpretiert werden. Die Reisezeit $C(e_r)$ eines Weges $(e_1, e_2, \dots, e_r)$ ergibt sich rekursiv durch

$$C(e_1) = c(e_1, 0) \qquad C(e_i) = c(e_i, C(e_{i-1})) + C(e_{i-1}), \text{ falls } i > 1.$$

Sicherlich ist nicht jeder solche Weg im mathematischen Netzwerk in der realen Problemstellung sinnvoll: Bei einem Weg, der die Verkehrsmittel Auto – Fuß – Auto – Fahrrad nutzt, steht in der realen Welt nach der Fußstrecke an einer beliebigen Kreuzung das benötigte Auto oder das Fahrrad gar nicht zur Verfügung. Daher erfolgt wie auch von Kirchler[17] und Barret et al.[18] vorgeschlagen die Nutzung des Konzepts zellulärer

[16] siehe auch: FGSV (2008): RIN. S. 11-53. / FGSV (2013): EAÖ. S. 13-22.

[17] KIRCHLER, Dominik (2013): E□icient routing on multi-modal transportation networks. Data Structures and Algorithms.

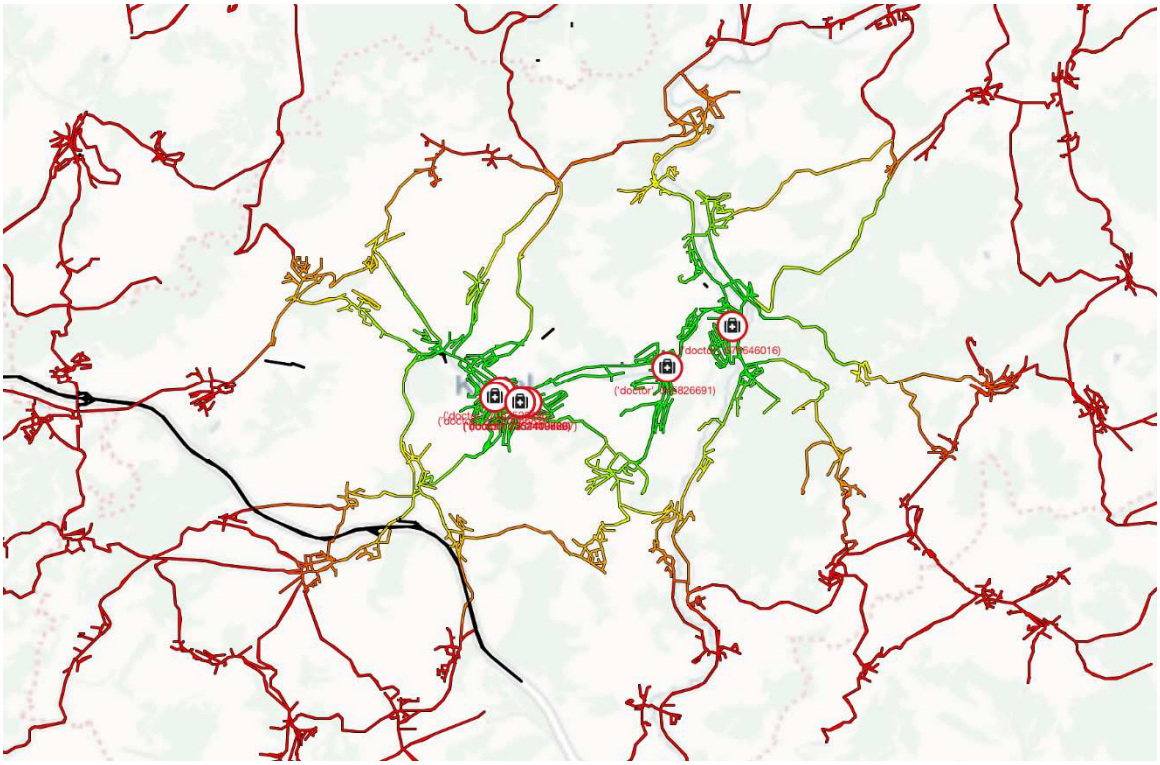
ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Automaten, um nur sinnvolle und vom Anwender gewünschte Konstellationen von Verkehrsmittelwechseln zu erlauben. Gesucht ist nun also der kürzeste Weg bezüglich Reisezeit zwischen zwei zuvor festgelegten Knoten, dessen Abfolge von Verkehrsmitteln vom zellulären Automat akzeptiert wird. Zur Lösung des Problems wird auf die in Kirchler[19] entwickelten Algorithmen zurückgegriffen.

Für die Modellierung der Verkehrsinfrastruktur wird zunächst auf OpenStreetMap-Daten zurückgegriffen. Dort sind Straßenzüge in gut dokumentierten Gebieten bereits mit zahlreichen Attributen versehen, die über die Nutzungsmöglichkeiten einer Straße oder eines Weges Aufschluss geben. Reisezeiten entlang der Kanten berechnen sich in den Fällen zu Fuß, Fahrrad und Auto durch Weglänge multipliziert mit Geschwindigkeit. Während Fußgänger und Fahrradfahrer im aktuellen Modell mit konstanter Geschwindigkeit unterwegs sind, wird die Geschwindigkeit beim Auto wiederum abhängig vom Straßentyp gemacht. Für die Reisezeiten des ÖPNV werden die exakten Fahrpläne, gewonnen aus einem GTFS-Datensatz, hinterlegt, sodass sich die Kantenkosten hier als stückweise linear herausstellen (reine Fahrtzeit + Wartezeit bis zur Abfahrt des nächsten Busses). Transferkanten zwischen den verschiedenen Verkehrsmitteln mit fixen Kosten beim Zu-, Aus- oder Umstieg ermöglichen die Modellierung von sinnvollen Umstiegszeiten, genauso können fixe Zeitspannen zum Einsteigen und Aussteigen aus dem Auto addiert werden.

Eventuelle Beschränkungen auf die am Stück zu Fuß zurückgelegte Strecke können modelliert werden, indem alle zu-Fuß-Kanten, die nicht im gewünschten Umkreis um Start- und Zielknoten und um Bushaltestellen liegen aus dem Netzwerk entfernt werden. Zuletzt werden die Knoten markiert, deren intermodale Erreichbarkeit analysiert werden soll. Dies können zum Beispiel die hausärztlichen Praxen oder Apotheken sein. Verbunden durch eine Hilfskante zu einem zusätzlich eingefügten Knoten ermittelt nun eine einzige als Backwards-Search durchgeführte Anfrage die Erreichbarkeit von jedem Knoten aus dem Netzwerk zur nächstgelegenen Einrichtung. Aufgrund der Fahrplanabhängigkeit sind die Erreichbarkeiten zeitabhängig. Daher wird eine Mittelung verschiedener solcher Anfragen zu unterschiedlichen Zeitpunkten vorgeschlagen, Zeitspanne und Zeitschritte können vom Anwender eigenständig festgelegt werden.

Die in Abbildung 4 dargestellte Karte zeigt die modellierte Erreichbarkeit der markierten Praxen in der VG Kusel-Altenglan über den ÖPNV – konkrete, einheitliche Schwellenwerte befinden sich jedoch ebenso wie die genauen Parameter und grafische Aufbereitung noch in Entwicklung und Abstimmung im Projekt.



[18] BARRETT, Chris / JACOB, Riko / MARATHE, Madhav (2000): Formal-Language-Constrained Path Problems. In: SIAM Journal on Computing 30.3 (Jan. 2000). S. 809–837.

[19] KIRCHLER, Dominik (2013): E□icient routing on multi-modal transportation networks. Data Structures and Algorithms. Ecole Polytechnique X.

Abb. 4: Modellierte ÖPNV-Erreichbarkeit eines jeden Knoten im Netzwerk der VG Kusel-Altenglan zu den markierten Arztpraxen (Grün = weniger als 13 Minuten, Rot = 23 Minuten und mehr zur nächstgelegenen Arztpraxis).

3.4 Output und mögliche Erkenntnisse

Grundsätzlich kommen für die Darstellung der im Modell hinterlegten Daten mehrere Optionen in Frage. Einerseits lassen sich klassische Karten mit Flächen-, Linien- und Punktsignaturen sowie Piktogrammen generieren (z.B. Einfärbung des Streckennetzes nach definierten Schwellenwerten und piktogrammatische Verortung der jeweiligen Einrichtungen), andererseits können beispielsweise Netzdiagramme für einzelne Ortsgemeinden erzeugt werden, die dann der Standortanalyse hinsichtlich verschiedener Einrichtungen dienen können. Ausgehend von dem Erreichbarkeitsmodell lassen sich die realen Daten dabei mit den in der Befragung erhobenen Präferenzen, Toleranzen und Bewertungen der Babyboomer, etwa durch ein Scoring bzw. Benchmarking, abgleichen und für eine zusätzliche normative Betrachtung der einzelnen Standorte und jeweiligen Versorgungslage heranziehen. Mit Blick auf die Planungspraxis erscheint zudem die mögliche Berechnung optimaler Standorte für neue Wohngebiete, die Verdichtung bestehender Siedlungsstrukturen sowie altersgerechte Wohnangebote (z.B. Seniorenheim. Mehgenerationenhaus) und soziale Einrichtungen für Senioren (z.B. Seniorenbüros, Nachbarschafts-Treffs) vielversprechend. Gleiches gilt für die Berechnung optimaler Trassen und Haltepunkte für Angebote des ÖPNV (Stichwort Netzoptimierung) sowie optimaler Standorte für (neue) medizinische Einrichtungen oder die Anpassung bestehender Organisationsformen.

4 MEHRWERT DES DECISION SUPPORT SYSTEMS UND AUSBLICK

Das angestrebte Erreichbarkeitsmodell bietet als ein Baustein des DSS ein mathematisches Analysetool für Akteure der räumlich planenenden Verwaltung (z.B. die kommunale Stadt-, Verkehrs- und Sozialplanung), um verschiedene Entwicklungsvarianten bei unterschiedlichen Entscheidungsoptionen nachvollziehbar und verständlich für politische Entscheidungsträgerinnen und Entscheidungsträger, Träger des öffentlichen Personennahverkehrs sowie Akteure der medizinischen Versorgungsforschung und Bedarfsplanung (z.B. Kassenärztliche Vereinigungen) aufzubereiten. Dadurch wird eine sachgerechte und datengestützte Entscheidungsfindung unterstützt.

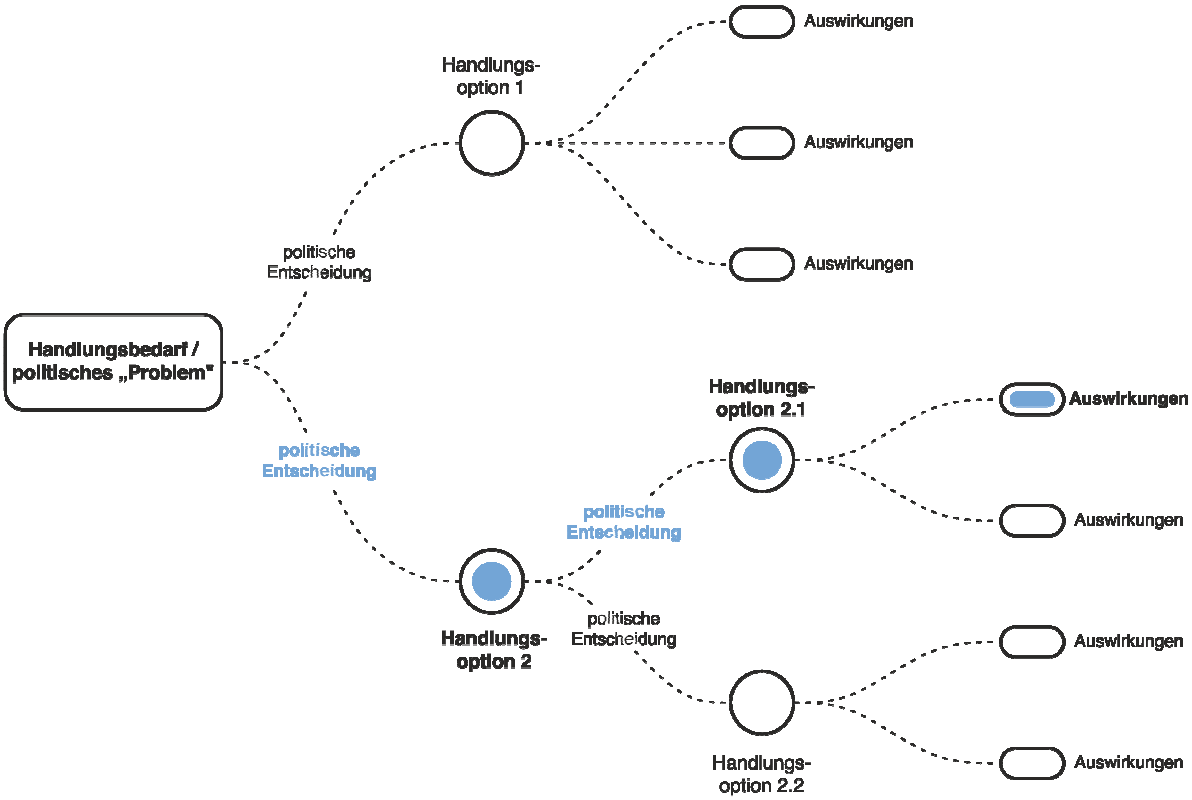


Abb. 5: Vereinfachter Entscheidungsbaum als grundlegende Funktionsweise des projektierten DSS.

Zukünftige Entwicklungen mit sich ergebenden Handlungsbedarfen bzw. -optionen und deren Auswirkungen sollen dabei mittels verschiedener Szenarien und Entwicklungsalternativen aufgezeigt und für den einzelnen Entscheidungsprozess der unterschiedlichen Akteure (blauer Pfad) herangezogen werden können (Stichwort

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Entscheidungsbaum, siehe Abb. 5). Neben der Identifikation von Versorgungslücken sowie der Optimierung von Siedlungssstruktur (v.a. Wohnstandorten), Verkehrs- und medizinischer Infrasstruktur ist zudem eine Ausweitung auf weitere Aspekte der Daseinsvorsorge, etwa Nahversorgung und Einzelhandel sowie Bildung denkbar und kann bei der weiteren Entwicklung des Decision Support Systems dazu beitragen, dass Einrichtungen und Leistungen der Daseinsvorsorge stärker integriert gedacht und entwickelt werden können. Dies wurde gerade für ländliche Räume als ein Erfolgsfaktor von dem Alpine Think Tank genannt: „In order to improve the delivery and ensure high quality of SGI (Anmerkung: SGI sind Servives of general interest) in the Alpine area, the members of the Think Tank have identified the following points: 1. The sectoral approach to SGI needs to be overcome through an integrated territorial approach. The approach should consider people's needs in a given territory, the territorial dimension, and the benefits of the synergies that can arise by combining different SGI sectors. (…) 8. New organisational approaches including social innovative practices and initiatives for the delivery of SGI must be tested and developed"[20] Das Erreichbarkeitsmodell liefert hier einen ersten Ansatz, indem die Gesundheitsinfrastruktur mit der weiteren Mobilitätsplanung verzahnt wird und wie oben angesprochen zudem das Decision Support System im weiteren Forschungsverlauf auf andere Bereiche der Daseinsvorsorge (z.B. Nahversorgung) ausgeweitet werden soll.

Der konkrete Mehrwert für die Babyboomer selbst und perspektivisch die Gesamtbevölkerung liegt in der Verbesserung des eigenen Lebensumfeldes und insbesondere der Versorgungslage, etwa durch die Sicherung einer hausärztlichen Praxis im ländlichen Raum oder die Verbesserung der Erreichbarkeit derselben und Unterstützung der eigenen Mobilität durch einen optimierten öffentlichen Personennahverkehr. Auf Seite der Verwaltung sind hingegen ein effizienterer Einsatz von Ressourcen (z.B. finanzielle Mttel, Personal) und die Verbesserung der Planung zu nennen. Lokale politische Entscheidungsträgerinnen und Eintscheidungsträger profitieren zudem von der Unterstützung bei der Entscheidungsfindung und einer verbesserten Argumentationsgrundlage. Ähnlich der Verwaltung liegt der Mehrwert für die Akteure aus der medizinischen Versorgungsforschung in einer zielgerichteten, nachfragegerechten Bedarfsplanung und leichteren Koordinierung der Nachbesetzung unter Erreichbarkeitsgesichtspunkten sowie damit in der Einsparung von Resourcen. Die Implementierung des Erreichbarkeitsmodells in das DSS bietet damit eine Grundlage für die Optimierung planerischer und politischer Entscheidungen.

5 LITERATURVERZEICHNIS

BARRETT, Chris / JACOB, Riko / MARATHE, Madhav: Formal-Language-Constrained Path Problems. In: SIAM Journal on Computing 30.3 (Jan. 2000), S. 809–837. 2000.

BBSR - BUNDESAMT FÜR BAU-, STADT- UND RAUMFORSCHUNG (BBSR): INKAR – Indikatoren und Karten zur Raum- und Stadtentwicklung, abgerufen am 22.02.2022 unter: https://www.inkar.de/

BUNDESINSTITUT FÜR BEVÖLKERUNGSFORSCHUNG: Altersaufbau der Bevölkerung in Deutschland nach demografischen Ereignissen (2019), abgerufen am 01.08.2022 unter: https://www.bib.bund.de/DE/Fakten/Fakt/Bilder/B07-Altersaufbau-Bevoelkerung-Ereignisse.png?__blob=poster&v=2

BMI - BUNDESMINISTERIUM DES INNERN, FÜR BAU UND HEIMAT: Deutschlandatlas - Karten zu gleichwertigen Lebensverhältnissen. Berlin, 2020.

BMG - BUNDESMINISTERIUM FÜR GESUNDHEIT: Hausarztsystem, abgerufen am 03.08.2022 unter: https://www.bundesgesundheitsministerium.de/hausarztsystem.html

BZGA - BUNDESZENTRALE FÜR GESUNDHEITLICHE AUFKLÄRUNG: 20 Empfehlungen für Gesundheit und Lebensqualität im Alter. Köln, 2020.

DAS ÖRTLICHE SERVICE- UND MARKETING GMBH: Standardsuche für die Ortsgemeinden der VG Kusel-Altenglan, abgerufen am 23.02.2022 unter https://www.dasoertliche.de/?form_name=search_nat&cmd=cmd_nav_startpage

EGGER, Thomas: Alpine Think Tank on Services of general interest – Thesis paper. Bern, 2019. Abgerufen am 03.08.2022 unter: Swiss Center for Mountain Regions (SAB): https://servicepublic.ch/en/interesting-documents/

FLEßA, Steffen / VAN DEN BERG, Neeltje / HOFFMANN, Wolfgang: Gesundheitsversorgung im ländlichen Raum, abgerufen am 28.07.2022 unter: https://www.bpb.de/themen/stadt-land/laendliche-raeume/334219/gesundheitsversorgung-im-laendlichen-raum/#node-content-title-0

GANS, Paul: Demografischer Wandel, In Akademie für Raumforschung und Landesplanung (Hrsg.) Handwörterbuch der Stadt- und Raumentwicklung. S. 376. Hannover, 2018.

GOOGLE: Google Maps, Standardsuche für die Ortsgemeinden der VG Kusel-Altenglan, abgerufen am 23.02.2022 unter: https://www.google.de/maps/preview

KASSENÄRZTLICHE BUNDESVEREINIGUNG: Arzt- und Psychotherapeutensuche für die Ortsgemeinden der VG Kusel-Altenglan, abgerufen am 23.02.2022 unter https://arztsuche.116117.de/

KIRCHLER, Dominik: Efficient routing on multi-modal transportation networks. Data Structures and Algorithms. Ecole Polytechnique X. 2013.

[20] EGGER, Thomas (2019): Alpine Think Tank on Services of general interest – Thesis paper. S. 4f.

SPELLERBERG, Annette: Soziale Differenzierung durch Lebensstile: Eine empirische Untersuchung zur Lebensqualität in West- und Ostdeutschland. Berlin, 1996.

STATISTISCHES LANDESAMT RHEINLAND-PFALZ: Mein Dorf, meine Stadt, abgerufen am 22.02.2022 unter: https://infothek.statistik.rlp.de/MeineHeimat/index.aspx?id=103&l=3&g=0733610&tp=46975

STEFAN, Benjamin / LOEPPKE, Yannick / SPELLERBERG, Annette: Babyboomer in Deutschland – demografische, soziale und räumliche Differenzierungen. Analysen auf Basis des sozio-ökonomischen Panels 2019. Kaiserslautern, 2022.

SUNDMACHER, Leonie / BRECHTEL, Thomas et al.: Gutachten zur Weiterentwicklung der Bedarfsplanung i.S.d. §§ 99 ff. SGB V zur Sicherung der vertragsärztlichen Versorgung. München, Leipzig, Bonn, Greifswald und Köln, 2018.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

🏆 *reviewed paper*

Biophilic Design Approach: Towards Better User's Urban Open Spaces Experience and Improve the Lingering Factor in the University Campus – Case study Faculty of Engineering Campus, Alexandria University, Egypt

Sagda Gamaleldin, Mohamed Ibrahim, Zeyad El-Sayad

(Assistant Lecturer Sagda W. Gamaleldin, Alexandria University, Alexandria, sagda.wael@alexu.edu.eg)
(Professor Emeritus Mohamed A. Ibrahim, Alexandria University, Alexandria, abdelallmai@alexu.edu.eg)
(Assistant Professor Zeyad M. El-Sayad, Alexandria University, Alexandria, zelsayad1@alexu.edu.eg)

1 ABSTRACT

Students spend most of their time in the university campus where they either study inside the internal spaces (lecture halls, studios,...) or in the external spaces around the campus buildings. Most universities provide well-designed external spaces inside their campus that allow students to spend their time there for any purpose they want, such as studying, waiting, or spending free time. After observing those outdoor spaces, it has been found that some of those spaces are crowded and others are abandoned at the same complex.

This study aims to find out the impact of natural elements and the biophilic approach of landscaping the outdoor university campus spaces on the students lingering and sense of the experience of such spaces. Moreover, to highlight the relation between using the biophilic approach and the livability of students' campus open spaces, a field study was conducted with several students of the Faculty of Engineering campus, Alexandria University in which the biophilic theory is applied as one of bringing nature into the space forms. It also aims to study whether this approach will affect the students' well-being and lingering factor.

Through observation, dialogues, and public questionnaires, the study ended up with several results describing the effects of implementing the theory of biophilia in the design of the campus' urban spaces. The results illustrate changes of the students lingering factors, as well as how biophilic design was affecting students' well-being and how the biophilic urbanism approach was influencing the vitality of the space.

Keywords: Lingering Factor, User Experience, Better University Campus, Biophilic Design, Urban Open Space

2 INTRODUCTION

A supportive mutual relationship is usually occurring between universities and their communities. They have a wide rich background of affecting each other's scientific, cultural, social, and economic characteristics (Ransom, 2015). Due to the escalating demand for internationalized university campuses that have a positive impact on their societies, and produce students that have flourishing characteristics of social and scientific skills, several governmental development authorities have initiated plans for higher education institutions that aimed to enhance the quality of their campuses to be more effective than just campus spaces. That corresponds to the emerging requirements of recent and futuristic university education and graduate image. This image is illustrated as the universities of the future utilizing their campus buildings, landscape, and open spaces to support comprehensive innovative learning (Abdelaal, 2019; Sidiropoulos, 2018).

On the other hand, despite the important aim and objectives of this vision, the presented actions and decisions in designing the university campuses tended to be conventional and naïve toward achieving this goal. Urban spaces, specifically in university campuses, do not provide opportunities and facilities for users to engage and participate comprehensively with each other or with nature. This is preventing the achievement of genuine social, psychological, and cognitive advantages for their users (Jan Gehl Architects, 2021).

This research explores and highlights the potential role of approaching the biophilic urbanism concepts through designing, planning, and developing the universities' urban spaces. This idea aims to stimulate students' innovative thinking process by experiencing the urban open space of their campus, as well as tracing the lingering factor variations of the urban spaces themselves. The essence of this research is to cover the gap between the lingering factor and the experiencing process in relation to the biophilic urbanism approach.

In response to this important relation, the paper explores the biophilic design values, principles, and framework. Moreover, it presents a brief vision of the characteristics of successful urban open spaces. The argument of this research is based on linking the relation and reflection of these points to each other.

Figure (1) illustrates the aim of this research, which is to analyze the implementation of biophilic design to enhance students' experience in existing university campus urban open spaces. It reflects the proposed logical framework of this research with biophilia as the first pillar, while the desirable urban open space plays the second role. The process ended up with the prospected aim and objectives of this research.

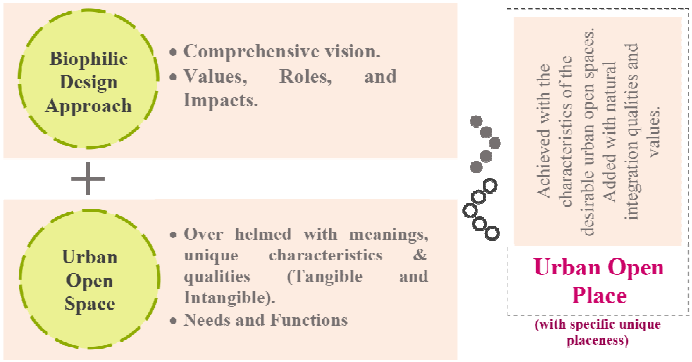


Figure 1: Research Logical Framework – between the biophilic urbanism and the characteristics of desirable campus urban space (source: author).

3 BIOPHILIA – A BRIEF OVERVIEW

Until the twentieth century, people have shown high demand for intensive contact with natural surroundings more than with urban or human-built environments. This desired context is considered as a multi-sensory surrounding, that is described by specific natural features such as light, odor, winds, sound, weather and climate, water, greenery, vegetation …etc. (Jones, 2013). Studies have been held by a group of neuroscientists, who have considered these biological phenomena using advanced computer-added technologies for imaging, that indicated an innate human need and eagerness for experiencing natural related actions and spaces (Zari, 2019) (Biederman & Vessel, 2006).

According to Kellert & Calabrese, 2015 biophilia, has been defined as the essential, innate, tangible, and intangible biological bonds between users and nature. It has also been defined as the interpretation of human attraction towards the natural environment into an existing built environment (Totaforti, 2020). Beatley, 2011, Zari, 2019. Others have explored and illustrated the positive impact of approaching the biophilic urbanism strategies toward the urban space users and stakeholders. Essentially, it is believed that the biophilic approach is considered as the main sustainable design intervention technique, that can affect directly and indirectly the users' experience of their surroundings (Xue, et al., 2019) (Carter, Derudder, & Henríquez, 2021). The following Table 1 illustrates the direct relation between biophilia's primary tangible and intangible tools and their impact on open space users.

Tangible Experience of Nature	Intangible Experience of Nature	Experience of Urban Place
- Greenery (Natural or Manmade) - Sunlight - Winds - Water (Natural or Artificial) - Animals, & Natural/Artificial Ecosystem - Weather and Climate - Textures and Materials	- Image of Nature - Sense of Materials - Sense of Colours - Sense of Shapes, Forms, and Natural Geometries - Simulating Natural Light and Air - Biomimicry Concepts	- Sense of Protection and Safety - Sense of Organisation and Complexity - Integration of Parts to Wholes - Transition in Spaces - Mobility and Wayfinding Process - Sense of Place Cultural and Ecological Bonds

Table 1: Biophilic urbanism approach attributes and experiences (source: upgraded from (Kellert & Calabrese, 2015) (Sayed & Nagy, 2020))

3.1 Biophilia as an Approach Towards Better University Campus Urban Open Spaces

Throughout history, the relationship between humans and nature is stated as an essential fundamental need and a biological human right. It affects human presence aspects of well-being, interaction, and health (Xue, et al., 2019). Gamage, Munguia, & Velazqu (2022), have illustrated the biophilic university, in which both

buildings and campus urban spaces are enhanced through environmentally approached elements of design, as well as that the university depends on environmental literacy for developing its educational system.

The Biophilic University is a philosophical concept that reflects the essential need for university campus users and the context of being connected with nature through several aspects, which requires a radical reform of modern society. Edward O. Wilson (1984), hypothesizes that biophilia in urban open spaces is the reflection of nature in several dominant aspects through architecture and the built environment. Thereafter, the university biophilic design approach has been developed over time to use surrounding conditions and elements of nature to enhance tangible, psychological, cultural, and spiritual human wellbeing (Kellert & Calabrese, 2015) (Abdelaal, 2019).

This research tries to present sufficient evidence that the values, patterns, and attributes of the biophilic approach could be injected as catalysts to revitalize the sense of belonging, creativity, imagination, …etc, and the capacity of campus users through the biophilic transformation of the campus urban open spaces (Gamage, Munguia, & Velazqu, 2022). A revision of selected references shows three biophilic levels of integration through the university campus urban space: indirect, incidental, and intentional. On the other hand, it could be determined that the benefits of this approach span from physical cognitive benefits to intellectual spiritual benefits. Through this research framework, it is proposed to focus on intellectual spiritual benefits and characteristics. The framework highlights the role of various values, patterns, and attributes of this design approach towards achieving this role (Xue, et al., 2019).

Kellert & Calabrese, 2015, propose nine values of the biophilic approach that can stimulate physical, emotional, intellectual, and moral benefits of students-nature relation and interaction. Naturalistic, scientific, symbolic, and aesthetic values-oriented campus design, has been suggested in their hypothesis. They believe in their substantial impact on the innovation capacity of university campus users (Table 2).

Biophilic Design Value	Description	Impact
Utilitarian	Natural functional benefits (e.g. use of natural materials and resources, …etc).	Enhance mental, emotional, and intangible capacities (Pretty, Barton, Sellens, & Griffin, 2005).
Dominionism	The dominant desire of controlling nature (e.g., topping a peak, a dashing river…etc).	Trigger the sense of safety, freedom, monolithic, self-regard, and risk-resolving capacity (Biederman and Vessel, 2006).
Naturalism	Source of revitalization, enhancement, and diversity that raise nature integration awareness.	Developing an increasing sense of clearness, power, and peace (Windhager et al., 2011).
Scientific	A source of experimental knowledge and literacy comprehension.	Promote critical thinking, issue-solving, and mental skills (Bringslimark et al., 2007).
Symbolic	Source of imagination, connectivity, and intellect.	Enhance imagination, renovation, connecting, and intangible mental maturity (Kaplan, 2001).
Aesthetic	Inspires a sense of beauty and attraction.	Develops curiosity, exploration, imagination, and discovery.
Humanistic	Source of attachment and emotional affection	The skill of forming friendly companionship bonds, cooperation, sociability, and trust (Windhager et al., 2011).
Negativistic	To avoid the fear of nature's harmful features through aversive reaction.	A positive sense of awe, esteem, appreciation, natural modesty & repentance (Shinew et al., 2004).
Moralistic	Source of ethical and spiritual inspiration	Promote a sense of significance, spiritual assets, self-esteem and dependency, nature, and beings' unity (Jirásek et al.,2016).

Table 2: Describes the Impacts of Biophilic values on the user's skills and performance through the innovative campus approach (source: author modified from (Abdelaal, 2019) (Kellert & Calabrese, 2015))

4 LINGERING FACTOR AND THE CHARACTERISTICS OF DESIRABLE URBAN SPACE

Immanuel, et al., (2021_, and others define the desirable urban open space as a place suitable for people to achieve their requirements, activities, and anticipations. People experience the city based on its urban open spaces where engagement with the communal and social life is granted between people, space, and function simultaneously (Zakariya, Harun, & Mansor, 2014). Primarily, urban open space comprehends several characteristics that aim to sense the place, to use of space, and the settings for interaction. In the case of university urban open places, the significance of their characteristics gets more essential and crucial over time. University's desirable or successful place is identified as well through what fulfills its role and is

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

characterized by certain meanings, qualities, and characteristics (Project for Public Spaces, 2018) (Trencher, Terada, & Yarime, 2015) (Gehl J., 2010).

It is important to identify these physical, social, and spatial characteristics. Layout and connectivity, social and diversity; historical and interactivity are various aspects that affect their functionality (American Planning Association, 2016). Indeed, a survey of references has explored the characteristics that are considered among urban open places. CMG, PPS, and others illustrate these characteristics of desirable or, as stated by them, successful, urban open places (Gamaleldin, Al-Hagla, & El-Sayad, 2020). The research considers these characteristics from three different approaches, as follows:

(1) Public Places Through Inherent Place Approach

The RIBA (The Royal Institute of British Architects, 2018) report is a multi-associations partnership, as a precursor for future place projects by pointing up idealistic placemaking experiences around the country. It considers the 'Ten Characteristics of Places where People want to Live' approach. It highlights the relationship between the desired characteristics in a human intimate place and the design quality of each characteristic (Table 3). The report investigates a wide range of case studies. It endorses the - Letwin Review, 2018 – an approach that considers better placemaking to increase the quality and supply.

	Characteristic	Quality
01	The right place for the right housing	Eligibility, Sense of belonging
02	Place to start and a place to stay	
03	Place which fosters a sense of belonging	Sense of loyalty and belongingness
04	Place to live in nature	Integration and Comfort
05	Place to enjoy and be proud of	Enjoyment and
06	Place with a choice of homes	Sense of Belonging and Comfort
07	Place where people feel at home	
08	Place with unique and lasting appeal	Distinctiveness
09	A sustainable place for future generations	Sustainability
10	Place where people thrive	Sociability

Table 3: the characteristics of desirable urban open space according to the RIBA's report (source: author).

(2) Public Place Through Designer Approach

As an exploration, the CMG studio (2014) works on increasing the well-being of the social and ecological aspects of places, through artful design missions. A survey has been created among the CMG studio designers considering "what makes a good public space?". The results (Figure 2) (Table 4) are based on the designers' experiences and consist of four main types of opinion as main factors: people, delight, flexibility, and function consequently.

Figure 2: Pie chart illustrates the percentage of enrolment of public place characteristics (source (CMG, 2014))

Designer	Description	Quality
Opinion 1	Prioritize the function. Illustrates that people are the most important factor affecting the success of public space. To vital (usable), then the prosperity of the public place is granted.	Presence of People
Opinion 2	Considers a sense of place, uniqueness, safety, refuge, and attractiveness simultaneous with the occurrence of people. Provide the ability to present their needs and to attract a wide diverse range of people from several backgrounds, all are free to use space as they decide.	Flexibility, Diversity & Sense of Place
Opinion 3	The balance between safety& wonder, comfort, and risk, distinctiveness, and function. It guarantees a sense of enjoinment and delight, bringing people out of their heads following their imaginations, and engaging them with themselves, the city, and their heritage.	Delight and Function

Table 4: The CMG's Survey Results (source: author)

(3) Public Places Through Observational Approach

Carmona (2001 & 2010), (Cattell, Dines, Gesler, & Curti, 2008), and others note that the main element is to adapt people's needs which vary regarding their culture and traditions. Through an observation process in different urban places, they have illustrated a group of principles:

- Crime control and resistance through a successful design of the public spaces.
- Provide opportunities for social interaction & vital celebration places in the place design process.
- Avoid the conflict between pedestrian movement and vehicle circulation.
- Prospering the quality of the urban open places regarding its design and control.
- The intangible & urban open space democratic concepts, that space is accessible and free for everyone.

Accumulatively, they illustrate five main principles are required to achieve a successful urban open space, which reflects that the urban open place is achieving its role in its city (Table 5)

Principal	Description
Comfort	Illustrates the linger factor as an indicator reflects people's comfort and reliefness toward a place. This principle depends on environmental, physical, psychological & social aspects related to the places or people themselves.
Meditation	The importance of the psychological aspects of a place's users. That would be achieved through providing the place with entertainment and relief elements of soft and hardscape to guarantee the balance with security issues.
Exploration	One of the main aspects that could guarantee the success of the public place. The diverse, distinctive, experimental, and trendy stimuli are required to prosper the public place.
In-Active Relationship	A supportive element leads to achieving comfort, meditation, and the needless direct folks/place interaction. Whyte (2001) explains that nothing grabs people's attention more than people themselves, thus the most vital places are those rich in pedestrians and allowing observers to watch others without eye contact.
Active Relationship	Refers to the direct intervention of people in the public place. This kind of intervention was observed by Cattell, Dines, Gesler, & Curti, (2008) as one of the most popular and substantial principles.

Table 5: The Five main aspects of a successful public place form an observational approach (source: Author upgraded from (Cattell, Dines, Gesler, & Curti, 2008))

Gehl Architects (2015) presents the 'Twelve Urban Quality Criteria' (Figure 3) that considers the important role of activities within urban open places. It provides qualities that could guarantee the invitation of all ages people, and elapse the users' sense of loss through experiencing the urban space.

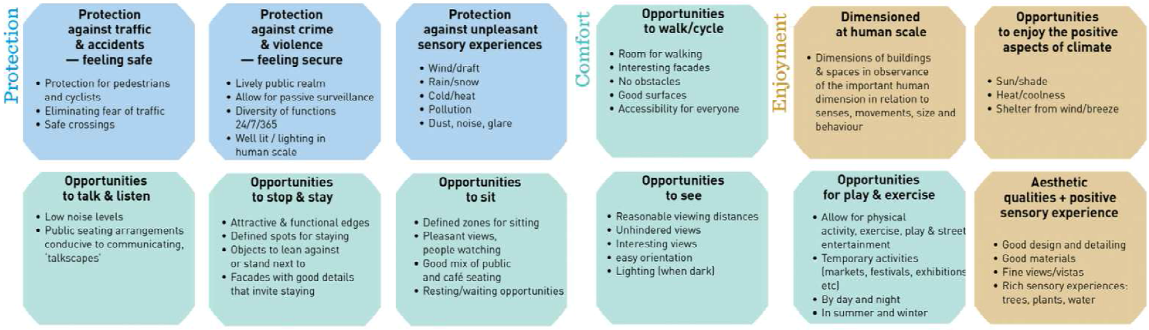


Figure 3: The Twelve Urban Quality Criteria by Gehl Institution Source: (Jan Gehl Architects, 2022)

Moreover, through worldwide observations, surveys, interviews, and workshops Projects for Public Spaces PPS believes that urban open spaces must be designed by people and uses. PPS has stated four main qualities: accessibility, activities, comfortable; and sociability in The Place Diagram (Figure 4) is a comprehensive tool, that describes the characteristics of desirable urban open spaces (PPS, 2018).

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

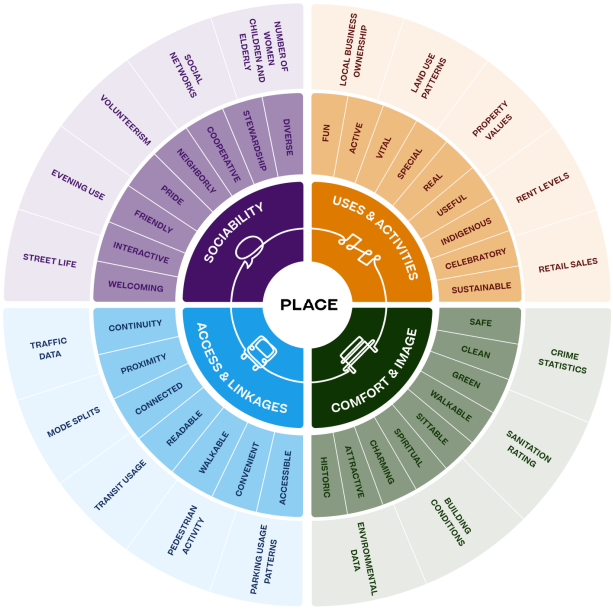


Figure 4: What makes a great place Diagram (Source (PPS Projects for Public Spaces, 2018))

4.1 Lingering Factor in Urban Open Spaces

Through the development efforts to achieve the desirable urban open space, the 'Lingering Factor' definition has been presented to the scene. PPS argued that desirable spaces could be achieved by people's presence, remaining when they have no pressing reason to stay, which has been defined next as the “lingering factor”.

The definition of lingering factor emerged, which describes the measurement and design of users' presence form, type, and shape in urban open spaces. It is observed that people's lingerness is affected by several aspects that would be analyzed and determined (PPS Projects for Public Spaces, 2016).

It is believed that the linger factor is an apparent threat that could be noticed to be apparent, in relation to the vitality of urban open space. It is inequitable to restrict urban space lingerness by this shallow perspective. It is important to study the various causes of dis-lingering urban open spaces, as well as, to develop a measurement tool for the linger factor of urban space.

As a secondary factor, PPS illustrates that the good management of urban space plays an important role in its success. This includes cleaning, offering utilities, scheduling events,..etc that could be managed by the community, individuals, or through local partnerships. It is believed that the lingering factor of urban open space is affected directly or indirectly by its main and secondary factors and characteristics (Soltanian & Mohammadi, 2015). Throughout this research, it is proposed to focus merely on the vitality as the apparent quality describing the lingering factor, despite the importance of the remaining qualities.

4.2 University Campuses’ Desirable Urban Open Spaces Characteristics – Natural Integrated Focus

It is believed that the more urban spaces users are interacting with, viewing, or sensing nature, the more function enhancements occur. Thus, the naturalistic development of university campuses based on biophilic design principles could help its urban spaces to address the users’ needs and functions positively, which are described through the characteristics of desirable urban open spaces. Aburas et al., (2017) illustrate accommodation and integration as essential mental requirements for university campus users. Hence, the biophilic approach to campus design offered essential changes in its settings, as well as achieving the characteristics assets of desirable urban space, which, accordingly, affects its users’ perception process.

There are numerous advantages of the biophilic approach campus design to stimulate, enhance and revitalize the users' capacity of needed functions, especially as university students. Figure (5), illustrates the cognitive, psychological, and physical demands of university campus users according to four different functioned-based zones type. First, the academic units, require a stress-reductive and self-esteemed increasing environment with a sense of concentration. Second, the project units foster increasing concentration, focus, and restoring attention. Third, the imaginative groups, provide explorative, spiritual, and physical well-being, as well as an attention-increasing environment. Fourth, the creative groups, play the role of social hub that fosters

connectivity, sociability, and users/users or users/society engagement opportunities. Nevertheless, it is proposed to achieve a natural, good academic educational environment through the campus urban open spaces (Abdelaal, 2019)(Sinxadi & Campbell, 2020) (Gamage, Munguia, & Velazqu, 2022).

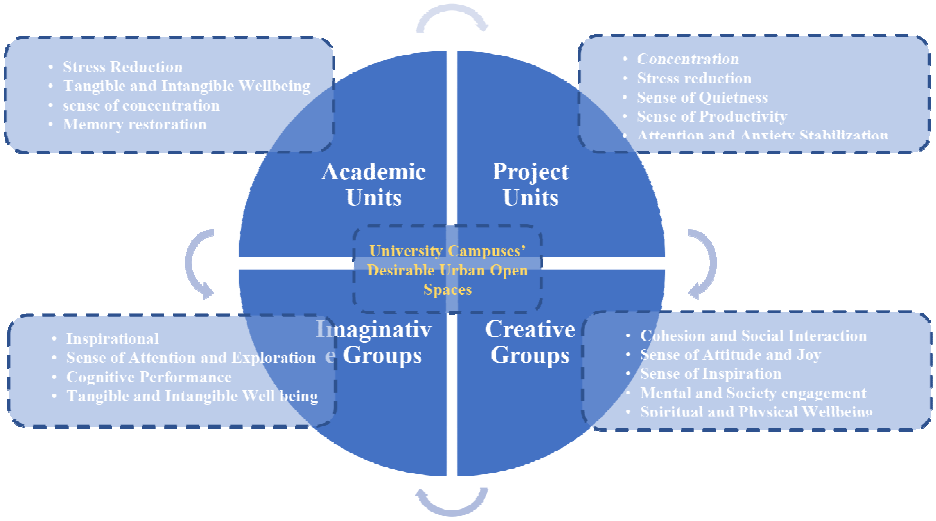


Figure 5: Biophilic Approach Impact on University Campus urban spaces units to achieve the sustainable-innovative campus (source: author upgraded from (Abdelaal, 2019))

5 THE ROLE OF BIOPHILIA TO IMPROVE THE LINGERING FACTOR OF URBAN OPEN SPACES

This research proposes that the interrelated connections between biophilic urbanism as an approach and the intervention process - of either developing or designing - the urban spaces of the university campus could be utilized and reconciled within a more effective spatial model of an innovative campus. This proposed futuristic model of campuses is believed to be the delivery tool toward achieving the characteristics of desirable urban open space through a naturalistic approach.

The following illustration (Figure 6) demonstrates a threefold pillar model that figures the interrelationship between the three main aspects of the research. First, the biophilic approach plays the role of natural stamina that drives the process of rejuvenating the urban open space. Second, the characteristics of desirable urban open space play the role of objected elements describing users' needs and functions on a university campus. Third, the lingering factor, as the apparent urban quality describes the urban space stimulating process. It is believed that through tracing the lingering factor of urban space the urban intervention process, prosperity, and decline, could be traceable and measurable thereafter.

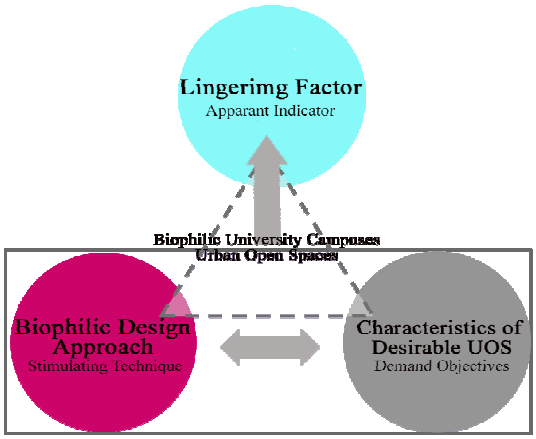


Figure 6: The Study Main Attributes (source: author)

Hence, the following model (Figure 7) combines and highlights the relation between the two action pillars of this research, biophilic and urban open space characteristics, through a mirror manner. It illustrates the overlapping end-experiencing qualities of both pillars. This framework aims to generate viable, vital, and

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

better university campus spaces for their users, and these campus spaces are proposed to reflect a positive increase in their lingering factor.

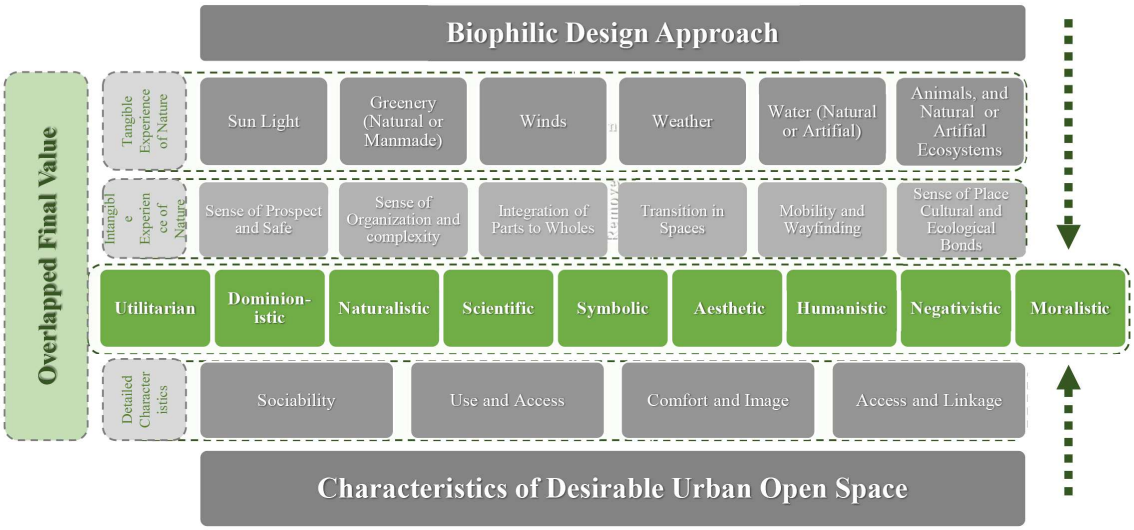


Figure 7: The Study Main Attributes Interrelationship (source: author)

The aforementioned model (Figure 7) reflects the proof of a steadily increasing body of both urban and neuroscientific research, that has considered the human body, and urban and social practices. The model highlights a noticeable connection between integration with natural processes and anxiety relief, a sense of safety, and belonging (Jan Gehl Architects, 2021; Jeon et al., 2018). Other benefits are illustrated by this model, such as stress reduction, academic performance improvement (Clayton, 2007), improved performance, and cognitive aspects (Han, 2010).

6 CASESTUDY - ALEXANDRIA UNIVERSITY, FACULTY OF ENGINEERING CAMPUS; URBAN OPEN SPACES

This study is proposed to take place at the Faculty of Engineering, Alexandria University Campus. This campus is one of the distinctive campuses all over the city. It has been established in 1941 under the command of King Fouad the First. In the light of the need for developing the quality of university education, his highness estated to design the university campus on an outstanding wide area of land, with added greenery and open spaces that are distinguished with unique greenery types and forms (Figures 8,9) (Alexandria University, 2022). Over the years, and due to several quick intervention decisions into urban planning and design of the campus, it is believed that the faculty campus conditions are not as authentic as they once were. Several space attributes have been changed, especially the greenery cover and aspects of these spaces (Figures 10, 11).

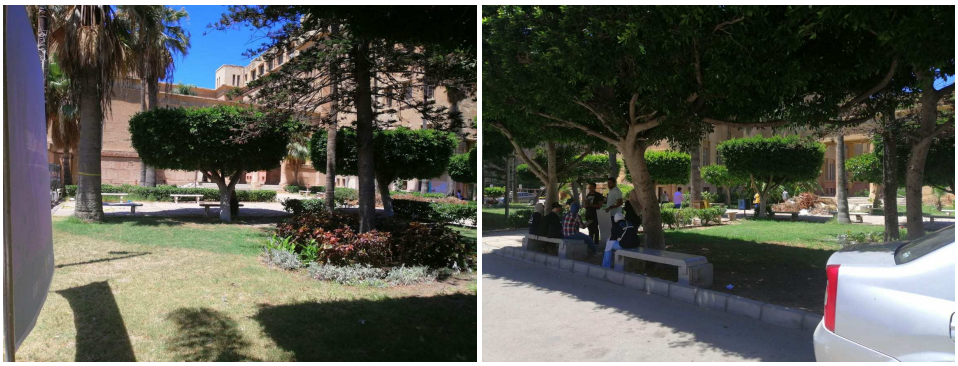


Figure 8, 9: Positive Greenery Conditions

Figure 10, 11: Negative Greenery Conditions – Either through removing or Snapping the Existing Green Cover (source: author and Salma Mohammed Photography, 2022)

This case study plays the role of a primary field survey of how the palpation of biophilic-urban characteristics are changing throughout the university campus. By observation, the researcher selected several spots of the university campus' urban open spaces according to the variations of how the users were experiencing them. The selection resulted in four different types of spaces (Figure 8).

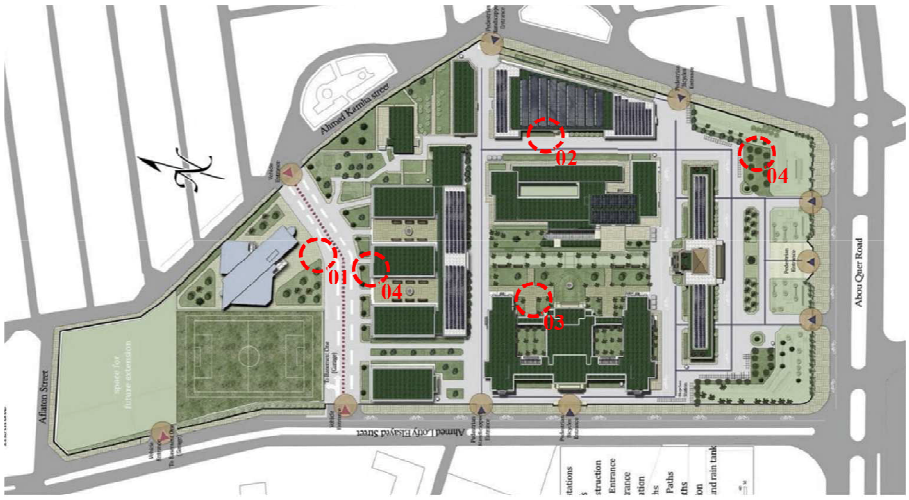


Figure 12: The Selected Spots – The Campus Key Plan Study Main Attributes (source: author, map by anonymous, verified by author, 2022)

This field survey methodology consisted of three main techniques: making dialogues with random respondents of urban place users, in-field observation, and approximate grading criteria. The dialogues took place with approximately twenty users per space. The in-field observation process was done through peal time density throughout the semester, with approximately sixty minutes per spot.

Through the dialogue, the approximate grading criteria appeared, while each respondent was asked to evaluate their own sense of biophilia and sense of desiring the urban space, as well as their willingness to stay in this urban space, as a reflection of the lingering factor from their own viewpoints. The following Table (6) is illustrating a summary of respondents' results from this field survey.

6.1 Field Survey List of Findings, Recommendations, and Further Studies

- As a process through this field survey, the researcher had the responsibility to demonstrate and illustrate the study's aspects, definitions, and dimensions for each participant, to guarantee a full understanding of this study's aim and objectives. This action has increased the biophilic/space knowledge of campus students, as well as delivered the importance of natural aspects to them, their university, and society's future.
- The field survey highlights the occurrence of strong interrelationships between the three aspects of the study.
- It is shown that the lingering factor is a reflection of the success of the biophilic urbanism approach of the campus.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

- Positive results have been indicated that the users were experiencing more quality and satisfaction towards biophilic places than non-biophilic ones.
- This experiment could be expanded to cover more intensively and accurately the aspects of the research using respondent analytical questionnaires.
- It is recommended that this study could be expanded to create a comparative case study between several campuses throughout the world.

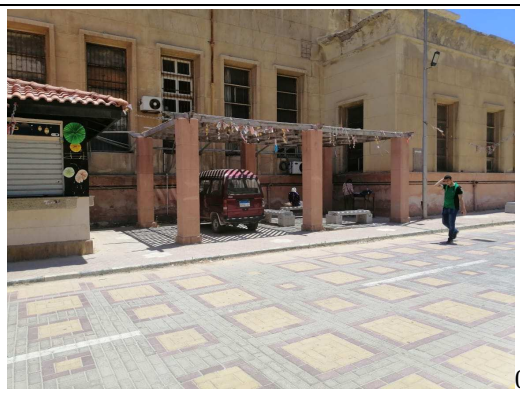
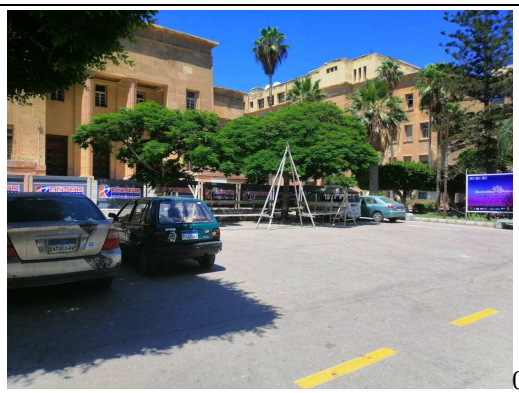
<table>
<tr>
<td> 
01</td>
<td> 
02</td>
</tr>
<tr>
<td>Biophilia | ~0% | ~5% | Desiring</td>
<td>Biophilia | ~1% | ~10% | Desiring</td>
</tr>
<tr>
<td>Lingering occurs only through an educational need.
The absence of Soft/hardscape elements.
Lack of amenities and natural comfort.</td>
<td>Lingering occurs only when buildings are needed.
Disorder space usage, the absence of space definers
Bad natural conditions of weather, shade, and greenery.</td>
</tr>
<tr>
<td> 
03</td>
<td> 
04</td>
</tr>
<tr>
<td>Biophilia | ~90% | ~95% | Desiring</td>
<td>Biophilia | ~95% | ~100% | Desiring</td>
</tr>
<tr>
<td>Lingering occurs almost during the length of the day.
High sense of place and biophilia.
Disorder space usage, the absence of space definers.</td>
<td>Lingering occurs throughout the day.
High sense of biophilia and values of the desired place.
Suitable for various types of campus units.</td>
</tr>
</table>

Table 6: Field Survey Summary Results for the Four Selected Spots (source: author, photography: author & Salma Mohammed Photography, 2022)

7 CONCLUSION

Throughout this research, numerous urban, empirical, neural, and social studies have been revealed, which illustrate the strong connection between experiencing the process of urban open space and the biophilic urbanism approach of design. First, Ulrich (1981), who has justified the increasing value of human mental & physical skills and patients' recovery rates in nature, more than in urban environments, due to the presence of natural elements. This paper illustrates that when thoughts and visions of university campuses were developed they went beyond the limited concepts of ordinary building block campuses. The study presents a brief comprehensive vision of characteristics of desirable urban open spaces perceived through different viewpoints.

The study illustrated how the interrelationship between the three main pillars of the study overlapped. A positive impact has been shown of the biophilic design approach towards the achievement of the characteristics of desirable urban open spaces, as well as the lingering factor of these spaces. Meanwhile, the

missing ring or the gap which was found in the literature was covered theoretically and supported by a brief field survey.

The primary outcomes of the proposed field survey have primarily proved the research hypothesis. Needless to mention and emphasize that this study needs to be expanded in further research by following up more intensively and by using a quantitative method for further case studies towards supporting this proposal. Finally, it could be indicated that the biophilic urbanism approach to design has shown positive results towards achieving more futuristic, social, and desirable campus urban open spaces.

8 REFERENCES

Abdelaal, M. S. (2019, January). Biophilic campus: An emerging planning approach for a sustainable innovation conducive university. Journal of Cleaner Production.

Aburas, R., Pati, D., Casanova, R., & Adams, N. G. (2016, 2017). The Influence of Nature Stimulus in Enhancing the Birth Experience. HERD Health Environments Research & Design Journal.

Alexandria University. (2022). AU History. Retrieved from Alexandria University Official Web Site: https://alexu.edu.eg/index.php/en/au-history

American Planning Association. (2016). Characteristics and Guidelines of Great Public Spaces. Retrieved January 12, 2018, from American Planning Association: https://www.planning.org/greatplaces/spaces/characteristics.htm

Beatley, T. (2011). Biophilic Cities Integrating Nature into Urban Design and Planning. Washington: Island Press.

Biederman , I., & Vessel, E. A. (2006). Perceptual Pleasure and the Brain. American Scientists. Retrieved from American Scientists.

Bringslimark, T., Hartig, T., & Patil, G. G. (2007). Psychological Benefits of Indoor Plants in Workplaces: Putting Experimental Results into Context. HortScience.

Carmona, M. (2001, November 11). Sustainable Urban Design - A Possible Agenda. (S. Batty, S. Davoudi, & A. Layard, Eds.) Planning for a Sustainable Future, pp. 165-192. Retrieved January 24, 2019

Carmona, M., Heath, T., Oc, T., & Tiesdell, S. (2010). Public Places, Urban Spaces: The Dimensions of Urban Design. Oxford: Architectural Press.

Carter, V., Derudder, B., & Henríquez, C. (2021). Assessing local governments' perception of the potential implementation of biophilic urbanism in Chile: A latent class approach. Land Use Policy.

Cattell, V., Dines, N., Gesler, W., & Curti, S. (2008, October). Mingling, observing, and lingering: everyday public spaces and their implications for well-being and social relations. Health Place.

Clayton, S. (2007). Domesticated nature: Motivations for gardening and perceptions of environmental impact. Journal of Environmental Psychology.

CMG. (2014). What Makes a Good Public Space? Retrieved November 27, 2018, from CMG.

Domesticated nature: Motivations for gardening and perceptions of environmental Impact. (2007).

Gamage, K. A., Munguia, N., & Velazqu, L. (2022). Happy Sustainability: A Future Quest for More Sustainable Universities. (F. Witlox, Ed.) Social Science.

Gamaleldin, S. W., Al-Hagla, K. E., & El-Sayad, Z. M. (2020). Urban Placeness: The Role of Augmented Reality Technology. Architectural Engineering. Alexandria, Egypt: AU Press.

Gehl, J. (2010). Cities for People. Washington, Covelo, and London: Island Press.

Han, K.-T. (2010). An exploration of relationships among the responses to natural scenes: scenic beauty, preference, and restoration. Environment and Behavior.

Immanuel, A., Ting, L. L., Tay, S., Conservation & Urban Design Group, Architecture & Urban Design Group, & Physical Planning Group. (2021). PlacemakingBook - How to Make a Great Place. Singapore: Urban Redevelopment Authority (URA).

Jan Gehl Architects. (2021). A coexistence toolkit for homelessness in public space. Nationwide, USA: Gehl Architects.

Jan Gehl Architects. (2021). Developing a green, social, and connected public space network. Wellington, New Zealand: Gehl Architects.

Jan Gehl Architects. (2022). Twelve Quality Criteria - Gehl Architects. Retrieved from Gehl Architects.

Jeon, J. Y., Yeon, P. S., & Shin, W. S. (2018). The influence of indirect nature experience on human system. Forest Science and Technology.

Jirásek, I., Veselský, P., & Poslt, J. (2016). Winter outdoor trekking: Spiritual aspects of environmental education. Environmental Education Research.

Jones, D. R. (2013). The biophilic university: A de-familiarizing organizational metaphor for ecological. Journal of Cleaner Production.

Kaplan, R. (2001). The nature of the view from home: Psychological benefits. Environment and Behavior.

Kellert , S. R., & Calabrese, E. F. (2015). The Practice of Biophilic Design. Biophilic-Design.

PPS Projects for Public Spaces. (2015). A Street You Go To, Not Just Through: Principles for Fostering Streets as Places. PPS.

PPS Projects for Public Spaces. (2016). You Asked, We Answered: 6 Examples of What Makes a Great Public Space.

PPS Projects for Public Spaces. (2018). What Makes a Successful Place? PPS.

Pretty, J. N., Barton, J., Sellens, M., & Griffin, M. (2005). The mental and physical health outcomes of green exercise. International Journal of Environmental Health Research.

Project for Public Spaces. (2018, April 12). What Makes a Successful Place? Retrieved February 23, 2018, from Project for Public Spaces: https://www.pps.org/article/grplacefeat

Psychological benefits of indoor plants in workplaces: Putting experimental results into context. (2007).

Ransom, J. (2015). Future of cities: Universities and cities. Universities UK. UK government.

RIBA-The Royal Institute of British Architects. (2018). Ten Characteristics of Places Where People Want to Live. The Local Government Association, Royal Town Planning Institute, and Chartered Institute of Housing. RIBA.

Sayed, A., & Nagy, J. (2020). Design Strategies for Integrating Biophilic Design to Enhance the Students' Performance in Existing Primary Schools in Egypt. FJE Fayoum University Journal of Engineering.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Shinew, K. J., Glover, T. D., & Parry, D. C. (2017). Leisure spaces as potential sites for interracial interaction: Community gardens in urban areas. Journal of Leisure Research.

Sidiropoulos, E. (2018). The personal context of student learning for sustainability: Results of a multi-university. Journal of Cleaner Production.

Sinxadi, L., & Campbell, M. (2020). Factors Influencing Urban Open Space Encroachment: The Case of Bloemfontein, South Africa. In Smart and Sustainable Cities and Buildings. Switzerland: Springer Nature.

Soltanian, F., & Mohammadi, A. (2015). Study of characteristics of urban public open spaces based on social interaction (Case study Salavatabad's 3-kilometer route). European Online Journal of Natural and Social Sciences. Retrieved November 27, 2018

Totaforti, S. (2020). Emerging Biophilic Urbanism: The Value of the Human-Nature Relationship in the Urban Space. Sustainability.

Trencher, G., Terada, T., & Yarime, M. (2015). Student participation in the co-creation of knowledge and social experiments for advancing sustainability: experiences from the University of Tokyo. Current Opinion in Environmental Sustainability.

Ulrich, R. S. (1981). Natural vs. urban scenes: Some psychophysiological effects. Environment and Behaviour.

Windhagera, S., Atzwangera, K., Booksteinab, F. L., & Schaefer, K. (2011). Fish in a mall aquarium: An ethological investigation of biophilia. Landscape and Urban Planning.

Xue, F., Gou, Z., Lau, S., Siu-Yu, L., Chung, K.-H., & Zhang, J. (2019). From biophilic design to biophilic urbanism: Stakeholders' perspectives. Journal of Cleaner Production.

Zakariya , K., Harun , N. Z., & Mansor, M. (2014, October). Spatial Characteristics of Urban Square and Sociability A review of the City Square, Melbourne. AMER International Conference on Quality of Life. Kota Kinabalu: Procedia - Social and Behavioral Sciences.

Zari, M. P. (2019). Understanding and designing nature experiences in cities: a framework for biophilic urbanism. Cities & Health.

🏆 *reviewed paper*

Climate Twins for Future – Equivalent Urban Climate as Starting Point towards more Climate-Adapted Cities

Bianca Pfanner

(Dipl.-Ing. Bianca Pfanner, TU Wien, Institute for Urban Design and Landscape Architecture, Department of Landscape Architecture and Planning, Erzherzog-Johann-Platz 1, 1040 Vienna, bianca.pfanner@tuwien.ac.at)

1 ABSTRACT

Climate change-related effects such as heat or drought stress for humans, animals and plants or overstrained infrastructures can be observed especially in urban areas. Since these increasingly problematic situations do not represent individual phenomena, but are embedded in a global system, a search for similar problems in other cities or regions followed by a transfer of solutions have evolved as proven approach in the urban, regional, rural, landscape planning and research discourse. Regarding the urgency of the climate crisis, the approach "Mainly something happens and quickly" could guide spatial development planning within this "learning from" approach. But a greater potential would exist by looking to urban structures, mainly open and green spaces, whose current urban climate point to the future for other cities. These climate forecasts combinded with specific spatial examples are called Climate Twins and are an explanatory path that allows comparisons between urban climates, but diverges on the components of time and place (Rey et al. 2020, Bastin et al. 2019, Rohat et al. 2018 and 2017, Nakageawa et al. 2017, Beniston 2014, Ungar et al. 2011, Peters-Anders et al. 2011, Loibl et al. 2010, Loibl and Peters-Anders 2009, Hallgatte 2009, Kopf et al. 2008, Hallegatte et al. 2007).

The aim of this paper is to put this modeling and climate research based method into an open and green spatial planning context and develop it as part of a more climate-conscious and climate-adapted planning paradigm. By using descriptive and explorative analytical methods, questioning what role climate has played in urban development historically, currently, but especially in the future may help to understand the climatic and planning relevance of “non-built” urban structures. Thus, this paper intends to develop Climate Twins as a research-led planning topic and starting point towards more climate-adapted and sustainable cities.

Keywords: Equivalent urban climate, Climate-Adatped, Urban Landscape, Climate Change Adaptation, Climate Twins

2 FUTURE HOT URBAN CLIMATE – NO SHORT-TERM SUMMER FUN BUT HARD REALITY

When heat waves occur in summer, the media like to draw comparisons with cities or regions where these temperatures are common. In most cases, this conveys a positive image, as it is supposed to create a “vacation mood”. In central Europe this applies mostly to destinations in the Mediterranean region. However, the comparisons should actually be taken seriously and should rather be seen as an outlook for future everyday life. The image of a short-term stay in emotional high spirits in warmer climatic zones, which has clearly different daily structures and behaviour patterns and a clear end date, should be replaced by an image of an adapted and changed everyday life in those warmer climatic zones. In particular, the record temperatures, reached so far in 2022 in some southern European countries (Spain, France, Italy, Slovenia, etc.), with drastic challenges (rationing of drinking water, threat of crop exhaustion in agriculture, forest fires, etc.), should be an urgent appeal to society that this tends to be the reality (DerStandard/APA 2022a and b, DiePresse/APA/DPA 2022, Zeit Online/DPA 2022). both for the countries addressed, but precisely also for the northern countries that are currently not directly affected.

For this narrative of the transformation of the vacation region into the everyday region, a lot of questions arise. First, what does "climate-equivalent" mean (section 3), what characterises existing urban open and green structures as “climate-adapted” in order to serve as "learning objects" for Climate Twins (section 4) and additionaly, if any, what role has climate played in urban landscape development (section 5).

3 EQUIVALENT URBAN CLIMATE – AN EXPLANATORY PATH OF CLIMATE RESEARCH

Climate forecasting and summarising in urban climate analyses is currently a field of activity in demand, which spatial planning increasingly has to take into account, or even do more intensively. In a specific

literature research on possibilities of climate change adaptations in urban areas, a universal but applicable statement could be found, which offers potential for deepening:

"How urban design can be positively influenced from a climatic perspective, can be seen by looking at building structures in other climates (e.g., shading in narrow alleys, radiation-optimised orientation of buildings)." (Henninger and Weber 2020: 159; translated from German[1])

This building-related approach of how to plan 'climate-adaptively' seems to be so applicable and helpful that the same demand can be formulated for urban and green spaces – the "non-built" city landscapes. At the same time, it is considered necessary to specify the wording "other climates". At this point, research results by climate researchers on climate-equivalent cities can be used as a basis for spatial adjustments. With a focused view to those cities whose future is depicted in a real setting, may be a promising way to take future climate conditions into account and to act on them at an early stage. In the climate science, research is being conducted under the terms Climate Twins, City Shifting or Climate Analogues.

Climate Twins stands for the "wandering" and "shifting" of cities along climate predictions by data modeling of climate elements (primarily temperature and precipitation). In scientific terms, there is a constant and increasing movement of the isothermal lines that define the large-scale climate zones, putting pressure on current cities and urbanisation. In this regard, the studies aim to identify cities that can be equivalently described in terms of their climatic characteristics through shifts in time and place. This is intended to illustrate where on earth the predicted climate for a particular city can already be found today, thus, can be described as climate-equivalent (Rey et al. 2020, Bastin et al. 2019, Rohat et al. 2018 and 2017, Nakageawa et al. 2017, Beniston 2014, Ungar et al. 2011, Peters-Anders et al. 2011, Loibl et al. 2010, Loibl and Peters-Anders 2009, Hallgatte 2009, Kopf et al. 2008, Hallegatte et al. 2007). A good explanation emerges from one study:

"Twin climate cities are pairs of cities for which it is appropriate to assume that the future climate of a city "A" will be significantly similar to the current climate of another city "B"." (Rohat et al. 2017: 929)

The authors find themselves in consensus that a worldwide "shifting trend" towards the subtropics (around the 20th latitude) is emerging: A southward trend in the northern hemisphere and a northward trend in the southern hemisphere will occur.

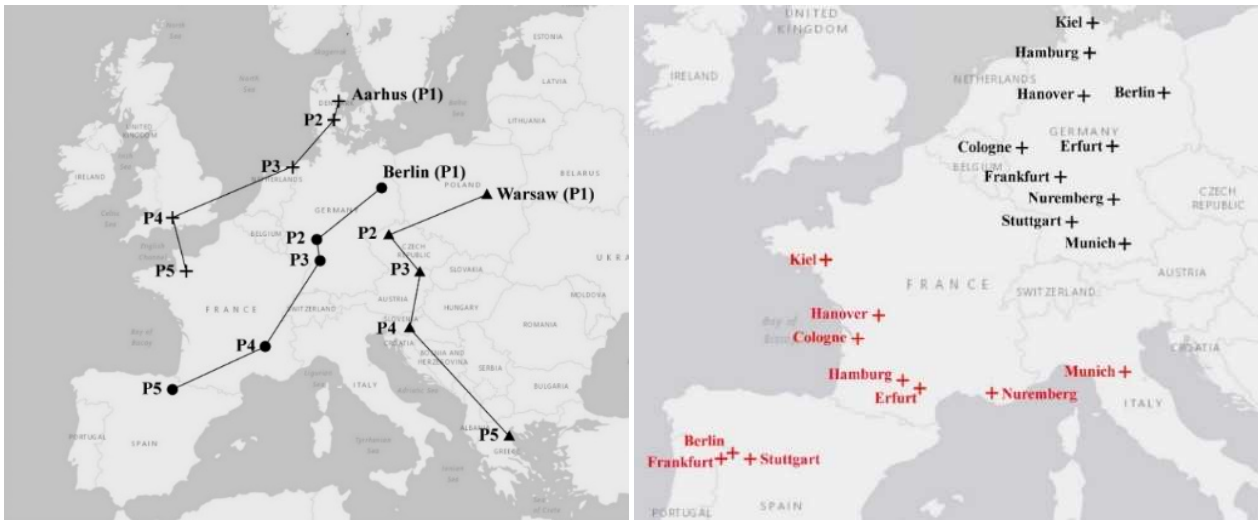


Fig. 1: Climate shift over the European continent for four cities, for the four 30-year shift time periods (Rohat et al. 2018: 438);
Fig. 2: Current location (black) of the main German cities and the location of their future climate (red) (Rohat et al. 2017: 938)

In a global study by Bastin et al. (2019), for 77 percent of cities a different urban climate is assumed than their own urban climate at present. By 2050, spatial climatic hifts can reach up to 1,000 kilometers, or about 20 kilometers annually. To make the data a little more descriptive, examples of Climate Twins are given:

[1] Original quote: „Wie aus klimatischer Sicht positiv auf den Städtebau eingewirkt werden kann, wird durch die Betrachtung der Bebauungsstrukturen in anderen Klimazonen ersichtlich (z.B. Verschattung in engen Gassen, strahlungsoptimierte Ausrichtung der Gebäude)."

“Madrid’s climate in 2050 will be more similar to the current climate in Marrakech than to Madrid’s climate today; London will be more similar to Barcelona, Stockholm to Budapest; Moscow to Sofia; Portland to San Antonio, San Francisco to Lisbon, Tokyo to Changsha, etc.” (Bastin et al. 2019: 7)

Comparatively, Rohat et al. (2018) quantified the southward movement of climatic conditions for European cities at an average of 200 kilometers within 25 years. Possible shifting paths for Aarhus, Berlin, and Warsaw indicate south to southwestern European regions as likely future locations (Figure 1). Rohat et al. (2017) further investigated whether and where climate-equivalent regions and cities exist in Europe. The results show that out of 100 European cities, there is one equivalent region for each of 70 cities and one equivalent city for each of 30 cities. Furthermore, possible Climate Twins could be identified for ten German cities; all are located in a more south-western location in Europe (Figure 2).

Beniston had the same research focus (2014) when he examined the geographical displacements on the European continent in three sections. Displacements of two to 14 kilometers per year can be assumed. These are expected to be more intense in continental and eastern European regions than in maritime regions.

Loibl and Peters-Anders (2009), Loibl et al. (2010), Peters-Anders et al. (2011) and Ungar et al. (2011) specifically developed a web-based tool to determine how to narrow down possible climate equivalent regions. With an example of a Czech city they illustrated the wide range of results and showed how difficult it is to define one or a few representative Climate Twins. For doing so, an adjustment of indicators and thresholds is necessary. This difficulty is the argument for the authors to use Climate Twins more as a digital communication tool to show generally the climatic shift of urban climates and to gain attention from the public and spatial planners too:

„Until now no satisfying validation method or data could be found to compare the Climate Twin results with. Therefore the fictive line between ‚good‘ and ‚bad‘ results can only be drawn subjectively by visual interpretations of result maps while variing the thresholds.“ (Ungar et al. 2011: 433)

Another example that pushes the visual representation of Climate Twins is the "Global Map: Shifting Cities" by Climate Central and World Meteorological Organization (WMO) (Figure 3). The map represents where selected cities have their climate equivalent "partners" around the world. In addition, the development path is shown under the assumption of a moderate emissions scenario (basis: targets of the international Paris Agreement of 2015), which would result in a less pronounced shift in the geographical location of all cities.

Based on these results, the Helmholtz Center for Environmental Research (ESKP - Earth System Knowledge Platform) also drews attention to the need for cities to adapt (Kandarr 2018). As examples, the authors picked out Berlin, which in the future will have the peak summer temperatures of Bucharest, up to 28.1°C. Also mentioned is Madrid, which is expected to have conditions like todays Erbil, Iraq, with a maximum temperature of 36.4°C. And in Riad, the mercury will be able to rise another 6°C in summer, up to 48°C (Figure 4).

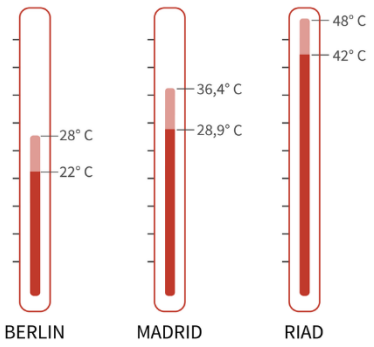


Fig. 3: Website “Global Map: Shifting Cities” (Climate Central and WMO); Fig. 4: Peek summer temperatures in future for Berlin, Madrid and Riad (Kandarr 2018)

Furthermore, Reusswig (2010) used the comparison in his book article "Berlin = Zaragoza?" to debate the multi-layered consequences of climate change. Reusswig referred to the study by Hallegatte, Hourcade and Ambrosi (2007) - numerous references of subsequent studies can also be attributed to this study. Using two models (CNRM ARPEGE, HadRm3H), the shifts in urban climatic conditions by 2100 in Europe were

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

calculated and visualised (Figure 5). For example, Vienna would find itself around Venice or Albacete in central Spain.

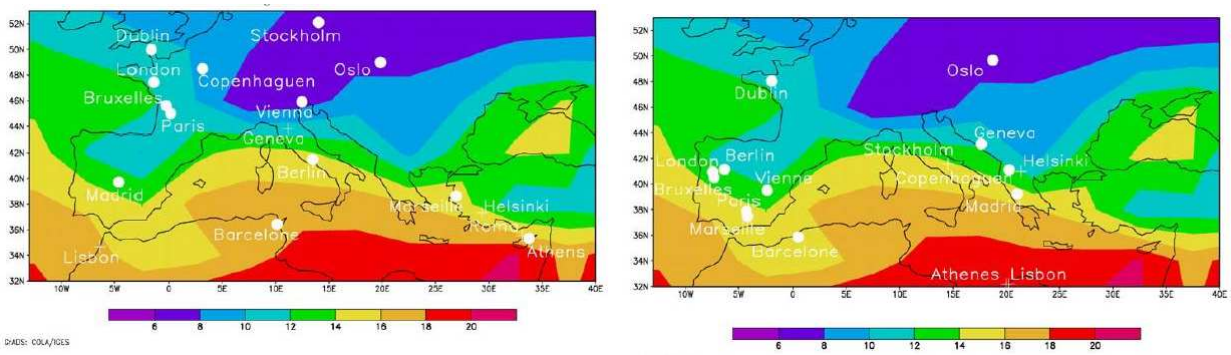


Fig. 5: Map of climate relocations of 17 European cities: Each city is plotted at the location of its "acceptable analogue"; left: ARPEGE-Climat model, right: HadRM3H model (Hallegatte et al. 2007: 50f)

Hallegatte et al. (2007) concluded that by comparing cities in different but realistic climatic regions, solutions for climate-adapted infrastructures, building architecture and street formations can be found. This statement addresses directly spatial planners and thus also forms the basis for this research work. Although this is a 15-year-old and unmistakable statement, planning oriented to Climate Twins is nevertheless largely unknown or considered novel.

Two years later, in 2009, Hallegatte specified the results:

"[...] a building built now to last 80 years would have to face over its lifetime, the climate of Paris [...; and the] climate of Cordoba. For an architect, it is not more difficult (nor more expensive) to design a building adapted to the climate of Cordoba than to the climate of Paris. But it may be more difficult (and more expensive) to design a building adapted to both [...]." (Hallegatte 2009: 241)

Hallegatte along with Kopf and Ha-Duong (2008), also researched to City Analogues to interpret climate change scenarios for cities. The authors investigated implied uncertainties and used the example of twelve European cities to show the limitations of the method, such as the exact location of a "best" or "good" climate-equivalent region or city. This research issue is also the reason why the scientific evidence for spatial planning is wavering. But at the same time, the clear trend towards a warm, mediterranean climate clearly shows that the previous, or let's call it "domestic", climatic conditions of the individual cities are no longer sustainable in order to maintain the quality of life and keep possible damage to residents' health as low as possible.

This excerpt of a literature review on equivalent climate locations clearly shows the relevance of climate studies for spatial planning. Through modeling and spatialisation, it shows in a further way the effects of climate change and formulates the need for action. Even if there are uncertainties due to the data basis (climate is more diverse and complex than can be described by just two elements) as well as the different methodological approaches, this creates an extremely exciting and relevant field of spatial planning activity: climate change adaptation of the urban body and fabric inspired by Climate Twins as contribution to qualifying existing adaptation solutions and to strengthen a more serious climate-oriented planning paradigm.

4 CLIMATE-ADAPTED URBAN STRUCTURES – WHAT DOES IT MEAN?

So far the impression might have arisen that Climate Twins and their urban structures are understood directely as ideally adapted to the climate. But, first, the "simple" fact is that increasing climate change is challenging all cities worldwide more and more and pushing them to their limits. Secondly, active research activities searching and investigating solutions for climate change adaptation and mitigation can clearly negate this point. Moreover, the constant natural change of the climate has as a consequence that a city can never be planned as "finished" and designated as finally "climate-adapted".

Despite this initial "rejection" of a definition of climate-adapted urban structures, there are nevertheless numerous examples of what 'climate-adapted' means. Thus, a lot of research projects have emerged in recent years that are dedicated to this question and are looking for solutions on how to implement them.

A first reference is provided by Laue (2019) with "Klimagerechte Landschaftsarchitektur"/"Climate-friendly landscape architecture". Laue goes into detail about the different planning principles of the global climate zones (Figure 6, 7).

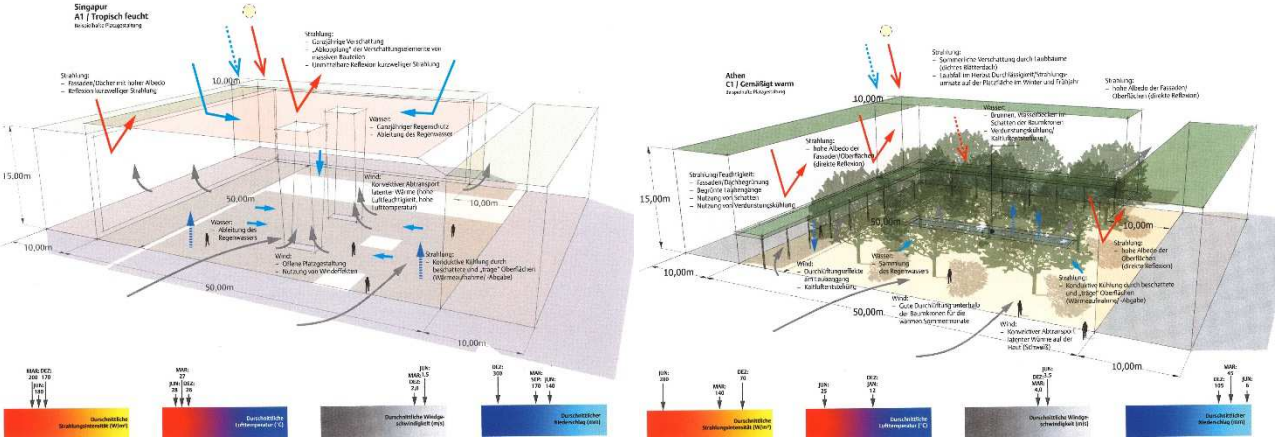


Fig. 6: Exemplary square design in Singapore in a tropical humid climate (Laue 2019: 75); Fig. 7: Exemplary square design in Athens in a warm temperate climate (Laue 2019: 95)

With these considerations, Laue describes intended target states, which can subsequently be described as "climate-adapted" and are consequently recommended for Climate Twins. However, this planning-strategic view touches only the theory. The practical component, the real, existing open spaces and green structures in the cities is a different one and would also require methodologically more application-oriented methods (on-site visits, photo documentations, spatial analyses, etc.).

Remaining in this level of analysis, a closer look shows a partly much less pronounced difference in planning principles between the different climate zones. Figure 8 shows that, for example, the strategy "shading of the open space" is recommended for eigth climate types, from tropical humid, dry and hot, warm temperate till continental with regard to the prevention of radiative transfer.

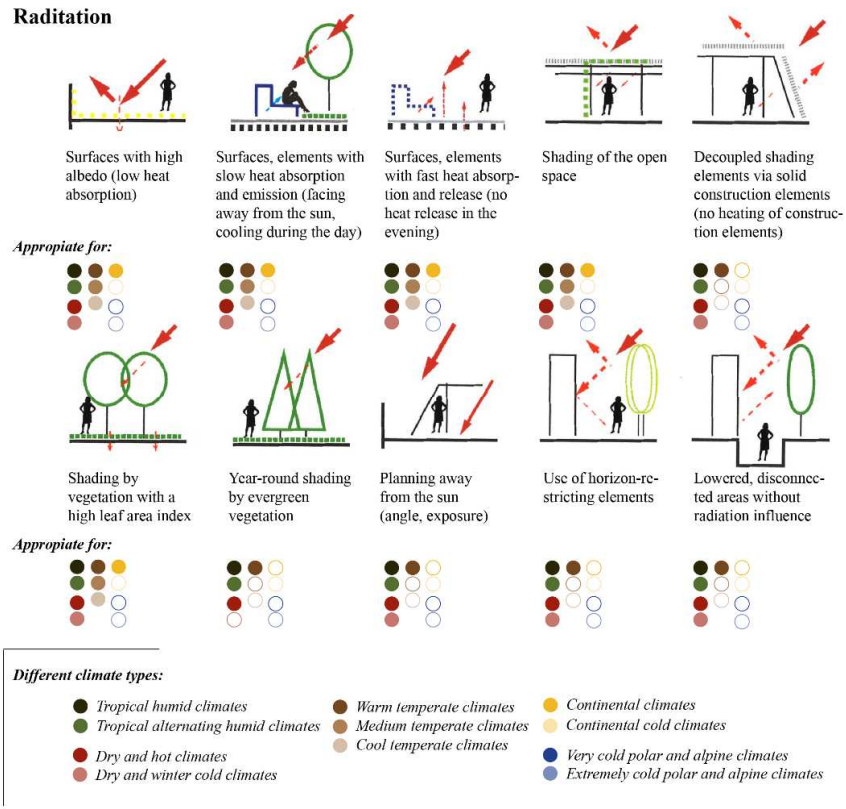


Fig. 8: Climate-adapted open spaces structures with cooling as the primary planning strategy – focus radiation, applicable to multiple climate zones (Laue 2019: 133; translated from German)

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Nearly the same applies for water-specific recommendations like vegetative surfaces to foster an evaporative circulation or water-storing surfaces and substrates. Differentely to radiation, sites within a tropical humid climate should use these guidelines less (Figure 9).

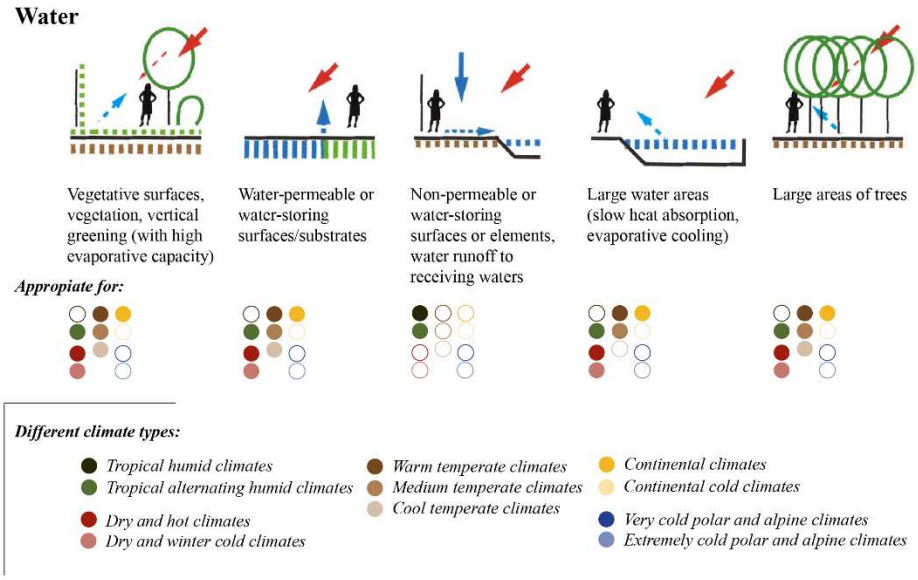


Fig. 9: Climate-adapted open spaces structures with cooling as the primary planning strategy, focus water, applicable to multiple climate zones (Laue 2019: 133; translated from German)

This may give the impression that the recommendations to planning and landscape architecture, structured by radiation, water and as well wind, are to be regarded as universal and that no specifics are necessary. This paper would like to counter this. First of all, climate zones are very large spatial unit. Accordingly, descriptions at this zonal, large scale can only remain general. Only through closer examination and spatial focussing will clear differences emerge, which result in significant differences in the quality of life. Furthermore, the overlap and repetition of spatial structures highlight the relevance of each recommendation to the design and shape of urban open and green space. For example, Laue writes about landscape architecture in relation to climate:

“Landscape architecture has a problem compared to architecture: All open spaces are always thermally linked to larger climatic units. […] An understanding of climate in its spatial gradations is therefore indispensable, especially for landscape architecture.” (Laue 2019: 14; translated from German[2])

5 CLIMATE IN A RETROSPECTIVE – ROLE IN URBAN LANDSCAPES

The simple question what climate-adapted means, however, highlightes that it is actually also unclear whether the current appearance of a city can be understood as an expression of climate adaptation at all. City as a spatial convolut and living beings is rather to be understood as a co-existence of difference, whereby a multitude of interests and developments shaped and shape constantely the appearance of a city. In a critical perspective, a further question is, if any, what role have climate played in urban landscape development?

Kuttler (2004) points out that urban climatological aspects already have historical “cult status” and were of interest when living conditions in cities declined dramatically:

“The beginnings of urban climatology can be traced back relatively far in time – even to antiquity. First works in this field are attributed to Vitruvius (75 B.C. - 26 B.C.; “Urban Planning and Climatic Conditions”) and Horaz (ca. 24 B.C.; “Air Pollution in Rome”) (compilation in Yoshino 1990/91, Müller 2003). In

[2] Original quote: „Die Landschaftsarchitektur hat im Vergleich zur Architektur ein Problem: Alle Freiräume sind thermisch gesehen immer mit größeren klimatischen Einheiten verknüpft. […] Ein Verständnis für Klima in seinen Raumabstufungen ist also insbesondere für die Landschaftsarchitektur unabdingbar.“

particular, problems of urban planning in connection with climatic and air-hygienic influences were dealt with […].” (Kuttler 2004: 188f; translated from German[3])

The far back presence of climate as a planning issue is also highlighted by Krautheim et al. (2014), who specifically address the relevance of climate as an architectural instrument:

“Climate has been of major influence on architecture for centuries. Orientation, form and materials were, for a long time, the logical consequence of local conditions. This has generated the many differnet traditional styles of architecutre, each with its own regional characteristics and resources. […] Traditional ways of city development correlate with environmental issues, such as the use of solar irradiation, natural ventilation and precipitation, the reduction of emissions […], bringing down the ecological footprint, minimising the energy consumption (etc.), up to the point of introducion complex recycling processes.” (Krautheim et al. 2014: 10)

An example of how natural ventilation harmonizes well with the existing urban and open space structure is the historic city of Korcula in Croatia (Figure 10, 11). Therefore, this example is formulated as

“adapted to the specific geographic, topographic and climatic conditions. The cold and gusty north winter wind (Bora) is being blocked by the street pattern, whereas westerly and easterly summer winds can easily access the urban fabric.” (Krautheim et al. 2014: 65)

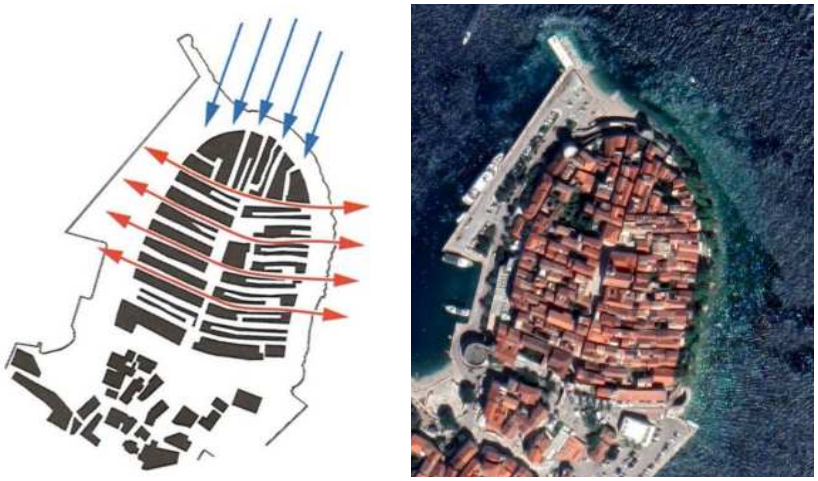


Fig. 10: Historic city of Korcula in connection with wind conditions (Krautheim et al. 2014: 65); Fig. 11: Orthophoto from Korcula (https://www.google.com/maps/)

From today’s (2014) point of view, the authors said that technical and technological progress disregard the orientation towards and planning according to natural and climatic conditions, and that the climate is not considered as a co-designing system element. Furthermore, Reusswig (2014) argues “the consumerist fossil city” has contributed to this since the 1960s:

“Notably since the 1960s a growing number of buildings became typologically identical, irrespective of their geographical location. The same applies to cities. Whereas the majority of medieval cities followed regional and climate specific conditions, many of the so-called ‚new towns‘ generate their own (ir)rational lay-out. Rational principles like optimising an infrastructural network, or irrational designs that create an allegorical image of the city rather than spatially programmed entities, seem to have long superseded a contextural urbanism.” (Krautheim et al. 2014: 10)

Learning from Climate Twins to best arrive at climate-adapted cities also means that looking at existing and historical urban landscape structures involves both parallelising and contextualising (Kurz 2022). Drawing parallels is fundamental, as landscape and vegetation are portraits and also information carriers of the past and present. In a further step, this acquired knowledge can be transferred into new concepts. Therefore, the procedure is the subject of transformation research and includes development steps such as preserving, updating, intervening, intensifying and rethinking.

[3] Original quote: „Die Anfänge der Stadtklimatologie lassen sich zeitlich relativ weit - sogar bis ins Altertum - zurückverfolgen. Erste Arbeiten auf diesem Gebiet werden Vitruvius (75 v.Chr. - 26 v.Chr.; 'Stadtplanung und Klimabedingungen') und Horaz (ca. 24 v.Chr.; 'Luftverschmutzung in Rom') zugeschrieben (Zusammenstellung bei Yoshino 1990/91, Müller 2003). Dabei wurden insbesondere Probleme der Stadtplanung in Zusammenhang mit den klimatischen und lufthygienischen Einflüssen behandelt […].“

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Keeping the question raised and also Kurz's (2022) notion of parallelisation and contextualisation, Rathore (2021) summed up her thoughts on this topic in her article "The City Adapted". She explains adaptation as an expression of three components: Preservation, reinvention and association.

"'Preservation' […] is a conscious attempt to attach value to architectural remnants belonging to different historical eras. […] Furthermore, the preservation of ecological interventions that date back to the city's inception, such as the interconnected systems of lakes in Udaipur, acts as a reminder of a pre-colonial existence; of capacities, skills and resources that can only have been the basis of a formalised settlement." (Rathore 2021: 56)

Regarding reinvention and assosciation, the author particularly addresses the cultural significance of existing urban landscapes as central components for adaptation. In this context, Paul Oliver (1999/2006) explored intensively in his "Encyclopedia of Vernacular Architecture of the World" the contradictions between these two "logics" or "rationalities" guiding design. "Vernacular" describes a category of architecture based on local needs, construction materials and reflecting local traditions. Through this explanation, "vernacular" can also be included in the set of definitions of "climate-adapted", albeit in a cultural-historical focus and less in a spatial planning understanding.

Also of interest is the contribution by Koohestanian (2021), who is researching on climate adaptation in cities through the use of a global approach with local solutions as part of the Fraunhofer Institute's Morgenstadt Global Smart Cities Initiative (MGI). He writes about Kochi (India, Kerala), one of the three pilot cities, where climate risks in the form of floods, storms and heatwaves are becoming increasingly problematic. By analysing the existing spatial structures, the researchers found that a complex network of rivers, tidal creeks and backwaters dating back to colonial times is present. With the supportive use of native vegetation (magroves) and wetland, this infrastructure offers the possibility to build a natural drainage system that protects the city from flooding events. This measure also has a direct effect on the necessary reduction of urban heat islands. It is interesting to note that the term "climate-adapted" is not used here, but the approach of recognising, understanding and further developing the use of existing natural and built structures is a clear expression of climate-adaptive planning.

The short excursion into the literature concerning the historical role or relevance of climate in the current appearance of urban landscapes shows multifaceted interpretations of climate-adapted cities and, additionally how important their cultural aspects are. At the same time, dealing with Climate Twins shows the urgency to think more intensively about the natural laws of climate in the planning and design of urban fabrics, both now and in the future.

6 CONCLUSION

Climate Twins as an additional topic of urban climate change adaptation raises a lot of questions but also challenges. The importance of up-to-date climate data and climate studies as a basis for climate-oriented spatial planning is highlighted, as well as the relevance and methodological challenge of comparative research. The central research object "existing urban structures" as learning objects are manifold, diverse and historically complexly interwoven. Thus detailed spatial analyses has to accompany research and planning in order to understand the local context and to translate it in transferable concepts for climate adaptation.

Learning from existing open and green space structures in equivalent climate zones can also broaden other exciting and current topics such as architecture, landscape architecture, urban planning, energy supply, but also the cultural significance of urban space. Additionally, describing the future urban climatic conditions with the help of climate-equivalent situations can possibly assist to move from the vacation image described initially to an everyday image and show the urgency of action against climate change.

Accordingly, Climate Twins can be considered as an interesting and promising starting point towards more climate-adapted cities and can also be described as an urgent field of research. Climate-equivalent orientated research may help spatial planners, urban designers and architects to move forward on the question: which urban structures and uses will face greater constraints under changing climatic conditions and how can they be adapted, inspired by their climatic twin?

7 REFERENCES

BASTIN, Jean-Francois; CLARK, Emily; ELLIOTT, Thomas; et al.: Understanding climate change from a global analysis of city analogues. In: PloS ONE, Vol. 14, Issue 7, pp. 1–13. 2019.

BENISTON, Martin: European isotherms move northwards by up to 15 km year -1 : using climate analogues for awareness-raising. In: International Journal of Climatology, Vol. 34, Issue 6, pp. 1838–1844. 2014.

CLIMATE CENTRAL; WORLD METEOROLOGICAL ORGANIZATION (WMO): Shifting Cities. Available: https://www.climatecentral.org/climate-matters/global-shifting-cities (last checked 27.01.2022).

DerStandard/APA a: Trinkwasser an der slowenischen Küste wegen Dürre rationiert. In: DerStandard/APA, 06.07.2022. Available: https://www.derstandard.at/story/2000137201645 (last checked 14.07.2022).

DerStandard/APA b: Verona rationiert Trinkwasser wegen anhaltender Dürre. Available: https://www.derstandard.at/story/2000137110948 (last checked 14.07.2022).

DiePresse/APA/DPA: Extreme Hitzewelle in Europa: Bis zu 43 Grad. Available: https://www.diepresse.com/6154191/extreme-hitzewelle-in-europa-bis-zu-43-grad (last checked 14.07.2022).

HALLEGATTE, Stéphane: Strategies to adapt to an uncertain climate change. In: Global Environmental Change, Vol. 19, Issue 2, pp. 240–247. 2009.

HALLEGATTE, Stéphane; HOURCADE, Jean-Charles; AMBROSI, Philippe: Using climate analogues for assessing climate change economic impacts in urban areas. In: Climatic Change, Vol. 82, Issue 1-2, pp. 47–60. 2007.

HALLEGATTE, Stéphane; LECOCQ, Franck; PERTHUIS, Christian de: Designing climate change adaptation policies: an economic framework. Policy Research working paper no. WPS 5568. Washington, D.C.: World Bank Group, 2009. Available: http://documents.worldbank.org/curated/en/596081468155974532/Designing-climate-change-adaptation-policies-an-economic-framework (last checked 16.06.2022).

HENNINGER, Sascha; WEBER, Stephan: Stadtklima. Paderborn: Ferdinand Schöningh (utb 4849 Geowissenschaften, Klimatologie, Stadtplanung), 2020.

KANDARR, Jana: Städte warmer als ihr Umland. Helmholtz Zentrum für Umweltforschung, ESKP – Earth System Knowledge Platform. 2018. Available: https://themenspezial.eskp.de/metropolen-unter-druck/stadtklima-und-lebensqualitaet/staedte-waermer-als-ihr-umland-93764/ (last checked 07.07.2022)

KOOHESTANIAN, Naral: The City of Kochi. In: Topos: European landscape magazine, Vol. 116, pp. 62-67. 2021.

KOPF, Sebastian; HA-DUONG, Minh; HALLEGATTE, Stéphane: Using maps of city analogues to display and interpret climate change scenarios and their uncertainty. In: Natural Hazards Earth System Sciences, Vol. 8, Issue 4, pp. 905–918. 2008.

KRAUTHEIM, Mareike; PASEL, Ralf; PFEIFFER, Sven; SCHULTZ-GRANBERG, Joachim: City and Wind: Climate as an Architectural Instrument. Berlin: DOM publisher, 2014.

KURZ, Peter: Kulturlandschaft: Relevanz und Aktualität des Konzeptes für Fragen der räumlichen Planung und der Regionalentwicklung. Defensio, Technische Universität Wien, 02.06.2022.

KUTTLER, Wilhelm: Stadtklima. In: Umweltwissenschaften und Schadstoff-Forschung, Vol. 16, Issue 3, pp. 187-199. 2004.

LAUE, Hendrik Matthias: Klimagerechte Landschaftsarchitektur. Handbuch zum Umgang mit Elementen und Faktoren des Klimas im Freiraum. Berlin/Hannover: Patzer-Verlag, 2019.

LOIBL, Wolfgang; PETERS-ANDERs, Jan: Climate twins – a climate change exploration tool, identifying future climate -current climate region pairs to learn how to adapt to climate change. Conference Paper ISESS. 2009.

LOIBL, Wolfgang; PETERS-ANDERS, Jan; ZÜGER, Johann: Climate Twins – a tool to explore climate impacts by assessing real world conditions: Exploration principles, underlying data, similarity conditions and uncertainty ranges. In: Geophysical Research Abstracts, Vol. 12, EGU2010-12149. 2010.

NAKAEGAWA, Tosiyuki; HIBINO, Kenshi; TAKAYABU, Izuru: Identifying climate analogues for cities in Australia by a non-parametric approach using multi-ensemble, high-horizontal-resolution future climate projections by an atmospheric general circulation model, MRI-AGCM3.2H. In: Hydrological Research Letters, Vol. 11, Issue 1, pp. 72–78. 2017.

OLIVER, Paul: Encyclopedia of Vernacular Architecture of the World. In: Traditional Dwellings and Settlements Review, Vol. 10, Issue 2, pp. 69-75. 1999. London: Routledge, 2006.

OLIVER, Paul: Built to Meet Needs: Cultural Issues in Vernacular Architecture (1st ed.).

PETERS-ANDERS, Jan; LOBO, Tomás Pariente; UNGAR, Joachim; LOIBL, Wolfgang: Using TaToo services to enhance information retrieval about climate change consequences – Demonstration of the Climate Twins scenario. In: EnviroInfo 2011: Innovations in Sharing Environmental Observations and Information. Aachen, 2011.

RATHORE, Rupal: The City Adapted. In: Topos: European landscape magazine, Vol. 116, pp. 54-59. 2021.

REUSSWIG, Fritz: Berlin = Saragossa? In: VALENTIEN, Donata (ed.): Wiederkehr der Landschaft/Return of Landscape. Berlin: jovis Verlag und Akademie der Künste, pp.92-101, 2010.

REUSSWIG, Fritz: Urban winds of change. In: KRAUTHEIM, Mareike; PASEL, Ralf; PFEIFFER, Sven; SCHULTZ-GRANBERG, Joachim (ed.): City and Wind: Climate as an Architectural Instrument. Berlin: DOM publisher, pp. 18-23, 2014.

REY, Joan; ROHAT, Guillaume; PERROUD, Marjorie; GOYETTE, Stéphane; KASPARIAN, Jérome: Shifting velocity of temperature extremes under climate change. In: Environmental Research Letters, Vol. 15, Issue 3, 034027. 2020.

ROHAT, Guillaume; GOYETTE, Stéphane; FLACKE, Johannes: Characterization of European cities' climate shift – an exploratory study based on climate analogues. In: International Journal of Climate Change Strategies and Management, Vol. 10, Issue 3, pp. 428–452. 2018.

ROHAT, Guillaume; GOYETTE, Stéphane; FLACKE, Johannes: Twin climate cities—an exploratory study of their potential use for awareness-raising and urban adaptation. In: Mitigation and Adaptation Strategies for Global Change, Vol. 22, Issue 6, pp. 929–945. 2017.

UNGAR, Joachim; PETERS-ANDERS, Jan; LOIBL, Wolfgang: Climate Twins – An Attempt to Quantify Climatological Similarities. Proceedings ISESS, pp. 428-436. Brno/Heidelberg, 2011.

Zeit Online/DPA: Große Hitze in Spanien, Portugal und Frankreich. Available: https://www.zeit.de/wissen/umwelt/2022-07/hitzewelle-spanien-italien-frankreich-deutschland-waldbrand-duerre?utm_referrer=https%3A%2F%2Fwww.google.com%2F (last checked 14.07.2022).

🏆 *reviewed paper*

Collection of Revealed Preference Mobility data of City Tourists – a Two-part Survey Design

Jonas Harz, Carsten Sommer

(Dipl.-Ing. Jonas Harz, University of Kassel, Chair of Transportation Planning and Traffic Systems, Mönchebergstraße 7, 34125 Kassel, Germany, jonas.harz@uni-kassel.de)
(Prof. Dr.-Ing. Carsten Sommer, University of Kassel, Chair of Transportation Planning and Traffic Systems, Mönchebergstraße 7, 34125 Kassel, Germany, c.sommer@uni-kassel.de)

1 ABSTRACT

Before the global Covid-19 pandemic, city tourism had been experiencing remarkable growth. Between 2014 and 2019, the market share grew from 22 % to 30 % (IPK International, 2020, 2015). With increasing numbers of visitors and the fact that tourists often concentrate around certain areas of interest, cities are experiencing growing problems (Gao et al., 2021). Furthermore, tourism has a considerable impact on greenhouse gas emissions, especially due to the arrival and departure of tourists, but also as a result of intra-destination trips by car (Gühnemann et al., 2021). Thus far, tourism transport has rarely been considered in urban transportation planning. For example, cost-benefit analyses for infrastructure that affects visitors, like a tramway line to a major touristic hotspot, do not consider the travel demand of tourists because the required data and instruments are mostly lacking.

With this submission, we present the method and results of a two-part survey that we conducted in 2020 and 2021 to collect data on the travel behaviour of tourists in Kassel, Germany. The first part of the survey was held as a Computer-Assisted Personal Interview (CAPI) on weekends at several touristic hotspots in Kassel. Visitors were asked about sociodemographic information, their main reason for visiting Kassel, their modes of transport for the journey, the duration of their stay, as well as planned and visited tourist attractions in Kassel. Overnight visitors were furthermore asked about their place of accommodation. For the second part of the survey, we chose two behaviourally homogeneous groups: overnight guests who arrived by car and day trippers who also arrived by car. It has been shown that the means of transport for arrival have a major impact on the modal choice of intra-destination trips (Bieland et al., 2017). The respondents were contacted again by phone one or two days after the first interview. The second part of the survey is based on the prevalent travel-diary approach and was held as a Computer-Assisted Telephone Interview (CATI). We altered the survey design of travel diaries to collect data on activities rather than trips because these are easier for visitors to reproduce. We surveyed all activities a visitor undertook on the day he or she was interviewed by us for the first time. For each activity, information was gathered about the start and end time, the type of activity, the location, and the means of transport.

In total, we were able to interview 2,050 visitors during the first part and 397 visitors with 1,186 intra-destination activities during the second part. The travel behaviour varied heavily between day and overnight visitors. When only counting visitors who made on-site trips (excluding undirected travel), day visitors made 1.6 trips on average, whereas overnight visitors made 3.2 trips per person per day. The modal split shows distinct differences between day and overnight visitors too. Daily visitors have a much higher share of car usage whereas far fewer trips were made by walking.

Keywords: tourism transport, revealed preference data, survey design, travel behaviour, travel diary

2 INTRODUCTION

It is common practice for cities, administrative regions, and even countries to conduct travel surveys in order to generate data about the travel behaviour of their population. These data are crucial for strategic transportation planning (e.g. Sustainable Urban Mobility Plans (SUMP)) and are often a basis for travel demand models that enable future traffic and the impact of transport and land use measures to be predicted. Generally, travel surveys are addressed to the population of a certain area, for example a city and its surrounding districts. A sample of this population is contacted and asked to record their travel behaviour for a specific time period (often a particular day or week) with the help of a travel diary. The resulting data are often regarded as a reflection of the traffic situation in the examined area, but this is not generally true. Because the sampling focuses on the area's population, tourists are not included in surveys and their travel behaviour is, therefore, neglected. This has led to an increasing data gap with the remarkable growth of city tourism in the last few years.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Between 2014 and 2019, the market share of city trips in all journeys worldwide grew from 22 % to 30 % (IPK International, 2020, 2015). This data gap has the consequence that, for example, travel demand models are not able to forecast transport for infrastructure projects geared towards tourists, like a new tramway line to a major tourist attraction. The growing number of visitors coupled with the fact that tourism concentrates around certain areas of interest and time periods is leading to growing problems for cities (Gao et al., 2021). Furthermore, tourism has a considerable impact on greenhouse gas emissions, especially due to the arrival and departure of tourists (Gühnemann et al., 2021) but also as a result of intra-destination trips if they are made by car. In correspondence with the political and societal demand for a transformation of the transport and mobility sector, the necessity is growing for traffic planners to take tourism into consideration. An established instrument for strategic traffic planning are travel demand models. These models can forecast transport and evaluate the impact of measures on current and future traffic networks. They usually rely on structural and sociodemographic data of the model area and its inhabitants. The travel demand generated by visitors is rarely considered in these types of models resulting in the inability to evaluate the impact of measures that are geared towards tourists, like new public transportation lines to touristic hot spots. To develop, validate and calibrate such models, data on travel behaviour is crucial. Therefore, the need to gather data on travel behaviour of tourists, such as by surveys, is necessary.

Visitor surveys are an established instrument for gathering data on tourists' behaviour. It is common to survey the mode of arrival and departure, but rarely is intra-destination travel behaviour included. Some studies, like Gutiérrez and Miravet (2016), have included items to survey aggregated information, but, to our knowledge, besides our survey, only Bursa et al. (2022) did a comprehensive study that gathered the revealed preference data of tourists in three alpine-touristic regions in Austria. Their survey design shows a lot of similarities to ours, for example they likewise decided to modify the concept of travel diaries to ask respondents about all their activities.

In this paper, we present the methodology and results of a revealed preference visitor survey we conducted in Kassel, Germany. The survey work is part of the research project "transport demand modelling of same-day visitors and tourists in cities", funded by the German Research Foundation (DFG), project number 409499825. The results of the survey were the basis for developing a modelling framework to integrate traffic generated by visitors into an urban travel demand model. We concentrated our surveying and modelling to common city tourists that either came as day or overnight visitors. Other visitor groups like business travellers can be added later to a modelling framework. Parts of the modelling work we did with the surveyed revealed preference data are described in Harz and Sommer (2022). There we present the methodology and results of choice models we estimated to analyse the mode choice behaviour of the interviewed tourists.

3 STUDY AREA

The city of Kassel with its 200,000 inhabitants is the regional centre of the north of the German federal state of Hesse. Due to its history as the former capital of the state of Hesse-Kassel, the city has a rich offering of parks and palaces, as well as a comprehensive number of museums. The most notable park is the Bergpark Wilhelmshöhe, one of the largest landscape parks in Europe. With its extensive water features, the Bergpark was granted World Heritage status by UNESCO in 2013, resulting in a distinct increase in the number of visitors. Additionally, every five years, Kassel hosts the Documenta, an exhibition of contemporary art that is one of the largest and most important worldwide. It lasts for 100 days and attracted nearly 900,000 visitors from all over the world in 2017. Due to its central location within Germany and its very good rail connections, Kassel is a very popular choice for conferences and business meetings, resulting in a very good hotel infrastructure. According to estimations by dwif (2020), there were 15.9 day visitors, 1.05 million overnight stays in accommodation like hotels or campsites, and 1.32 million overnight stays with friends or family in Kassel. We chose Kassel as the study area for our research because of our good local knowledge and access to local and regional data from the city and tourism authority. Kassel is representative of midsize major cities in Germany for urban tourism.

4 SURVEY WORK

4.1 Overall design

The visitor survey had the objective of generating (1) data about the socio-demographic and socio-economic structure of tourists, (2) information about their journey, and (3) revealed-preference travel and activity data during their time in Kassel. The target group of the survey was visitors to Kassel who were 18 years old or older and were not visiting the city for business purposes or an event. We decided to only interview visitors who were 18 years or older to avoid obtaining consent from parents. Business travelers and visitors of events were excluded because, as described, we wanted to concentrate our modelling framework to common city tourists for the time being and we assumed that these groups of visitors differ substantially in their travel behaviour.

This included all overnight visitors as well as day visitors who arrived from places that were more than 25 km away from downtown Kassel.

The survey was split timewise and methodically into two parts. In the first part, visitors were recruited for the survey and asked about their general personal and journey related information. The purpose of the second part of the survey was to survey all activities by a selected individual during the day he or she was interviewed for the first time, the so-called 'activity chain'. The surveying of the revealed-preference activity data was conducted for two behaviourally homogeneous groups based on their type of visit (overnight or daytime) and the mode of transport for their journey (by car or public transport). It has been shown that the mode of transport for arrival has a major impact on the modal choice of intra-destination trips (Bieland et al., 2017). We decided to choose the two largest groups of day visitors arriving by car and overnight visitors arriving by car to maximise the number of surveyed trips. Visitors who belonged to one of these two groups were asked to participate in the second part of the survey. As an incentive, we gifted each participant of the second part of the survey a lottery ticket for the German TV lottery.

The survey was conducted in Kassel in two timeframes: one in September and October 2020; and the other in August and September 2021. During both timeframes, the infection numbers of COVID-19 were very low in Germany resulting in relatively normal domestic tourism.

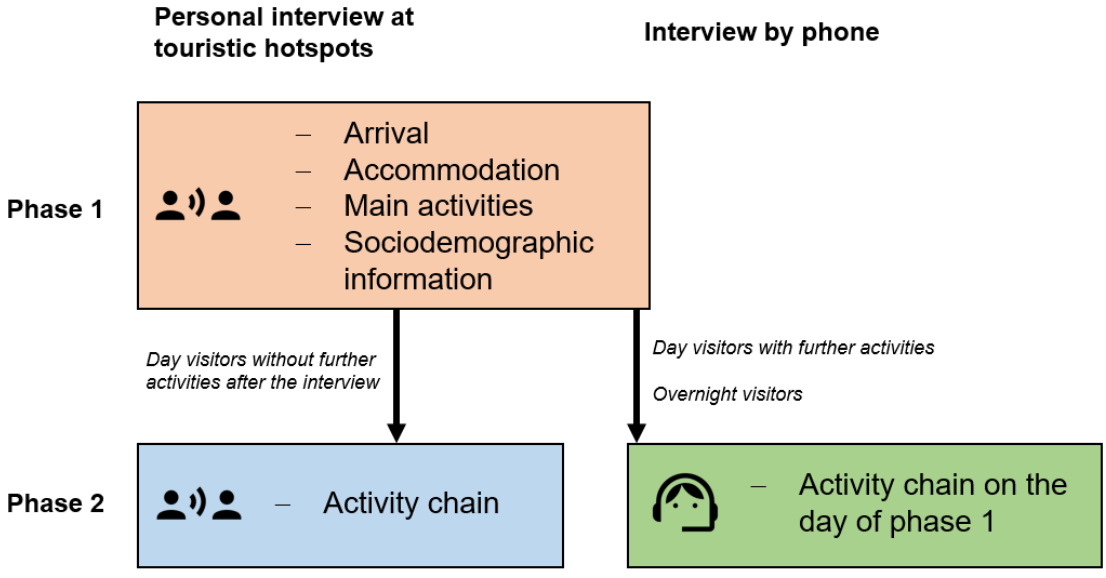


Figure 1: Overview of the different phases of the survey

4.2 Part 1: Visitor survey

The first part of the survey was held on ten weekends (five in 2020 and five in 2021) as a computer-assisted personal interview (CAPI) on tablet computers.

In contrast to conventional travel surveys, the population size is unknown, and the sample cannot, therefore, be drawn from an existing directory. Furthermore, there is no possibility of contacting tourists before they arrive in Kassel. Many surveys use an approach whereby tourists are contacted at hotels and interviewed

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

either using pen and paper or with the aid of a tablet computer. Unfortunately, this approach only works when interviewing overnight visitors staying at a hotel. Overnight visitors staying at different types of accommodation and day visitors cannot be contacted in this way. Furthermore, this approach is linked with a great amount of effort to get hotels to cooperate and participate in the survey. Even though this type of approach is a complete census, by experience, the return rate of completed surveys is rather low.

We chose another common approach, namely, to contact visitors randomly at places that are attractive to tourists and frequently visited by them. Of course, with this approach, screening is needed to differentiate locals from visitors. Because the probability that a visitor is chosen for an interview is limited by the places chosen, surveys that use this type of contact approach are not strictly seen as random sampling. This means that the data produced is not representative of all visitors to Kassel and a certain bias is expected. The interviewers were trained to choose interviewees randomly. In practice, this meant that, due to the ongoing inflow of visitors, the interviewers approached the next arriving visitor after a successful interview or unsuccessful interview approach. Limiting the population to visitors to the touristic hotspots on the given days and times, we nonetheless regard the sampling as mostly random due to the randomness of the inflow of visitors. Where visitors travelled in a group, one member of the group was chosen or decided to give the interview himself or herself.

The questionnaire consisted of four parts:

- Screening questions to filter out locals, business travellers, and visitors of an event
- Questions about the socio-demographic and socio-economic status of visitors
- Questions about the journey, e.g. mode for arrival and departure, and length of stay
- Citing of touristic sights visited or planned to be visited

Additionally, overnight visitors were asked about the type and location of their accommodation. Because the survey was conducted during the COVID-19 pandemic, we included questions regarding whether the pandemic had any influence on visitors' choice of accommodation and mode of arrival. While there was no clear indication that COVID-19 influenced the choice of accommodation, 8.4 % of visitors who arrived by car stated that they would have taken public transport if COVID-19 had not existed.

2,050 visitors were interviewed in the first part of the survey. They consisted of 760 same-day and 1,290 overnight visitors.

4.3 Part 2: Activity survey

The purpose of the second part of the survey was to record all activities by a selected individual during the day he or she was interviewed for the first time. This was carried out in two ways. Most visitors were contacted again by telephone one or two days after they had completed the first part of the survey and then interviewed again using a computer-assisted telephone interview (CATI). In this way, the interviewees were able to reproduce all the activities of their vacation day.

Like Bursa et al. (2022), we used the concept of travel diaries as a basis to survey the activities of visitors. Travel diaries are the most prevalent approach to gather data on everyday travel behaviour and are used widely by many administrative regions, like cities or countries. Prominent examples are the surveys "Mobility in Germany (MiD)" (Follmer and Gruschwitz, 2019) and the Dutch travel survey OViN (Centraal Bureau voor de Statistiek, 2018).

However, we decided to survey activities instead of trips because we expected that visitors were better able to reproduce them. This meant that only the structure of a trip diary needed to be changed by surveying the trip information by means of the prior and following activity. Arrival and departure were regarded as activities. Because we assumed that visitors are often unable to tell us the exact address of activities, we asked them to state a point of interest instead. For example, the location of a restaurant could be stated as "Italian restaurant near the city hall". For each activity, we asked for the following information:

- Type of activity (trip purpose)
- Location of the activity (trip destination)
- Mode of transport to reach the activity

- Start and end time

Some activities were not suitable to be surveyed in that way. This affected, on the one hand, activities that solely comprise moving in itself, like taking a walk. Mokhtarian and Salomon (2001) summarise this kind of trip and many others, including horse-back riding, cycling, etc., under the term ‘undirected travel'. In addition, we noticed that it is difficult to survey multiple activities conducted in a confined space, like shopping in a shopping street. In a strict sense, every shop visited would count as a new activity. We decided to condense multiples of the same kind of activity during the survey into one. These kinds of activities as well as undirected travel are summarised as so-called ‘spatial activities’ for our survey. Spatial activities differ from point activities by the fact that they have a start and end point that can either be different or the same. An example of a daily activity chain is depicted in figure 2.

As a certain non-response is expected, we decided to increase the response rate by preponing part two and conducting it right after part one of the survey for day visitors who responded that they would not participate in any more activities after the current one. In this case, the interview was carried out like the first part of the survey as a CAPI.

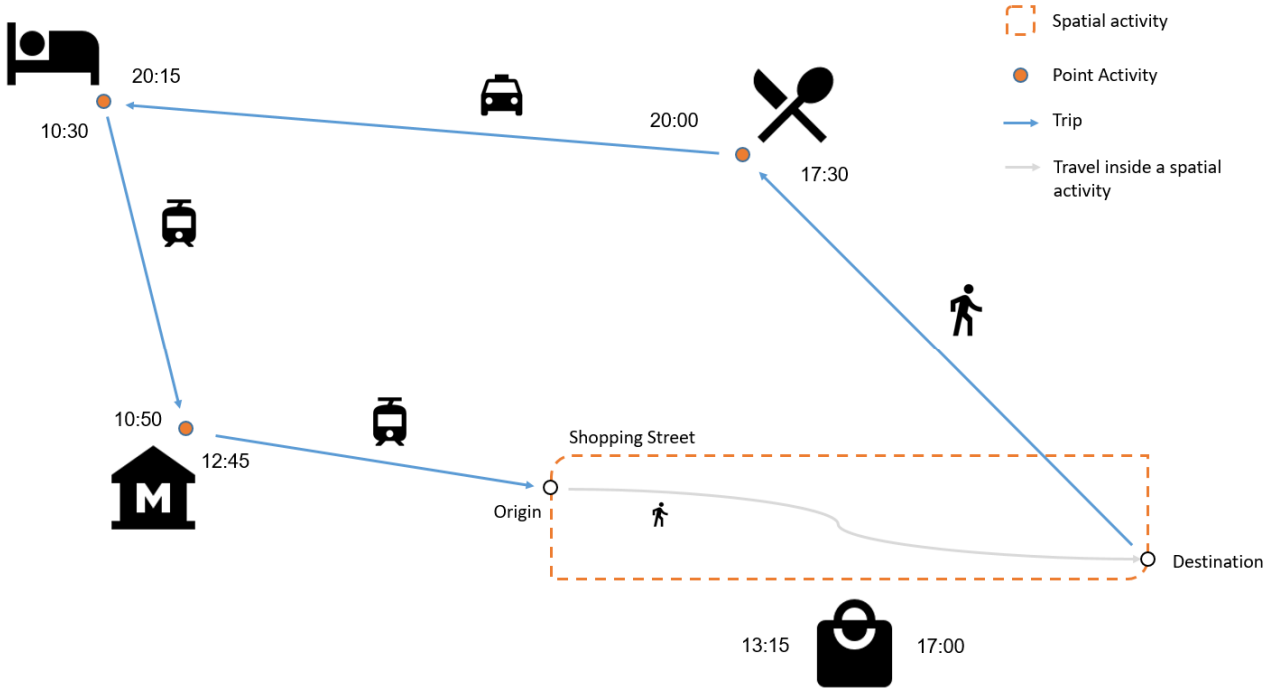


Figure 2: Example of a complex daily trip chain of a visitor with point and spatial activities

4.4 Data preparation and enhancement

The survey results needed comprehensive data preparation for further analysis. The filter logics created inside the survey software enabled inputting non-plausible information to be avoided in many cases during the interview. Nevertheless, some datasets had to be corrected manually, mostly because some interviewees stated that they were staying for more than one day and later stated that their hotel was clearly outside the Kassel region. These visitors were manually converted to day guests.

The most time-consuming part was the geolocation of all location information. As described, we asked visitors for points of interest instead of exact addresses. To geolocate this information, we manually allocated spatial coordinates and information about the accuracy to each dataset. The accuracy information was necessary because we were not able to reproduce all of the coordinates on an address level. For more vague location information, like a street or neighbourhood, we allocated coordinates, but lowered the level for the accuracy variable.

For further analysis, the surveyed activity data were transformed into trips and trip chains. Due to the popularity of the Bergpark, a great number of walking trips was made within the park or within the immediate vicinity. We assume that a large share of these trips is part of the visit and, therefore, the trip itself is the activity. This can be compared to for example zoological gardens or outdoor museum where trips

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

inside the vicinity are not regarded as part of the travel behaviour but rather part of the visit and the activity itself. The Bergpark can be entered from all directions free of charge what makes distinguishing trips to the park from trips inside the park more difficult compared to definite attractions with fixed entry points.

As the park is only accessible on foot, there is no mode choice process for the trips described. We, therefore, decided to exclude these trips from parts of our analysis.

5 RESULTS

In the following, we present the results from the visitor and activity survey. Social demographics, economics, and journey-related analysis (5.1 and 5.2) relate to adult visitors (18 years or older). The analysis of travel behaviour, activity, and trip chains (5.3 and 5.4) involve adult visitors who arrived in Kassel by car and, therefore, have a car available for their intra-destination travel.

5.1 Social demographics and economics

Visitors interviewed were in 59.5 % of cases female with no noteworthy difference between day and overnight visitors. We cannot rule out that this might have to do with the fact that in travel groups female visitors are more likely to speak with our mostly female interviewers. The median age of (adult) visitors is 46.2 years with no distinct difference between day and overnight visitors.

The large majority of visitors with no noteworthy difference between day and overnight visitors were employees (72 %), pensioners (13.8 %), or students (8 %). Because we did our interviews on weekends, it could be expected that employees form the highest share of visitors. On weekdays, their share would have been lower (BMWi, 2014). The level of education showed no large differences: 52.6 % of visitors had the highest level of German school education (Abitur) and 26.3 % the certificate of secondary education (Mittlere Reife).

Due to the ongoing Covid-19 pandemic, 96.6 % of visitors came from Germany. In 2021, the share of foreign visitors was 1.5 percentage points higher than in 2020. The largest group of foreigners in both years was the Dutch (1.6 % of all visitors). Regarding the origin of visitors from Germany, it is noteworthy that day visitors come from places nearer to Kassel than overnight visitors. For example, 28.5 % of day visitors come from Hesse, the state where Kassel is located, whereas only 14.8 % of overnight visitors do.

Households of day visitors tend to be slightly larger on average with 43.2 % of households having three persons more in comparison to 35.8 % of overnight visitors. 10.3 % of visitors had no cars in their household and 49.5 % had two or more. There was no significant difference in car ownership between day and overnight visitors. Comparing the net household income, one can observe small differences between the income groups with slightly more day visitors in the lower income groups (39.7 %), meaning less than 3,000 Euro per month, compared to overnight visitors (35.8 %).

5.2 Journey-related information

Visitors divided into 37.1 % who visited Kassel for only one day and 62.9 % who stayed overnight. For 62.4 % of visitors, the main reason for visiting Kassel was a city trip or cultural journey. Interestingly, there are distinct differences between day guests (75.5 %) and overnight guests (54.7 %). The second most stated reason was to visit friends or family with 26.4 % of all visitors. Again, this differs between day guests who only visited someone in 15.4 % of cases whereas overnight visitors stated that this was the reason for their journey in 32.8 % of cases. Other reasons, like shopping or a spa treatment, represented only less than 5 % of cases each. In 48.8 % of cases, visitors travelled in a group of two. While 71.6 % of overnight guests travelled alone or in a group, the group sizes of day guests were on average bigger with only 57.4 % of people travelling alone or in a group of two. Travel groups of day guests also consisted more often of children (22.8 % of cases) in comparison to overnight visitors (11.2 %).

The predominant mode for arriving in Kassel was the car (see fig. 3). Overnight visitors more often chose the train for their arrival (20.4 %) compared to day visitors (14 %). Furthermore, in total, 4.5 % of overnight visitors arrived by motorhome. Other modes of transport, e.g. bicycle or long-distance bus, only accounted for 1.5 % of all journeys.

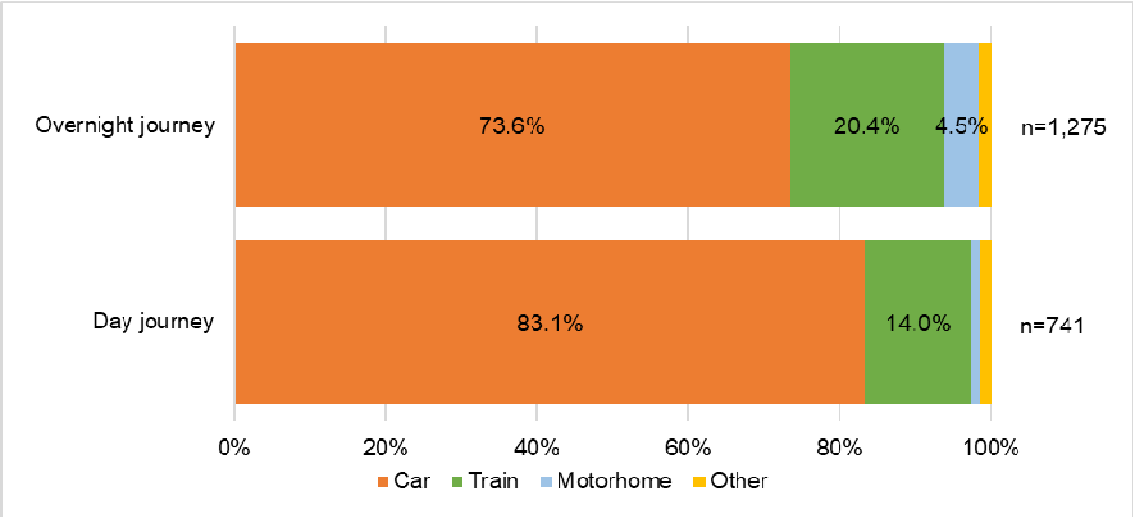


Figure 3: Modal split of trips for arriving and departing Kassel

Interestingly, 24.1 % of day visitors stated their day trip was not from their home, but from another holiday location. These are, for example, visitors who take a holiday of several days at a nearby location, like Lake Edersee, and do day trips into the surrounding area, for example Kassel. Overnight visitors predominantly stayed in hotels or guesthouses (56.7 %) and with friends or family (24.1 %). Other types of accommodation were holiday homes (6.2 %), camping sites (6.3 %), and a clinic (4.4 %). While AirBNB plays a big role in the accommodation market of many major cities, only 2.3 % of visitors to Kassel rented a room or an apartment with AirBNB. The durations of stay are rather short. 23.7 % of visitors stay for only one night and 46.5 % for two nights. This indicated that most visits are typically short holidays over the weekend.

5.3 Travel behaviour

Travel behaviour varied heavily between day and overnight visitors who arrived at Kassel by car. Some visitors only made undirected travel during their stay. We excluded these people and got a dataset of 129 trips from 82 day visitors and 476 trips from 151 overnight visitors. When only counting visitors who made on-site trips (excluding undirected travel), day visitors made on average 1.6 trips, whereas overnight visitors made 3.2 trips per person per day. The modal split shows distinct differences between day and overnight visitors too (see fig. 4). Day visitors had a much higher share of car usage (75.2 %), whereas far fewer trips were made by walking (15.5 %) compared to overnight visitors (33.6 %).

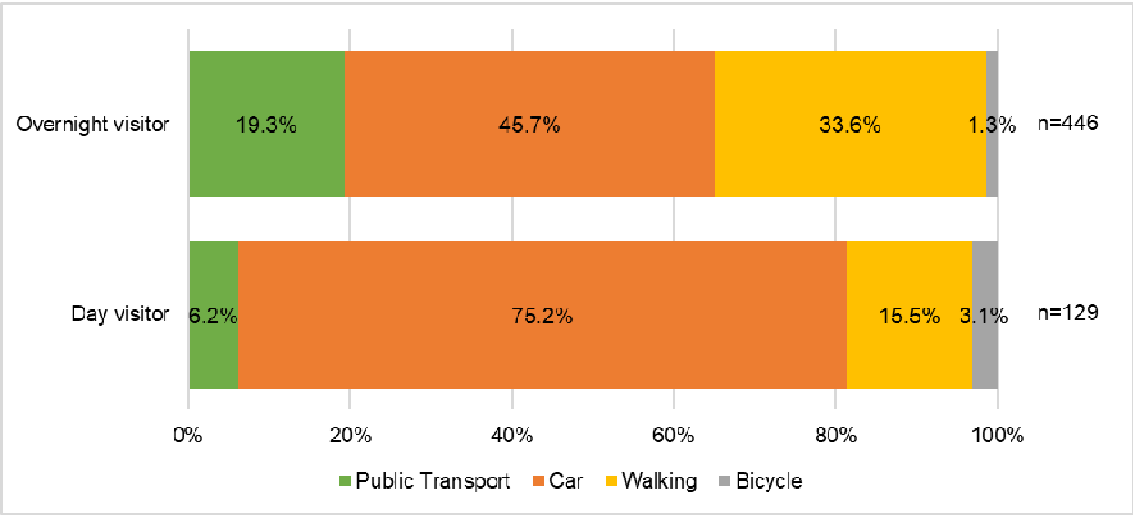


Figure 4: Modal split of intra-destination trips

5.4 Trip and activity chains

Activity chains and trip chains often describe similar circumstances, but from a different point of view. Esztergár-Kiss et al. (2017) define activity chains as chains that “contain all regular […] and non-regular […] activities of a traveller”, mostly between leaving and returning home. Trip chains extend the concept by

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

regarding the trips in between the activities and the chosen modes of transport. Because we are only interested in tourists' activities and trips at the destination, we also define that activity as trip chains starting and ending at the place of accommodation or upon arrival or departure. This leads to the special case where day tourists who only undertake one activity do not perform any intra-destination travel and, therefore, no trip chain is attributed to these activity chains. In our case, 59.4 % of all activity chains by day visitors consisted of only one activity, in most cases the Bergpark. As described, the Berpark is the main tourist attraction in Kassel that presents visitors with a variety of different activities inside the park area leading to longer durations of visits. Because of the special nature of the Bergpark, we decided to consider it in activity chains as a separate type of activity. Single-trip chains are another anomaly that can occur when either day visitors only undertake two activities or overnight visitors undertake one activity on the day of arrival or departure.

We distinguished between the following activities:

- B: Visiting the Bergpark
- T: Other touristic activity
- V: Visiting friends or family
- R: Restaurant or other gastronomical facility
- S: Shopping or private errands
- A: Arrival
- D: Departure
- H: Stay at hotel or other type of accommodation

In Table 1, we summarise the five most common activity chains for day and overnight visitors. In the case of multiple visits to attractions inside the Bergpark in a row, we combined these into one activity. It can clearly be recognised that the activity chains of overnight visitors are far more diverse than those of day trippers. We observed 49 different chains performed by day trippers in comparison to 93 different chains by overnight visitors. For both, visiting the Berpark as the only activity of the day is the most common activity chain, but, while this accounts for 15.5 % of overnight visitors, 52.8 % of day visitors arrive in Kassel, visit the Bergpark, and leave again without any other activity. This means that these visitors did not generate any intra-destination trip chain in Kassel. Their travel behaviour consisted only of arrival and departure.

Day visitors		**Overnight visitors**	
Activity Chain	Frequency	Activity Chain	Frequency
ABD	121 (52.8 %)	HBH	26 (15.5 %)
ATD	15 (6.6 %)	HBRH	11 (6.5 %)
ASBD	8 (3.5 %)	HBSH	8 (4.8 %)
ABRD	7 (3.1 %)	HBD	6 (3.6 %)
ABTD	7 (3.1 %)	HTH	6 (3.6 %)
Total:	229	Total:	168

Table 1: Frequency of the five most common activity chains for day and overnight visitors.

When analysing trip chains, i.e. the whole sequence of trips between the place of accommodation and arrival or departure respectively, 312 chains with 101 day visitors and 212 overnight visitors were surveyed. To analyse the trip chains, we did not exclude trips that consisted of undirected travel. The complexity, i.e. the number of trips the chain comprises, varied distinctly between day and overnight visitors (see fig. 5). The average number of trips in a trip chain amounted to only 1.6 for day visitors whereas overnight visitors undertook on average 3.0 trips per trip chain. It is noteworthy that 62.2 % of all day visitor trip chains consisted of only one intra-destination trip.

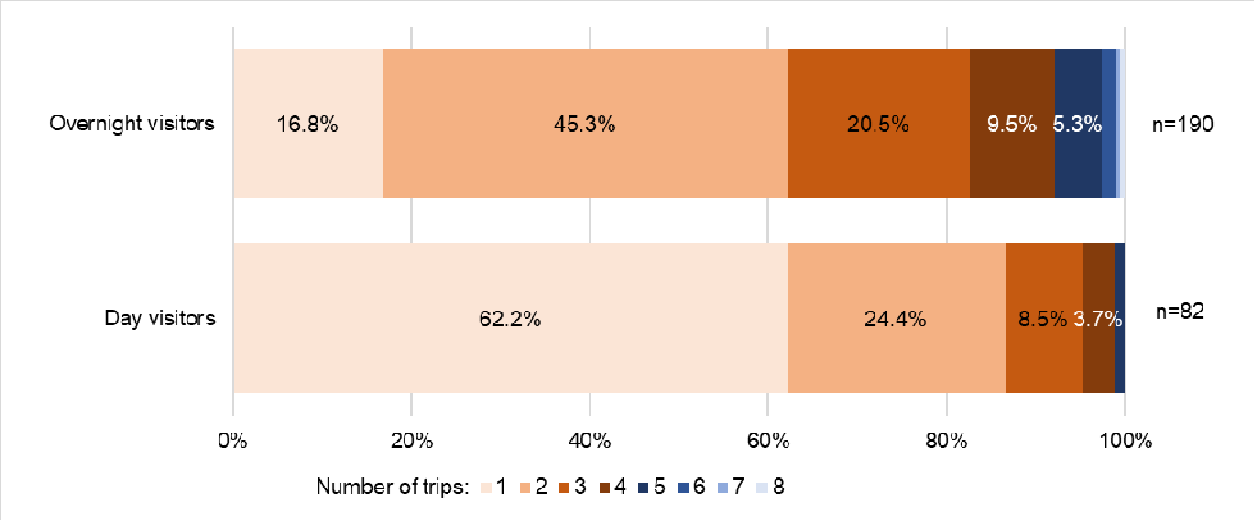


Figure 5: Complexity of day and overnight visitors' trip chains

Trip chains can be unimodal if all trips in the chain are made using the same mode of transport or they can be multimodal if more than one mode of transport is used (Schneider et al., 2021). In our case, 85 % of day and 78.3 % of overnight visitors' trip chains were unimodal (see fig. 6). Day visitors chose solely to drive by car for 76.3 % of their trip chains; public transport or walking played a minor role. In contrast, only 38.2 % of overnight visitors' trip chains were made solely by driving a car. 29.6 % of trip chains were made by walking only with an additional 9.9 % of multimodal trip chains combining walking and car driving. Furthermore, 22.3 % of trip chains involved using public transport. All in all, day visitors tended to prefer using the car for their intra-destination trip chains whereas overnight visitors were more open to choosing other modes of transport even though both groups arrived at Kassel by car.

Figure 6: Distribution of unimodal and multimodal trip chains of day and overnight visitors

6 DISCUSSION AND CONCLUSION

In this article, we have illustrated a survey method for gathering the travel behaviour data of tourists for their arrival and departure travel as well as their intra-destination travel. The two-part design proved useful to recruit short-term travellers including day visitors. The results show distinct differences in travel behaviour between day and overnight visitors. Both day and overnight visitors with car availability prefer to arrive in Kassel by car, but overnight visitors are a bit more likely to arrive by public transport or by motorhome. The activity and trip chains of day visitors are in the majority much simpler compared to overnight visitors. Many day visitors visit just one attraction, mainly the Bergpark, and leave again, resulting in no intra-destination traffic. It seems that day visitors are much more unlikely to change from the mode of transportation they arrived with for their trips at the destination. In contrast, overnight visitors have a much higher willingness to leave their car at their accommodation and travel by public transport and on foot. All visitors tend to prefer not changing their mode of transport during a trip chain.

The method of the survey and, therefore, also the results of course have certain limitations. The method of recruiting people at places of touristic relevance meant that tourists who did not visit these attractions did not have any opportunity to be included in the survey. Of course, it would have been possible to have extended the number of places to interview people, but this would have increased the cost, especially as the ratio of visitors to residents would have worsened. Alternative approaches, like recruiting visitors at hotels, on the other hand, would have neglected day visitors.

To survey travel behaviour using activity diaries proved to be a useful instrument, but it is linked with certain limitations. We experienced that it proved difficult for interviewees to remember exact time and location information. The start and end time of activities were so often implausible that we decided not to include relevant analysis for travel time and activity durations in this paper. It proved helpful for interviewees to state points of interest for location information, but it drastically increased the effort to process the data and still meant that records did not have exact location information. This proved to be especially challenging

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

when we estimated mode choice models based on travel times using these data. Separating activities into point and spatial activities was, in theory, a good method to identify undirected travel and sequences of the same activity but proved to be challenging to record both for interviewees as well as interviewers.

To improve data quality, a mixed approach combining location data generated by mobile phones with a phone-based survey that lets users correct data, like mode of transport and type of activity, as well as answer questions about sociodemographic and mobility related information might be promising. Mobile applications, like "TravelVu", that was tested by Hubrich et al. (2020) in the city of Dresden, Germany already offer these capabilities. Of course, in comparison with our survey, recruiting participants is more complicated and costly, resulting in a lower sample size. On the other hand, the issues with activity diaries described would be less of a problem with an app-based solution. Exact location and time information, in particular, as well as the possibility to better identify undirected travel would be a big advantage of such a surveying method.

We conclude that further research regarding the travel behaviour of tourists is clearly needed. With the study by Bursa et al. (2022) on alpine tourists and ours on city tourists, including day visitors, there are two initial studies that have gathered revealed-preference travel data. As we concentrated on tourists who arrived by car, in-depth research regarding visitors who chose public transport would be welcome.

7 REFERENCES

Bieland, D., Sommer, C., Witte, C., 2017. Uncommon leisure traffic – Analyses of travel behaviour of visitors. Transportation Research Procedia 25, 3971–3984. https://doi.org/10.1016/j.trpro.2017.05.236.

Bundesministerium für Wirtschaft und Energie, 2014. Tagesreisen der Deutschen, 94 pp.

Bursa, B., Mailer, M., Axhausen, K.W., 2022. Intra-destination travel behavior of alpine tourists: a literature review on choice determinants and the survey work. Transportation. https://doi.org/10.1007/s11116-022-10267-y.

Centraal Bureau voor de Statistiek, 2018. Onderzoek Verplaatsingen in Nederland 2016: Onderzoeksbeschrijving, 49 pp. https://www.cbs.nl/-/media/_pdf/2018/28/2017ep33-onderzoeksbeschrijving-ovin-2016.pdf.

dwif, 2020. Wirtschaftsfaktor Tourismus für die Stadt Kassel, 2020.

Esztergár-Kiss, D., Rózsa, Z., Tettamanti, T., 2017. Comparative analysis of test cases of the activity chain optimization method. Transportation Research Procedia 27, 286–293. https://doi.org/10.1016/j.trpro.2017.12.136.

Follmer, R., Gruschwitz, D., 2019. Mobility in Germany: Short report. Edition 4.0 of the study by infas, DLR, IVT and infas 360 on behalf of the Federal Ministry of Transport and Digital Infrastructure (BMVI) (FE no. 70.904/15), 32 pp. (accessed May 25, 2022).

Gao, Y., Liao, Y., Wang, D., Zou, Y., 2021. Relationship between urban tourism traffic and tourism land use: A case study of Xiamen Island. JTLU 14, 761–776. https://doi.org/10.5198/jtlu.2021.1799.

Gühnemann, A., Kurzweil, A., Mailer, M., 2021. Tourism mobility and climate change - A review of the situation in Austria. Journal of Outdoor Recreation and Tourism 34, 100382. https://doi.org/10.1016/j.jort.2021.100382.

Gutiérrez, A., Miravet, D., 2016. The Determinants of Tourist Use of Public Transport at the Destination. Sustainability 8, 908. https://doi.org/10.3390/su8090908.

Harz, J., Sommer, C., 2022. Mode choice of city tourists: Discrete choice modeling based on survey data from a major German city. Preprint. https://doi.org/10.20944/preprints202208.0019.v1

Hubrich, S., Weber, J., Wittwer, R., Gerike, R., 2020. TravelVu and TravelViewer – New Ways of Collecting and Evaluating Travel Survey Data: A Site Report from Dresden, Germany. https://www.researchgate.net/publication/349882431_TravelVu_and_TravelViewer_-_New_Ways_of_Collecting_and_Evaluating_Travel_Survey_Data_A_Site_Report_from_Dresden_Germany.

IPK International, 2015. World Travel Trends Report 2015 / 2016.

IPK International, 2020. World Travel Trends 2020, 8 pp. https://bw.tourismusnetzwerk.info/wp-content/uploads/2020/03/ITB_World_Travel_Trends_Report_2020.pdf (accessed April 4, 2022).

Mokhtarian, P.L., Salomon, I., 2001. How derived is the demand for travel? Some conceptual and measurement considerations. Transportation Research Part A: Policy and Practice 35, 695–719. https://doi.org/10.1016/S0965-8564(00)00013-6.

Schneider, F., Ton, D., Zomer, L.-B., Daamen, W., Duives, D., Hoogendoorn-Lanser, S., Hoogendoorn, S., 2021. Trip chain complexity: a comparison among latent classes of daily mobility patterns. Transportation 48, 953–975. https://doi.org/10.1007/s11116-020-10084-1.

🏆 *reviewed paper*

Comparison of a Direct Line System and a Renewable Energy Community on the Basis of a Pilot Plant in Thannhausen

Robert Pratter, Thomas Nacht, Martin Ruby

(DI Robert Pratter, 4ward Energy Research GmbH, Reininghausstraße 13A, 8020 Graz, robert.pratter@4wardenergy.at)
(DI Dr Thomas Nacht, 4ward Energy Research GmbH, Reininghausstraße 13A, 8020 Graz, thomas.nacht@4wardenergy.at)
(DI Martin Ruby, EOS Power Solutions GmbH, Franz-Pichler-Straße 32, 8160 Weiz, martin.ruby@eospowersolutions.com)

1 ABSTRACT

With the renewable energy directive of the European Commission the path has been set toward more emancipated end consumers in the energy system, by allowing shared energy use schemes such as renewable energy communities. These were transposed into national law in Austria in July 2021. But even before that, energy could be shared between a producer/prosumer and one or multiple users via a so-called direct line or direct line system. While the technical and legal requirements for operating a direct line (system) are a major barrier to overcome, direct line (systems) have for a long time been the only means to exchange renewable energy between different buildings in the Austrian energy system. In the municipality of Thannhausen such a direct line system with multiple end users has been installed and is in a test phase since September 2021. During the implementation of the direct line system the legal framework for energy sharing has changed and renewable energy communities have been introduced in Austria. The question arose, whether the direct line system can compete with renewable energy communities. In this paper a comparison between these two types of energy sharing schemes, a direct line system and a renewable energy community is made on basis of the Thannhausen pilot. As mentioned before, in Thannhausen, a direct line system, consisting of multiple direct lines to connect eight consumers with one photovoltaic generator was built. For the same configuration a renewable energy community was investigated by means of a simulation model. Even if it might seem, that the direct line system is outdated by the new possibilities which are provided by the renewable energy communities, a closer look showed, that both systems have their advantages and disadvantages. For the direct line system structural measures are necessary, which result in a certain amount of investment costs which are higher than for a renewable energy community, where the public grid is used. In contrast to that, no grid fees have to be paid for the energy distributed via the direct line system. Another advantage of the direct line system is the possibility of an islanding-mode in case of a disruption of the public grid. However, it always depends very much on the initial situation. Direct line systems are an attractive solution only in cases where the consumers are located closely to each other, so that the digging effort is manageable. In case of the Thannhausen pilot, the evaluation showed, that the direct line system enables similar savings for the participants to a renewable energy community, when the subsidies granted are taken into account. Since there are no grid fees for the direct line system, a higher feed-in tariff is made possible for the municipality, which amortises the higher investment costs, so that the direct line system has even the higher net present value at the end of the period under consideration.

Keywords: energy sharing, micro grid, renewable energy community, pilot plant, direct line system

2 INTRODUCTION

To increase the share of renewable energy sources and to provide incentives to produce and use the energy locally, the EU renewable energy directive (European Commission, 2018) has planned to advance the process of emancipating the end consumers towards active participants in the energy system. Parts of that directive have been transposed to national law in the “Erneuerbaren-Ausbau-Gesetzespaket” in Austria in July 2021 (Republik Österreich, 2021), which enables the establishment of ‘renewable energy communities’. A renewable energy community is a community of producers, consumers and ‘prosumers’ amongst which renewable energy can be exchanged. In case of renewable electricity, the public distribution grid can be used. To create additional incentives the energy exchanged in the community is subject to reduced grid fees, taxes, and levies. But even before the law was established in July 2021, it was possible to share (renewable) energy, even though a much higher technical effort had to be made, by installing and operating “direct lines”, privately operated power lines outside the jurisdiction of a grid operator. Given the arrival of ‘energy communities’, direct lines might seem outdated. A closer look shows, that both systems have their advantages and disadvantages. Therefore, this paper intends to compare an operational direct line system with a fictional renewable energy community based on the municipality of Thannhausen.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

The municipality of Thannhausen owns and operates a photovoltaic (PV) generation plant on one of its buildings in the village centre. Additionally, there is potential for more PV generators on other buildings in the village centre owned by the municipality. Since the existing PV-generator produced substantial surpluses, and there was an incentive to install additional capacities, the idea of sharing the electricity with neighbouring buildings via a micro grid was born. At the time, when the pilot project was developed, the Austrian legislation did not allow for direct electricity trade between different users via the public grid without an energy supplier acting as intermediary which would be possible later in renewable energy communities. For this reason, it was decided to create a microgrid consisting of new direct lines to allow for direct supply of neighbouring consumers with electricity. In total eight consumers, consisting of private households, small enterprises, small companies and the municipality buildings have been identified, which were interested and suitable to participate in the microgrid. All of them are in proximity of one another, to make the realisation of a direct line system possible. The basic parameters are shown in Table 1.

Participant	Consuption per period (01.01.2022 – 30.06.2022) [kWh]	Peak load [kW]	Distance to the PV-plant/Lengh of the direct lines [m]
Household 1	1915	5.5	134
Small Enterprise	7940	19.2	28
Household 2	5338	8.9	118
Municipality	4953	5.4	62
Small Company 1	1600	3.7	62
Small Company 2	753	1.8	62
Small Company 3	1927	5.4	62
Small Company 4	1700	2.7	150

Table 1: Consumption data of the users of the direct line system in Thannhausen for the period 01.01.2022 – 30.06.2022

To supply the direct line system, a new PV generator with a maximum capacity of 29.6 kWp was installed on the roof of the waste collection centre, one of the municipality buildings. By the time the decision was made, the existing PV-generators had a high funded feed-in tariff, which made it less attractive to use them for the supply of the direct line system.

For the same configuration a renewable energy community was investigated by means of a simulation model. Following Key Performance Indicators (KPIs) have been defined for the comparison of the two kinds of energy sharing schemes.

Number	Indicator	Measurement unit	Description
KPI 1	Own consumption rate	[%]	Share of the PV-production which could be used within the energy sharing schemes (direct own consumption of the municipality + indirect own consumption of the participants of energy sharing schemes) divided by the total energy production.
KPI 2	Self supply rate	[%]	Share of the PV-production which could be used within the energy sharing schemes divided by the total energy demand of all participants of the energy sharing schemes.
KPI 3	Net present value	[EUR]	Net present value of the municipality (investor of the PV-generator respectively the direct line system) after 20 years.
KPI 4	Savings of the participants	[EUR/period]	Amount and distribution of the savings among the participants in relation to a 100 % grid consumption.

Table 2: Key Performance Indicators (KPIs) for the comparison of the two types of energy sharing schemes

In addition to the KPIs, further advantages and disadvantages of the two types of energy sharing schemes are discussed, such as the possibility of an emergency operation in case of a power failure of the public grid.

3 THE DIRECT LINE SYSTEM IN THANNHAUSEN

The pilot in Thannhausen, which is part of the FFG project SoWeiT Connected[1] and the Interreg Alpine Space project ALPGRIDS[2], was taken into operation at the end of 2021 and the monitoring is still ongoing but will be concluded by September 2022. It consists of the eight consumers (grid coupling points) shown in Table 1, which are connected to the public low voltage (230/380 V) grid. As shown in Figure 1, each of the users can be connected to the PV generator with an individual direct line (orange lines) or to the public grid (blue lines), depending on whether the entire consumption can be satisfied via the direct line or not. This is necessary due to the legal requirements for direct lines (Nacht T. et al., 2018). The PV generator also has a switch which allows separation from the public grid, which would effectively turn the system into a microgrid, but this will only be used in the case that islanding is necessary.

Each of the users is equipped with a measurement unit to measure the total power consumption, in addition a measurement unit was installed on each direct line and for the PV generation and the consumption of the municipality. The measurement units at the user's sites were installed behind the official metering units of the grid operator. These measurement units only have a purpose for the control unit, while the measurement units on the direct line also serve a metering purpose for billing and thus need to be gauged.

The control unit (an energy management system) receives its data via Ethernet cables which are placed together with the cables for the direct lines. Ethernet cables are also used to control the switches of the direct lines which are be implemented as air gap switch.

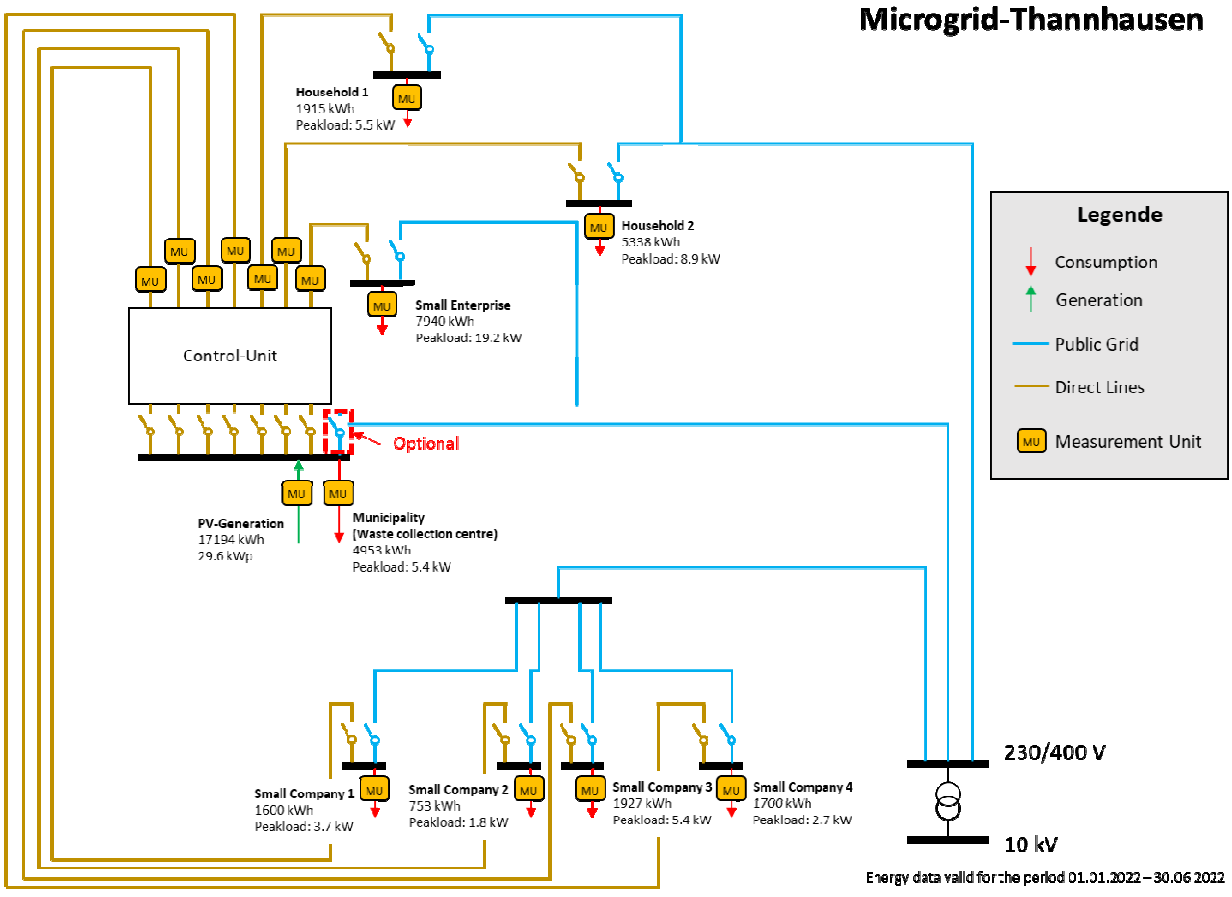


Figure 1: Technical set-up of the pilot in Thannhausen

The energy distribution within the direct line system happens because of the switching process of the direct lines. For normal operation, the following rules apply for the control regime:

- First off, the consumption of the municipal buildings will be covered, only excess energy will be provided to the direct line system.

[1] https://nachhaltigwirtschaften.at/de/sdz/projekte/soweit-connected.php
[2] https://www.alpine-space.org/projects/alpgrids/en/home

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

- The control unit will then check the power consumption values of the users and will sort them according to an internal ranking system so that most of the PV generation can be used directly.
- Only users whose demand can be fully satisfied by the PV generation will be connected to the direct line system and separated from the public grid.
- The internal ranking system will ensure that over the course of a certain period distribution of PV generation will happen on a fair and transparent basis.
- Any remaining excess PV generation will be fed into the public grid

To ensure the fair distribution of the PV generation between all users, the target function of the ranking system consists of two parts. The first part addresses the maximisation of the self-consumption within the direct line system, and the second part covers the equal distribution of the PV generation. Two weighting factors were used to determine, which part is more important for the ranking system. For the Thannhausen pilot a balanced setting was chosen, which ensures a fair distribution with only slight reductions of the self-consumption rate in comparison to the maximum possible one.

The equality of the distribution is controlled by applying a prioritising factor for each user in the target function of the optimisation algorithm, thus increasing or decreasing the importance of individual users. This factor is updated daily and reflects how much energy each user has already obtained from the direct line system. The user who got the lowest share of energy, in relation to his total energy demand by the time of the factor update gets the highest factor, and so one. A high factor means, that this user also has a higher priority for the optimiser. A low factor indicates that a user has already got a high relative share of energy in relation to the other users and therefore has a lower priority in the ranking system.

The optimisation is carried out every 15 seconds by the control system. To avoid a constant switching between the direct line system and the public grid a “clocking prevention” was implemented. This was necessary to prevent premature wear of the switching elements and increase the lifetime of the system. A certain switching contingent is available to the control system. If this switching contingent has been exceeded, users may be reconnected to the direct line system no earlier than five minutes after their switchover from the direct line system to the public grid. If this is not the case the users can be connected already after one minute. At times when no switching operations are necessary, e.g. during night time, the switching contingent is successively increased again. This ensures that the maximum number of switching operations (time when the components must be replaced) is not reached prematurely.

Switching from the direct line to the public grid is possible at any time to ensure that no more PV-energy is drawn from the direct lines than is actually available.

3.1 Legislative framework

Operating a direct line or a direct line system is made possible by the Elektrizitäts- Wirtschafts- und Organisationsgesetz (ElWOG) (RIS, 2022), Austria’s federal energy law. The concept of “direct line” is defined in the basic provision of Section 7 (1) no.8 ElWOG as follows:

“"Direct line: either a line connecting a single production site to a single customer, or a line connecting an electricity producer and utility company for the purpose of direct supply to their own permanent establishment, subsidiaries and approved customers; lines within residential complexes are not considered direct lines.”

For that reason, the system must consist of multiple lines and each consumer will be connected only to one direct line as well as the public grid and each direct line will thus only be connected to the PV generator (production site) and one user (single customer). The direct line system is operated outside the domain of the grid operator.

While the ElWOG provides only very limited rules, guidelines or general information on how to operate direct lines, the following basic principles need to be taken into account (Nacht T. et al., 2018):

- There must be separation between the direct line(s) and the public grid to avoid direct exchange of electricity between the direct line(s) and the public grid
- It is not allowed to fed PV surplus into the public grid via the direct line
- The direct line must be operated by the producer

- A star network, as used in Thannhausen, is not a contradiction to applicable electricity law

3.2 Tariff system

In Thannhausen, a uniform tariff for all participants of 8.14 cent/kWh before taxes was fixed for the first months of operation. In July, the tariff has been increased to 15.00 cent/kWh, which is still far below to the average energy costs on the market at the moment and also below the feed-in tariff which is been offered by the OeMAG at the moment (see Table 3). The municipality deliberately accepts revenue cuts to provide participants with a favourable energy supply.

In order to make the two systems easily comparable, a different direct line tariff was chosen for the calculations, so that the same savings results for the participants in both systems. In case of the direct line system, the purchase tariff of the consumers is also the feed-in tariff of the municipality. To calculate the savings in comparison to a 100 % grid consumption, current consumption and feed-in tariffs were used, as shown in Table 3.

Tariff for the consumption of electricity from the direct line system	41.86	Cent/kWh
Tariff for the feed-in of energy in the direct line system	41.86	Cent/kWh
Tariff for the consumption of energy from the public grid (incl. grid fees and taxes) – based on current marked tariffs (E-Control, 2022b)	50.17	Cent/kWh
Tariff for the feed-in into the public grid – OeMAG Tariff for the 3. Quarter of 2022 (E-Control, 2022a)	30.70	Cent/kWh

Table 3: Tariffs used for the calculation of the economic effects of the direct line system

The remaining energy, which is not supplied via the direct line system has to be purchased from an energy provider via the public grid on individual basis. For simulation purposes all users have the same grid tariff, as depicted in Table 3. The investment costs of the direct line system were taken over by the municipality. Therefore, no investment or operational costs applies to the consumers. The consumers only pay for the energy consumed via the direct line system.

4 RENEWABLE ENERGY COMMUNITY

A renewable energy community may generate renewable energy itself, consume, store, and sell self-generated renewable energy to members, act as an aggregator, and provide energy services. For these purposes the public power grid can be used, and reduced grid fees, taxes, and levies apply. A more detailed description is provided on the homepage of the Coordination office for energy communities. (Österreichische Koordinationsstelle für Energiegemeinschaften, 2022)

4.1 Legislative framework

A number of legal requirements apply to energy communities, which are regulated in the Erneuerbaren-Ausbau-Gesetzespaket (Republik Österreich, 2021) and the ElWOG (RIS, 2022). The most important ones are summarised in the following section. First, the membership in energy communities is limited to:

- private consumers
- small and medium enterprises
- public bodies (such as municipalities) and their commercial bodies

Therefore, large enterprises and energy providers are not allowed to participate. Moreover, a formal membership in the energy community is required. The energy community itself needs to take the form of a legal body (e.g. an association, cooperative, business partnership, or corporation). Whichever form of organisation is chosen, the energy community must operate as non-profit organisation. The financial benefit must stay with the members of the community. Furthermore, the members have to be in close proximity to one another. The degree of proximity is defined by the grid levels the members are connected to (see figure 2). In this respect, a distinction can be made between two types of energy communities.

- Local energy communities: This includes levels 6 and 7.
- Regional energy communities: This includes levels 5 to 7 and also the “Sammelschiene” (collector) at level 4.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

During the founding phase of the energy community, it needs to be decided whether the energy community will be implemented as local or regional energy community. The proximity type also influences the cost savings the members of the renewable energy community can generate. For each kWh exchanged within the energy community, the receiving member will be partially exempted from paying grid fees and from certain taxes and payments. For local energy communities the grid fees are reduced by 57 % and for regional energy communities the reduction is 28 % for the grid levels 6 and 7 and 64 % for the grid levels 4 and 5.

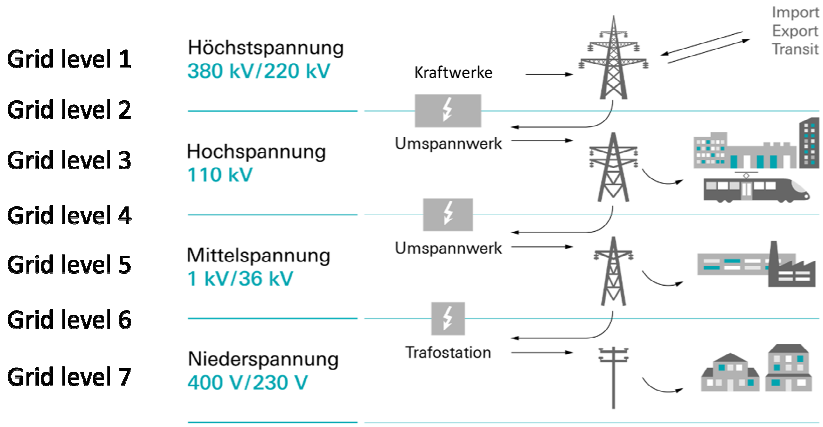


Figure 2: Grid levels in Austria, based on (Verbund, 2022)

For metering purposes smart meters need to be installed for every consumer. The grid operator will measure the consumption and generation of each member with a temporal resolution of 15 minutes. The totally available infeed by the members (omitting self-consumption) will be subsumed and divided amongst the members according to a distribution key provided to the grid operator. The distribution key describes how the available energy within the energy community is split amongst the members. Each member will thus receive two or possibly even three bills for electricity supply, one from its regular energy supplier (which according to EU law can be changed at will by the consumer) and one from the energy community. Furthermore, if the bill from the grid operator is not part of the bill from the energy supplier, this will become the third bill.

A renewable energy community with local proximity, founded as an association, was chosen for the comparative calculation of the Thannhausen pilot.

4.2 Tariff system

The renewable energy community was designed in such a way that only the costs necessary for the operation of the energy community (fees association, billing, etc.) remain in the community itself and all other savings are divided among the participants and the municipality. This is about 130 EUR per year. The current relief package of the Austrian government was not taken into account, as it was assumed that it will not be available in this form over the entire period under review.

For the calculation of the energy community, a fixed uniform tariff was chosen for all participants of the renewable energy community. The purchase tariff for electricity from the public grid was also set uniformly for all participants as specified in Table 4. The feed-in tariff of the renewable energy community was set at 32 cent/kWh. This ensures that the municipality benefits from the feed-in to the renewable energy community, despite the high feed-in tariff of 30.7 cent/kWh currently granted by the OeMAG (E-Control, 2022a). Even if these financial incentives were not decisive in the case of the municipality of Thannhausen this assumption was made because it might be in many other cases.

Tariff for the consumption of electricity from the renewable energy community	42.70	Cent/kWh
Tariff for the feed-in of energy in the renewable energy community	32.00	Cent/kWh
Tariff for the consumption of energy from the public grid (incl. grid fees and taxes) – based on (E-control, 2022b)	50.17	Cent/kWh
Tariff for the feed-in into the public grid – OeMAG Tariff for the 3. Quarter of 2022 (E-Control, 2022a)	30.70	Cent/kWh

Table 4: Tariffs used for the calculation of the renewable energy community

5 RESULTS

In this chapter the results of operating the direct line system in Thannhausen are compared with the results of the simulated renewable energy community by comparing the values of the KPIs, indicated in Table 2. The analyses are based on the monitoring data from the first half of 2022 (1st of January until 30th of June). This approach was chosen due to the reason that the final configuration of the direct line system was put in operation by the end of 2021, and therefore no full year of measurement and operational data was available. The renewable energy community was simulated with the data from that period, using the measured consumption data of the energy demands and the generation data from the PV-production as input, to compare the two possibilities to exchange renewable energy.

In Figure 3, the comparison of the own consumption rate (KPI 1 – see Table 2) for the direct line system and the energy community are shown. The direct own consumption value describes the share of energy which is consumed directly by the municipal building on which the PV-generator is installed on. Both systems, the direct line system and the renewable energy community are designed in that way, that the energy demand of the municipal building, is covered first. This share of energy is not part of the energy sharing scheme, neither in the direct line system nor in the energy community. Only the remaining PV-surplus was distributed amongst the other users/participants (which makes up the indirect own consumption). Therefore, the own consumption of the municipality is the same for both systems.

The share of energy, which can be distributed via the energy sharing schemes, is lower in case of the direct line system as compared to the renewable energy community for several reasons. The first reason is, that at each given point of time, the participants of the direct line system have to be either completely supplied via the direct line system or completely supplied via the public grid. A partial supply from both the grid and the direct line system at the same time is not allowed (Nacht T. et al., 2018). So, whenever the total consumption exceeds the available PV-surplus, one/some of the users will not be supplied via the direct line system and parts of the generation will be fed into the public grid. This is different in the case of the dynamic distribution of PV-surplus in the renewable energy community. There the whole PV-surplus can be (arithmetically) distributed between the participants, even when the energy demand exceeds the PV-surplus. The remaining demand will be supplied via the public grid. If the total energy demand within the energy community is lower than the PV-surplus, the remaining PV-energy has to be feed-in to the public grid (surplus shown in Figure 3). In this calculation scenario it was assumed, that the municipality feeds in its surplus itself.

Another reason is the implemented clocking prevention, which is described in section 3. The immediate reconnection of a user to the direct line system is prevented if he was disconnected from it a short time ago. That means that after a user is disconnected he stays disconnected for a certain time to prevent a premature wear of components. Even if these intervals are kept rather short (in most cases one minute), a slight reduction in the achievable own consumption via the direct line system must be accepted due to the clocking prevention. And finally, another reduction of the maximum achievable own consumption is consciously accepted to achieve a fair distribution between the users (see section 3).

Due to these reasons, the own consumption via the direct line system is six percentage points lower than the own consumption rate in case of a renewable energy community.

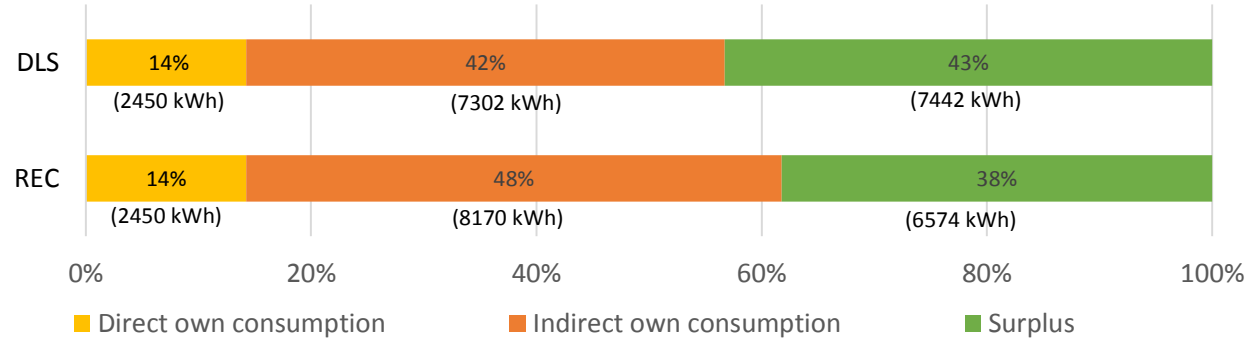


Figure 3: Comparison of the own consumption between the direct line system (DLS) and the renewable energy community (REC) based on data of the first half of 2022

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

The same reasons as for the own consumption also led to a lower self-supply rate in the direct line system. While an overall self-supply rate of 40 % can be reached by participating in a renewable energy community, the overall self-supply rate of the direct line system is 37 %. Figure 4 compares from which sources the demand is satisfied (direct and indirect own consumption as well as grid consumption). The direct own consumption is only possible for the municipal building on which the PV-generator is operated, while all other participants are either supplied via the direct line system/energy community or the public grid (indirect own consumption).

It has to be mentioned that the self-supply rate needs to be rated differently for both approaches. The direct line system is able to switch in an islanding mode in case of a failure of the public grid, which means that theoretically it would still be able operate in such a case. In the current state of the direct line system this islanding operation is not possible as the required flexibilities to balance out generation and consumption (control reserve) is not yet installed. But it would technically be possible to implement the required components and thus allow for an islanding operation. This is not possible with a renewable energy community. A high self-supply rate of the renewable energy community means, that less energy has to be purchased from the public grid. However, as the public grid is used for the energy shared within the renewable energy community, the energy community is not able to operate in case of a failure of the public grid.

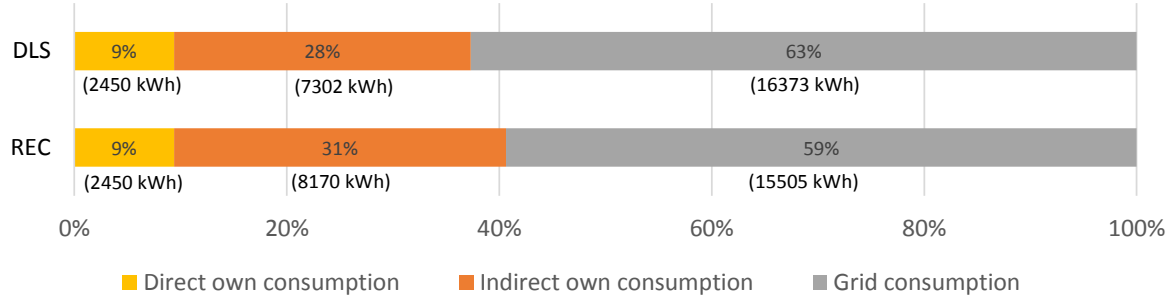


Figure 4: Comparison of the self-supply rates between the direct line system (DLS) and the renewable energy community (REC) based on data of the first half of 2022

The cost saving potentials of the participants are shown in Figure 5. In both cases this is strongly dependent on the chosen tariff system, which is described in section 3.2 for the direct line system and in section 4.2 for the renewable energy community. In the evaluation the tariff of the direct line system was set in such a way, that the total savings for the participants would be the same for both systems to make them easily comparable. Therefore, the tariff of the direct line system was defined with 41.9 cent/kWh, instead of 15 cent/kWh which is the currently used tariff in Tannhausen. The reference were the costs of grid purchase, which were assumed to be 51.7 cents/kWh incl. grid fees and taxes. (see Table 3).

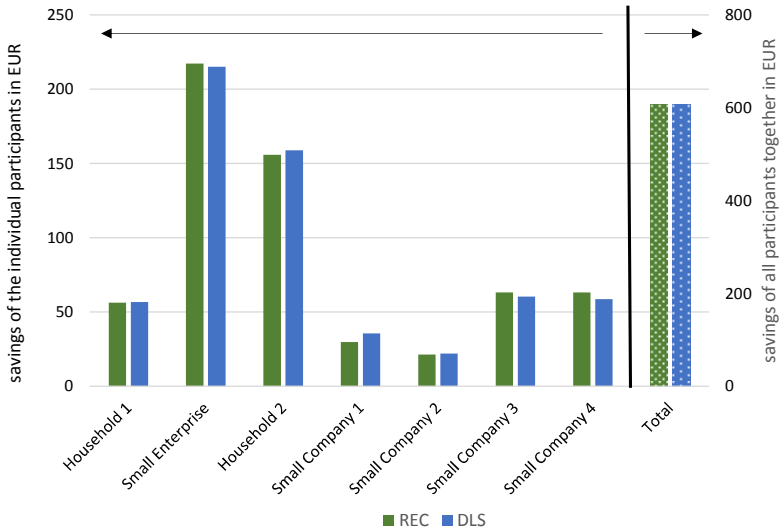


Figure 5: Cost savings of the participants of the energy sharing schemes in comparison to a 100 % grid consumption for the period of 01.01.2022 – 30.06.2022 (half year)

It was shown, that with this setting the savings of the individual participants are similar for both systems. This confirms that the algorithm of the direct line system for the equal distribution works well and that the PV-surplus is distributed in a fair way between the participants. The benchmark would be the savings of the renewable energy community, as the PV-surplus is distributed in relation to the actual consumption. Savings in comparison to a 100 % grid consumption were achieved for all participants, so that from a financial point of view, the participation is advantageous for all. The savings are in a range between 21 EUR (small company 2) and 216 EUR for the small enterprise in a half year. The savings are dependent on the energy demand of the participants as well as on the daytime when most of the energy is needed. The Small Company 2 is the participant with the lowest energy demand (see Table 1) and has further a high base load demand during night times. Therefore, only a small share of their electricity demand can potentially be supplied by the energy sharing schemes. The Small Enterprise on the other hand is the largest consumer, with most of the energy consumption occurring during daytimes. The others are in between.

In case of the direct line system no grid costs apply, which makes a higher feed-in tariff possible for the municipality in comparison with the renewable energy community. This results in higher revenues compared to feeding the energy into the public grid. While the municipality can assume additional revenues in the range of 212 Euro/year in case of an energy community, the expected revenue is significantly higher for the direct line system with about 1853 Euro/year. In contrast, however, higher investments are required for the direct line system as shown in Table 4. In case of the renewable energy community only the costs of the PV-generator incur, while for the direct line system additional costs for the direct lines, the excavation work and the energy manager apply.

	without funding	with funding*
Costs of the direct line system (without PV-generator)	50 723 EUR	27 311 EUR
Costs of the PV-generator	10 285 EUR	22 358 EUR

Table 4: Investment costs for the direct line system and the renewable energy community with and without funding. *the amount with funding corresponds to the total costs minus the funding support which could be achieved for the Thannhausen pilot.

In Figure 6 the development of the net present value is shown for both approaches. In this calculation, it was assumed that the savings and costs of the second half of the year, equals those of the first half. The selected tariffs were assumed constant over the years and the effective interest rate was defined with 2.5 % per year. The currently (08.2022) exceptionally high electricity prices in Austria have led the government to pass a relief package which reduces the taxes and levies on electricity consumption for all consumers. This also affects energy communities, as inner-community consumption would be exempt of the same taxes and levies. For the economic analysis of the energy community this relief package was neglected, as no indication exists that it will be continued after 2023.

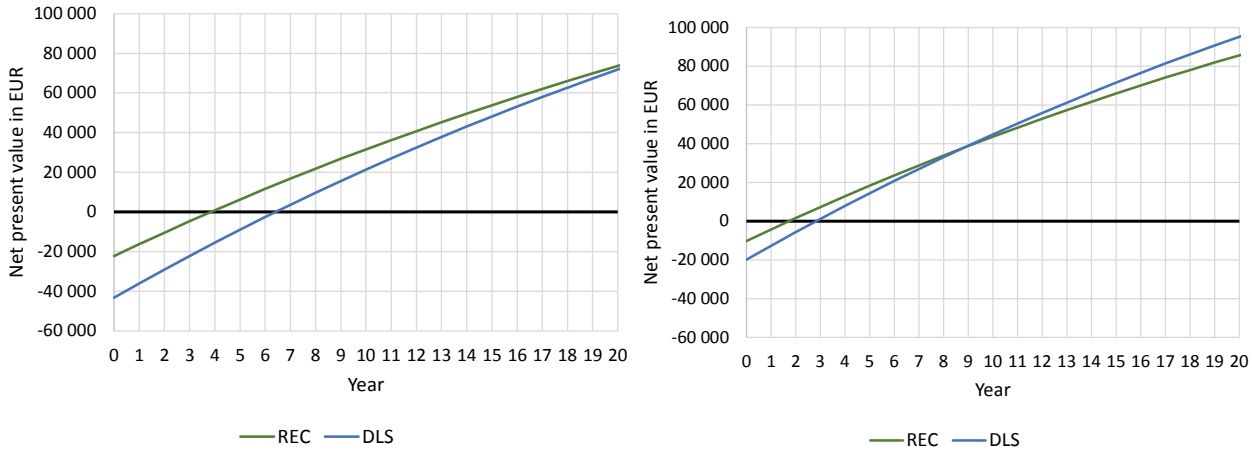


Figure 6: Comparison of the development of the net present value between the direct line system (DLS) and a renewable energy community (REC) – left: without funding of the investment costs; right: with funding of the investment costs

If no funds would be received, the investment costs would be amortised after four years in case of the renewable energy community (only the PV-generator) and after seven years in case of the direct line system (PV-generator and direct line system). At the end of their lifetime, both would have approximately the same net present value.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

If the received funding money is considered, the amortisation occurs already after two, respectively three years, and after nine years, the net present value of the direct line system exceeds the renewable energy community.

Especially in times when the situation on the electricity market is changing very quickly, evaluations with assumptions of energy tariffs of the next 20 years are subject to a certain degree of uncertainty. Nevertheless, the evaluation shows, that direct line systems can still be an interesting alternative to renewable energy communities also from the financial perspective if the initial situation is appropriate.

6 CONCLUSION

The evaluation shows that in case of the Thannhausen pilot, the direct line system enables similar savings to the participants as a renewable energy community, when the subsidies granted are taken into account. In order to operate the direct line system economically, it is important that all participants are located within close proximity to each other to minimise the necessary excavation work. In addition, certain amounts of energy are required on both the generation and consumer sides to ensure amortisation of the additional investment costs within a reasonable period of time. In this respect, an energy community has greater flexibility. The distances between the participants, apart from the legal limitations, are not relevant in this case and it is easier to integrate a larger number of participants. It is therefore to be expected that energy communities will be the common type of micro grids in the near future. It would also be questionable whether the construction of a parallel grid infrastructure, as is the case with a direct line system, is to be supported on a large scale. It needs to be considered, that the direct line system is an additional infrastructure, which is operated in parallel to the existing and well working infrastructure of the public grid. This is a critical point as the macroeconomic effects of operating a direct line system are not considered in this paper.

Furthermore, the currently high electricity prices work well in favour of the direct line system, as an amortisation of the investment costs is reached earlier. While this holds true for the investment costs of the energy community as well, the total costs of the energy community are far less in relation to the energy shared than the costs of the direct line system. Thus, the energy community case would reach an amortisation even in case of lower energy tariffs.

In some cases, however, direct line systems may still be an interesting option in the future. Direct line systems enable an island operation, which means that they can also be operated in the event of a power failure of the public grid. A direct line system is therefore the better option if the focus is on fail-safe operation or blackout protection and a smaller number of participants are to be connected at a short distance. It is also possible to integrate a (central) storage into the direct line system which would further increase the self-supply rate.

7 REFERENCES

E-CONTROL. (08.08.2022a): Aktueller Marktpreis gemäß § 41 Ökostromgesetz 2012, https://www.e-control.at/de/marktteilnehmer/oeko-energie/marktpreis

E-CONTROL. (08. 08 2022b): Tarifkalkulator, https://www.e-control.at/konsumenten/service-und-beratung/toolbox/tarifkalkulator#/

EUROPEAN COMMISSION: Renewable energy directive. Brussels, 2018, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2018.328.01.0082.01.ENG&toc=OJ:L:2018:328:TOC.

NACHT T. et al.: Demonstration eines Gebäudeübergreifenden PV Stromaustausches. Graz, 15. Symposium Energieinnovation,2018

ÖSTERREICHISCHE KOORDINATIONSSTELLE FÜR ENERGIEGEMEINSCHAFTEN. (09. 08 2022): Energiegemeinschaften in Österreich. https://energiegemeinschaften.gv.at/

REPUBLIK ÖSTERREICH: Erneuerbaren-Ausbau-Gesetzespaket. Vienna, 2021, https://www.parlament.gv.at/PAKT/VHG/XXVII/I/I_00733/index.shtml.

RIS: ElWOG. Vienna, 2022, https://www.ris.bka.gv.at/GeltendeFassung.wxe?Abfrage=Bundesnormen&Gesetzesnummer=20007045

Verbund. (26.09.2022): Wie funktioniert das Stromnetz. https://www.verbund.com/de-at/privatkunden/themenwelten/strom-aus-wasserkraft/stromnetz

🏆 *reviewed paper*

Context Driven Model to Optimise Recreational Open Spaces in Residential Neighbourhoods

Abdel Fattah Elmously, Khalid Elhagla, Yasmina Youssef

(Professor Abdel Fattah Elmously, Alexandria University, afmously@yahoo.com)
(Professor Khalid Elhagla, Alexandria University, khagla@hotmail.com)
(Yasmina Youssef, Alexandria University, yasminayoussef@adj.aast.edu)

1 ABSTRACT

People can feel affiliated with their cities through dealing with its elements and engaging in activities within its various spaces. Recreational open spaces (ROS) considered to be the essential element of vitality in human's daily life, known internationally as the right to recreational open spaces. As discussed by World Health Organization; recreational open spaces not only indicate the quality of life in any city, but also have a direct reflection on humans' mental and physical health. On the other hand, providing recreational open spaces is considered to represent the urban century's dilemma. This is due to the rapid increase of local population in cities. There is a severe deficit between the standard area and the available area of ROS. To provide the intended standard of ROS area, a valid urban policy which is compatible with the city's conditions should be formulated and followed.This research aims at a methodology for shaping an urban policy for the purpose of recreational open spaces in residential neighbourhoods. Typically following the key steps of this methodology should present an urban policy model ideologically driven from the condition of the city itself. This paper presents the complex mechanism of the ROS urban policy and how it should be correctly identified to formulate a valid urban policy model.

Keywords: neighbourhoods, context, public spaces, recreational open spaces, urban policy

2 INTRODUCTION

(Heckscher, 1977) states that "open space is associated with pleasure, with recreation, with human encounters and communal celebration, as it plays a significant role in renewing and stabilising the cities' social and economic base". Typically different types of activities take place in gardens, parks, and outdoor areas, Outdoor sports are typically stated to be more successful than others; nature activities must happen in the presence of nature; and outdoor break times are stated to enhance the employees' productivity. Consequently, the cities' open spaces are one of its necessary elements that instantly bond the modern city with its local citizens.

The World Health Organisation standardised a minimum 9 m² of open space per person. Located every 500 m, within an average of 12-min walking time. Cities face this deficit differently. Some cities recognised this challenge previously, and situate it currently in a specific urban policy process. Other cities recognised the urban challenge more recently and are trying to copy the pioneer cities' urban policies that proved their effectiveness in their respective cities. A third category of cities experiences the urban challenge in the absence of an urban policy model. Accordingly, following an urban policy model that responds to this challenge is crucial.

This paper studies the challenge of recreational open spaces (ROS) for urban policy. It proposes a theoretical method that could be used to generate an urban policy model for the provision of recreational open spaces.

3 RECREATIONAL OPEN SPACE (ROS)

ROS are those spaces where the recreational activities take place (active and passive urban recreation) regardless of whether the open spaces are softscape spaces or hardscape (WAKABA, 2016). Perry (1929) states "Open space, as a functional space comprises spaces used in a certain manner and for certain purpose, with a role in forming the city and providing the ecological conditions of healthy dwelling. Their roles in the housing zone are: spaces for communication, leisure time and recreation, varied usage spaces such as the integral spaces with the city content, preservation of the environment"

Other literature argues that the main role of open space in a residential complex is to create a balance between construction and human density, providing appropriate levels of a necessary framework which allows some activities (Mohammadzadeh, 2011).

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

3.1 ROS values

The provision of ROS contributes to several benefits to the city and its users. WAKABA (2016) concluded four main values for ROS:

- Environmental and Ecological value where ROS brings important environmental benefits to urban areas such as: the abatement of the urban heat island effect, an improvement of the air quality and the absorption of atmospheric pollutants, natural habitat protection
- Social Value as these spaces shape the cultural identity of an area, contribute to its unique character and build a sense of place for local communities, bring communities together, provide meeting places and foster social ties which have been disappearing in many neighbourhoods, cities and towns. The locals take some pride in the area they live in.
- Economic value as investors are attracted to locations offering well designed and well managed public spaces which in turn attract highly skilled employees and services. Their influence ranges from raising property values, increasing the business turnover for retailers, creating employment opportunities, contributing to the regeneration of the inner city neighbourhood, and promoting tourism.
- Aesthetic value as ROS give the users a pleasant break; a chance to escape the usual urban setting. Thus, people feel good being in these spaces and also feel refreshed as they appreciate the beauty of these places. This fosters an attachment to the spaces by the users.

3.2 Characteristics of recreational open spaces

General qualitative concepts were highlighted by scholars identifing ROS charactertics as the proximity, accessibility, knowledge that they may be used at any time of day and their attractiveness (Jacobs, 1961, WAKABA, 2016, W. Whyte, 1980, L. Bravo, 2013, N. Abelaziz, 2017). Other scolars are more concerned about the ROS location and their serving citizens. WAKABA (2016) states that ROS of the residential neighborhood should serve 4500-8000 residents, and thier walking distance is 250-300m. Also, WHO (1965) standarlised an average of 12-minutes walking time and its location to be isolated from the motor traffic every 500 m. (Petar Mitković, 2004), N. Abelaziz (2017) concluded several functions that may take place at ROS in a residential neighbourhood: sitting, resting and meditation, elders‘ outdoor sports, basketball courts, climbing structures, children playground, small event space, meeting and socialising space, educational spaces so that children can gain a better understanding of nature.

3.3 Ownership and the provision dilemma

The provision of public urban spaces usaually is the responsibilty of the government. On the other hand, cities’ governments suffer from the increase of responsibilties and the limitation of resources. Nevertheless, the rapid increase of the population prioritised other demands such as the provision of housing and water. and cities responded differently. Scholars unpacked public openspaces into three parts:

- Ownership: Studies and practices of several cities confirm that public sector ownership is not the only scenario cities may follow. Privatisation is another method to remedy the deficiency of spaces. Castello (2013) calls them diluting the boundaries between public sector and private sector which clarifies the contemporary view that tends to be more tolerant in this regard.
- Sponsership: open space is not only described as void but also as a positive void that performs its role positively. In order to create and sustain vitality, open spaces demand sponsorship through the life cycle of the open space; design phase, construction phase and post erection phase. Spaces may be monitored and sponsored by the public sector, private sector or the public themselves.
- Use: whether the public has access to the space or not (Carmona et al, 2012) does not identify an ideal public space. But instead it offers variable, competing perspectives, which therefore raise the question of “for whom” a space might be more or less public. In other words, if people (users) think that a space is public, then it is a public space. Another concern of public space is whether the space is actively used and shared by different individuals and groups in terms of age and gender.

Consequently, open spaces may be owned and sponsered by the private sector but publicly used or public in terms of ownership, sponsorship and use or a private space in terms of use and ownership but sponsored by the public sector.

4 URBAN POLICY

4.1 City Challenges

” cities faced and will always face challenges” (Claire Edwards, Rob Imrie, 2015)

Tracing one of the historical city challenges, the provision of water, Roman engineers designed and constructed aqueducts. Roman engineers constructed a complex network of aqueducts and before that the Greeks built sophisticated sewage systems in their cities, such as Knossos in Crete. Nevertheless, the Egyptian Sadd E; Kafaea in wadi Garawa built around 650 BC for flood control is considered the oldest dam of such size (110m) x14m (Agaiby et al, 2013). Thus, cities have and always will face challenges and provided urban solutions to overcome then. Claire Edwards, Rob Imrie (2015) agreed that time provokes different city challenges and stated that the current reasons are massive increase of population and the consequences of new technologies. Paul Cheshire, Max Nathan, Henry G.overman (2014) also confirmed that technology drives changes to cities periodically.

4.2 Definitions

“Policy“ as defined by the Oxford Dictionary is a plan of action agreed or chosen by any party The Cambridge Dictionary defines it as a course of actions adopted or proposed by an organisation or individual. Adding the word urban as described by Claire Edwards, Rob Imrie (2015) is the scope of the plan of action, in other words, all that corresponds to the city’s buildings, forms, and infrastructure. As defined by the Oxford Dictionary “Method“ is used to describe a well-organised systematic action. Thus, urban policy is a planned method for overcoming a city challenge. It is important to highlight that urban policy is not restricted to a governmental plan and scholars debate other creative responsible parties for urban policies. However, the generic use of the word is to describe the governmental plan (Glaeser, 2011).

Snook (2021) highlights that cities are different and according to these differences, urban policies are shaped uniquely for each city. Defining the city’s resources form its characteristics and describe its limitations. In conclusion, urban policy is a planned method which formalises the available city’s resources in order to overcome a specific city challenge.

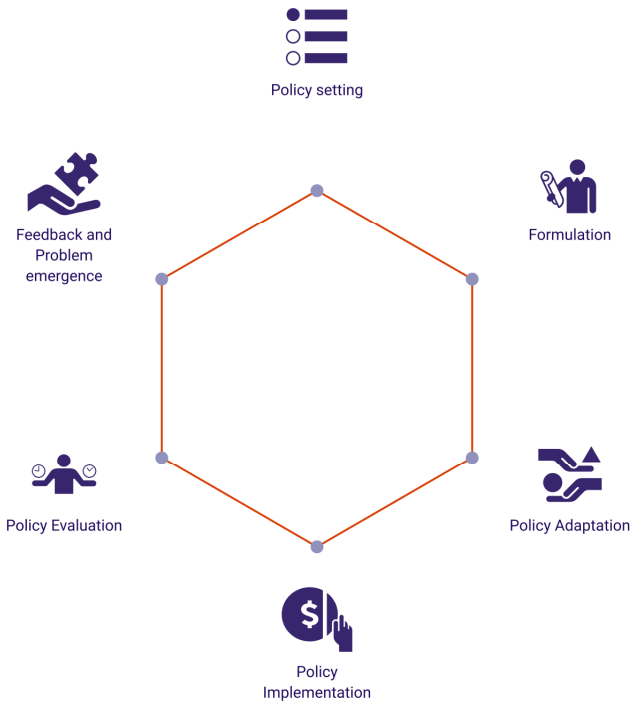


Fig. 1: policy process stages, source: researcher.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

4.3 Policy Process

To reach a successfull policy that fits the context, cities must go through several stages. They start with setting the agenda that prioritises the challenge. Then the actual start of the process is the formulation of the policy. This stage divides into two phases: firstly, designing different models and choosing the best option, secondly, formulating the coding regulation for the chosen model. The third stage is the adoption of the policy by the different city departments and devising execution instruments. This stage transforms the model into a policy. The implementation of the policy is the stage where the policy should solve the challenge partially or totally which should go through several periodical evaluations. The evaluation stage should always reflect on the policy agenda setting accordingly. The whole policy process serves as a cycle that repeat its stages. The focus of this paper is to elaborate a model at the policy formulation stage.

4.4 Policy dimensions

Despite the difference of urban challenges, scholars found common dimensions and layered solutions layered to these dimensions. Consequently, should these strongly agreed dimensions be approved for any type of urban policy, scholars would have to study those dimensions (the components of the urban policy) to reach an integral urban policy. The following paragraphs introduces, defines and presents the references for the dimensions of the urban policy (Table 1).

Reference	Physical dimension	Social dimension	Economical dimension	Political Dimension	Managerial Dimension	Environmental Dimension	Cultural dimension
(Paul Cheshire, et al, 2014)	Strongly agreed (built form)	agreed	Strongly agreed (market forces)	agreed	Not mentioned	Not mentioned	Not mentioned
(Claire Edwards, Rob Imrie, 2015)	Strongly Agreed (places)	Strongly agreed	Strongly agreed	Strongly agreed	Not mentioned	Strongly agreed (Ecological suistanability)	agreed
(R, 1993)	Strongly agreed	Strongly agreed	Strongly agreed	Strongly agreed	Strongly agreed	Not mentioned	Not mentioned
(J. Clark)	Strongly agreed	Strongly agreed	Not mentioned	Not mentioned	Not mentioned	Not mentioned	Not mentioned
(Batty & Hutcherson, 1980)	Strongly agreed	Not mentioned	Not mentioned	Strongly agreed	Strongly agreed	Not mentioned	Not mentioned
(Jacobs, 1961)	Strongly agreed	Strongly agreed	agreed	Not mentioned	Strongly agreed	Not mentioned	agreed
(Parkin, 2014)	Strongly agrees	Strongly agrees	Strongly agrees	Strongly agrees	agrees	Not mentioned	Not mentioned

Table 1: The agreed diemnsions of urban policy by different scholars, source: researcher.

4.4.1 Physical dimension:

Cities' physical dimension is their materialistic form. Urban scholars have much focused on this dimension. Different studies strongly agreed (R, 1993, Dolotwiz & March, 1993, Claire Edwards, Rob Imrie, 2015) on the physical dimension which they consider to tackle the challenge's materialistic elements (Batty & Hutcherson, 1980, Jacobs, 1961).

4.4.2 Social dimension:

Jane Jacobs as described by Paul Cheshire, Max Nathan, Henry Goverman (2014) is the prime sociologist woman who first bonded urban policy and sociology. She described the city as a complex organism that should be organised through dealing with its citizens and spaces simultaneously to remedy the city's problems. Dolotwiz & March (1993) state that the problem of urban policy transfer lies in the socio-cultural differences; in other words, the society of the city is a crucial factor for the acceptance or the refusal of the urban policy. The social dimension is concerned with the values, norms and roles of the society, emanating from the cultural dimension of the society which differentiates one group from another.

4.4.3 Economic dimension

The economic dimension, which tackles the economic functioning of the challenge, (Paul Cheshire, Max Nathan, Henry Goverman, 2014) claims that despite the importance of the economic dimension at the urban policy formulation, scholars lack economical insights. Economical understandings improve urban policy design and delivery. Strong market forces highlight currently the importance of paying attention to the outcomes for the people as well as the places.

4.4.4 Political dimension

The political dimension is according to Collins Dictionary the way power is achieved and used in a country. According to Christoph Knill and Jale Tosun (2008) the political dimension is where the power lies which strongly relates to any urban policy in terms of political organisation, political laws and regulations, role of government and political ideology of the city. Dolotwiz & March (1993) considered that the political dimension strongly relates to economic and social dimensions as it seeks the community's good subject to economical affordance.

4.4.5 Managerial dimension

Management is the planning, organising, leading and controlling aspect of urban policy (M Carmona et al, 2008). According to G Chase et al (1983) it is the guarantee of any urban policy to sustain and evolve. Many beneficial urban policies that lacked the managerial aspects lost their chance.. Chase also clarifies that the managerial dimension is the process that turns policy into practice. Urban policies could remain statements or they could arise as practical solutions in the political and managerial dimension. Batty & Hutcherson, (1980), R, (1993), G Chase et al, (1983) and Jacobs (1961) strongly agree on the link between urban policy, physical dimension and political dimension.

In conclusion, scholars strongly agree that physical dimension is the most important dimension in urban policy. Several scholars also agree on the economic and social dimension, while the political and management dimensions are given priority as they relate to the dimensions priot to new urban policy. The cultural dimension could be included in the social dimension (socio-cultural) dimension or it could be studied separately.

5 LINKING URBAN POLICY WITH ROS: A METHOD FOR DEVELOPING A CONTEXT DRIVEN MODEL

Each chosen dimension has several parameters which are identified according to the given challenge. They contribute to the identification of resources and limitations of each city as a basis for alternatives. A context driven model should be based on the specific resources and limitations of each city. The provision of recreational open spaces is the challenge adopted by this paper, aiming to define its parameters and alternatives. Determining alternatives for each parameter leads to different models suitable for the city's context.

5.1 Parameters of ROS urban policy

5.1.1 Spatial parameter

The physical dimension relates to the ROS challenge by means of the spatial parameter of the city. This parameter is defined as spaces of the city. R.Krier (1979) categorises urban spaces as spaces with a positive role in the city and among other existing spaces, regardless of their other characteristics, such as their area, ownership, etc. Spaces that have no role in cities, are the focus of many theorists as they are considered to be the first step towards emptying spaces (Council, 2015). Theorists adopted the idea that those spaces can be upgraded to postive open spaces. Spaces that have lost or have no role are the type of spaces this paper is adopting. (W. Whyte (1980), L. Bravo (2013), N. Abelaziz (2017) clarify that those spaces are considered one of the city's assets; properties that can be efficiently utilised and returned to use within a short time. In conclusion, the spatial parameter is available unutilised spaces of a city.

Spatial Alternatives:

Three main characteristic should be identified to drive a suitable model: area, ownership and location in the neighbourhood (Council, 2015), (Borough, 2016). The paper categories the spaces firstly according to scale (Table2): small areas up to 500m2 as pockets and mini pockets, medium size up to 1000 m2 as squares, gardens and plazas, large size greater than 10,000 m2 as parks or promenades. Some areas can be located between small and medium distancing (500m2-1000m2) while others are found between the margin line of medium and large (5,000-10,000m2) (W.Whyte, 1980, N. Abelaziz, 2017. Sitte, 1889. Heckscher, 1913, Mathew Carmona, Steve Tiesdell, Tim Heath, Taner OC, 2003). Quantitatively, the area is an indicator of its the potential affordance. Qualitatively, the area is also an indicator of the function selection. The location of space is considered its second characteristic. WHO (1965) stated that the location of the space is a primary

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

characteristic that is used as an indicator of the service radius. Another fundamental characteristic is the ownership of the space (public, private, shared). Each city should examine its affordable spaces' in terms of their areas, ownership and location.

spatial parameter data					
Space alternative	**Space num.**	**Area**	**Location**	**Ownership**	
small scale					
small-medium scale					
medium scale					
medium-large scale					
large scale					
Major space alternative	Total number	Total area	From the centre	The major ownership	

Table 2: the data needed to identidy the spatial parameter, source: researcher.

5.1.2 Financial parameter

The economic dimension has several parameters relates to different urban challenges. Gallent, Filion, & Gurrran (2021), Parkin (2014) state that financial capital is one parameter of the urban economics that plays an important role in enabling any development. Financial capital is money, credit, and other forms of funding that is used to achieve a target. Financing the development project for any city is a main constraint, depending on the support of government's direct fund hardly affordable (Paul Cheshire, Max Nathan, Henry Goverman, 2014). Nevertheless, guaranteeing and well managing funds describes the existence of the solution on the physical level. Several beneficial urban policies didn't exist due to the demand of non-existing grant funds. APM (2021) states that depending on several funding sources is favorable for any project. Consequently, it is important to define the existing and the limiting funding resources of the neighborhood in order to shape its suitable model. Innovative funding alternatives evolved in several cities, such as London, New York, Amsterdam and others (R, 1993) due to the uniqueness of economic factors in every city. The paper grouped the funding alternatives according to the funding sources as four alternatives that will be discussed next.

Financial alternatives:

Finance parameter data			
Financing alternatives	**Method**	**Name of the parties**	**Scale of fund**
Basic public finance	Example; taxes		
Private sector			
Organizations			
Donations			
Major available alternative	Total available method	Total involved parties	Total fund

Table 3: The data needed for identifing finance resources, source: researcher.

Different financing options were introduced over time in order to obtain and structure the money needed to provide recreational open space. Firstly, Lindfield, Michael, Teipelke, Renard (2018) describe basic public finance which depends directly on the government sector. This option could come from different tax collections, building permit fees, public utility tariffs. Secondly, the private sector alternative depends on government supervision but structuring the money depends on the private sector. This alternative developed differently over time, due to cities guaranteeing various benefits at different levels. The third alternative is organisations. National and international organisations may provide the money for the provision of open spaces. Several NGOs which adopt crucial interests, such as climate mitigation problems, go-green strategy and other related ideologies are considered as financing source for their provision. Global organisations which have adopted international agendas for sustainable development have established funds that provide concessional loans and technical assessment grants to projects that address at least one of their focal areas (biodiversity, international waters, land degradation, chemicals and waste, and climate change mitigation, or cross-cutting issues). Multi-lateral development banks provide loans at lower interest rates and/or longer repayment periods, commonly available in the local capital market, thus making debt easier than at standard market prices due to public welfare terms. In most cases, such concessional loans require a guarantee (by a national government), which will usually pass on the loan money either as debt and/or partial grant to city

governments.The last alternative are donations; this alternative can help projects at a small scale or provide last mile finance steps. Crowdfunding may also be an example of donation, for individuals of particular interest. or for social benefits to a neighborhood with a symbolic return.

5.1.3 Parties parameter

Political dimension relates to urban policy in many ways that differ from one challenge to another. Two major parameters were studied to attach a political dimension to ROS. The first is the general mechanism of urban policy, the method of handling the resources of the neighbourhood, meaning the organisation and operational system of the policy; how parties work together, how resources are managed. The mechanism of ROS do not only relate to the resource but also the time and scheduling which transform the ROS policy into a strategy. The parties are the second major parameter. Some theorists study the two parameters separately while others merged the two parameters. There is a difference between the parties and the system itself; the key parties represent the participants while the system is the operational system of those participants. The paper seperates the two parameters: that of the parties and that of the mechanism. G. Chase et al (1983), Claire Edwards, Rob Imrie (2015), Dolotwiz & March (1993) find that there is a difference between the key parties and the actors in the policy process. Through the different stages of the policy different actors have certain jobs during agenda setting, policy formulation, policy implementation and policy evaluation. Those job may change and disappear during the changing policy stages, while the key policy parties are the participants who assign and manage those actors. Policy actors may be referred to as policy key parties. For example, the executives are the policy actor while the government is the key party of the policy who assigned the executives to do a certain job, besides other legislators, judiciaries and administrators.

The set of actors that adopt the policy are the key parties of the urban policy to deal with this challenge. This parameter defines the evolved parties that will adopt and operate the urban policy. This parameter is undoubtedly entwined with the finance parameter. On one hand, the finance parameter includes the crucial parties that finance the policy, on the other hand, ROS policy has crucial roles other than financing (G. Chase et al, 1983). The parties' parameter does not only embrace the financial source parties but extends to parties responsible for the key roles.

Parties Alternatives

According to Christoph Knill & Jale Tosun (2008) and Ddolotwiz & March (1993) the key parties could be grouped as follows:

- Government, understood as the public sector: The public sector refers to institutions, organisations, and companies where the government is the highest shareholder. These organisations are controlled, operated, and managed by the government. Their aim is the citizens‘ quality of life (in Egypt: gehaz tanseek alhadary)
- Institution, organisation: a legal entity organised and operated for a collective, public or social benefit, in contrast to an entity that operates as a business aiming to generate a profit for its owners. Nonprofit organisations are accountable to the donors, founders, volunteers, programme recipients, and the public community (for example, World Health Organisation)
- Political parties: individuals who favour community individuals in order to seek governmental power, their aim is the governmental power
- Investors, market referred to as the private sector: The private sector refers to organisations and institutions owned by private individuals. The private sector is controlled, operated, and managed by private companies and their higher aim is investment finance (for example, investor of real estate as a person or an organisation)
- Community as interest group: Communities exist around particular interests. They comprise any association of individuals or organisations, usually formally organised, that, on the basis of one or more shared concerns, attempt to influence policy in their favour. All interest groups share a desire to affect government to benefit themselves or their causes which represent a segment of society, but whose primary purpose is non-economic and usually focused on promoting a particular cause or value not specific to one area but to the interest as a whole. Their motive is their cause.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

- Community as place: A community is a particular place or neighbourhood related to a group of people who co-exist within geographical boundaries. These people do not necessarily share interests but they inhabit the same area. They are referred to as individuals with no specific activity, as inhabitants or users with no particular moto.
- Community organisation: Inhabitants of a neighbourhood may form a resident association to represent shared concerns about their area. Their motto is the area concern.

Parties parameter data		
Parties Alternatives	Name	Responsibilities
Government		
Organization		
Political parties		
Investors		
Community and interest group		
Community organizations		
Major and minor involved parties	Total number of parties	

Table 4: the data needed to identify the parties parameter, source: researcher.

5.1.4 Morality parameter

The term moralisation was introduced by psychologist Paul Rozin in the late 1990s to describe the process by which people's preferences are transformed into values. The act in which a certain behaviour, bad behaviour is not accepted by general people, while other behaviour is considered acceptable to a certain group of people. Those groups of people are considered to have a certain value not just a preference that all of them accept for several reasons. Moralisation is fundamental for politicians in the past and now (Claire Edwards, Rob Imrie, 2015). Throughout history, cities used morals to gather people around them to believe them and credit them officially. Since charity and volunteering is a moral value, responsibility for the city is a value, exclusiveness is a value, healthy life style is a value, equality is a value. Theorists studied the relation between those values and place (Mathew Carmona, Steve Tiesdell, Tim Heath, Taner OC, 2003, W. Whyte, 1980, Jacobs, 1961). They highlighted that the moral parameter is the intangible preference that rises from the socio-cultural dimension of a neighbourhood, the values and believes of its residents. These values will link the residents to the ROS as they offer a place for practicing their common values. Each neighbourhood's residences are known for a certain moral. It could be defined as "the values that the space holds". ROS are not only built on its users' values but they also strengthen and level up other values as they contribute to the provision of the ROS. Thus morals are a resource that should be defined and managed to formulate the adequate ROS policy that fits society.This parameter guarantees the support of the ROS users through acknowledging their values. Nevertheless, it also builds higher positive values, such as responsibility, charity, goodness and welfare.

Morality Alternatives:

A moral parameter at the urban scale means the values that a space generates for its users and the values that the space accepts or considers to be wrong, even if the rules accept it. The moralisation parameter has a process, stated by Rozzen (1999), and it takes place at different scales. Values are numerous and different from one society to another. This parameter necessitates the selection of a value most common and known to the society that will contribute to the provision of ROS in this city. For example, German society cherishes self-responsibility. Gated community spaces hold values of segregation for a certain social level. The values of the users of urban spaces of the city develop, positively or negatively, a process that happens gradually and with intension. Values can be grouped into four main ensembles. The first is individualism; which garners individual values, such as responsibility, happiness, positivism, self-building. The second is pluralism or socialism; which relates individual values to others, such as accepting others, considering others, time commitment. The third are citizen and place values, which contain the values that link the individual to the city and to place, such as cleanness, volunteering, responsibility to the city and public services. Values that relate to religion and cultural traditions should also be identified and cherished.

Morality parameter data		
Morality alternative	present	needed
Individualism		
Pluralism		
Citizenship		
	Total number of morals	Total number of the needed morals

Table 5: the data needed for identification of morality parameter.

5.1.5 Control parameter

Carmona et al, (2008) highlighted the importance of guaranteeing the quality of public spaces, assuring that the quality of public space is achieved by managing different parts of space in termd of coordinating responsibilities, controlling the physical environment; approach to maintenance, in addition to controlling user behaviour and safety. This explains the attempt to define methods of controlling space and user behaviour in order to select the aprropriate control alternative for the ROS model. Bostrom, Bravell, Lundgren, & Bjorklund (June 17, 2013) and D. Carro, S. Valera, T. Vidal, (2008) find three major sources of insecurity: environmental factors such as lighting, cleanliness or presence of "uncivil" behaviours; the social construct of a place as safe or unsafe; and the ability of the individual to cope with these variables. According to Kohlberg (Figure 3), people behave according to their education, cultural backgrounds, community, family, religion, ethics and values. Their life experience shapes their overall background. Kohlberg, proposes a model that packages people behaviour into a reasoning model. Baumeister & Tierney (2011), Baumeister, Vohs, & Tice (2007) and several other theorists followed this ladder to define an adequate model to control behaviours in public spaces. Consequently, grouping these models are alternatives to dealing with different users at ROS. Mathew Carmona, Steve Tiesdell, Tim Heath, Taner OC (2003) grouped the urban space into four parts of buildings, landscape (hard and soft), infrastructure and uses. His study proposes that control of the physical dimension of urban space should be scheduled and planned to cover the designed urban elements. It is important to highlight that the 'kit of parts' was only one part of Carmona's study/ The other two parts were context for actions and qualities to study the character of the urban space. RO Noak (2018) established alternatives that link the kit of parts devised by Carmona and maintenance duration to the budget and the user density of the place.

Control Alternatives:

In the end ROS are public spaces that welcome people from all walks of life. Assigning spaces for users of ROS to do/ don't actions, cannot be controlled in a single way, due to the different backgrounds of the users. According to Kohlberg, dealing with users in terms of do and don't should be done differently. Users should be made aware of simple rules at stage one and certain circumstances if they do not obey them., Stage two should provide society supporters who would give social norms encouragement and applaud the desired action by the society. At stage three people should try to understand the reasons why they do not comply with social rules. Instead of controlling people actions directly spaces may be controlled by rules secured by design (SBD, Loukaitou-Sideris and Banerjee, 1998: 183–5. Instead of heavy hand control soft hand control may achieve better results using closed circuit television and pacification alternatives.

Control parameter data		
behavioral control	Method	Name
Soft hand		
Heavy hand		
Operational control	Frequency	Model
Enclosing elements		
Elements within enclosure		

Table 6: the data needed to identify the control parameter, source: researcher.

6 CONCLUSION

ROS are those spaces where the recreational activities take place, one of their roles in residential neighbourhoods is to create a balance between construction and human density. The provision of ROS has several benefits fpor the city and its users: environmental and ecological value, social value, economic value, aesthetic value. ROS characteristics are identified as proximity, accessibility, knowledge that they may be used at any time of day and its attractiveness. Other charcteristices are identifed as location and serving

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

citizens. ROS may be owned and sponsored by the private sector but still considered as public space because it is used publicly. Urban policy is a planned method, which was formalised due to available city resources to overcome a specific city challenge. To reach a successful policy that fits the context, cities have to work through several stages. Formulating several models guarantees choosing the best option to solve the challenges according to the city context.

Although urban challenges differ widely, scholars identified common dimensions and that solutions were layered according to these dimensions. Scholars agree stongly that the physical dimension is the most important one. Several also agree on the economic and social dimension but attrtibute priority to the political and management dimensions as they relate to the physical and social dimensions. The precise parameter of each dimension is identified according to the challenge intended to be overcome. Regarding the ROS challenge, spatial, finance, morality, parties and control are the parameters of the five dimensions respectively. Three main characteristic are identified to drive a suitable model for ROS: area, ownership and location in the neighborhood. The paper categorises the recreational spaces according to size: small areas up to 500m2 as pockets and mini pockets, medium size up to 1000 m2 as squares, gardens and plazas, large size greater than 10,000 m2 as parks or promenades. Different financing options were introduced over time in order to obtain and structure the money needed to provide the recreational open space: basic public finance organisations, the private sector and donations. There is a difference between the key parties and the actors in the policy process. The parties alternatives for a model are Government referred as the public sector, Institution/organization, political parties, Community as interest group, Community sector/organization. A moral parameter on the scale of urban means the values that a space generates to its users and the values that the space accepts or considers to be wrong even if the rules accepts it. Values can be grouped in four main packages. The first is individualism; which pack the individual values as responsibility, happiness, positivism, self-building. The second is pluralism or socialism; which packs the individual values with others as accepting others, considering others, time commitment. The third is citizen and place values, which contains the values that link the individual with the city and place as cleanness, volunteering, responsibility to the city and public services. Values that relates to religion and cultural traditions also should be identified and cherished. the quality of public space is achieved by controlling the physical environment; maintenance approach in addition to controlling user's different behaviors.

7 REFERENCES

Lindfield, Michael ; Teipelke, Renard ;. (2018). How to finance urban infrastructure. london: C40 Cities.

Agaiby et al. (2013). Learning from the past:the ancient egyptians and geotechnical engineering. 4th international seminar on forensic geotechncal engineering (pp. 38-69). Bengaluru, India: Research gate.

APM. (2021, 1 27). www.apm.org.uk. Retrieved from apm: https://www.apm.org.uk/resources/what-is-project-management/what-is-investment-appraisal-and-project-funding/#:~:text=Project

Batty, M. H. (1980). Systems analysis in urban policy making and planning. NATO advanced research institute on sustems analysis in urban policy making and planning (p. vol12). New college, Oxford: Plenum press.

Borough, B. l. (2016). An open spaces strategy for barnet. London: Barnet London Borough.

Bostrom, M., Bravell, M., Lundgren, D., Bjorklund, A. (June 17,2013). Promoting sense of security in old age care. Health, vol.5, 6b.

Christoph Knill and Jale Tosun. (2008). Policy making. Oxford: Oxford Unversity Press.

Claire Edwards, Rob Imrie. (2015). The short guide to urban policy. Britain: Policy press.

Council, G. C. (2015). In Openspaces practices in high density areas. Goldcoast.

D. Carro, S. Valera, T. Vidal. (2008). Perceived insecurity in the public space: personal, social. Science+Business Media B.V. 2, 304-316.

Dolotwiz, D., & March, D. (1993). Learning from Abroad: The Role of Policy Transfer in Contemporary Policy Making. Political studies, 343-353.

G. Chase et al. (1983). How to manage in the public sector. United States of America: Mcgraw-Hill.

Gallent, N., Filion, P., & Gurrran, N. (2021). the self- build experience: urban policy,planning and built environment. Britain: Bristol University Press.

Glaeser, E. (2011). Triumph of the city. London: Macmillan.

Heckscher, A. (1913). The life of American cities. New York: Harper and Row.

Heckscher, A. (1977). Open spaces, the life of American cities. United States

J. Clark. (n.d.). Policy through practice: Oxford University.

Jacobs, J. (1961). Death and life of great American cities.

L. Bravo. (2013, may). Open spaces, public spaces, open minded places. IN_BO. Ricerche e progetti per il territorio, la città e l'architettura, pp. 4. 1 - 4. 10.6092/issn.2036-1602/3708.

M. Carmona et al. (2008). Public space: the management dimension. New York: Routledge.

Mathew Carmona, Steve Tiesdell, Tim Heath, Taner OC. (2003). Public Places Urban spaces. London: Routledge.

Mohammadzadeh, R. (2011). Assessment of Spatial and Physical Factors Quality of Sahand New Town Residential Communities Open (Outdoor) Spaces. Honar-Ha-Ye-Ziba: Memary Va Shahrsazi, 3(47), 29-38.

N. Abelaziz. (2017). Pocket parks design. vol2,no.2,pp.51-60.

Parkin, M. (2014). Economics. England: Pearson.
Paul C. Cheshire, Mx Nathan, Henery G. Overman. (2014). Urban economics and urban policy. UK: Edward Elgar Publishing.
Perry, C. (1929). The Neighbourhood Unit. London: Routledge.
Petar Mitković, I. B. (2004). OPEN AND RECREATIONAL SPACES. Architecture and Civil Engineering Vol. 3, 79-97.
R, R. (1993). A guide to learing through time and space. London: Chatham House.
R. Krier. (1979). Urban space. London: Academy editions London.
R. O. Noak. (2018). Comprehensive park and open spaces maintenance plan.
Sitte, C. (1889). The art of building cities. Vienna: Martino.
Snook, A. (2021, August). Policies-and-procedures-in-the-workplace. Retrieved from i-sight.com: https://www.i-sight.com/resources/policies-and-procedures-in-the-workplace-the-ultimate-guide/
Whyte, W. (1980). The social life of small urban spaces. Project for public spaces.
Wakaba. (2016). An assessment of the quality of open spaces in University of Nairobi.
WHO. (1965). Standards for outdoor rec reational areas. Chicago: American society of planning officials.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

🏆 *reviewed paper*

Creating Future-Proof Spaces for Megacities by an Impact-Oriented Participative Approach – Case Study Experiences from India

Laura P. Spinadel, Petra Bußwald

(Mag. Dr. Arch. Arq. Laura P. Spinadel, BUSarchitektur ZT GmbH & BOA office for advanced randomness GmbH, Schulgasse 36/2/1, 1180 Vienna, Austria, spinadel@busarchitektur.com)
(DI Petra Bußwald, akaryon GmbH, Grazer Straße 77, 8665 Langewang, Austria, busswald@akaryon.com)

1 ABSTRACT

A lot is discussed how climate change puts threats on future urban and rural spaces. Indeed, this is highly relevant and needs to be reflected in the creation of these spaces in the frame of impact analyses. In addition, it seems even more relevant to integrate the human component into the processes of driving future real estate in order to shape spatial transformation in rural and urban spaces jointly and sustainably in a "better way".

URBAN MENUS (urbanmenus.com) is a novel platform for participative spatial development processes combining data understanding, data crunching, modelling, visualisation, and critical impact analysis, operationalised in an easy-to-use, high-end interactive real-time app with 3D visuals. URBAN MENUS quickly displays images of the future, allows a walkthrough, and evaluates effects in terms of resources and ecology (with the carbon footprint as one recent lead indicator), society and urbanity, and profitability – as an overall profile of resilience. This allows structured and fact-based, multi-perspective considerations on a project, steering holistic, future-proof space optimisation and investment security.

The paper describes the experiences with impact-oriented participative spatial development processes in Pune, India. India has a very long democratic tradition as a good basis for participative processes and we observed a higher average appreciation of Women's inputs compared to Europe. Yet, according to our experience, the caste system still strongly influences the mindset and hinders equal treatment of concerns across population segments. Furthermore, the relationship with decision makers, which play a crucial role in development projects, is widely characterised by widespread mistrust, counteracting consensus-finding at all levels.

To this end, our conclusion is focused on the need of an onboarding phase, making all participants familiar with impact-thinking and creating awareness on the benefits of cooperation and the joint targets of happiness on a resilient basis. Furthermore, the young generation and their decision makers should be involved more to advance future spaces, combined with established classic stakeholders. Together they can yield best results, especially if orientation is provided for instance by archetypical examples deducted from previous processes. For India we have elaborated the following "archetypes" with high needs and potentials: a) smart rural development based on the circular economy, b) re-definition of development around historic heritage, c) city concepts based on new green production and mobility, and d) multi-sectoral and inclusive city enlargements.

Keywords: Inter-Sectoral Development, Impact Analysis in Spatial Development, Holistic Decision Making, Future Planning, Community Interaction

2 IMPACT-ORIENTED, MULTI-SECTORAL AREA DEVELOPMENT AND URBAN MENUS

Profound knowledge about an area in question and stakeholder involvement are central for multi-sectoral resilient system planning: To think about the future of space, the history and the present cannot be neglected. Therefore, it is important to identify framework data to understand the case, current and possible future problems, and potentials. To elaborate a joint vision, stakeholders with a driving influence, not only for commercial or positioning reasons, need to be identified, motivated and integrated.

Our method URBAN MENUS assists such a multi-sectoral, agile, proactive urban and regional development. It offers a digital participation technology to gather input from all stakeholders about the area's status quo. Future visions thereof can then be elaborated along three main interests: (1) ecology & sustainability, (2) urbanity & society, (3) density & (economic) efficiency. 3D visualisation allows to walk through, adapt and choose the best future for all in an interactive process. Integral impact assessment in line with the EU Green Deal, UN SDGs, diversity, and gender aspects shows the impact of scenarios on happiness, safety, innovation, profitability and circularity values – this supports resilience and benefit optimisation in line with (changing) interests of all stakeholders, framework conditions and sustainability strategies.

Users benefit from precise identification of areas for improvement, intelligent fact assessment and transparent presentation of development alternatives, objective dialogue about future dreams with all relevant stakeholders, accurate representations for communication, support in building the right alliances and access to inspiring contemporary demo projects.

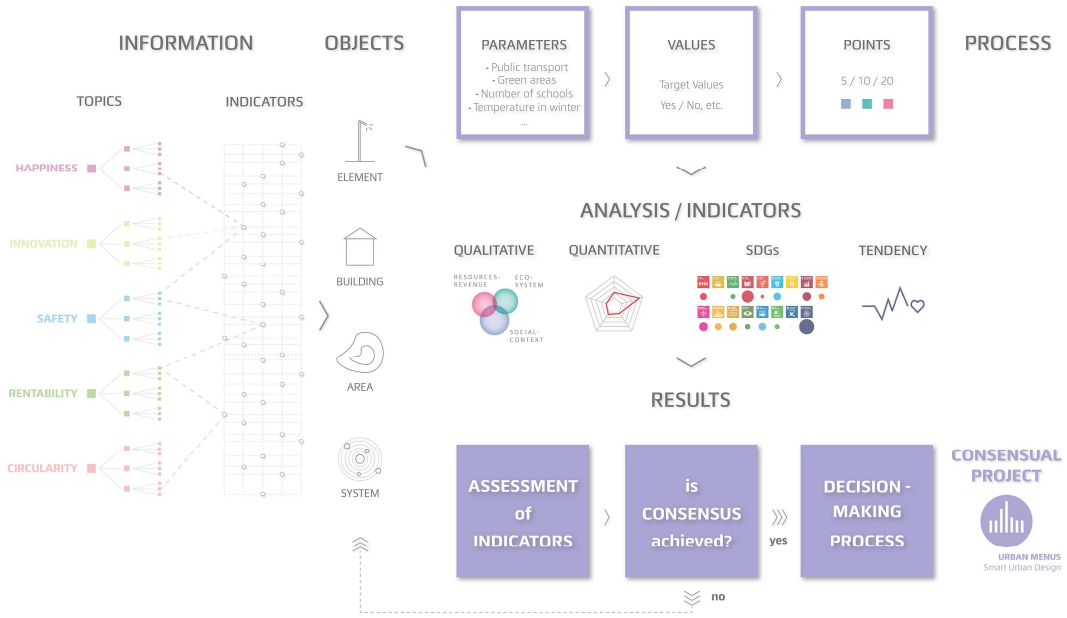


Fig. 1: URBAN MENUS Smart Development Methodology.

3 AREA DEVELOPMENT IN INDIA, FOCUS ON PUNE REGION

The chapter presents current characteristics of the planning and development scene in India, economic and other influencing factors, stemming from our and project-related experiences with stakeholders.

3.1 General framework conditions

Focus on acute problems and moderate ambitions: Indian megacity regions, in contrast to classic European ones, are primarily focused on acute challenges such as water scarcity, water and air pollution, traffic chaos and noise[1], which therefore dominate in the visioning process. Looking into the future beyond these dimensions is less important to most of the stakeholders. Development as a goal, connected with the need to change (and curiosity towards the new), is clearly common sense different from Europe. However, the ambition of "making the best" and leveraging utmost potential is overarched by "achieving a moderate good". Certain circumstances are accepted without any discussion, improvements seem "out of any reach".

Stakeholder communication – caste and other influences: To gather stakeholder commitment for effective multi-sectoral processes requires great efforts within the Indian society, due to hierarchical and orderly thinking especially influenced by caste – caste plays a role at every stage of an Indian's economic life" (cf. MUNSHI 2019, p. 781) as well as religion, but maybe also British Empire and Commonwealth history. We experienced personal acquaintance as a kind of precondition for top-level cooperation and a cautious attitude towards digital and low-threshold-meetings. According to another experience report on the topic of participatory urban development in India, "urban land politics is entrenched in overlapping class, caste, religion and ethnic moorings". (Salamah 2021, p. 139) For a researcher observing Indian's fascination with colonial heritage and the hegemonic discourse, an "[…] emphasis on order […], seems to be "at the centre of powerful discourses at the level of both, the state and citizens." (Perera, 2018). This obedience to authority may contribute to all the difficulties with introducing development ideas bottom-up.

Stakeholder engagement and digital participation are in the initial phase

[1] Participants in the status quo assessment of cases (see chapter 3.1.2) focused on the following problems: safety issues impeding open structures, lack of environmental efforts, water and food related infrastructure challenges. In addition, villagers tend to face connection issues.

Stakeholders are increasingly involved (e.g., Mumbai First; mumbaifirst.org). In the recent past, methodologies were tested to assess key sustainability values for spatial development, such as the analytic hierarchy process (AHP) technique combined with stakeholder identification (cf. Kwarta et al. 2021). However, public participation is still highly administrative, largely conducted without digital technology.

Often, consultations are even conducted pro forma about draft plans for which the decision has basically already been made. (cf. Samah 2021, p. 137) "Although the concept of stakeholder engagement is gaining increased acceptance and significance […], there are yet no established normative frameworks and practices […] by courtesy of the varying social, economic and political conditions across settings." (Tyagi 2019, p. 813) The complementary use of technologies such as VR and AR and also drone and satellite data is just emerging.

Shift in traditional role models: Due to female empowerment in India, women reach high positions in the labour market and in the local village life. This also influences development processes and mindsets. The change in the social fabric comes with new space design needs, concerning Women's safety at campuses and workplaces for example, but also their children's security in new environments. Also, new equality-oriented social gathering spaces are needed apart from traditional ones. The National Policy for the Empowerment of Women expresses efforts in this direction: "Women's perspectives will be included in […] planning of housing […] both in rural and urban areas. Special attention will be given to providing adequate and safe housing […]." (Government of India 2001) Although there are already government housing schemes for women in place, reservation principles are providing discounted access to infrastructure, and services for disadvantaged influence the housing market, further development is needed regarding affordability, optimum integration of respective housing units into surrounding infrastructure and proximity to workplaces. (cf. Saxena 2020)

3.2 Density

Redevelopment, extension and gentrification

Pune, an inner-city, wants to boost its image, given the high outward migration in the last 10–20 years: It is characterised by densification and high-rise tendencies pushed by new development control rules from 2017 (Pune municipsl corporstian 2017), slum redevelopment, heritage palace refurbishment and large-scale mobility projects such as Maharashtra Metro Rail Corporation Limited (Maha-Mryto) are all entailing gentrification more or less. However, due to the tenancy law, the Maharashtra Rent Control Act from 1999 (Government of Maharashtra 2016), protecting old rents is tempting landlords not to invest in maintenance or improvement. The suburbs are characterised by a lot of new infrastructures and residential development, due to the settlement of tech companies in the last 20 years, among others, throughout India.

3.3 Ecology

Increased awareness for ecological and social aspects

A comprehensive ESG legislation comparable to the European market (Paulesich et al. 2023), such as for example the Corporate Sustainability Reporting Directive (European Commission 2021) which is intended to replace the current guidelines on sustainability reporting with new requirements for sustainable action even for SMEs in 2023. or the EU Taxonomy Regulation (European Commission 2020), exerting pressure to invest sustainably in all economic sectors, is not in place in India, but aspects are already in focus. Since 2003 water retention reservoirs are mandatory for every new building (IELRC 2003) in Pune and NGOs and foundations managed significant river clean-up. The 2016 Compensatory Afforestation Fund Act establishes afforestation as compensation for certain building project-induced deforestation. (Government of India 2016) Also, citizens are active, organised via social media but also at the university level: A forest-threatening ring road project around Pune was halted by activists in autumn of 2021 for example, and trees are planted on their own initiative. Generally, action under the term Smart City became more respectable. There is also a model for sustainable metro station development, "Transit Oriented Development" TOD (Government of India 2017), dedicated to creating compact, pedestrian-oriented, mixed-use communities around high-quality train systems. Politics currently focus on infrastructure image projects like overall street layout, public spaces and modal split, especially bicycle and pedestrian infrastructure.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

3.4 Urbanity

Conflict between community spirit-driven willingness to open structures (boundary-free / fence-less design) and security concerns

In Indian cities, public spaces are rare due to density. 'Katta's', small corners off the street, are their only places for informal meetings. Longing for more "public urban life" is ascertainable – especially among returnees, but there are concerns about how to guarantee safety in such spaces.

4 CASE STUDY EXPERIENCES

Between March 2021 and September 2022, over 100 Indian and international participants were involved in exploring impact-oriented, multi-sectoral area development approaches.

4.1 Case study overview

In order to show the potential of impact-oriented multi-sectoral development processes in different areas of application in a structured way, e.g., with regard to target groups, geographical conditions, focus topics, administrative frameworks, cases were defined in close cooperation with Prof. Asmita Joshi and her team from Dr. Bhanuben Nanavati College of Architecture for Women (BNCA), Pune. The cases, all situated in Pune metropolitan region, represent focus challenges of Indian area development:

- Case study 1 – Cummins College Road and surrounding area → interaction campus-city
- Case study 2 – Village Ranmala → multi-sectoral, circular, inclusive rural development
- Case study 3 – Mandai Road / Laxmi Road → development around historic heritage
- Case study 4 – Baner Balewadi → residential suburbia city extension

Each case was assigned a local and an Austrian group as case coordinators and one or more local experts matching the case challenges. A list of further stakeholders was prepared to involve those with an essential case relation.

4.2 Case study workflows & experiences

Case studies involved more than 30 stakeholders from public and private institutiond of planning and development, academia, politics, and others, around 30 planning and development related students, around 40 interested locals, a 10-person Indian team and the 13-person URBAN MENUS R&D team in Austria.

The basic phases of case study processing:

(1) Start meeting to lay the groundwork and create a basic understanding of expectations and opportunities, provide an outline of the case study process, and build teams

(2) Analysis and impact-assessment work of the teams in India and Austria including online meetings and think tanks with different stakeholders to identify the challenges and potentials of each case.

(3) Testimonial workshops with around 20 international testimonials of successful development projects with strong motivation to create synergies

(4) Development of possible futures, utopian realities based on collective dreams to trigger fantasies of a better world in order to build a consensus.

4.2.1 Status Quo analysis survey

The status quo was assessed by personal interviews, group discussions and a survey along the five main URBAN MENUS values. Within the introductory general weighing, safety, innovation, happiness and circularity came out more or less equally important, profitability was ranked lower. Happiness tended to be most important. The final ranking was: 1 Happiness, 2 Safety, 3 Circularity, 4 Profitability, 5 Innovation.

The personal perception of the significance of these values at the case sites delivered broad ranges – nearly on the whole scale from 0 to 100 each. This variety can be explained, a) by different perceptions as such, b) by calibration varieties based on the personal predisposition and different concept definition understandings respectively. Additionally, status-quo and potential analysis were mixed in the explanations, showing that it was difficult for respondents to clearly focus on the status quo and neglect the perceived potentials. Therefore, already in the status quo assessment, cases with higher future potential obtained higher scores.

The status quo analysis results of Case Study 1 are described in 4.2.3.

4.2.2 Testimonial workshops

In additional workshops, all participants had the chance to exchange with those responsible for innovative process approaches from all over the world. They were: Kibbutzism from Israel, collective open approaches from Mexico and Columbia, sponge city and open WU Vienna campus from Austria, perception-based reconstruction and landscape law from Chile, neighbourhood-based approaches from Washington, social housing from Catalonia.

A workshop on foresight language and methods was added in March and April 2022, held by internationally active futurologist Karla Paniagua from Mexico. The goal was to develop skills for the detection of signals of change and trends, the visualisation of alternative futures for a given system, the synthesis of a long-term vision and the appropriate methods of participatory intervention to realise the desired future (strategy).

4.2.3 Example Case Study 1: Cummins College Road (Local Authorities / Public)

Case study 1 was the most comprehensive one and is described here in more detail. The other cases, so far, could only be accompanied by status quo and first draft scenarios.

(A) Process

Stakeholder involvement and stakeholder needs

A series of interviews were conducted with stakeholders of various spheres, however, a joint think tank meeting could not be achieved, with the resulting drawback, that everybody tends to shift the problem-solving competencies to other parties that were not yet present in the same meeting. Nevertheless, different perspectives on stakeholder needs could be collected by the project team, There is a strong desire for more public spaces and informal gathering places, as these do not exist today. However, traffic safety, security concerns about underage girls, as well as necessary flood protection during the monsoon seem to be obstacles. The approach of combining the campus and productive city elements closer with each other was seen as difficult due to sectoral barriers.

Impact assessment of the status quo

Dealing with scarce data was one of the biggest challenges. This ranged from inaccuracy of marked locations in Google Maps to lack of GIS data as Open Data in the administration and official plans are only available in heavily pixelated raster format. Yet, enough material could be combined for analyses. The Status Quo Impact Assessment of 15 participants, scoring each of the 5 URBAN MENUS values between 0 and 100 widely reflected the qualitative results of interviews and discussions:

Happiness: Highly frequented by young people, the area is very lively. Green areas and a river are part of the campus but are not being used. A community feeling and leisure activities seem to be missing. Status Quo Survey Median: 55 (room for improvement!).

Safety: Constant traffic and areas with no proper sidewalks endanger pedestrians. No streets except the main street are adequately lit, creating safety issues at night, especially for women. Safety being one of the biggest concerns is also well reflected by the status quo survey median of only 30.

Innovation: The campus offers R&D programmes and is an example of sustainable energy use (solar). However, the potential for innovative synergies with the surrounding area needs to be exploited. A survey median of 32 (from 100) underlines that. Although this is a university area, the perceived degree of innovation is rather low.

Profitability: The area is mainly university-focused, with a proliferation of small businesses especially promoted by the young. This value achieved the highest status quo median of 60, which can also be explained by the fact, that the private college does not face too many economic problems (also for all those attending the college economic problems are not prevailing).

Circularity: Solar energy and the material flow inside the campus and water storage outside determine a certain level of circularity. Yet, the car-oriented, energy-intensive area and polluted river demand more – the status quo median is accordingly low at 40.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Fig. 2: URBAN MENUS classify today's prevailing collective objectives into five main topics

(B) Results

Four future scenarios were developed and discussed with experts and case coordinators. All scenarios focused on how the university cohabits with the city:

- Catalyst – Pockets of Curiosity:

The campus is an innovation hub where start-ups, sustainable space use concepts such as densification pockets, adaptive re-use, technologies such as photovoltaics and the diversity of the local population meet in a recreational landscape, walkable and easily reachable by public transport.

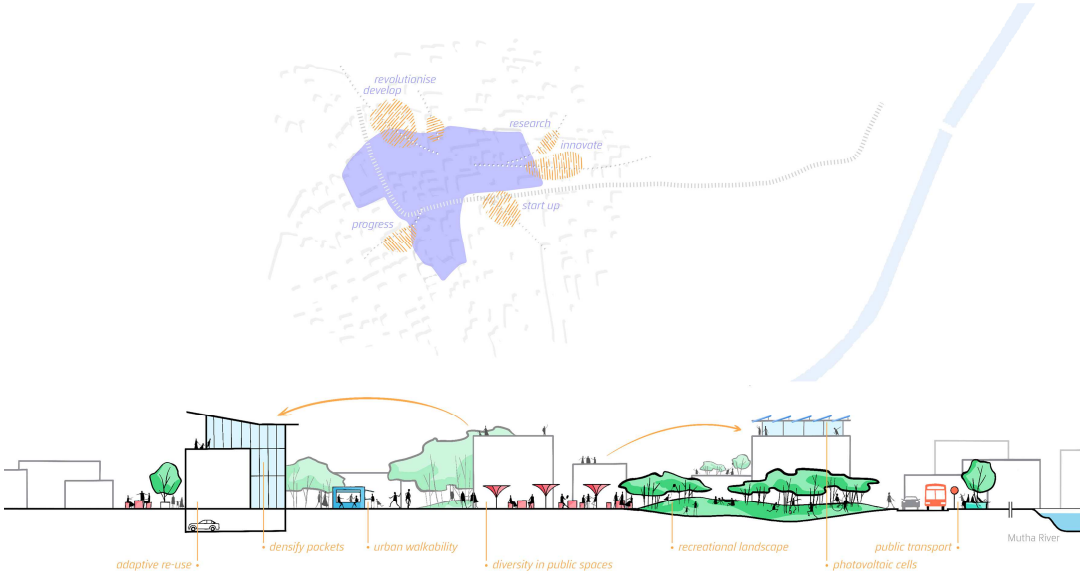


Fig. 3: URBAN MENUS Cummins Case Vision 1 | Catalyst – Pockets of Curiosity.

- EcoSystem – Biocenosis of Life:

Fig. 4: URBAN MENUS Cummins Case Vision 2 | EcoSystem – Biocenosis of Life.

Biodiversity and sustainability as goals lead to rethinking processes in terms of circularity and promoting engagement, They encompasssed water retention, sponge city, aquaculture, new mobility, bike sharing, renewable energy, smart spaces, river clean-up, waste management and urban gardening. A focus is also on structures for pedestrians like experimental under- and overpass solutions.

- Acropolis – Archipel of discovery:

Learning and socialising in connection with nature as a strong signpost are materialised by a resource-wise autonomous university. Rooftop gardens, that contribute to the concept, can also be used as event spaces.

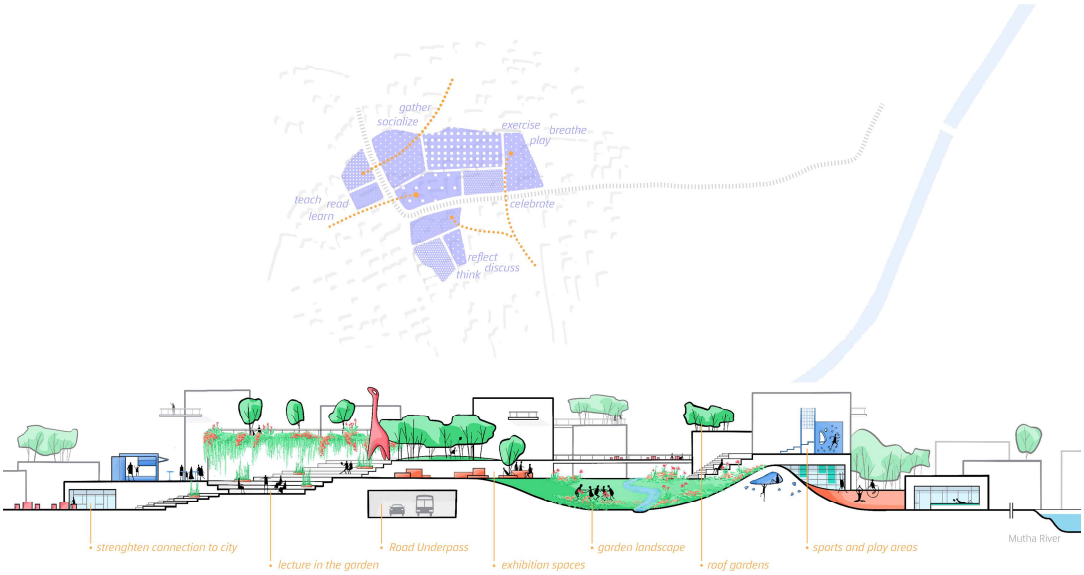


Fig. 5: URBAN MENUS Cummins Case Vision 3 | Acropolis – Archipel of discovery.

- Agora – EduSpace of pleasure:

Education has a strong focus on culture / creation and community / connection. Neighbourliness and peer exchange are encouraged by a cultural centre.

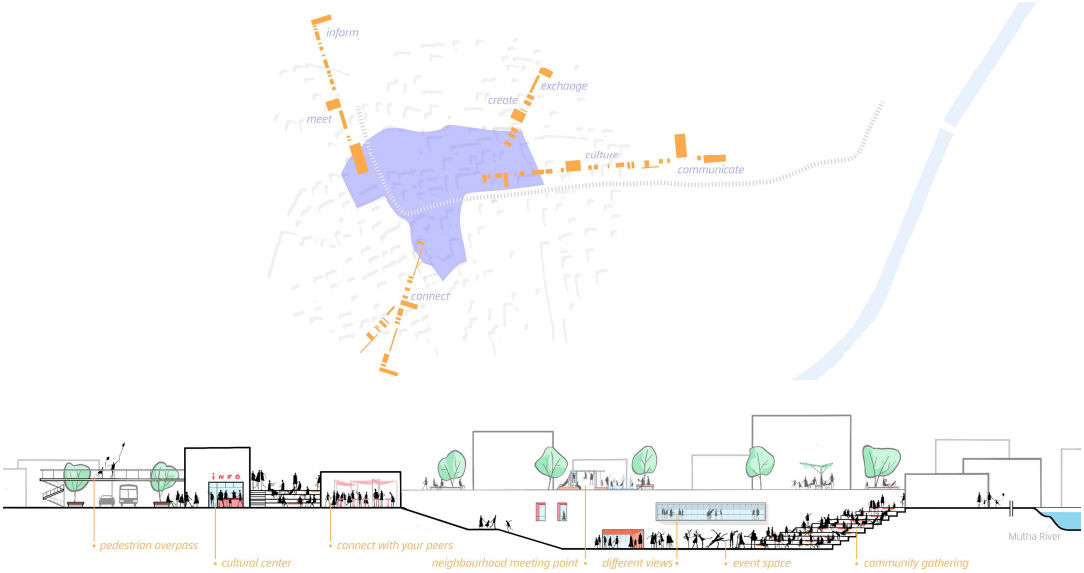


Fig. 6: URBAN MENUS Cummins Case Vision 4 | Agora – EduSpace of pleasure.

In a feedback session with the case expert and case coordinator, the concepts were well received, however always underlined by critical safety concerns.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Fig. 7: URBAN MENUS Cummins Case Analysis.

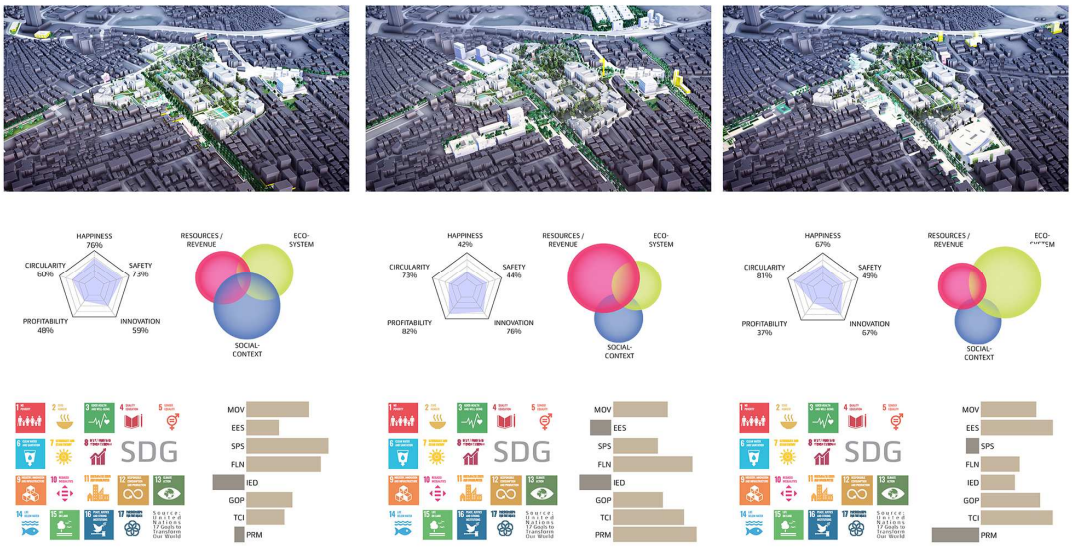


Fig. 8: URBAN MENUS Cummins Case Analysis.

5 DISCUSSION AND CONCLUSION

From the mainly case-based approach we can summarise our learnings on how impact-oriented multi-stakeholder area development can be successfully implemented in India or in similar settings as follows:

5.1 Status quo analysis

This phase worked well in a hybrid approach by which we made up for data gaps due to the low level of local data availability, detail and digitisation. We had little access to local/specific data – sources were on the one hand Google Maps data, which does not always deliver an accurate picture, on the other hand, materials from stakeholders – pictures, development plans, channel plans, but much of it was pixelated and not in vector format, partly unorganised and not comprehensive. However, this material was of great help and compensated for the fact, that we couldn't be there in person (due to the pandemic project period).

More than half of all statutory towns and more than three-quarters of all census towns have no master plans to control spatial development and investments, and the ones who have a plan are often lacking a proper strategy. There is also a lack of personnel, which further complicates accessibility. Of the only about 4,000 sanctioned positions nationwide, more than 40 per cent are vacant. (Government of India 2021, p. 58) Work is in progress since 2009 to integrate mapping technologies and data science into a model curriculum to train the workforce, and since 2020 with a stronger focus on participation (Government of India 2021, 71-72), the development is only slowly gaining momentum.

Regarding impact analysis of the status quo we learned that, in order to establish a uniform understanding of the impact criteria and the resilience goal, it would be wise to hold context-related definition workshops for calibration purposes before moving to case analysis. Also, it needs to be underlined that the status quo analysis and the potential assessment should be evaluated strictly separately from each other, which is often not easy for participants.

For the presentation of the results, we feel confirmed in the multimedia approach. Visualisation alone cannot always represent the depth of the analyses. For example, it is not always easy to understand from a picture alone that a district has higher innovation values because an IT hub is located there. Relationships between elements are complex and additional explanations are valuable.

5.2 Stakeholder involvement

It was difficult to get through to high-level stakeholders to conduct detailed analysis and work together to develop visions and find contractors for implementation. Our hypotheses on the reasons for barriers to reaching decision-makers include, among others, the top-down hierarchy shaped by caste thinking and history, the strong economic interest behind the implementation of project ideas, and a lack of comprehensive sustainability/impact-oriented legislation to generate more drivers towards resilience.

Indian experts already agree on the importance of multi-stakeholder partnerships (Metchant 2021) and a A Multi-Sectoral Development Programme (Government of India 2011) was already applied earlier in minority management, however, economic motives often prevent integrative and multifunctional planning. ”The rhetoric of urban areas being engines of economic growth runs the risk of overriding other functions of the urban space” (Salamah 2021, p. 137)/ Universities are often seen as the economic engine of the surroundings by local stakeholders, which is one reason why changes are treated so cautiously.

“[E]xploring an efficient method to balance the power of different participants in the participation process” (XUE et al. 2020, p. 1.), one of the biggest challenges in multi-sector partnerships internationally, is also a barrier in India.

5.3 Positive drivers from the stakeholders’ perspective

By the end of all case processes, we asked stakeholders about their learnings from the process: “Why do you think investors, developers and local authorities should opt for impact-oriented participative area development?” They underlined that they have experienced the process as very suitable to steer prospective and strategic thinking and collective action. Detailed aspects they raised lead to the following “local recommendations”:

- Tangible (visual) impressions count. If the goal is to change an entire system, it is even more important to make this visually concrete. The discussion of feasibility and resilience aspects, based on 3D interactive illustrations, beforehand is very valuable.
- For building trust, involving known institutions is helpful. Good care to avoid open conflict is important, as there is a strong tendency to avoid losing face. Female empowerment is central.
- Local authorities tend to use public interest projects for generating votes. In this context they are often fascinated by dashboards showing numbers (30% to 50% green for example), which brings them an argument to like impact analysis results.
- Real estate investors are in place, but mainly look for monetary benefits and favor profitability calculations that clearly point out economic perspectives.
- City planners seek opportunities to work on big projects for recognition as well as monetary benefits.
- If stakeholders are convinced by an innovative idea, they will proudly strive for implementation as a first mover.

5.4 Overall conclusions

Our conclusion regarding stakeholder involvement is focused on the need to involve the young generation and their decision makers more intensely to advance future spatial development, together with classical established stakeholders. Especially private sector and non-profit partner involvement is necessary to advance smart city agendas, as for example the Smart Cities Mission (Government of India 2022).

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Worldwide just 16% of cities are able to self-fund required infrastructure projects and need support (Deloitte 2018). India also faces financial challenges (Government of India2021). Archetypical examples deducted from previous processes, can steer and inspire such stakeholder involvement and the process as a whole.

For India we have elaborated the following "archetypes" with high needs and potentials:

- Smart rural development based on circular economy
- Re-definition of development around historic heritage
- City concepts based on new production
- Multi-sectoral and inclusive city enlargements

On a meta-level we experienced, that applying our methodology in the new setting in India, also significantly helped to critically review it internally. Consequently, we are planning to extend the process, especially at the beginning: We want to include an onboarding phase with a strong personal and "value calibration" element, which can at the same time, involve individuals more tightly in the process, create awareness on the benefits of co-operation, teach them on impact and resilience analyses and make them feel more relevant, confident and therefore also more active throughout further discussions.

In this sense, many insights gained from the Indian case studies can therefore be incorporated into our general methodology for participative and future-proof area deeloped and afterwards transferred to other (similar) regions.

6 REFERENCES

BUSarchitektur: CAMPUS WU - A holistic history by BUSarchitektur. Vienna, 2013.

EUROPEAN COMMISSION: Proposal for a Directive of the European Parliament and of the Council amending Directives 2013/34/EU, 2004/109/EC and 2006/43/EC and Regulation (EU) No. 537/2014 as regards corporate sustainability reporting. COM/2021/189 final. Brussels, 2021. https://eur-lex.europa.eu/legal-content/DE/TXT/?uri=CELEX:52021PC0189

EUROPEAN COMMISSION: Regulation (EU) 2020/852 of the European Parliament and of the Council of 18 June 2020 establishing a framework to facilitate sustainable investments and amending Regulation (EU) 2019/2088 (Text with EEA relevance). PE/20/2020/INIT. Brussels, 2020. https://eur-lex.europa.eu/eli/reg/2020/852/oj?locale=en

DELOITTE: Using public-private partnerships to advance smart cities. Part two: Funding and financing smart cities series. p. 3. London, 2018. https://www2.deloitte.com/content/dam/Deloitte/global/Documents/Public-Sector/gx-ps-public-private-partnerships-smart-cities-funding-finance.pdf (last accessed: 30.07.2022)

GOVERNMENT OF INDIA, Ministry of Housing and Urban Affairs: National Transit Oriented Development (TOD) Policy. New Delhi, 2017. https://mohua.gov.in/upload/whatsnew/59a4070e85256Transit_Oriented_Developoment_Policy.pdf (last accessed: 30.07.2022)

GOVERNMENT OF INDIA, Ministry of Housing and Urban Affairs: Smart Cities Mission. https://smartcities.gov.in (last accessed: 30.07.2022)

GOVERNMENT OF INDIA, Ministry of Law and Justice: The Compensatory Afforestation Fund Act. New Delhi, 2016. https://legislative.gov.in/sites/default/files/A2016-38_1.pdf (last accessed: 30.07.2022)

GOVERNMENT OF INDIA, Ministry of Minority Affairs: Guidelines for implementation of Multi-sectoral Development, Program during 12th Five Year Plan. New Delhi. 2011 https://minorityaffairs.gov.in/sites/default/files/guideline.pdf, https://www.slideshare.net/DrLipilekhaPatnaik/12th-five-year-plan-and-niti-ayog (last accessed: 30.07.2022)

GOVERNMENT OF INDIA, Ministry of Women & Child Development: National Policy for the Empowerment of Women. New Delhi, 2001. https://wcd.nic.in/womendevelopment/national-policy-women-empowerment (last accessed: 30.07.2022)

GOVERNMENT OF INDIA: Reforms in Urban Planning Capacity in India. Final Report, p. 71-72. New Delhi, 2021. https://www.niti.gov.in/sites/default/files/2021-09/UrbanPlanningCapacity-in-India-16092021.pdf (last accessed: 30.07.2022)

GOVERNMENT OF MAHARASHTRA, Law and Judiciary Department: Maharashtra Act No. XVIII of 2000. The Maharashtra Rent Control Act, 1999. (As modified up to the 8th February 2016). Mumbai, 2016. https://lj.maharashtra.gov.in/Site/Upload/Acts/9%20H%204117%20(The%20Maha.%20Rent%20Control%20Act,%201999).pdf (last accessed: 30.07.2022)

GOVERNMENT OF MAHARASHTRA, Water Resources Department: Maharashtra State Water Policy. Mumbai, 2019. https://wrd.maharashtra.gov.in/Site/Upload/PDF/State%20Water%20Policy%2005092019-pages-32-55.pdf.

IELRC: Maharashtra State Water Policy 2003. Geneva, 2003. ielrc.org/content/e0306.pdf (last accessed: 30.07.2022)

KWATRA, Swati; KUMAR, Archna; SHARMA, Sumit; SHARMA, Prateek: Stakeholder participation in prioritizing sustainability issues at regional level using analytic hierarchy process (AHP) technique: A case study of Goa, India. In: Environmental and Sustainability Indicators, Volume 11. 2021, https://doi.org/10.1016/j.indic.2021.100116. (last accessed: 30.07.2022) (last accessed: 30.07.2022) (last accessed: 30.07.2022)

MERCHANT, Prachi; ALEXANDER, Ansu Susan; VERMA, Ashish; KARAMANOS, Panagiotis: An Accelerator to a Sustainable Urban Future. The Case of EU's IURC Programme. In: Shashwat (Annual Magazine of GRIHA Council), Feature 112. New Delhi, 2021. https://www.iurc.eu/wp-content/uploads/2021/12/Shashwat-December_2021-for-web.pdf (last accessed: 30.07.2022)

MUNSHI, Kaivan: Stakeholder participation and and the Indian caste system. Caste and the Indian Economy. In: Journal of Economic Literature, Vol. 57, No. 4, pp. 781-834, p. 781, 2019. https://pubs.aeaweb.org/doi/pdfplus/10.1257/jel.20171307 (last accessed: 30.07.2022)

PERERA, S.: Space as political text, urban coherence and dissonance in the politics of beautifying Colombo. Economic and Political Weekly, 53(50), 2018. https://www.epw.in/journal/2018/50/perspectives/space-political-text.html (last accessed: 30.07.2022)

PAULESICH, Reinhard.; FESER, Diana.; STROHMAIER, Maximilian (in print): Ethisch ökologische Unternehmenspolitik. Springer Gabler Management, Heidelberg, 2023.

PUNE MUNICIPAL CORPORATION: Development Control and Promotion Regulations 2017 for Pune Municipal Corporation, 2017. https://pmc.gov.in/sites/default/files/DCR_PUNE_FINAL.pdf (last accessed: 30.07.2022)

SALAMAH, Ansari: Participatory Urban Development in India: A Tale of Two Townships. In: Environment and Urbanization ASIA 12(1), pp. 136-147, 2021. https://journals.sagepub.com/doi/pdf/10.1177/0975425321990316 (last accessed: 30.07.2022)

SAXENA, Swapnil: India's Housing Crisis: A Gender Perspective, 2020. https://www.urbanet.info/indias-housing-crisis-a-gender-perspective (last accessed: 30.07.2022)

TYAGI, Aditi: Prospects of Stakeholder Engagement in Public Policy: A Case of India. In: International E-Journal of Advances in Social Sciences, 4. Jg., No. 12, pp. 813-822, p. 813, 2019.

XUE, Yan; TEMELJOTOV-SALAJ, Alenka; ENGEBØ, Atle; LOHNE, Jardar: Multi-sectoral co-operation in spatial development in the urban development context: A scoping review. In: Journal of Cleaner Production, Vol 268, 122291. Trondheim, 2020. https://www.sciencedirect.com/science/article/pii/S0959652620323386 (last accessed: 30.07.2022)

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

🏆 *reviewed paper*

Cultural Backgrounds Effects on Travel Mode Choice of International Communities in Vienna

Süleyman Nurullah Adahi Şahin, Takeru Shibayama, Abdulkadir Özden

(MSc. Süleyman Nurullah Adahi Şahin, Sakarya University of Applied Sciences, Sakarya, Turkey, adahisahin@subu.edu.tr)
(DI Dr. Takeru Shibayama, Technische Universät Wien, Vienna, Austria, takeru.shibayama@tuwien.ac.at)
(Asst. Prof. Dr. Abdulkadir Ozden, Sakarya University of Applied Sciences, Sakarya, Turkey, aozden@subu.edu.tr)

1 ABSTRACT

There are many factors influencing daily travel behaviour. For example, information and communication, living space, policies, and urban planning, are among the parameters that are known to affect travel behaviours. Lifestyle and socioeconomic and demographic structures can also be attributed. Although the cultural background of a person may be a determining factor in all parts of our living space and directing our behaviour, it may not have always been taken into consideration in the context of travel behaviour research. In this study, a multilingual online questionnaire was designed to understand and measure the impact of cultural differences of international communities on transportation mode choices and travel behaviour, and an online survey was carried out in Vienna. 213 participants took part in the questionnaire. After the elimination of invalid ones from the data set, for instance, responses from those living outside of Vienna, 150 responses are used for analysis. The data collected from the participants are split into the ones from international communities with non-Viennese origins, native Viennese people, and a mixed/intermediate group. The transportation mode choices and travel behaviours among these communities are compared by statistical analysis. The preliminary analysis among the international communities. evaluating commuting, grocery shopping, and leisure travel shows signs of cultural influences on using transportation modes, frequency and duration. It also implies that more comprehensive and detailed studies are needed on this subject. The result implies that existing policies should be more dynamic and adaptive, especially taking account of the widespread migration wave nowadays.

Keywords: Travel Behavior, Mode Choice, Cultural Background, Transportation Policy, Vienna

2 INTRODUCTION

Travel behaviour and travel mode choice affect the daily lives of individuals and have an important place in their activities. Many factors determine them: household size, income level, gender, socio-demographic and transportation parameters. as as well as social status such as culture, ethnicity, and immigration (Klinger and Lanzendorf, 2016). Due to war, economic crisis, and conflicts experienced throughout the world, immigration has occurred and has been experienced in previous years. It has also manifested itself in Asia, the Middle East, and finally Europe in this last decade. Although integration and adaptation to the conditions of the region emerge in the countries and continents where these communities live, it cannot be ignored that the ethnic origin and culture that they belong to continue to be kept alive.

In this study, a multilingual online questionnaire was designed to understand and measure the impact of cultural differences of international communities on transportation mode choices and travel behaviour, and an online survey was carried out in Vienna. 213 participants took part in the questionnaire. After the elimination of invalid ones from the data set, for instance, responses from those living outside of Vienna, 150 responses are used for analysis. The data collected from the participants are split into the ones from international communities with non-Viennese origins, native Viennese people, and a mixed/intermediate group. The transportation mode choices and travel behaviours among these communities are compared

We undertook an empirical study in Vienna, the state and capital of Austria (Fig. 1), a city with roughly 2.000.000 residents and above in 2021 to collect data on, and contribute to the empirical scholarship on immigrants' everyday travel behaviour. One of Vienna's biggest proportions of citizens who live here are those with foreign citizenship (31.5%), and even more (41.9%) have immigrant heritage. Serbian and Turkish immigrants were the major immigrant groups in Vienna in 2021, accounting for 5.3% and 4% of the city's overall foreign population, respectively. Following these groups were citizens from Germany, Poland, and Romania (Stadt Wien, 2021).

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

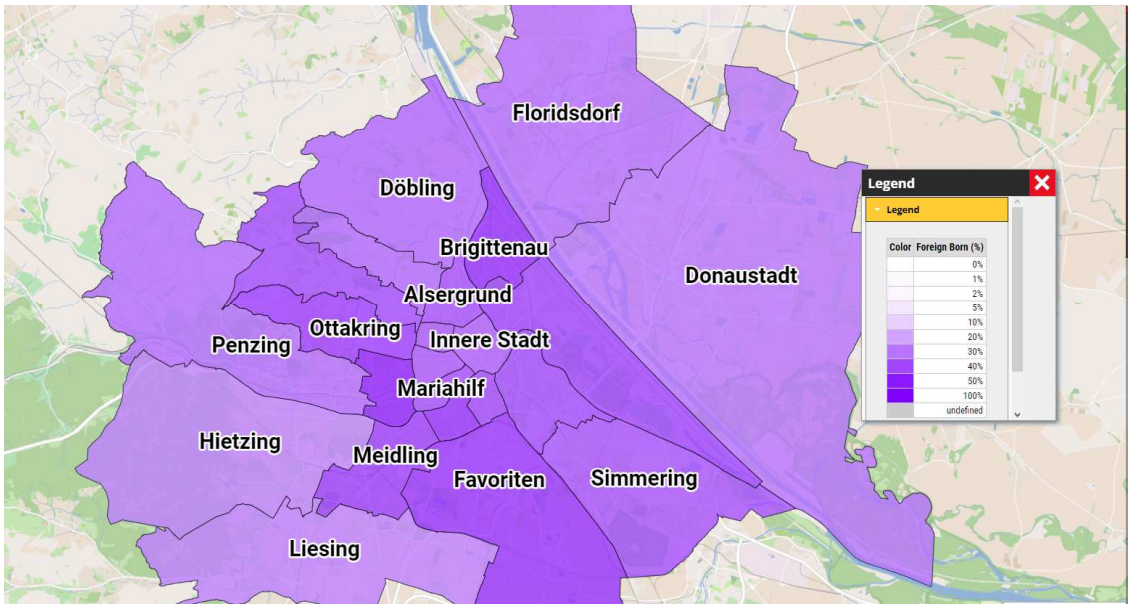


Fig. 1: The map of Vienna with foreign percentage (City Population, 2022)

As can be seen in Fig.2 the modal split percentages are shown for Vienna for the year unti 2020. Types of transportation that are taken into account in urban transportation; walking, public transportation (tramway, subway, train), bicycle, and motor vehicle use. In 2020, car usage, walking, cycling and public transportation usage are 27%, 37%, 7% and 27%, respectively.

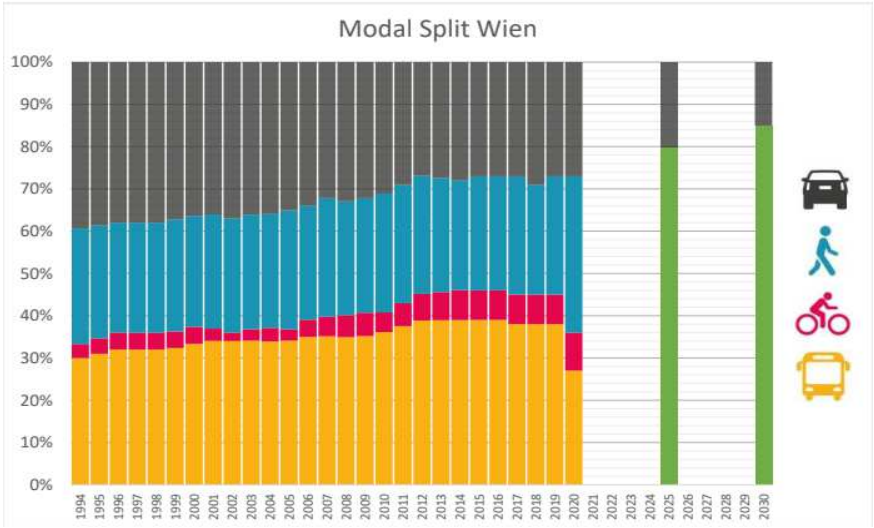


Fig. 2: Modal split of Vienna by years (Stadt Wien, 2021)

Blumenberg (2007) used the descriptive statistics method in his study by using the data of the United States national transportation survey and took into account the integration status of the immigrant population and culture by years, and produced a result. However, it is very difficult to determine the impact of cultural differences, since this study was only able to consider limited information such as ethnicity and place of birth. Although it is very difficult to examine the effect of culture, these communities generally live close to each other, keep their kinship relations strong, due to the immigration that developed with the effect of cultural differences. This is due to the difficulty of sometimes being recognised indirectly or directly by the culture of the geography they live in (Haustein et al., 2020).

A study conducted in Offenbach am Main in Germany revealed that the use of cars and public transportation is not related to cultural difference, but only creates a difference in cycling. It shows that cultural codes can be effective in modes such as bicycles and scooters within the scope of sustainable transportation that have emerged as a new incentive and orientation in the world (Welsch et al., 2018). In addition to all this preliminary information, it is necessary to think about how understanding of culture can be completed. Culture can be defined as general values, beliefs and behaviours (Ashmore et al., 2017). At the same time, it

is thought that daily activities can be taken into this context and some symbolic indicators can also participate in this situation. The fact that the public transportation infrastructure of developing countries (the global south) is generally weak and the car is seen as a status symbol is another phenomenon that permeates cultural codes (Ashmore et al., 2018). Where diversity is created can be accelerated with a better transportation plan and infrastructure, rapid integration of the current situation, decisions to be taken and policies to be implemented.

3 LITERATURE REVIEW

3.1 Transportation mode choice and travel behaviour

Travel behaviour, understanding, and forecasting are very important in terms of creating a city's transportation network in a way that will benefit policy makers for their decision-making and policy making in transportation planning, (Abdullah et al., 2020). The perception and status of people's mobility can also change according to their habits, activities, and lifestyles (Shamshiripour et al., 2020). The effect of the built environment on travel behaviour is also considered a highly studied subject. Wang and Zhou (2017) listed the built environment scales as follows: home-work relationship, transportation access, neighborhood structure, population density, living area, and street structure.

The mode choice is another significant aspect in terms of estimating demands encountered in travel planning and understanding how much area is allocated for transportation in the city (Cheng et al., 2019). The parameters affecting the mode choice can be shown as age, gender, income level, vehicle ownership, education level and household structure (Li et al., 2012). It will be more effective and usable to establish the transportation structure and infrastructure of the cities by combining the alternatives to be selected in the mode choice with travel behaviour. For this reason, besides the existing factors affecting these two terms, it is very important to create decisions or policies that will cover all segments of the society and bring them to reality.

3.2 Travel Behaviour with Immigration and Cultural Differences

Immigrants or international communities decide their travel behaviour depending on the parameters of individual or household, spatial assimilation, ethnic origins, employment status, legal regulations, and culture (Dingil et. al., 2019). As for the cultural impact, the prominent situation, the transportation status in the country or city where a person grew up or in which he/she carried his culture, and the gender relationship came to the fore (Bloomenberg, 2009). In their study Haustein et al. (2020) examined the travel behaviours of international communities in Denmark and the Netherlands but only in terms of bicycle use under the concept of immigration. Danish citizens used bicycles 21% more than non-Western immigrants, while Dutch citizens preferred 23% more bicycle use compered to non locals. In their analysis based on the Survey of American Communities Ruggles et al. (2008) revealed the transportation distribution of native and immigrant populations in this direction, as can be seen in Figure 3.

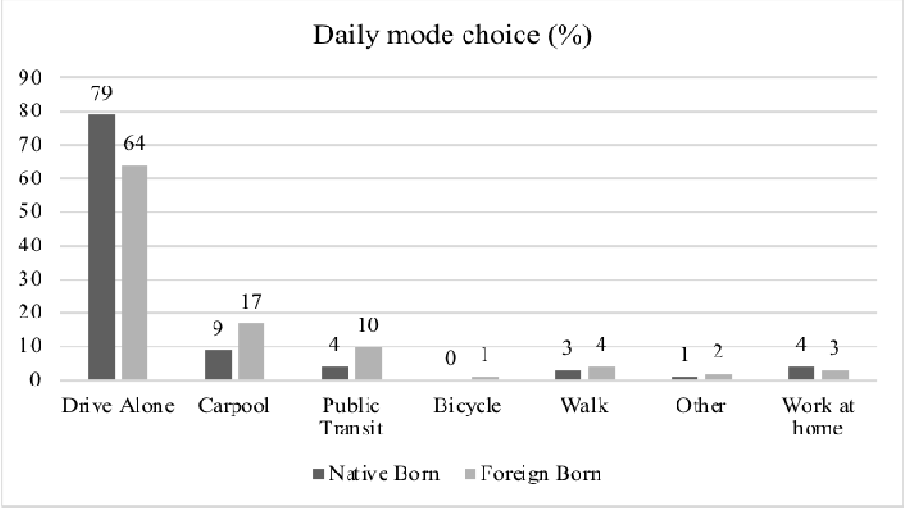


Fig. 3: Survey of American communities, mode choice (Ruggles et al., 2008)

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

In a study they conducted in Germany Welsch et al. (2018) noted that compared to non-immigrants, immigrants have fewer cars or bicycles per household, and are also less likely to cycle or drive and have access to such modes of transportation. They stated that the most important mode of transportation is the private car and that immigrants, especially women, use public transportation more frequently, second after using the private car, while bicycle transportation tends to be a typical mode of transportation, especially for men and non-immigrants. Chatman (2014) used a telephone survey with immigrants living in New Jersey and the local people in his study investigating the issue of car use by immigrants and showed that immigrants tend to drive less, but this use may change over time, which is possible with the change of the living environment and neighbourhood. Emphasising that the immigrants' background and culture will be to first use cars, he stated that they will be less likely to drive. Ashmore et al. (2019) evaluated the mode choice of train and road bus systems in public transportation. They tried to deal with cultural and geographical differences by making a distinction between country category, Global North and Global South, and by making use of Hofstede's distinctions. They tried to analyse the type choice by including the distinction between individualist, collective and divisive communities and stated that rail system use is more common in the global north. They described this situation as the 'poor cousin' of vehicles such as buses used in Asian regions.

In a study he conducted in the United States, Barajas (2020) hypothised that the cycling behaviours of individuals of foreign or immigrant origin may differ, and then investigated this issue with 23 interviews in the southern region of San Francisco. He suggested that new policies and practices should be developed in cooperation with immigration institutions to encourage the use of bicycles depending on the effects of neighbourhood culture and structure as well as gender factors. Handling the immigration issue from many aspects and its relationship with the transportation type preference has been made in a very limited way and only according to ethnic origins, and it has been tried to be explained with the results that emerged as a result of the general national surveys. The effect of transporting the codes of the country of origin on travel behaviour and type preference has been a phenomenon that is rarely mentioned.

4 METHODOLOGY APPROACH

213 people responded to an online survey about their socio-demographic, mobility, and cultural backgrounds, throughout the survey, which was designed and distributed using the online survey platform SurveyMonkey. 150 valid responses were used for analysis after data cleaning. Incomplete responses from people who skipped questions without completing all the survey questions were excluded. Participation in the survey was limited to those who were at least 18 years old. Respondents had the choice of answering in German, Turkish, Croatian/Serbian/Bosnian, Croatian, or English. To ensure that roughly half of the participants were female, a quota was established. The survey data includes socio-demographic details such as household size, the number of cars per home, net household income, and the location of each household by postal codes. The majority of the responsdents (89 percent) live in Vienna. To ascertain their immigration history, we questioned them about their home nation in different ways, such as asking about their edcutaion language until university used mostly, the language within households or family, the country where they grew up, and their parents' backgrounds as an immigrant. This way made us distinguish respondents into three categories. Participants were asked to identify whether they had a driver's license, whether they knew someone who had a bicycle. Participants also rated both behavioural questions and perceptions in terms of traffic and daily routines regarding their cultural background. These items and additional statements about the perception of the neighbourhood were measured.

Among the methods used to understand the cultural backgrounds of the participants, parameters such as the language spoken in the family, the language of education they received until the age of 18, and the categories of the languages they preferred for the videos they watched for entertainment were brought together. Among the analysis, these data were extracted as tables with the frequentist system. To begin with, we prepared the descriptive statistical analysis to include the samples and variables of the questionnaire including socio-demographic structures such as age, gender, and income. Then, these socio-demographic structures were presented using crosstab methods determined in line with the purpose of each activity in terms of daily transportation mode choices and travel behaviours. Also, the predicted modal split was given under the condition of the international communities' perspective.

Statistics revealing the differential distribution between local people and international communities, work, general shopping, grocery shopping and leisure activities are given as a comparative statistical analysis for each mode of transportation. Regarding the cultural background, the t-test analysis, and factor analysis according to the answers of the participants have revealed which variable of traffic and transportation behaviours is significant and how much of it will be explanatory if a possible model is established. As the last step, t-tests and factor analysis were applied to determine the impact of different communities' transportation mode choices and cultural differences, through the impact of demographic variables of perceptions. In addition, the participants' daily transportation uses have been revealed.

5 RESULTS

In Vienna, 48.6% of the participants constitute international communities, while 67.2% of these communities represent the Turkish community. The remaining 32.8% of the participants have their backgrounds from countries such as Iran, the Czech Republic, Serbia, Romania, and Bosnia and Herzegoivina. Almost 50% of the Turkish community have lived in Vienna for more than three years. More than 50% of the respondents of other international communities have lived in the city of Vienna for less than three years. When we asked how the international communities felt while living in Vienna, 60% of the Turkish community participants felt comfortable and accepted in Vienna, while nearly 20% described themselves as natives of Vienna. Very few of the participants stated that they felt lonely or isolated. Although a similar situation is observed in other international communities, the rate of feeling like a native is quite low at 7%.

	Viennese	Turkish	Other
Gender [%]			
Female	48	57	45
Male	52	43	55
Age			
Average	32	28	26
Max.	62	58	53
Min.	18	18	18
Std. Dev.	3,248	2,471	2,186
Education status[%]			
Under Secondary	22	22	42
Job oriented	9	18	
Bachelor	24	33	12
Master	45	27	46
Occupation [%]			
Full or part time employee	61	64	50
Unemployed	4	14	4
In education	27	16	42
Retired	8	6	4
Average household income per year [€]	40.000	42.000	35.000
Average household size	2,45	2,72	2,83
Percentage of vehicles in household (having one vehicle or more) [%]			
Car	48	64	25
Bicycle	95	58	63
E-Bike	8	0	0
E-Scooter	3	8	8
Having driving license [%]	91	81	79

Table 1: Sample description by communities

Daily travel behaviour and mode choice are asked in relation to four different trip purposes: commuting, grocery shopping, occasional shopping (shopping other than grocery, such as clothes, sports tools, etc.), and leisure activities. In the category of commuting mode, natives tend to choose mostly to bike and to use public transportation (PT) while the Turkish community choose mostly PT and ‘other’ communities tend to use PT, walking, and cycling respectively. Interestingly, people in the Turkish community are much more likely to use a personal car when going to work on their daily travels, while none in this community uses a bike. For grocery shopping, all communities are supporters of walking probably due to the grocery stores in near

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

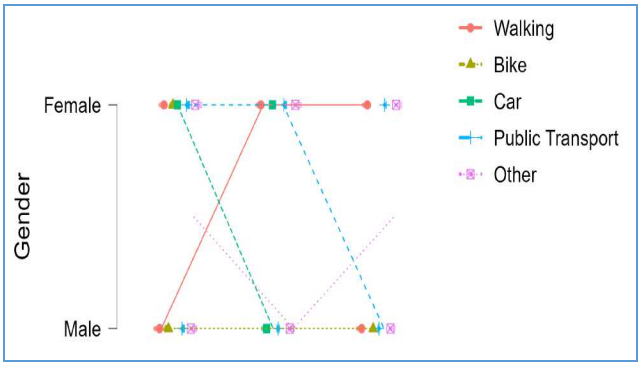
proximity of the living places of participants. As for the personal car, the Turkish community has the highest percentage of use, and the same applies to PT. This might mean that the Turkish community chooses different supermarkets for their groceries. For general shopping and leisure activities, two different modes are getting the attention for daily travel behaviour: car and bike. The Turkish community tends to use the car more than others. On the other hand, when the topic is using the bike for shopping or leisure, natives are a higher proportion. For each activity, other modes have no significant difference.

As shown in Table 1, socio-demographic factors differ among the three groups These three groups were named. The following terms were used: for local people 'Viennese', for Turkish community 'Turkish' and for all foreign people 'Other'. International communities (Turkish and Other) are younger than natives and participation of the female population is higher in the Turkish community than in natives and other categories. Higher education status is much higher for natives rather than international communities. When the international communities are compared, the rate of those who continue their master's education seems to be quite high among the participants in the 'other' category, which shows that there is more participation from the student group in the low average age. Interestingly, the average annual earnings of the Turkish community were higher than those of the indigenous and 'other' communities. Another point of interest is that the Turkish community has more personal car ownership than 'other' communities and natives, but in bike ownership natives outnumber international communities (almost every native participant owns a bike).

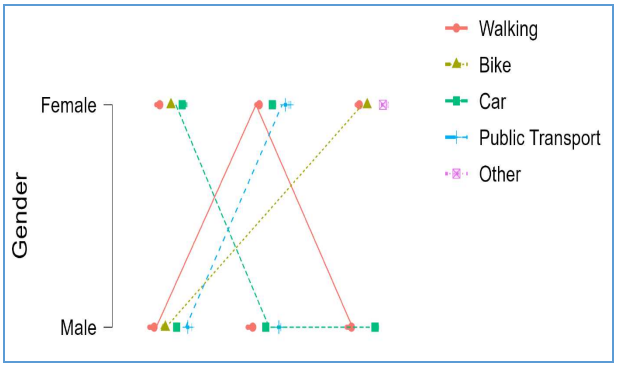
	Viennese	Turkish	Other
Commuting mode			
Car	5	19	0
Public transportation	48	71	50
Walking	7	4	30
Bike	35	0	12
Other	5	6	8
Grocery mode			
Car	10	23	12
Public transportation	2	12	0
Walking	78	65	80
Bike	10	0	4
Other	0	0	4
Occasional shopping mode			
Car	16	29	12
Public transportation	41	49	54
Walking	19	14	21
Bike	23	0	9
Other	2	8	5
Leisure activity mode			
Car	9	21	4
Public transportation	38	51	63
Walking	13	22	17
Bike	40	2	16
Other	0	4	0

Table 2: Daily mode choices of communities by activities

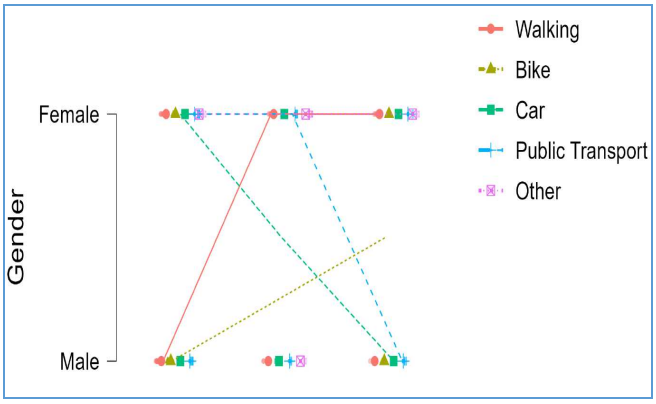
Looking at the daily travel behaviour from a general perspective it may be sufficient to understand the comparison of native and international communities. Yet, in Fig. 4, when the results are split by gender of the respondents, understanding of the daily travel behaviour gets clearer. As for commuting, while natives have almost an equal distribution to the transportation modes among both genders, the females of the Turkish community tend to walk much more than the males (Fig 4.a). For grocery shopping, none of the native female respondents report the use of PT, and Turkish and other males never cycle (Fig. 4.b.). Turkish, native and other community males are more likely to walk at the same percentage when they are going shopping. The native and other community female's choice is the private car at the same level of daily routines for shopping activity (Fig.4.c.). For the leisure activities, while natives and Turkish males are sharing the same walking usage as other category's females, native females and other community males have the same proportion of car usage. The difference between Turkish males and females is that the males tend to use cycling while heading to leisure activities (Fig. 4.d.).



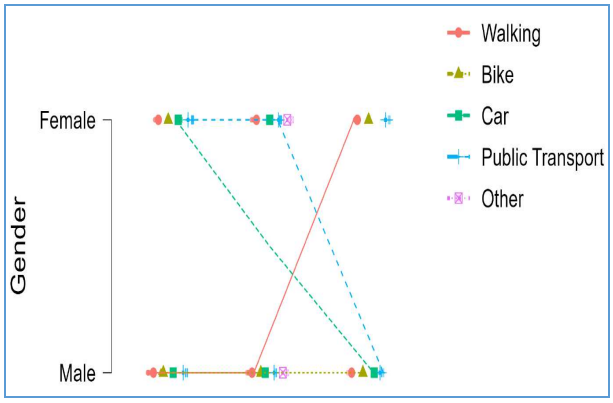
4.a. Commuting



4.b. Grocery

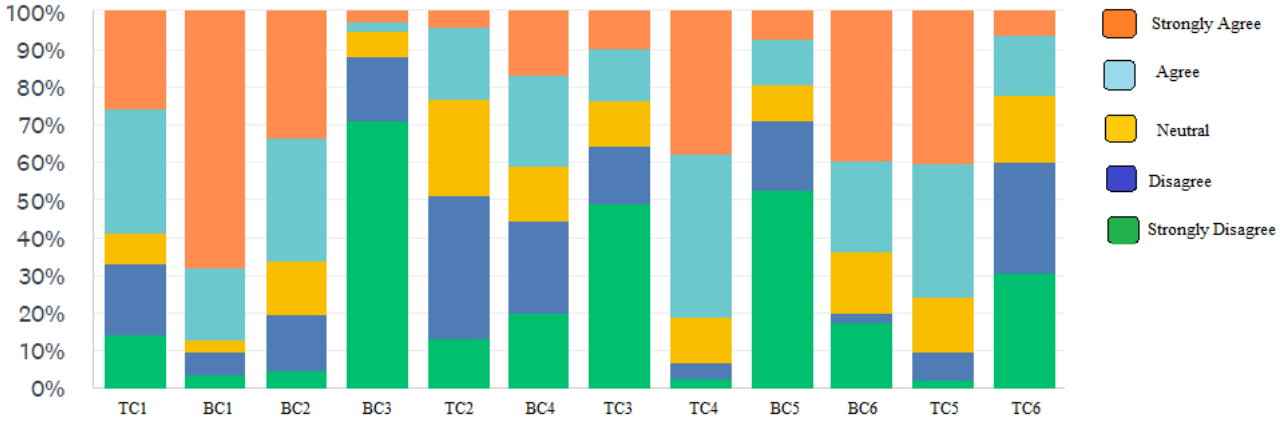


4.c Shopping



4.d. Leisure

Fig. 4: Daily mode choice by gender and origin (for each figure: left: Viennese; middle: Turkish; right: other).



TC1: Even if there is no traffic, I wouldprefer waiting at a red light.
BC1: Even if Vienna has no ticketcontrol of the entrance, Itake myself for granted that I buya public transport ticket.
BC2: I miss attending crowded eventswith my friends.
BC3: I regret to use public transport,bicycle or walking because I cannot afford to buy a car.
TC2: The destination is moreimportant than the entire trip.
BC4: Cars are more comfortable thanthe other modes of transport.
TC3: Building more roads and parkingfor cars would help to ease thetraffic situation in Vienna.
TC4: In Vienna, I can changetransportation modes easily.
BC5: I feel more successful if I own acar.
BC6: I want to park my car as closeas to my home.
TC5: I feel myself contributing to theenvironment when I ride a bicycleand also when I use publictransport.
TC6: Cycling and walks are sport, not transport!

Fig. 5: Behavioral and traffic culture perceptions in general

	TC1	BC1	BC2	BC3	TC2	BC4	TC3	TC4	BC5	BC6	TC5	TC6
t-test	7.12	23.4	12.75	-13.6	1.62	3.61	-2.92	22.78	-4.64	9.31	19.97	-0.97
Factor analysis	0.540	N/A	N/A*	0.679	N/A	0.79	0.821	N/A	0.82	0.759	-0.594	0.473

Table 3: T-test and factor analysis of perception

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

The questionnaire included several questions asking about attitude and behaviours using the Likert scale of the participants' daily travel behaviour in terms of traffic and cultural backgrounds. In Fig. 5, the general perceptions of the participants were shown in two separate categories: behaviour and traffic culture (BC and TC). As a result of the t-test and factor analysis (Table 3), BC1 and BC2 in behavioural culture and TC2 and TC4 in traffic culture were statistically insignificant ($p < 0.05$). In addition to the general situation of the other results in these two categories, a distinction was made according to cultural differences. The most important differences vary from the general opinion on BC6, parking the car near the home and TC1, waiting at red light, according to the cultural background (Fig. 6 and 7). Although most of the participants stated that they gave a positive answer for BC6, a substantial number of locals chose the option "strongly disagree (represented as 1)", while the majority of the Turkish community turned to the answer "strongly agree (represented as 5)" (Fig.6.).

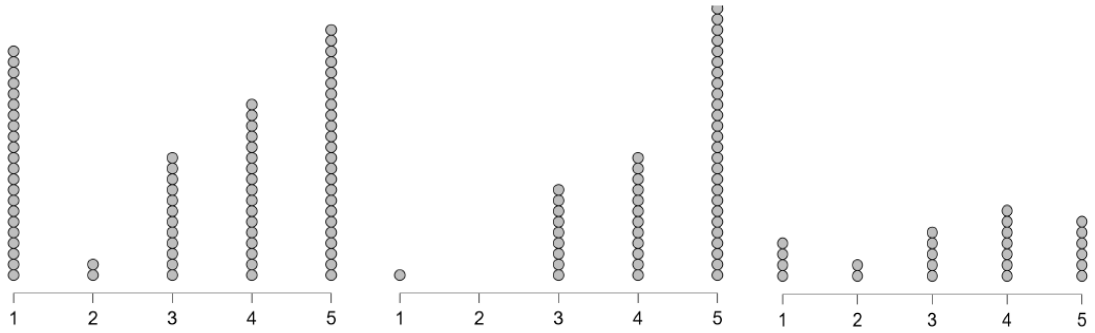


Fig. 6: "Parking car to near at home" (BC6) perception by origin (left: Viennese; middle: Turkish; right: other)

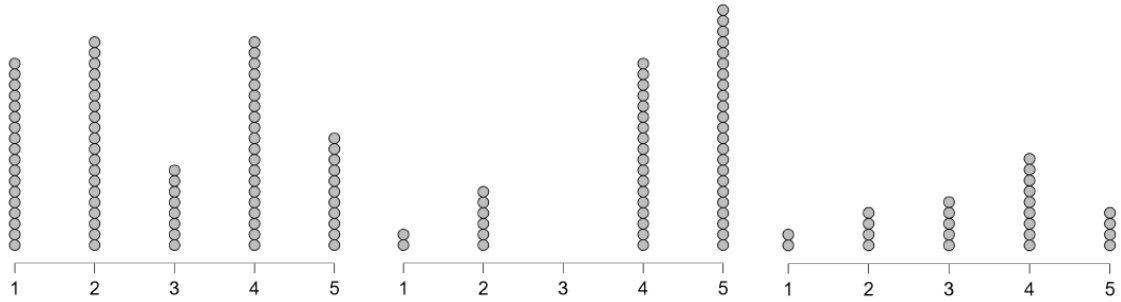


Fig. 7: "Even if there's no traffic, I'd rather wait at a red light." (TC1) perception by origin (left: Viennese; middle: Turkish; right: other)

with "even if there's no traffic, I'd rather wait at a red light." The percentage of the participants who said so are around 60% in general. In this regard, when the cultural differences are examined, the "disagree (represented as 2)" and "strongly disagree (represented as 1)" options of the natives seem to be higher than the rate of those who agree with this opinion, while the rate of saying "agree (represented as 4)" is quite high for Turkish and other communities (Fig. 7). Another difference was realised in the TC3 question, building more roads and parking spaces, although it was not as obvious as in the given graphs. While the vast majority of locals respond to this statement by saying "strongly disagree", in international communities, agreeing and disagreeing seems to be almost equal.

6 CONCLUSION

The findings of this study provided fresh perspectives on the parallels and variations in travel habits between non-immigrants and immigrants in Vienna. Our findings are comparable to those in the US when it comes to the use of automobiles or public transportation. International communities are less likely to own a driving license but more likely own a car than natives. This may be explained by the tendency of being conscious of sustainability as regards the use of cars by the native community. Especially in the Turkish community, the usage of personal cars is much higher than other groups. Bicycle ownership and usage are often higher among non-immigrants than among immigrants. The group of women in the international community that also has the biggest proportion of non-cyclists is the exception in this regard. The findings suggest that local users are aware of sustainable transportation concerns and have a positive and accurate opinion of them as a

result of their social interactions. In this regard, the presentation to, and education about the produced policies of the general public can be made more effective by using brief, informative booklets and website advertisements in the languages of the populations with a migration background.

We conducted our survey because there was no national survey available; it is somewhat exploratory and relatively small because it only covers one location (Vienna) and a small number of respondents. The participants' general level of education is above average, which can be attributed to the fact that educated persons are more likely to be willing to participate in a survey. Additionally, we believe that immigrants who speak English well are more likely to take part in a survey. When analysing the findings, it is important to keep these restrictions in mind. Additionally, Vienna's international communities are a population that is becoming more and more diversified. They vary in terms of their countries of origin, geographic dispersion, cultural backgrounds, and educational levels.

Despite these caviats, our study offers new empirical findings about the travel habits of individuals with an international background living in Vienna, a population that has been largely overlooked by mobility research but whose numbers have increased recently and will likely continue to do so in the future. There is an urgent need for more research because many facets of immigrants' travel behaviour are currently poorly understood or perhaps completely unknown. All demographic groups must have their mobility demands and travel habits known; otherwise, it increases the likelihood that decisions about transportation planning or policy would be ineffective. Vienna has a large population of immigrants, and public transportation is generally reliable in the city. Promoting the use of this and non-motorised modes of transportation helps ensure the independent mobility of immigrants who do not have a driver's license and/or do not have a car. For low-income households, encouraging walking and bicycle use can provide affordable options for short trips. In Vienna, several organisations offer cycling courses for immigrants, especially for women. Together with improved cycling infrastructure, these initiatives should be supported more fully and extended to other groups of people to encourage cycling use. emphasising that immigrants, especially recent refugees, would greatly benefit from improvements towards an easily accessible, barrier-free, affordable, sustainable, and intermodal transportation system.

7 ACKNOWLEDGEMENTS

Special thanks go to the following volunteers who helped to translate the questionnaire: Leo Kotska and Denis Šipuš. Special thanks go to Martin Spendlhofer for language editing. Many thanks for insightful advice on how to build a good structure for Maegan Hendow. For help, every step of this survey special thanks go to all colleagues at TU Wien, Research Center of Transportation Planning and Traffic Engineering: Gunter Emberger, Tadej Brezina, Harald Frey, Helmut Lemmerer, Igor Ripka, Ulrich Leth, Barbara Laa, Benjamin Tschugg, Lisa Gallian, Mohammad Aminian, and Norihiro Miwa.

8 REFERENCES

Abdullah, M., Dias, C., Muley, D., & Shahin, M: Exploring the impacts of COVID-19 on travel behavior and mode preferences. In: Transportation research interdisciplinary perspectives, 8, 100255, 2020.

Ashmore, D. P., Pojani, D., Thoreau, R., Christie, N., & Tyler, N. A: Gauging differences in public transport symbolism across national cultures: implications for policy development and transfer, In: Journal of Transport Geography, 77, 26-38, 2019.

Barajas, J. M: Supplemental infrastructure: how community networks and immigrant identity influence cycling. In: Transportation, 47(3), 1251-1274, 2020.

Blumenberg, E: Moving in and moving around: immigrants, travel behavior, and implications for transport policy. In: Transportation Letters, 1(2), 169-180, 2009.

Chatman, D. G: Explaining the “immigrant effect” on auto use: the influences of neighborhoods and preferences. In: Transportation, 41(3), 441-461, 2014.

Cheng, L., Chen, X., De Vos, J., Lai, X., & Witlox, F: Applying a random forest method approach to model travel mode choice behavior. In: Travel behavior and society, 14, 1-10, 2019.

City Population: https://www.citypopulation.de/en/austria/wiencity/ available at 21.07.2022

Dingil, A. E., Rupi, F., Schweizer, J., Stasiskiene, Z., & Aalipour, K. (2019). The role of culture in urban travel patterns: Quantitative analyses of urban areas based on Hofstede’s culture dimensions. Social sciences, 8(8), 227.

Haustein, S., Kroesen, M., & Mulalic, I: Cycling culture and socialization: modeling the effect of immigrant origin on cycling in Denmark and the Netherlands. In: Transportation, 47(4), 1689-1709, 2020.

Klinger, T., & Lanzendorf, M: Moving between mobility cultures: what affects the travel behavior of new residents?, In: Transportation, 43(2), 243-271, 2016.

Li, H., Raeside, R., Chen, T., & McQuaid, R. W: Population aging, gender and the transportation system. In: Research in transportation economics, 34(1), 39-47, 2012.

Ruggles, S., Sobek, M., Alexander, T., Fitch, C.A., Goeken, R., Hall, P.K., King, M. and Ronnander, C: Integrated Public Use Microdata Series: Version 4.0 [Machine-readable database]. Minneapolis, MN: Minnesota Population Center [producer and distributor], http://usa.ipums.org/usa/, 2008.

Shamshiripour, A., Rahimi, E., Shabanpour, R., & Mohammadian, A. K: How is COVID-19 reshaping activity-travel behavior? Evidence from a comprehensive survey in Chicago. In: Transportation Research Interdisciplinary Perspectives, 7, 100216, 2020.

Stadt Wien: Vienna's population 2021 - facts and figures on migration and integration. In: https://www.wien.gv.at/english/social/integration/facts-figures/population-migration.html available at 21.07.2022

Wang, D., & Zhou, M: The built environment and travel behavior in urban China: A literature review. In: Transportation Research Part D: Transport and Environment, 52, 574-585, 2017.

Welsch, J., Conrad, K., & Wittowsky, D: Exploring immigrants travel behavior: empirical findings from Offenbach am Main, Germany. In: Transportation, 45(3), 733-750, 2018.

🏆 *reviewed paper*

Delineating and Assessing Urban Green Infrastructure in Cities: Application of the Patch Matrix Model in Alexandria, Egypt

Esraa M. Abdel-Gawad, Hany M. Ayad, Dina M. Saadallah

(MSc. Candidate Esraa M. Abdel-Gawad, Faculty of Engineering Alexandria University, Alexandria, Egypt, Esraa.Gawad@alexu.edu.eg)
(Prof. Dr. Hany M. Ayad, Faculty of Engineering Alexandria University, Alexandria, Egypt, hany.m.ayad@alexu.edu.eg)
(Assoc. Prof. Dina M. Saadallah, Faculty of Engineering Alexandria University, Alexandria, Egypt, dina.saadallah@alexu.edu.eg)

1 ABSTRACT

Cities face crucial issues related to urbanisation, declining quality of life, inadequate infrastructure, and ecosystem degradation. Those issues have huge impacts on the health and wellbeing of communities. In response, the World Health Organisation (WHO) recommends granting each person in a city a minimum of 9 m2 of urban green spaces that are functional. Many cities face challenges to achieve this requirement due to limited green public areas and their under-exploration as green infrastructures. In Egypt, due to high urbanisation rate and increased densification, some cities, particularly large ones, are struggling to provide a proper share of open spaces per capita.

Exploring and promoting urban green spaces in cities could contribute to an improved quality of life (QOL) and ecosystem services. In this respect, “urban green infrastructure” (UGI) responds to such issues by offering opportunities that attempt to preserve values and functions of ecosystems, as well as solutions to support biodiversity and urban healthy environments. This research focuses on green spaces as a main component of UGI in Alexandria, Egypt's second-largest city, through the application of the Patch Matrix Model (PMM). Since the 1980s, PMM has been a fundamental principle in landscape ecology, as it describes the horizontal landscape structure in a simple practical way by delineating homogeneous areas and by quantitatively assessing their spatial arrangement and diversity.

It is proposed to adopt PMM to classify and analyse UGI on an urban scale in Alexandria's Al Montazah district. Using remotely sensed data, Esri Sentinel-2 Land Cover maps, as well as existing local spatial information systems, delineation of existing and potential patches, corridors and matrices is performed. Homogenous areas of open spaces are analysed in terms of their shape, size, and functions. Linear spaces in the city are also investigated and the spatial arrangement of the PMM components is developed. Based on the implementation on a highly urbanised district, discussions extend to the potential and limitation of this approach for quantifying urban landscape patterns. The research results confirm the validity of PMM in delineating and providing scenarios for UGI development, and in proposing a tactic plan for city-scale interventions.

Keywords: Urbanization, Urban green spaces, Patch Matrix Model, Urban Green Infrastructure, Landscape ecology, Ecosystem

2 INTRODUCTION

According to the United Nations (UN) (2018), sixty-eight percent of earth’s population will be living in urban areas by 2050. Also, it is reported that in 2000, forty-seven percent lived in urban areas, which increased to fifty-five percent in 2018 with the fastest urbanisation rates experienced in Africa and Asia (United Nations, 2018). The global claim addressed is that urbanisation is a process that replaces vegetated areas, which provide shading, cooling, rainwater harvesting and infiltration functions, with built surfaces. Being a life itself, a single tree can have a great impact on a whole system of green spaces across the city.

Egypt, the third most populous country in Africa, is characterised by regional varieties of natural resources, labor force characteristics, and culture. Egypt, however, is suffering from severe desertification, land degradation, and drought as a result of both natural and human-caused factors, such as climate change, sea level rise, improper management of resources, overgrazing, and rapid urban growth (MPED, 2021). According to the latest data by the World Bank, Egypt’s agricultural land areas represents 3.9% of total land area in 2018, while forest land areas represent 0% in 2020 after being 0.1% in 2015, which are low values compared to other countries, knowing that its urban population represents 43% of total population with annual growth of 2%. In this regard, Green initiatives in Egypt made up 691 projects in the 2020–2021 investment plan, accounting for around 14% of all public investments. The plan prioritises green projects and gradually phasings out unsustainable projects by increasing public green spending as a percentage of public

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

investments to 30%. Furthermore, Egypt also launched the Sustainable Development Strategy (SDS): Egypt Vision 2030 in 2016 aspiring to ensure quality of life (QOL) through sustainable projects and initiatives such as "Haya Karima" (Decent Life) initiative that started in 2020 (MPED, 2021).

Following the previous facts, addressed challenges need effective scenarios for green spaces across cities. On this matter, green spaces described by the term '(urban) green infrastructure' (UGI) is relatively new to academic literature, however the idea is long existing (Wito Van Oijstaeijen et al., 2020). UGI can be broadly defined as a strategically planned network of high quality natural and semi-natural areas with other environmental features, designed and managed to provide benefits from nature to people in both rural and urban settings. Additionally, it aims to enhance nature's ability to deliver valuable ecosystem goods and services, such as clean air or water. For example, permeable vegetated surfaces, green roofs, public parks, green walls, urban forests, green alleys and streets, and community gardens are all UGI elements that can exist in cities (Gill et al., 2009).

To understand UGI, there should be a recognition of its importance, classification approaches and evaluations methods. Consequently, the aim of this research is investigating compositions of UGI systems in an urban setting. The research mainly focuses on two broad objectives. Firstly, delineating UGI components by land use/cover and their categorisation in the city of Alexandria, Egypt. This requires a review and inspection of a variety of related tools or methods. Owing to existing literature, models can be analysed to be compared to each other and the most suitable model can be chosen to be adopted in the study area. This process introduces the second objective, focusing on the assessment of UGI in their local context based on principles of the chosen model: the patch matrix model, and the reason of its choice will be explained as the research proceeds.

3 LITERATURE REVIEW

Through its evolving over time, many approaches shaped UGI such as greenways or parkways as environmental features, developed first in the USA, and promoted by the work of Frederick Law Olmsted through his 1870s famous Boston's Emerald Necklace system of parks. Later, Ebenezer Howard initiated the garden cities movement in Europe (Fábos, 2004). Subsequently, similar examples assure the roles of UGI to facilitate a more inviting and interactive landscape that people could use as quotidian recreational spaces (Hall, 2002).

For the most part, principles of UGI have been supporting ideas of landscape ecology, which proposes that environments are made up of networks of ecological resources (Forman, 1995). Hence, Landscape ecology can provide the spatial framework that enables green space management. Plus, it can be proposed to consider ecosystem services (ES) to support UGI, rather than as a separate line of scholarly argument. In view of ES, common international classifications of ecosystem services are supporting, provisioning, regulating, and cultural ES, reflected on types of UGI. Moreover, landscape ecology theories and models offer choices for urban planning. In essence, landscape ecology encourages spatial relationship models, gathering of novel data on spatial dynamics, and investigating spatial scales (Pickett and Cadenasso 1995). Coupled with geographic sciences, rapid advancements in landscape ecology, and satellite imagery, predicting landscape change has become simpler over time (Turner, M. G., & Gardner, R. H., 2015).

In assessing the effects of landscape variability, spatial models have a significant impact. Most crucially, models should never be ends in themselves, but rather instruments for reaching a certain aim. In fact, models come in a variety of forms, and mathematical models are frequently used in landscape ecology. It is tremendously beneficial to compare different models before deciding which one is suitable in any case study (Turner, M. G., & Gardner, R. H., 2015).

This research tackles methods mentioned in gray literature, peer reviewed literature or books to compare and choose the most suitable one for adoption later. Wito Van Oijstaeijen et al. (2020) reviewed several assessment toolkits to support investments of UGI from an urban planning point of view, which has been a great aid in this research. Types of toolkits include webtools, spreadsheets, computer software or textual guides. This research investigates some models/ tools, groups them by types and compares their capabilities.

The first group of webtools include "Nature Value Explorer (NVE)", an application to support the quantification and valuation of ES (Vito et al., 2022). It evaluates cultural, and regulating ES in terms of denitrification, air quality and noise mitigation (Broekx, S., et al., 2013). The main advantages are its

accessibility, and ease to combine results in GIS. On the other hand, it works on small local scales only and cannot include a district or a city, does not include all types of ES and was built for a certain case study whereas scenarios input in Egypt might differ. In addition there are: "Greenkeeper" to identify the value of a green space (Wito Van Oijstaeijen et al., 2020), "NEVO (Natural Environment Valuation Online tool)" to estimate the value of an area for delivering ES and biodiversity, "ORVal (Outdoor recreation valuation tool)" to predict the number of visits to greenspaces in England, and "Co$ting Nature" to allow scenarios understand the impact on ES delivery. The first three tools are not accessed in Egypt, while "Co$ting Nature" is limited to 1 km2 data entry.

Secondly, computer software like "Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST)", is used to map and value the goods and services from nature that sustain human life according to Stanford University definition. InVEST modelling approach focuses on carbon storage, sediment erosion, and pollination (Grafius, D. R., et al., 2016). Yet, it is limited to a certain scale and resolution with high expertise requirement. Also, "i-Tree eco" is a software by USDA Forest Service that uses field data from trees to quantify environmental effects on society (Wito Van Oijstaeijen et al., 2020). Additionally, "ARIES" is a software used in spatial mapping and quantification of ES, but it is time-consuming, and not independent of GIS as InVEST. These software are not inclusive to many aspects by which UGI can be fully described. A collaboration with another type of tools might be needed, which can be time consuming.

Thirdly, spreadsheets are found to be vital in some cases. For instance, "Green infrastructure valuation toolkit (GI-Val)" by The Mersey Forest, UK, establishes the value of green assets, using calculator Tools, and "Capital Asset Value of Amenity Trees (CAVAT)" by London Tree Officers Association (LTOA) helps decision-making when a publicly owned tree needs to be expressed in monetary terms (Wito Van Oijstaeijen et al., 2020). Their calculations are specific and requires high expertise in certain fields.

The fourth group includes textual guides or published documents. To name a few, "the mosaic model/ the Patch-Corridor-Matrix Model (PMM)" describes and understands the spatial configuration of landscapes (J. Ahern, 2007) in addition to "the MAES framework (mapping and assessment of ecosystems and their services)" (On Yi Liu & Alessio Russo, 2021). The MAES framework offers a linear structure of steps easy to comprehend and apply on ES limited by availability of data. Nevertheless, PMM is simple, compatible with GIS, understandable, requires moderate computational expertise, simplifies representations to mock conventional maps, and most importantly reflects how humans perceive landscapes. It is limited by the lack of established standards for classifications, ground truth of data, and the need for discrete boundaries of land uses (Lausch, A., et al., 2015). To sum up, 21 toolkits, 12 of which were mentioned above and summarised in figure (1), have been explored, where some limitations of each tool are mentioned in the previous paragraphs.

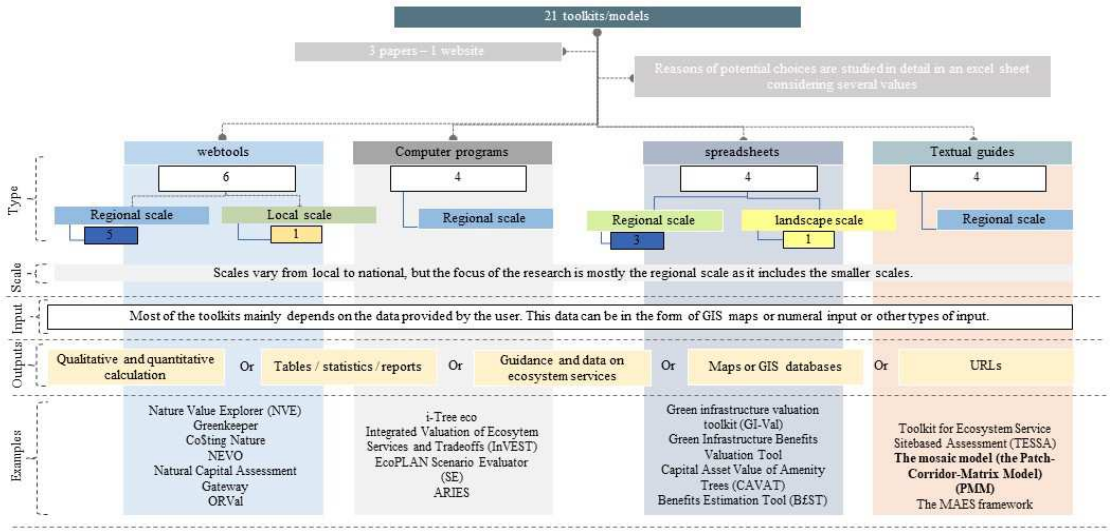


Fig. 1: Methods/Models/Toolkits investigated on the matter of UGI, ES, or landscape ecology (the researcher, July 2022).

The previous review aims to choose a suitable approach for analysing a district in Alexandria, Egypt. The decision is based on how approaches define UGI in urban settings, what the output is and how it is displayed.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Moreover, it is preferred that a model offers ways to re-evaluate the input when proposing scenarios. It is found that PMM is a flexible model to adopt due to its classification methods, instructions and metrics that formulate a dataset of cells assigned to categories of patches, and their functions. Furthermore, landscape structure is the spatial arrangement of landscape elements including patches, corridors, and the matrix itself. Quantitative analyses based on patches vary such as patch size distribution, and perimeter-to-area correlations. These quantitative metrics are used to assess how different or similar landscapes are by comparing them. Consequently, theses metrics play a vital role in landscape studies, which will be the approach adopted in this research (Turner, M. G., & Gardner, R. H., 2015).

4 METHODS AND TOOLS

Up to this point, PMM is selected to address how to delineate and assess UGI in Al Montazah District, Alexandria. The objective of landscape ecology goes beyond measuring patterns in the landscape, and spatial analysis is just one technique used to understand the relationships that make up landscapes. Describing and quantifying spatial patterns are required to emphasise such relationships (Turner, M. G., & Gardner, R. H., 2015). In this paper, the structure of the research, summarised in Figure (2), follows a linear flow of steps that each contributes to building the structure of the final results.

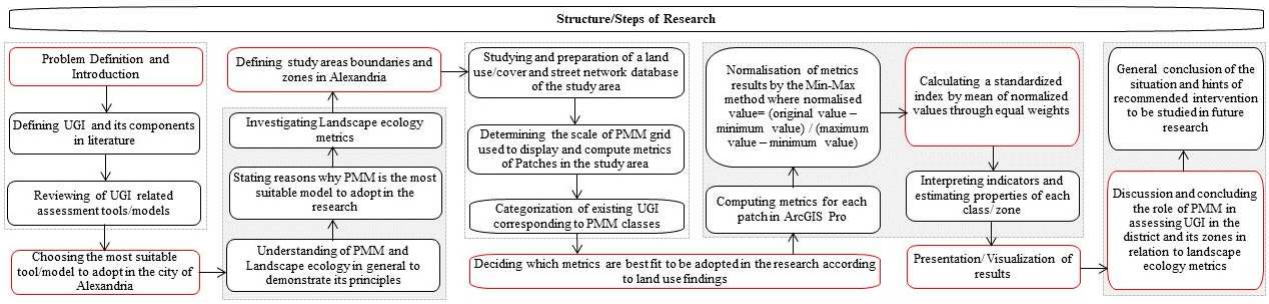


Fig. 2: Structure/steps of the research (the researcher, September 2022).

4.1 Study Area

The study area of Al Montazah District, one of Alexandria's far east districts, corresponds to about 53.83 km2. This district, like the city of Alexandria, has a long history of human developments and archaeological heritage from previous eras still in existence to the present date. Conventionally, the district has had access to a port whose development in recent years is currently a massive ongoing project.

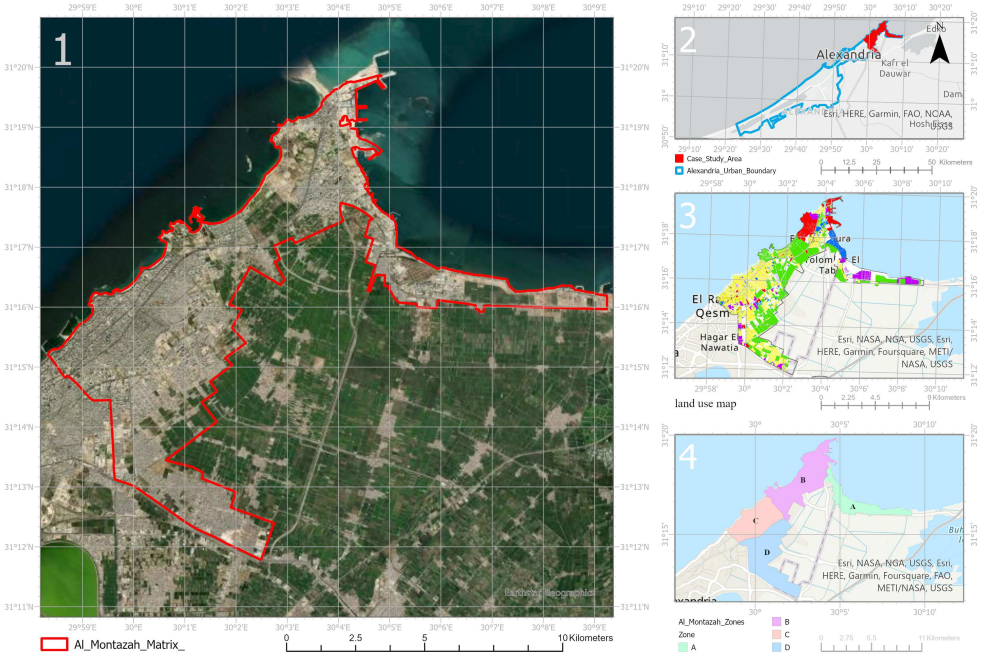


Fig. 3: Map 1: Al Montazah District study area boundary. Map 2: the location of the district in context of the city. Map 3: Al Montazah district land uses. Map 4: Zones of the district (The researcher via ArcGIS Pro, July 2022)

Obviously, the district features many beaches, some of which are accessed through the famous garden of Al Montazah palace, a national asset itself. As shown in maps in Figure (3), the expansion of this urban district to the south is threatening a lot of agricultural lands, which are gradually being invaded. As seen by land uses, residential blocks, parks or agriculture, administrations, and service exist descendingly. In this paper, the district will be conveyed as 4 zones as in map (4), where zone A represents the new extension of the district that contains many projects under construction. Abou-Qir area in zone B accesses the port and contains an important historical castle ruins. Zone C is a highly built-up residential zone. Likewise, Zone D is the expansion of the residential area in zone C, with some agricultural presence.

4.2 Utilisation of PMM in the research

Admittedly, Landscape ecology theories are valid for assessing UGI, as well as its concepts of degrees of connectivity, fragmentation, landscape function, dynamics, and sustainability (Wu, J., 2012). Customarily in landscape ecology, scales must be chosen based on the study's inquiry or goal. To reduce bias when calculating landscape metrics, the extent of the study landscape should be 2–5 times greater than landscape patches (Turner, M. G., & Gardner, R. H., 2015). This means that decreasing the size enhances the quantity of patches since more detail is resolved at the smaller scale. To apply this, the matrix is divided into grid cells of 100 m*100 m for presentation of UGI in the case study. Following their detection by land use, patches can be counted, and their areas and perimeters can be calculated. Accordingly, reporting of statistics on the patch level is more accurate. It is more helpful to report the number of patches as a density value: number of patches divided by landscape area.

Traditionally, there is no formula to figure out how many and which metrics are required to describe a landscape, yet one sole metric is inadequate (Turner, M. G., & Gardner, R. H., 2015). Thus, selected metrics should be relatively independent of one another. Without considering their location on the landscape, metrics of landscape composition measure what is present and in what quantities. Overall, the metrics considered in this study are: perimeter area ratio (PAR), number of patches (NP), patch density (PD), total edges (TE), edges density (ED), patch richness density (PRD), the largest patch index (LPI), mean patch size (MPS), patch size standard deviation (PSSD), patch size coefficient of variation (PSCV), the gamma index (γ), patch shape index (PSI) and Fractal Dimension Index (FRAC). They are compared to each other in Table 1.

Metric	Description	Choice of a metric in case of duplication
PAR	PAR = P/A: P is perimeter of a patch, and A is area of the patch.	FRAC reflects shape complexity overcoming limitations of other metrics, so it will be the one computed in the research.
PSI	PSI = $p/2\sqrt{A\pi}$	
FRAC	FRAC=2ln(.25P)/ln(A)	
NP	The total number of patches in the landscape.	PD represents the density; therefore, it will be computed.
PD	The number of patches per square kilometer (i.e., 100 ha).	
TE	The sum of the lengths of all edge segments (unit: meter).	ED represents the density; therefore, it will be computed.
ED	The total length of all edge segments per hectare for the class or landscape of consideration (unit: m/ha).	
PRD	The number of patch types per square kilometer (or 100 ha).	PRD is not informative on the patch level
LPI	The ratio of the area of the largest patch to the total area of the landscape (unit: percentage).	
MPS	The average area of all patches in the landscape (unit: ha).	PSCV is the metric that will be computed as it embraces MPS and PSSD within itself.
PSSD	The standard deviation of patch size in the entire landscape (unit: ha).	
PSCV	The standard deviation of patch size divided by mean patch size for the entire landscape (unit: percentage).	
γ	The Gamma index of network connectivity (0-1), γ= L/3(V-2): L is the number of links and V is the number of nodes in the network.	

Table 1: Landscape ecology metrics considered in the research (Wu, J., 2012).

4.3 Delineating and assessing UGI in the Al Montazah study area

Adopting PMM, the research carried out its steps of classifications. This was performed by gathering land use/ cover information from local datasets. Forman and Gordon (1986) defined a patch as “a nonlinear

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

surface area differing in appearance from its surroundings". Patches are valuable spatial abstractions depending on the study, and not treated as fixed components. In light of this, PMM enabled the categorisation of patches into 6 main classes, each including certain land uses, shown in Table (2) and represented in figure (4). These classes embrace: 1) environmental resource patches correspond to natural areas, or relatively permanent areas reflecting the normal heterogeneity of the environment. 2) constructed or built-up introduced patches dominate an aggregation of individuals or materials by human activities and will last if management regimes maintain them (Jacinta Fernandes et al., 2020). 3) planted introduced patches depend on green human activities such as gardens and site landscaping. 4) vegetation patches of any agriculture or forestry. 5) disturbance patches that result from acts of disturbance over any period such as areas used for cattle grazing. 6) remnant patches represent earlier life spans of other classes, managed to persist disturbance and are left as proof. In this regard, a mosaic can be obtained based on the mixture of these classes making up the whole matrix. Furthermore, the categorisation also included the corridors in the matrix by dividing them into 2 classes: built-up corridors such as roads, railways and pipelines and stream corridors responsible for carrying water flows along a linear form.

Patch class	Land use/ cover of UGI elements associated with the patch class in Al Montazah District, Alexandria
Environmental resource patches	Beaches and sandy waterfronts, lagoon areas.
Constructed or built-up introduced patches	Cemeteries, swimming pools, Playgrounds, parking spaces, infrastructure facilities such as water supply or sewage stations, squares.
Planted introduced patches	Parks, gardens, green spaces, plantations, or nurseries.
Vegetation patches	Agricultural lands.
Disturbance patches	Farms and grazing fields.
Remnant Patches	Abandoned farms and fields.

Table 2: Patch class classification of Land use/ cover corresponding to UGI in Al Montazah District, Alexandria (The researcher, May 2022).

Once each metric is calculated on the patch level, they are compared to each other by representation on the class level to describe the matrix. Further steps are performed on these calculations to present findings on maps. Graduated scales in maps will be indicators of fragmentation, function, and richness of classes. These indicators will be speculated by a standardised index combining all normalised values of the 5 chosen metrics ranging from 0 to 1, 1 being the highest. This index will be responsible for showing how optimal the landscape is and where. Besides, the connectivity in the matrix is described using the gamma index where its values range between 0 and 1, by considering intersections of corridors as nodes in this case.

5 RESULTS

Based on the findings, the output is represented through more than one outlook. One presentation of data in Figure (4) includes identification of classes in their spatial locations and arrangements. The compilation of this data is tallied and statistically compared to know insights into each zone of the district, and into each UGI class, for more in-deep perspectives. Eventually, reflecting landscape metrics findings on grid cells will disclose and facilitate the procedure of assessing the matrix. Just as important, the transformations in the district is described before analysing its components as follows. In many landscapes, changes usually occur in a gradual form, making effects more difficult to observe. However, signs of transformations can be determined on a timeline. Some processes may interfere with each other, but it is the cycle that builds the landscape. It can be seen in satellite images that changes to vegetation in the district is less abrupt than in built-up areas. Acts of perforations, fragmentation, shrinkage, and attrition occurred simultaneously since 1996. Meanwhile, dissections are observed more recently with new major projects in the last 4 years and are assumed to continue because of still ongoing infrastructure projects that may completely reshape the boundary of the matrix.

In accordance with available datasets, results of PMM classifications and metrics are concluded by values shown in Table (3). According to NP, vegetation and planted patches are the most dominant, as shown in Figure (4), which makes the matrix highly sensitive because they are affected by any interventions and require the most maintenance. Environmental resource patches are the least existing which shows scarcity in

habitat areas, relatively permanent or reflecting normal heterogeneity of the environment which can be a disadvantage for the ecosystem.

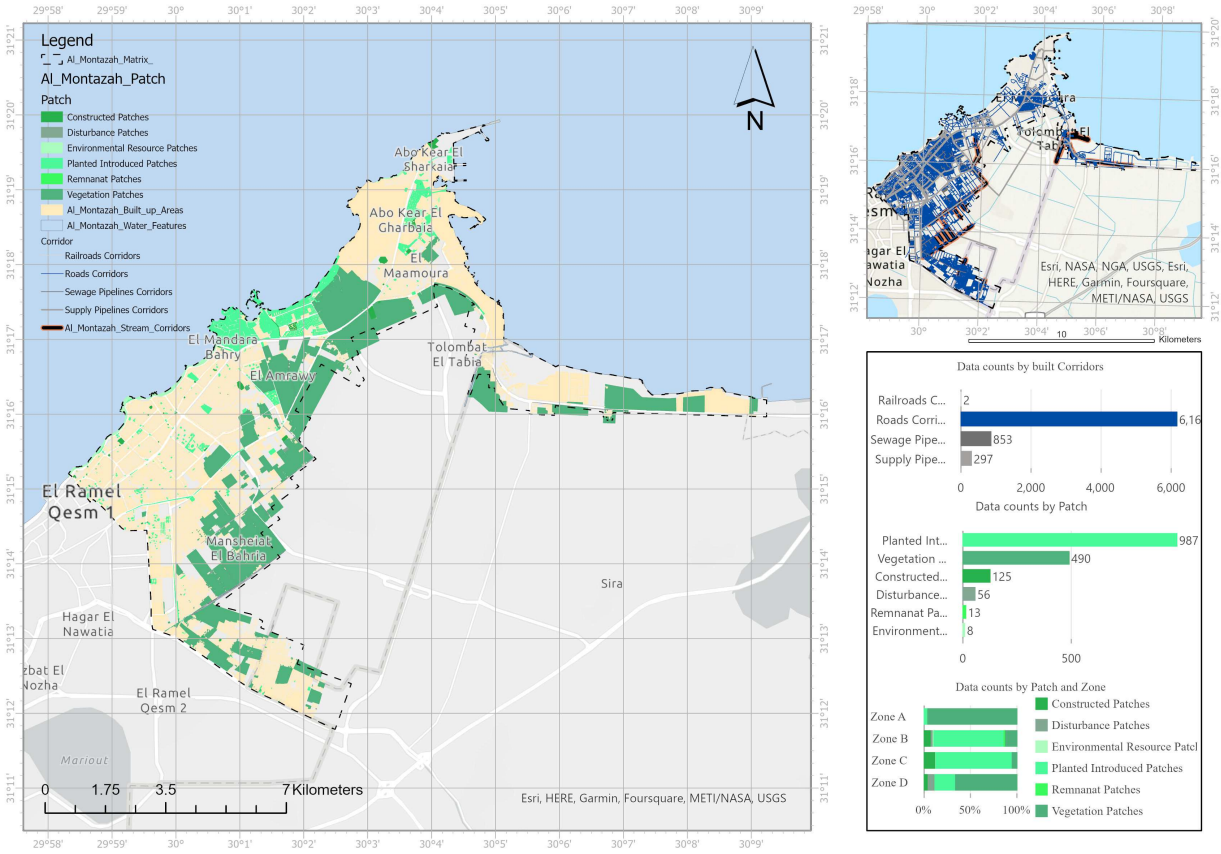


Fig. 4: Map 1: Distribution of patches in the district. Map 2: Distribution of Corridors in the district. Chart 1: Statistics of patches and corridors classifications according to PMM in Al Montazah district (The researcher via ArcGIS Pro, July 2022).

Furthermore, results by LPI, PSCV, PAR, PSI, and FRAC includes observations about the surface areas of patches, where large patches are supplemented with scattered small patches and some large patches exist solely, indicating a nearly optimum landscape. Also, large to small varieties of sizes are observed in all classes. Meanwhile, less convoluted shapes than smooth, and elongated to round shapes are the highest variability in environmental resource patches, and the lowest in remnant patches. The presence of more compact simple patches is observed in all classes, and it is effective in conserving internal resources because it minimises the exposed perimeter to outer effects. Remnant patches have some changes in shapes with few complexities. Conversely, environmental resource patches have the most changes in shapes because beaches depend on the natural curving of the Mediterranean Sea with more highly convoluted, plane-filling perimeter shapes. All in all, the matrix is not complex, extensive towards the sea, but limited towards southern agricultural lands, although that did not prevent past urban expansions. Spatial arrangements of patches and corridors can be seen in Figure (4). Arguably, data counts by patches and zones does not reflect a variety between zones as it is actually in the matrix because one class seems to always dominate a zone.

In order to further analyse the landscape, the gamma index helps to determine the level of connectivity in the landscape. Although its original use is applied to a bigger extent, it produced a logical output. In this case, the number of junctions where corridors intersect is around 27,539 nodes, while the number of links are around 5,542 direct links represented by built-up and stream corridors. By computing the index, its value was around 0.067, approaching zero. For this reason, it is a sign of low connectivity in the matrix, in spite of holding relatively high values in zone C and D respectively. When compared to the map, the low connectivity in the landscape is not shocking despite high concentrations of corridors in many areas. That is because most corridors do not serve UGI enough and roads are known to be highly traffic congested, lack greenery and suffer from poor infrastructure.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Normalised Values	patches					
	Constructed	Disturbance	Environmental Resource	Vegetation	Remnant	Planted Introduced
PAR	0.120	0.050	0.000	0.492	0.005	1.000
PSI	0.041	0.036	0.222	0.041	0.050	0.073
FRAC	0.250	0.250	0.500	0.250	0.308	0.327
NP	0.120	0.049	0.000	0.492	0.005	1.000
PD	0.330	0.906	0.000	0.008	1.000	0.273
TE	0.077	0.017	0.061	0.839	0.000	1.000
ED	0.419	0.754	0.228	0.000	1.000	0.566
PRD	0.035	0.210	0.027	0.000	1.000	0.003
LPI	0.142	0.165	1.000	0.035	0.097	0.000
MPS	0.033	0.002	1.000	0.670	0.000	0.043
PSSD	0.052	0.486	1.000	0.860	0.000	0.071
PSCV	0.034	1.000	0.028	0.039	0.000	0.038
standardization index	0.235	0.615	0.351	0.066	0.481	0.241

Table 3: Results of metrics calculations after normalisation and calculation of a standardised index (The researcher, September 2022).

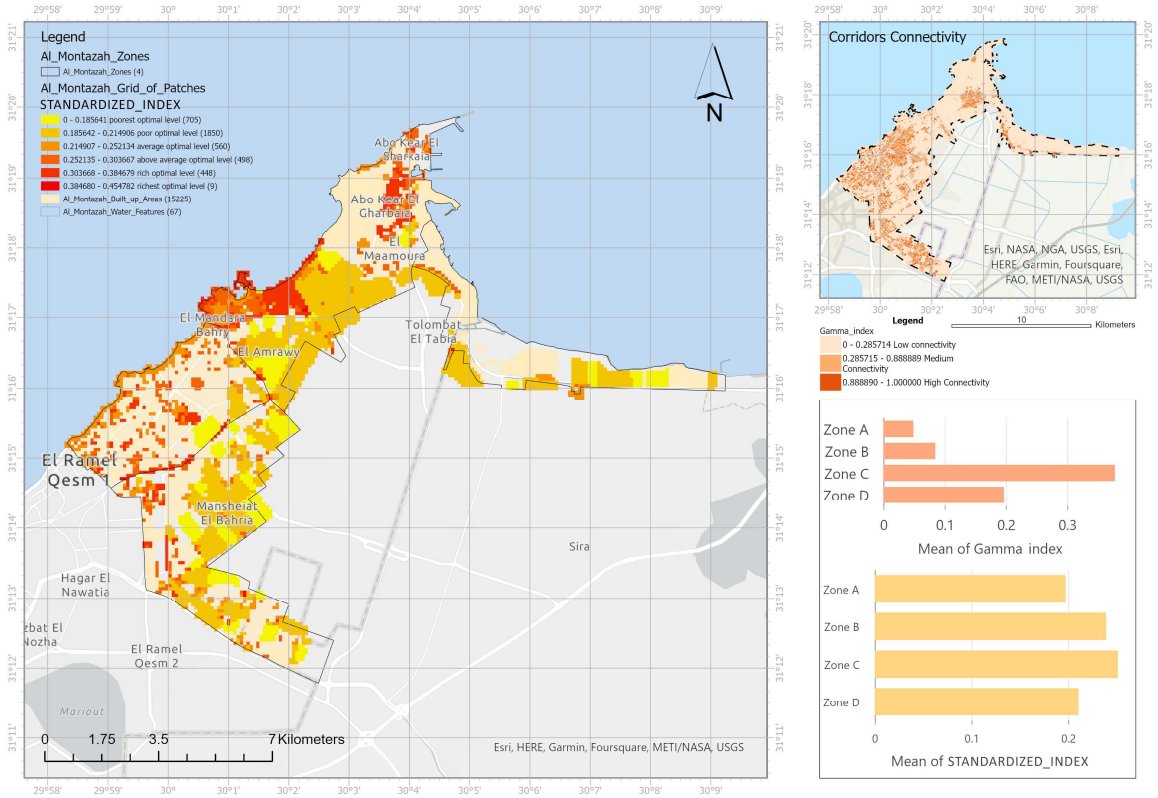


Fig. 5: Maps and charts showing results of graduation of standardized index for UGI patches, and graduation of the Gamma index corridors according to PMM in Al Montazah district zones (the researcher, July 2022).

To recapitulate, it can be said that the matrix is vulnerable because of the abundance and concentration of vegetation in the district zones. Additionally, it is not highly fragmented, and the distribution of this fragmentation among patches is valid, for the highest fragmented holds the least number of patches throughout the matrix: high fragmentation in remnant patches and lower fragmentation levels in other patches, concluded by PD. Moreover, corridors are concentrated more in the built-up residential zone C. It is also clear that most of UGI concentrations exist in zones B and D respectively. Despite being fragile, UGI represents 30.34% of the whole matrix, which makes the built-up areas the real triggers in the performance of the matrix and are dominating its personality.

6 DISCUSSIONS

Above all, landscape metrics are numerically related or correlated. In this research, the weights of metrics are proposed to be equal, and therefore effects of each metric are easily monitored. It is evidenced by scatter plots diagrams in Figure (6) that PSCV has the most impact on the value of the standardised index, especially in zone B. Also, FRAC is contributing more to the index than other metrics, considering that there are similarities in the effects caused by PD, ED, and LPI. Putting it all together, relationships prove that areas of patches are a crucial factor in this assessment, since area is an essential parameter in the calculations.

To review, the percentage of patches that are considered the richest and more likely to be optimum represents 0.2% of the total patches, spread in all zones except zone A. Just as important, rich patches are more existing in the zones, around 11% of total patches. It is an advantage that highly valued patches are not concentrated in one zone; however, they obtain their values by being planted introduced patches only. Therefore, being rich does not mean there is a variety in the zone. On the contrary, 45.5% of the matrix are poor patches, seen in all zones, but the least in zone C. This percent consists mostly of vegetation patches that are not blending with heavy residential areas. Notwithstanding, most optimal patches are present in zone C followed by zone B. This may be due to the fact that gardens, squares, parking, and beaches in these zones are numerous, but occupy small areas. In addition, the national park of Al Montazah is a vital landmark of the city of Alexandria that exists in zone B and contributes to the richness of the district.

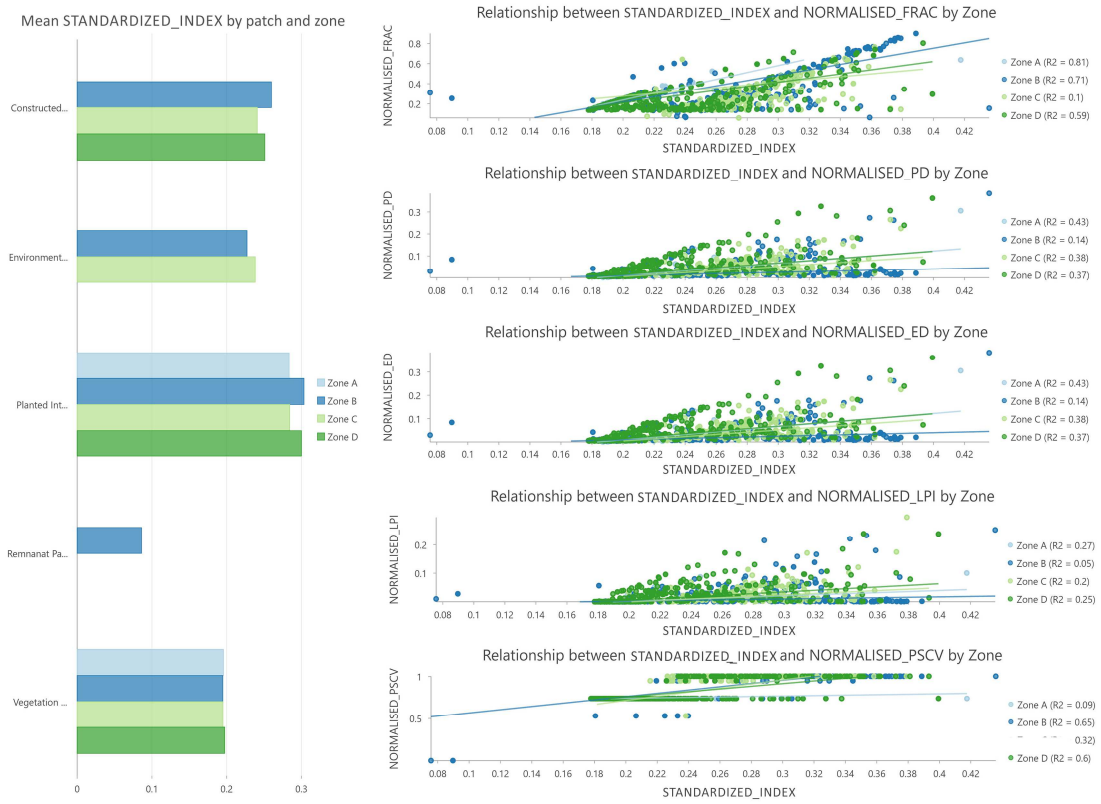


Fig. 6: Mean standardized index distribution by patch classes and zones and Scatter plots of relationships between metrics and the standardized index (The researcher, July 2022).

Without considering the quality of service these patches provide, the assessment is based on spatial properties. With this in mind, high positive correlations are found between the standardised index and all metrics especially PSCV, where their relationship is stronger and closer to forming straight lines as shown in Figure (6). The findings in this paper can summarise UGI in Al Montazah zones as moderately variable, and not very rich. Zone B, with its dominant park, is the richest by embracing all classes in variable amounts. In contrast, zone A is the poorest, due to its many construction sites and only embraces vegetations and planted open spaces that are not all open and usable by the public, unfortunately. Otherwise, there is no harm that environmental patches are limited to zone B and C due to their direct seafront, for this will encourage movement between zones. However, it is a disadvantage that they are limited to beaches and no other varieties.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

The main challenge in interpreting existing data in the mosaic is not recognising intangible motivations that could not be evaluated through PMM alone. However, today's intensive industrial and logistic uses in the study area reflects an economic juxtaposition with natural conservation locations in the mosaic. Undoubtedly, UGI solutions at the local level will have implications to overcome any possible hazardous scenarios and contribute to obtaining balance between interests if possible.

7 CONCLUSION AND RECOMMENDATIONS

To wrap things up, the patch matrix model (PMM) is proved to be a useful tool for describing landscape pattern. On the whole, UGI was assessed based on analysing its components according to PMM, and landscape metrics. Results were validated by a standardised index, and correlations between this index and landscape metrics were discussed as indicators to guide green space planning. In short, UGI in Al Montazah district in Alexandria, Egypt is striving to be an optimum landscape according to the statistics attempted in this research. Accordingly, complexities could be solved through simple UGI solutions such as reviving zone B remnant patches as pilot projects, making use of stream corridors or linear patches to increase connectivity, and many other opportunities related to identifying hotspots for conservation strategies of existing landscape and its sustainable management. Further recommendations could be made upon the displayed results to localise action plans and suggestions in the district to enhance UGI and encourage keen NGOs or decision makers.

8 REFERENCES

ALI, P. J. M., et al. Data normalization and standardization: a technical report. In: Mach Learn Tech Rep, Vol. 1, Issue 1, pp. 1-6. 2014.

AMUNDSEN, O. M., et al. Green infrastructure planning: Recent advances and applications. In: Planners Advisory Service Memo. American Planning Association, Chicago, IL. 2009.

BROEKX, S., et al. A web application to support the quantification and valuation of ecosystem services. In: Environmental Impact Assessment Review, Vol. 40, pp. 65-74. 2013.

CUSHMAN, S. A. and K. McGarigal. Landscape metrics, scales of resolution. Designing green landscapes, Springer: pp. 33-51. 2008.

ELMQVIST, T., et al. Urbanization, biodiversity, and ecosystem services: challenges and opportunities: a global assessment. 2013.

FERNANDES, J., et al. The Winds and the Waves That Carved Out Today's Coastal Landscape of Sines (Portugal). In: Humanities, Vol. 9, Issue 4, pp. 120. 2020.

FORMAN, R. T. Some general principles of landscape and regional ecology. In: Landscape Ecology, Vol. 10, Isssue 3, pp. 133-142. 1995.

FRAZIER, A. E. and P. Kedron. Landscape metrics: past progress and future directions. In: Current Landscape Ecology Reports, Vol. 2, Issue 3, pp. 63-72. 2017.

GÖKYER, E. Understanding landscape structure using landscape metrics. Advances in landscape architecture. 2013.

GRAFIUS, D. R., et al. The impact of land use/land cover scale on modelling urban ecosystem services. In: Landscape Ecology, Vol. 31, Issue 7, pp. 1509-1522. 2016

I.MELL: Global Green Infrastructure: Lessons for Successful Policymaking, Investment and Management. Routledge, 2016.

J. AHERN: Green infrastructure for cities, the spatial dimension. In, in Cities of the future, towards integrated sustainable water and landscape management. IWA Publishing. 2007.

J.C. O'CONNELL: The Legacy of Frederick Law Olmsted's Emerald Necklace in Contemporary Boston. Cambridge, 2016.

J.G. FÁBOS: Greenway planning in the United States: its origins and recent case studies. In: Landscape and Urban Planning, Vol. 68, Issues 2–3, pp 321-342. 2004.

J. WU: Landscape Ecology. 2012.

LAUSCH, A., et al. Understanding and quantifying landscape structure–A review on relevant process characteristics, data models and landscape metrics. In: Ecological Modelling, Vol. 295, pp. 31-41. 2015.

LUCIUS, I., et al. Green infrastructure. Sustainable investments for the benefit of both people and nature. In: WWF Danube-Carpathian Programme, WWF Germany, Giurgiu County Council. 2011.

M.G. TURNER, R.H. Gardner: Landscape Ecology in Theory and Practice: Pattern and Process. 2015.

O'CONNELL, J. C. The Legacy of Frederick Law Olmsted's Emerald Necklace in Contemporary Boston. Proceedings of the Fábos Conference on Landscape and Greenway Planning. 2016.

ON YILIU, Alessio Russo: Assessing the contribution of urban green spaces in green infrastructure strategy planning for urban ecosystem conditions and services. In: Sustainable Cities and Society, Vol. 68, pp. 102772. 2021.

PETER HALL: Cities of tomorrow, An intellectual history of urban planning and design since 1880. John Wiley & Sons, 2014.

S.T. PICKETT, M.L. Cadenasso: Landscape ecology, spatial heterogeneity in ecological systems. In: Science, Vol. 269, Issue 5222, pp. 331-334. 1995.

SUSANNAH GILL, J.F. Handley, Roland Ennos, Stephan Pauleit: Adapting Cities for Climate Change: The Role of the Green Infrastructure. 2009.

THE MINISTRY OF PLANNING AND ECONOMIC DEVELOPMENT: Egypt's 2021 voluntary national review, 2030 vision of Egypt. Cairo, 2021.

UNITED NATIONS, DEPARTMENT OF ECONOMIC AND SOCIAL AFFAIRS: Population Facts. 2020.

VAN OIJSTAEIJEN, W., et al. Urban green infrastructure, A review on valuation toolkits from an urban planning perspective. In: Journal of environmental management, Vol. 267, pp. 110603. 2020.

🏆 *reviewed paper*

Designing Inclusive Cities from the Elderly Perspective

Judith Ryser, Teresa Franchini

(Judith Ryser, judith@urbanthinker.com)
(Teresa Franchini, terefran@temanova.com)

1 ABSTRACT

Societies are aging rapidly worldwide which affects global, national and local economic structures. Such demographic change is attributed to increasing longevity and decreasing fertility, arguably due to higher living standards. International migration has also contributed to changing population age structures. According to the World Health Organisation the percentage of the population over the age of 60 will increase by 34% between 2020 and 2030, already exceeds that of children under five and will surpass young people between 15-24 by 2050.

These trends led the UN and other international organisations to seek answers. UN World Assemblies on Ageing produced Plans of Action and principles for older persons, recognising their specific needs, most specifically exclusion, but also isolation, paternalism and neglect. Among others, WSIS focused on ICTs and older persons, DESA addressed elder abuse and UNIDOP adopted an age-inclusive agenda. UNDP stated that the UN Sustainable Development Gaols have to recognise older persons as active agents of societal development, not just vulnerable people, to achieve truly transformative, inclusive and sustainable development outcomes. WHO produced an international perspective of age-friendly cities and communities, set up an environment-friendly environments mentoring programme and a global database of age friendly practices. Many other international and intergovernmental organisations undertook initiatives for ageing societies with remarkable cooperation between them across their specialised fields.

This paper focuses on digitalisation, intergenerational relations, and of course planning and design solutions for age-friendly cities, considering them of particular interest to professionals of the built environment. When examining scope for action it relates these issues to the four aspects related to the Leipzig Charter (discussed by the authors in their CORP 2021 contributions) – social: unwanted loneliness and technological neglect; economic: minimum pensions to cover the cost of living and in particular of ICT access; environmental: inadequacy of urban spaces and mobility provision; political: neglect of priorities for elder persons as opposed to ‘urgent’ ones; and enactment of labour legislation which tends to exacerbate age discrimination.

A key issue emerging from this situation are the intergenerational effects of the treatment of old age. The paper explores what measures could be adopted in an ageing society to achieve a more equitable balance between the generations. This includes the response of young people to the comparative disadvantage of maintaining the current state of affairs for the elderly and whether they would support redress which may affect their relative advantages.

The second part of the paper will explore how the decade of action in which international policies have focused on the elderly has translated into their everyday life and critically comment on selected results. it will attempt to identify how these actions distinguish themselves from other initiatives to provide for special needs, in response to research on ageing, such as that undertaken by ARUP, and whether the recommended interventions have managed to improve specifically the quality of life of the elderly. It will also refer to undertakings both in Spain and the UK. The paper will conclude by identifying more age-friendly urban developments and how planning and urban design practices could facilitate them.

Keywords: ageing, design for special needs, user-friendly built environment, equal access

2 PREAMBLE

Ageing issues have only recently been included in urban planning and public space design. According to the authors, these issues have not been part of the concerns of urban planners until the late 1980s, when health-related agencies, especially the World Health Organisation (WHO), pointed to the necessity of adapting the physical environment to accommodate the needs of this growing segment of the population. At that time, the working-age male was no longer the generic reference for urban planning, giving rise to the concept of inclusive urban space, capable of responding to the needs of diverse social groups: children, women, the

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

physically handicapped, the elderly. The technical responses to these demands produced a wide catalogue of tried and tested urban interventions.

However, the elderly are a special group within the social diversity as their needs are framed in a specific life time, strongly linked to the conditions of the existing health and care environment. This uniqueness places the issue of the elderly in a sphere of action that goes beyond the prescriptions of urban planning: how to ensure the welfare conditions of the elderly in cities and, in particular, in rural areas affected by the ex-migration of the young population? For the authors, the adaptation of the physical fabric to the conditions of the elderly – and of the entire population at some point in their lives – focuses on the action of the fourth pillar of urban sustainability: the political-administrative one.

This paper explores these aspects. First, it focuses on the 'problem' of ageing and documents the origins of the issue; secondly, it reviews urban planning practices designed in this regard; and thirdly, it reviews some municipal responses designed to contribute to creating age-friendly cities and communities as mandated by UN-Habitat, detecting their similarities and singularities.

3 INTRODUCTION: THE UNDENIABLE AGEING OF THE POPULATION

The rapid and worldwide aging of societies is affecting global, national and local economic structures and – of relevance to planners – their repercussions on cities and how they are used, managed and transformed. Although they vary in different parts of the world overall current demographic trends are attributed to both increasing longevity and decreasing fertility, arguably due to higher living standards.

Data from the United Nations (UN) World Population Prospects 2022 shows that worldwide, people aged 65 and over outnumbered children under five for the first time in 2018. In 2022, there will be 771 million people aged 65 and over, three times more than in 1980 and projected to reach 994 million in 2030 and 1.6 billion in 2050. As a result, by 2050 there will be more than twice as many people aged 65 and over as there are children under the age of 5, and their number will be almost the same as that of children under the age of 12. While in some countries the rapid growth of the older population is mainly due to sustained high fertility levels in the past, the continued reduction in premature mortality of successive generations is the main driver in other countries.

The spatial distribution of this trend varies. Europe and North America had the most ageing population in 2022 (almost 19% of people aged 65 and over), followed by Australia and New Zealand (16.6%) and will continue to age considerably in the coming decades. The same is true for Latin America and the Caribbean, with an increase of over 65s of 9% in 2022 and 19% in 2050. In East and South-East Asia, it will increase from about 13% in 2022 to 26% in 2050. On a smaller scale, Sub-Saharan Africa over 65s are projected to increase from 3% in 2022 to almost 5% in 2050.[1]

4 WHEN THE PROBLEM OF THE ELDERLY IN CITIES GAINED INTERNATIONAL ATTENTION

The intergovernmental organisations – United Nations (UN), World Health Organisation (WHO), UN Habitat – were at the forefront of recognising the global issue of ageing. Already in 1977 WHO singled out the importance of health for productive lives. in 1986, The Ottawa Charter for Health Promotion stipulated strategies, among them “making supportive environments: physical, social, economic, political, recreational and cultural”.[2] In 1982, the First World Assembly on Ageing took place in Vienna under the auspices of the UN. It was a forum for debate on a new demographic reality: the ageing of the population that affected the countries with the highest economic levels. The purpose of the Assembly was to guarantee the rights of the elderly and the implementation of a series of measures to that end. In 2002, the 2nd World Assembly on Ageing was held in Madrid. By then, population ageing had spread throughout the world and the Assembly proposed its International Plan of Action on Ageing. It recognised the right of older people to enjoy a dignified life by participating through their own efforts in the socio-cultural, economic and political

[1] United Nations. Department of Economic and Social Affairs (2022). *World Population Prospects 2022: Summary of Results.*
[2] WHO. (2007). *Global Age-Friendly Cities: A Guide* https://apps.who.int/iris/handle/10665/43755

development of the environment in which they live. It also adopted the concept of "active ageing", coined a few years earlier.

The specific treatment of ageing in cities can be traced back to the Age-Friendly Cities project, conceived in 2005 at the 18th World Summit on Ageing during the XVIII World Congress on Gerontology in Rio de Janeiro. Promoted by WHO, the congress aimed to devise a model of an age-friendly city. The result "Global Age-Friendly Cities: A Guide" was published in 2007 and presented on 1st October, on the International Day of the Elderly. The Guide was based on the results of a research protocol (Vancouver Protocol) applied in 33 collaborating cities in all regions of the world. The focal points of the Guide addressed several aspects under eight headings: outdoor spaces and buildings, transport, housing, social participation, respect and social inclusion, civic participation and employment, communication and information, health and community support services.[3] In 2010, WHO created the Global Network of Age-Friendly Cities and Communities with the aim to connect cities, communities and organisations that share this common vision. Currently the network includes 1.333 cities and communities in 47 countries covering over 298 million people worldwide.[4] In 2016, WHO adopted the Global Strategy and Plan of Action on Ageing and Health as the Decade of Healthy Ageing for the period of 2016-2020, later extended to 2021-2030. A comparison of international initiatives of age-friendly environments relevant to planners identifies three particularly sensitive issues: the allocation of percentages of affordable housing for older people; the participation of older people in the design of public space and mobility; and the distribution of health and care facilities to enable "ageing at home".[5]

The UN 2030 Agenda for Sustainable Development launched in 2015 also included the elderly issue, although its mention was limited and somewhat random. Despite this, the Agenda offered several strategic entry points which could be used to raise the visibility of older people.[6] The New Urban Agenda adopted by UN-Habitat in 2016 focused on quality of life of older people in cities. It highlighted the importance of built space as a key factor for the quality of life of older adults, underlined the need for age-sensitive planning and committed governments to promote safe, secure, healthy and inclusive environments, by engaging stakeholders in governance to strengthen civic dialogue. Specific areas of intervention are mobility and transport, housing, public green spaces, communication facilities and public service provision, including information technology, considered as a component of accessibility.[7]

The actions taken by the various branches of the UN successfully mobilised many other international and intergovernmental organisations into cooperation across their specialised fields to seek specific responses to the ageing problem. In 2021, the European Commission launched the Green Book of Ageing to produce a broad policy debate on the matter The book sets out the principles for an ageing and prosperous European society, including the promotion of healthy and active ageing, lifelong learning, access to education, the provision of new opportunities after retirement and the implementation of adequate, fair and sustainable pension systems to avoid poverty in old age.[8] Among others organisations addressing ageing are the World Summit of the Information Society (WSIS) which focused on Information and Communication Technologies (ICT) and older persons; the UN Department of Economic and Social Affairs (DESA) which addressed elder abuse and the UN International Day of Older Persons (UNIDOP) which adopted an age-inclusive agenda.

[3] https://apps.who.int/iris/handle/10665/43755
WHO (2007), Global Age-Friendly Cities: A Guide
[4] WHO. *Global Network for Age-friendly Cities and Communities*
https://extranet.who.int/agefriendlyworld/who-network/
[5] Bosch-Meda, J. (2021). *Is the Role of Urban Planning in Promoting Active Ageing Fully Understood? A Comparative Review of International Initiatives to Develop Age-Friendly Urban Environments.* ACE: Architecture, City and Environment, 16(47)
https://www.researchgate.net/publication/356616659_Is_the_Role_of_Urban_Planning_in_Promoting_Active Ageing_Fully_Understood_A_Comparative_Review_of_International_Initiatives_to_Develop_Age-Friendly_Urban_Environments
[6] Courtis. C. (2017) *Las personas mayores y la Agenda 2030 para el Desarrollo Sostenible: oportunidades y desafíos.* CEPAL, UN
https://www.cepal.org/es/enfoques/personas-mayores-la-agenda-2030-desarrollo-sostenible-oportunidades-desafios
[7] UN. (2016). *The New Urban Agenda.*
https://habitat3.org/wp-content/uploads/NUA-Subject-Index-English.pdf
[8] European Commission (2021). *Green Book of Ageing*
https://ec.europa.eu/info/files/green-paper-ageing-fostering-solidarity-and-responsibility-between-generations_en

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

These proposals are not dissimilar to those formulated for sustainable and inclusive cities for all, proposed by UN Agenda 21.

5 REDESIGNING INCLUSIVE CITIES FOR ELDERLY PEOPLE

After forty years of global action on ageing to guarantee economic and social security for older persons, the concrete actions proposed have not yet produced adequate preparedness for ageing dynamics.[9] Although a comprehensive approach is recommended for actions focusing on health, work, education, income, social cohesion, multigenerational wellbeing and climate sustainability, the generic nature of government recommendations on adapting the built environment to ageing have limited the amount of age-specific actions. The most practical solutions are mainly proposed by age-related interest groups and NGOs.[10]

There exists a plethora of guidelines for good design of age-friendly cities. However, many of them are reiterating attributes which characterise liveable cities more generally. Criteria of good design for special groups have been directed towards children, youth and the disabled and did not specifically respond to the vulnerability of the elderly.[11] While many constraints of the elderly also apply to other groups with special needs it remains important to identify the specific provisions for age-friendly cities. The intention here is not to address abstract knowledge of good design and regulations, but to deliberate how they can be translated into practice. Such an undertaking has to start from the 'is-state' and, in particular, the broad range of living conditions of the less affluent older people. They vary considerably from city to city, country to country as well as globally, as they are affected by the actual configuration of cities, as well as place-based economic barriers and political impediments.

For planners and urban designers there are numerous questions that remain without concrete answers, most important among them: are cities designed and prepared to manage long-life societies? how to promote healthy ageing when this aspect has not been part of the design and management of urban spaces? how to provide for active ageing and how to accommodate the economy, services, housing, transport to the way the elderly use urban space? The needs and demands of older people require more specific studies also on other aspects: where do the elderly live? what are their housing conditions? how do they use unadapted public spaces? what are the reasons for their strong sense of place and of the neighbourhoods where they live? what about their low mobility, routine behaviour, home ownership? Do they want to stay in their homes as long as autonomy allows or do they prefer to move to desired locations such as coastal cities or childhood environments? To what extent does their interest in the neighbourhood or the city in which they live disappear when they are forced to move to sheltered residences? Many questions are raised about age-friendly cities and communities but answers remain often generic and overlap with solutions for other special needs groups.[12] There seems to be general consensus that best practice needs to enable older people to get involved in the design of their urban environment. The Age-Friendly Movement may be best placed to help develop new models of age-friendly cities, age-friendly assessment tools, and to provide criteria for age-related digitalisation of society. What really matters is how to reduce physical and psychological fears, real or perceived, produced by a combination of spatial (accessibility, quality of housing), environmental (noise, pollution) and social (crime, insecurity, poverty, health, abandonment, loneliness) aspects.

6 PRACTICAL ANSWERS FOR THE DESIGN OF INCLUSIVE AGE-FRIENDLY CITIES

Finding answers for gerontological urbanism involves reviewing the available information, both theoretical and practical. An example is the research undertaken by ARUP, presented in "Cities Alive – Designing for

[9] Oxford Institute of Population Ageing (2022). *Forty Years of Global Action on Ageing: what has been achieved? And what next?*
https://www.ageing.ox.ac.uk/blog/Forty-years-of-Global-Action-on-Ageing-what-has-been-achieved
[10] Ageing Well: A Housing Manifesto, Older People's Housing Champions, 2017
[11] Specific references are lacking on the emerging issues and recommendations by thematic areas in the Report of the Ninth Session of the World Urban Forum, May 2019
[12] J van Hoof, HR Marston, JK Kazak, T Buffet. (2021). *Ten questions concerning age-friendly cities and communities and the built environment.* In Building and Environment 199 107922, Elsevier
https://reader.elsevier.com/reader/sd/pii/S0360132321003267?token=67578CB5DE2D84D25F5DBBD575EF2BEB4AA896562ACC5B39731708505BDBC6FF1FDC9335005CDAED76CEEA5B4AC8CF95&originRegion=eu-west-1&originCreation=20220715105132

Ageing Communities".[13] It analyses four basic needs of older people – autonomy and independence; health and well-being; social connectedness; safety and resilience which have been identified and acknowledged internationally as discussed above. The research proposes 14 strategies and 28 actions to meet these needs. 40 case studies from all over the world illustrate evidence of age-friendly places and neighbourhoods based on these criteria and design interventions.

The 14 strategies encompass physical as well as social approaches. In terms of design tasks they create walkable environments, ensure access to public transport, enable ageing-in-place by adapting homes, and provide wayfinding and city information with landmarks and tools suitable for the elderly to preserve their autonomy and independence. Urban design solutions also provide access to health services within reach, space for exercise and recreation and facilitate connections to nature for the elderly to enhance their health and wellbeing. Security and resilience of age-friendly neighbourhoods and homes are achieved by preparedness for extreme climate incidents, safe design of streets and public spaces and special urban design solutions for dementia-safe surroundings. Combining spatial with social solutions fosters connectedness by creating intergenerational spaces and adapting spaces for older people to stay in their communities, thus alleviating loneliness and isolation and promoting inclusion and civic participation.

From the 40 case studies the research extrapolates 28 very practical and well-rehearsed urban design and planning solutions to satisfy the four basic age-related needs respectively. Actions for autonomy and independence include: creating compact mixed use development, redesigning public spaces for all users, locating housing, jobs and amenities along transit routes, making transit access suitable for people with limited mobility, improving their homes, retrofitting homes and designing new housing adaptable to senior use, improving the public realm and providing way-finders. Actions towards health and wellbeing include: locating health facilities near transit and co-locating them with provision for daily needs, places for adult and active recreation, more green spaces and buildings with biophilic principles. Actions for social connectedness aim to empower older people to organise their own community activities and give them a role in planning their built environment; they also include: designing intergenerational housing so that elderly can live with or near family, co-locating facilities and places for seniors and youth, and broadening house types by adding accessory units and spaces to facilitate downsizing within their community, reducing costs for the elderly and freeing space for the younger generations. Actions for security and resilience include: mitigating heat wave effects, retrofitting buildings for climate change, ensuring walkability with physical infrastructure, improving dangerous intersections, and creating dementia friendly neighbourhoods and dementia villages.

7 CASES CONTRIBUTING TO AGE-FRIENDLY CITIES AND COMMUNITIES"

The Global Network of Age-Friendly Cities and Communities is compiling a comparative review of international incentives which cities the world over are putting into place to adapt themselves better to the needs of the elderly. A study of the specific plans which cities have elaborated following the requirements of the Global Network of Age-Friendly Cities and Communities[14] assesses to what extent these criteria have been taken into account. From the results, it could be argued that many solutions these cities have implemented apply equally to needs of other groups: children, people with physical or mental impairments, communities with specific cultural, religious backgrounds guiding their customs, behaviours and aspirations. This may mean that specific adaptation of cities to the elderly is unlikely to command particular attention.

7.1 The Madrid Plan

Madrid joined the Global Network of Age Friendly Cities in 2013[15] and approved its first Elderly Friendly City Action Plan for the period 2017-2019. The Madrid Plan encompasses ageing in three strategic areas: 1 Civic and social environment: a city for all generations; 2 Prevention and comprehensive care: a city that

[13] ARUP (foresight, research and innovation and integrated city planning teams). (2015). *Cities alive, Designing for Ageing Communities*
https://www.arup.com/perspectives/publications/research/section/cities-alive-designing-for-ageing-communities
[14] WHO (2018). *The Global Network for Age Friendly Cities and Communities, looking back over the last decade*
https://www.who.int/publications-detail-redirect/WHO-FWC-ALC-18.4
[15] Ayuntamiento de Madrid (2021). *Plan Madrid Amigable con las Personas Mayores 2021-2023*
https://www.madrid.es/UnidadesDescentralizadas/Mayores/Especial%20informativo/Madrid,%20ciudad%2migable/Plan%20de%20Acci%C3%B3n%20Madrid,%20ciudad%20amigable%20con%20las%20ersonas%20mayores%202021-23.pdf

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

responds to the needs of the older population; 3 Friendly urban environment: a city that adapts to all people. The Madrid Plan contains many strategies towards creating a more user friendly city which aims to be inclusive of all people with special needs, thus also the elderly. For that reason fewer actions may be specifically designated for the ageing population, although that group is singled out in the strategy for care. Nevertheless, the strategy to create a friendly environment for all people includes several actions specifically directed towards ageing. Among them are: allocating 5% of rental housing of the Municipal Housing Company to the over 65, according to family circumstances, disability or degree of dependency; social interventions in neighbourhoods with and for the elderly specified in the neighbourhood plans; maintenance and promotion of the use of areas for the elderly, including elementary sports circuits; dynamic evaluation of facilities for the elderly in areas with 20% or more population over 65, subject to availability of vacant land; promoting pedestrianisation with special itineraries for the elderly to municipal centres; improving mobility and safety for the elderly in public spaces; planting trees in parks near municipal senior citizen centres; ensuring universal accessibility and safety of public transport use also for the elderly. Furthermore, the many actions in the Madrid Plan aimed to improve the sustainability of Madrid's environment benefit the ageing as well.

7.2 The Greater London Plan

Greater London in the UK has not joined the age-friendly WHO network, possibly because strategically, the London Plan 2021[16] does not devise specific policies to satisfy the needs of the elderly. London is selected to illustrate the interdependence – synergies as well as unplanned contradictions between sectoral objectives which is inherent in all strategic and urban planning. This applies also to the relation between age-friendly and other city strategies identified in the latest London Plan adopted in 2021. One example is the compelling strategy to improve air quality, considering that London's air pollution is exceeding recommended maxima most of the year. Some 4000 deaths are attributed annually to poor air quality in Greater London, among them disproportionately the elderly. However, better air quality aims to reduce the death toll overall which would also benefit children and persons with respiratory diseases among others. Implementation of this strategy brought about unforeseen consequences. The congestion charge in central London, aimed to reduce car journeys, led to segregation between those who could afford the charge and the less affluent, not least those with compelling reasons to travel by car to the central area. Adding ULEZ (Ultra Low Emission Zone) up to the inner ring road aimed to reduce car journeys and encourage the use of electric cars, but again discriminated against those who could not afford to scrap their petrol and diesel cars. Extending ULEZ to the boundaries of Greater London will simply increase segregation, especially in outer areas with poor public transport. While air quality had improved noticeably during covid lockdowns air pollution is now exceeding pre-covid levels as workers were encouraged to use their cars to avoid catching covid on public transport. Another example is affordable housing, a key strategy of the labour mayor's London Plan. Providing more of it should benefit the poorer elderly, but many other families on low income share this need and leave demand unfulfilled.

7.3 Ageing in Manchester

Although a relative young city due to its student population and attracting younger workers, by 2040 one third of the population will be 50 and older.[17] As 36% of the Manchester's older residents were income deprived, while 59% of older people lived in the most deprived neighbourhoods at the turn of the century the city decided to act. Manchester, the second largest metropolitan area of the UK became a pioneer on ageing and was first to join the WHO Age Friendly World.[18] In 2003 it devised its initial age friendly strategy: "Valuing Older People", transformed in 2009 into "A Great Place to Grow Older"[19] updated in 2017. This led to three strategic priorities: promotion of age equality, age-friendly neighbourhoods and age-friendly

[16] Mayor of London, The London Plan, A Spatial Strategy for Greater London, March 2021
file:///C:/Users/teref/Downloads/III_plan_amigable_personas_mayores%20(4).pdf
[17] City Monitor (2020). *Manchester follows Asia's lead in designing age-friendly cities.*
https://citymonitor.ai/community/neighbourhoods/manchester-follows-asias-lead-in-designing-age-friendly cities
[18] WHO. *Age Friendly World: Manchester UK*
https://extranet.who.int/agefriendlyworld/network/manchester/
[19] Age-Friendly Manchester Programme. *A Great Place to Grow Older*
https://www.manchester.gov.uk/download/downloads/id/25294/manchester_a_great_place_to_grow_older.pdf

services. For their implementation the city government set up the Manchester Older People's Board, the Manchester Age Friendly Assembly with senior representation, and the Age Friendly Culture Working Group, a network of over 100 older volunteers who help increase the cultural participation of older people in the city. Other concrete measures are: a 50+ employment and skills support group, dissemination of information on age-friendly work and the council becoming an age-friendly employer. The council also initiated the "Take a Seat Campaign" asking local businesses to make seating, toilets and drinking water freely available for the elderly. A 1 million £ initiative funded by Sport England led to pilot projects in 8 neighbourhoods which, inter alia, involved the elderly in the design of ways for them to take up physical activity with tangible results.[20] Acknowledging that age friendly initiatives remain a patchwork across the city of Manchester has pledged to achieve age-friendly features in each neighbourhood, quotes concrete actions to get there and has instated a monitoring system to measure progress.

7.4 The Bilbao City Plan for an age-friendly city

After the city joined the International Network of Friendly Cities in 2010, Bilbao drafted three documents: Plan I (2012-15), Plan II (2016-2019) and Plan III (2020-2024). The current Plan[21] is structured around 10 strategic objectives responding to the conditions of the environments recommended by WHO: outdoor spaces and buildings, mobility and transport, activities and social life, citizen participation and employment. The Plan focuses in particular on five areas aimed at improving the living conditions of older people in the city: fostering social participation; strengthening community relations in neighbourhoods from an intergenerational perspective; contributing to the empowerment and social recognition of the elderly; guaranteeing their quality of life from the perspective of care; moving towards new residential models; improving their mobility and accessibility; involving older people in sustainable urban development and promoting active and healthy ageing. The 34 actions associated with these objectives are mostly related to social aspects (25), with comparatively few actions related to urban space (9). The measures are of a generic nature, mostly supported by ongoing municipal initiatives. Actions of a social nature are aimed at stimulating the participation of older people in the life of the city and its neighbourhoods and municipal governance, contributing to their empowerment through lifelong learning and changing stereotypes and attitudes that hinder their social recognition. Physical, mental and emotional health, unwanted loneliness, social exclusion and gender inequality are crucial issues, which are addressed by strengthening care services, promoting physical and sporting activities and taking measures to improve accessibility to information and reducing the digital divide. The actions aimed at urban space focus on three aspects: housing, mobility and sustainable development. With regard to housing, the goal is to delay the need for residential care homes by means of adaptation and accessibility measures for existing housing and by developing pilot projects to investigate new residential models for the elderly. With regard to mobility and accessibility, the municipal plans incorporate the age perspective and promote the participation of the elderly in their design. In relation to sustainable urban development, the plan aims to involve older people in the UN Sustainable Development Goals and to tackle the climate crisis by promoting the use of renewable energies and recycling.

8 CONCLUSION

The concept of "age-friendly city" is not new. As the paper shows, Intergovernmental organisations like the United Nations, the World Health Organisation and many others have promoted age-friendly cities for some decades, although progress has been slow. Measures to make cities more age-friendly are both managerial and physical. The latter, aiming at adaptations of the built environment are concerning architects, urban designers and planners. Age-friendly technical as well as design solutions have been developed and applied to buildings, mainly housing, but also workplaces and public buildings, albeit not at the scale necessary.

[20] Greater Manchester Moving. *Active Ageing Programme*
https://www.gmmoving.co.uk/commitments/people-families-and-communities/active-older-adults/active ageing-programme

[21] Ayuntamiento de Bilbao (2020). *III Plan Amigable con las Personas Mayores*
https://www.bilbao.eus/cs/Satellite?blobcol=urldata&blobheader=application%2Fpdf&blobheadername1=Content-disposition&blobheadername2=pragma&blobheadervalue1=attachment%3B+filename%3DIII_plan_amigable_personas_mayores.pdf&blobheadervalue2=public&blobkey=id&blobtable=MungoBlobs&blobwhere=1274334927749&ssbinary=true

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Equally, age-friendly urban design solutions have been developed and implemented, focusing on parks and open spaces, streets and mobility, again not at a pace which could satisfy all needs of the elderly.

In planning, the four case studies show how cities have incorporated age-friendly policies in their plans. They reveal the differences between cities that have joined the WHO international network (Madrid, Bilbao and Manchester) and those that have not (London). The former three show how the instructions contained in the WHO Age-Friendly Cities Guide have guided municipal actions in adapting the content of their plans to the needs of the elderly. The case of London reveals that a strategic urban plan is not the ideal instrument to address the needs of a specific segment of the population. The initiatives to curb excessive pollution and to redress the lack of affordable housing are affecting the whole London population and aspects directly related to ageing would require specific instruments leading to targeted policies.

The three cities associated with the WHO network focus their interests on different but concurrent strategic areas. Madrid aims to be a city for all generations responding also to the needs of the older population. Manchester actively promotes age equality, age-friendly neighbourhoods and age-friendly services. Bilbao calls for empowerment and social recognition of the elderly and includes many sectoral measures to improve their quality of life. However, most measures put in place for older people focus on social aspects to the detriment of spatial aspects, while all these measures apply also to the whole population. Madrid stands out for setting aside a percentage of rental housing for the elderly in public developments and its studies on the dynamics of facilities in areas with a high percentage of elderly people; Manchester for generating numerous age-friendly organisations after the approval of its plan; and Bilbao for empowering older people through lifelong learning, access to information, reduction of the digital divide, prevention of loneliness and involvement in the Sustainable Development Goals.

Over the recent past, age-friendly city strategies have been devised and implemented by many cities, albeit pragmatically, often as pilot projects, rather than as successful comprehensive city strategies which may be attributed to the inertia of the built environment. Nevertheless, the paper aims to show that many actions which benefit the elderly are taking place in the real world and are therefore doable. It suggests that the reasons why age-friendly solutions are not more mainstream may well lie outside design solutions and social engineering. Fragmentation into silos unwilling to cooperate or share is widespread in planning and design and history shows that such segregation may well be an inherent characteristic rooted generally in the structure and organisation of human society and its power relations. Arguably. the way the needs of older people are divided into four categories and treated separately in the case studies of the ARUP research may indicate such unconscious but deeply internalised features of human perception and understanding of its own nature. Thus progress may have to shift from spatial or technical solutions to political action, leading to changes in human behaviour to achieve not only age-friendly cities, but cities where all parts of society can find a sustainable way of life.

The paper demonstrates that age-friendly design and planning measures are equally applicable to other special needs groups, and indeed are the attributes of what are conceived as liveable sustainable cities today. It is therefore difficult to isolate specific measures for the elderly, although they tend to benefit from innovative designs and urban management approaches developed for more general purposes, such as recent adaptation and mitigation of adverse climate change effects, or adjustment of the built environment to pandemic conditions. It may be argued that good architecture and urban design would have to produce buildings and neighbourhoods which are user-friendly for all groups of society. This does not mean though that there is no need to understand and provide for the specific needs of the elderly when adapting existing buildings and neighbourhoods or designing new ones. The four short case studies show initiatives towards age-friendly cities at the strategic planning level, but also in terms of practical solutions. An important aspect to take into account when designing age-friendly cities is the compatibility or possible contradiction between special needs and how to reconcile them with each other, or to negotiate compromise design solutions. For example, parks are used by very different types of people and ideally such open spaces should be able to accommodate contradictory needs which presents real design as well as political challenges.

Finally, assertive user groups have led to wider community engagement and mobilised the built environment professionals to adopt new planning and design approaches, design codes being among the most recent ones. However, even the latest design criteria, such as the compact city, the 15 minute city, mixed uses or blue-green corridors are not really new. They have existed for a long time among the planning paraphernalia,

albeit in a more prescriptive form, such as desired maximum distance between a school, a bus stop or even a high street and housing estates when land use was segregated and confined to zones rather than integrated. This planning history should be taken into account when thinking of how to incorporate demands of more consciously recognised special needs, including those of the elderly in rapidly ageing societies.

9 ACRONYMS

CIFAL Global Network
DESA Department of Economic and Social Affairs
ICT Information and Communication Technology
ILC International Longevity Centre
INPEA International network for the Prevention of Elder Abuse
SDG Sustainable Development Goals
WHO World Health Organisation
WSIS World Summit of the Information Society
UN United Nations
UNDP United Nations Development Programme
UNFPA UN Population Fund (former: UN fund for population activities)
UNHCR United Nations High Commission for Refugees
UNIDOP United Nations International Day of Older Persons
UNITAR UN International Training Centres for Authorities and Leaders

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

🏆 *reviewed paper*

Die gesunde Stadt im Kontext der Mobilitätswende – Einflüsse der gebauten Umwelt auf ein nachhaltiges und bewegungsförderndes Verhalten

Kerstin Kopal, Dirk Wittowsky

(MSc. Kerstin Kopal, Universität Duisburg-Essen, Institut für Mobilitäts- und Stadtplanung, Universitätsstr. 15, 45117 Essen, kerstin.kopal@uni-due.de)
(Prof. Dr.-Ing. Dirk Wittowsky, Universität Duisburg-Essen, Institut für Mobilitäts- und Stadtplanung, Universitätsstr. 15, 45117 Essen, dirk.wittowsky@uni-due.de)

1 ABSTRACT

Städte und Gemeinden bilden komplexe Mikrokosmen, in denen Menschen mit unterschiedlichen Bedürfnissen und Fähigkeiten leben. Die Stadt bestimmt mit ihrer baulichen Gestalt und Funktionalität die Räume für individuelle Mobilität, mit Einfluss auf Gesundheit und Lebensqualität der Bevölkerung. Dabei stellen die Einflüsse der gebauten Umwelt auf die Gesundheit und das Mobilitätsverhalten einen zentralen Forschungsgegenstand für eine umfassende Verkehrs- und Mobilitätswende dar. Vor allem vor dem Hintergrund des Klimawandels und der Energiewende, sowie neuen Anforderungen an urbane Systeme durch zunehmende Extremereignisse oder Pandemien wird deren Bedeutung umso wichtiger. Um diesen interdisziplinären Zusammenhang zu erforschen, wurde am Institut für Mobilitäts- und Stadtplanung (imobis) der Universität Duisburg-Essen eine interdisziplinäre Empirie mit milieuspezifischen Elementen zu gesundheitsbezogenen Aspekte, Umfeldqualität, Mobilitätsverhalten und Aktionsradius sowie personenspezifische Einstellungen, Mobilitätskultur und Zukunftswünsche als Online-Befragung mit 500 Personen in Essen konzipiert und durchgeführt. Für die gebaute Umwelt sind unter anderem Items des deutschen Neighborhood Environment Walkability Scale (NEWS) eingeflossen sowie auf Grundlage der Theory of Planned Behavior (TOPB) Items zur Erklärung des Mobilitätsverhaltens eingebunden und kartengestützt Aktionsräume erfasst. Damit konnte eine umfassende Datenbasis geschaffen werden, um Abhängigkeiten und Wechselwirkungen zwischen den Qualitäten der gebauten Umwelt und aktiven Bewegungs- sowie Verhaltensmustern aufzudecken und zu analysieren.

Was sind aber die diskriminierenden Faktoren für ein aktives Mobilitätsverhalten im Spannungsfeld von Wohnumgebung und Quartier, baulichen Strukturen sowie individuellen Einstellungen und Normen?Zur Beantwortung dieser Frage werden mobilitätsrelevante Indikatoren und Aktionsradien sowie die bauliche Umgebung analysiert und multivariate Analysen durchgeführt, um die Art und Richtung von Effekten auf die Gesundheit und das Mobilitätsverhalten abzuschätzen. Außerdem können durch die Identifikation der Indikatoren bzw. Umfeldvariablen Handlungsempfehlungen für eine bewegungs- und gesundheitsförderliche Kommune abgeleitet werden. Im Sinne des „Health in all Policies“-Ansatzes ist es für alle Kommunen wichtig, die Themenbereiche Mobilität und Stadtgestaltung integriert zu betrachten, um die Gesundheit proaktiv zu fördern und gleichzeitig das Klima zu schützen.[1]

Keywords: Verhalten, Stadtplanung, Gesundheit, Mobilität, Mobilitätswende

2 EINLEITUNG

Der Verkehrssektor ist nach wie vor für den größten Anteil des Schadstoffausstoßes verantwortlich, allen voran der motorisierte Individualverkehr (MIV) und der Flugverkehr (Heinrich-Böll-Stiftung und VCD Verkehrsclub Deutschland e.V. 2019). Dies wirkt sich auf verschiedenen Ebenen negativ auf die Gesundheit der Bevölkerung aus: zum einen trägt ein autoorientierter Lebensstil zu einer bewegungsarmen Mobilität bei, zum anderen ist der Schadstoffausstoß für die Gesundheit und Atemwege schädlich (Schulz et al. 2019; Conrad et al. 2018). Menschen atmen täglich etwa 10.000 Liter Luft pro Tag ein und dennoch gehört Luftverschmutzung laut WHO zu den größten negativen Einflussfaktoren auf die Gesundheit. Insbesondere Städte sind in Folge des hohen Verkehrsaufkommens und der dichten Bebauung einer hohen Luftverschmutzung ausgesetzt. Der Straßenverkehr steht hier im Fokus, da die Konzentration von Luftschadstoffen fast ausschließlich an Straßen sehr hoch ist, darüber hinaus leben viele Menschen in deren unmittelbaren Umgebung. Die verkehrsinduzierten Schadstoffe können Erkrankungen der Atemwege, Herz-Kreislauf-Beschwerden und Herzinfarkte auslösen oder verstärken - jährlich sterben 8,8 Millionen Menschen

[1] Dieses Paper enthält Exzerpte aus dem Beitrag „Stadtgesundheit als Baustein der Mobilitätswende – Wie beeinflusst die gebaute Umwelt ein nachhaltiges und bewegungsförderndes Verhalten?“, welcher im Rahmen des 14. Wissenschaftsforum Mobilität veröffentlicht wird.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

vorzeitig an den Folgen schlechter Luft. (Heinrich-Böll-Stiftung und VCD Verkehrsclub Deutschland e.V. 2019) Hinzu kommt die Umweltbelastung durch den Verkehrssektor für Flora und Fauna, aber auch durch die Versiegelung der Flächen ist ein natürlicher Luftaustausch innerhalb von dicht bebauten Gebieten nicht gegeben und die Gefahr von innerstädtischen Hitzeinseln steigt (WHO 2019). Zudem ist die Mobilitäts- und Gesundheitsgerechtigkeit an dieser Stelle weiterzuführen, da die Überlagerung von hohen Verkehrsbelastungen mit starken Schadstoffen, geringer aktiver Mobilität und der Zugang zu neuen Mobilitätsformen sowie dem Bewusstsein für nachhaltige Verhaltensweisen untersucht werden müssen.

Klimawandel und Gesundheit sind eng miteinander verwoben und bedingen die Gegebenheiten in der Stadt gleichermaßen für die gesamte Bevölkerung. An dieser Stelle sind auch die Synergien zwischen Gesundheit und Mobilitäts- und Stadtplanung relevant, wenn man berücksichtigt, dass das Mobilitätsverhalten und die alltägliche körperliche Betätigung auch durch die baulichen Gegebenheiten in der Wohnumgebung beeinflusst werden. (Conrad et al. 2018; Reyer 2017) Wenige städtische Strukturen fördern jedoch eine aktive und gesunde Mobilität und oftmals sind unzureichende oder gänzlich fehlende Infrastrukturen zu beobachten, die eine barrierefreie und komfortable Nutzung mit aktiven Mobilitätsformen erschweren (Schmidt et al. 2018). Anhand dieser Synergien und Verknüpfungen lässt sich die direkte Verknüpfung von Stadt, Mobilität und Gesundheit ableiten. Daher befasst sich dieses Paper mit der „Trias“: gebaute Umwelt (Stadtplanung), räumliche Mobilität (Mobilitätsplanung) und Gesundheit (Gesundheitswissenschaften).

2.1 Methodik und Ziel

In dem vorliegenden Forschungsprojekt steht die Frage im Mittelpunkt, welche die diskriminierenden Faktoren für ein aktives Mobilitätsverhalten im Spannungsfeld von Wohnumgebung und Quartier, baulichen Strukturen sowie individuellen Einstellungen und Normen sind. Durch die interdisziplinäre Empirie und eine umfassende Datenbasis ist ein Vergleich zwischen Aktionsradien, dem Mobilitätsverhalten sowie der gebauten Umwelt und deren Infrastrukturen möglich. Mit Hilfe von statistischen Modellen können die Effektgrößen auf die Gesundheit und das Mobilitätsverhalten abgeschätzt und einzelne Indikatoren bzw. Umgebungsvariablen für eine bewegungs- und gesundheitsförderliche Kommune abgeleitet werden. Dieses Paper zeigt erste Einblicke und Ergebnisse in die aktuelle Forschung. Die Ergebnisse werden in der geplanten Dissertation „Die bewegende Stadt - Einflüsse der gebauten Umwelt auf eine gesunde Mobilität in der Stadt“ durch die Autorin dieses Papers weiter vertieft.

3 STAND DER FORSCHUNG

Der vorliegende Beitrag behandelt das interdisziplinär angelegte Konstrukt der Trias (siehe Abbildung 1). Im Folgenden wird zunächst das erste Forschungsfeld der Trias, die gebaute Umwelt, dargelegt. Darauf folgt die Erläuterung des zweiten Forschungsfelds, die räumliche Mobilität. Die Synergien des dritten Forschungsfeldes, die Gesundheit, fließen in die Auslegungen der beiden ersten Forschungsfelder ein. Abschließend folgt die Erläuterung zum Mobilitätsverhalten im Kontext des Trias, welches innerhalb des zweiten Forschungsfeldes (Räumliche Mobilität) seine Verankerung findet.

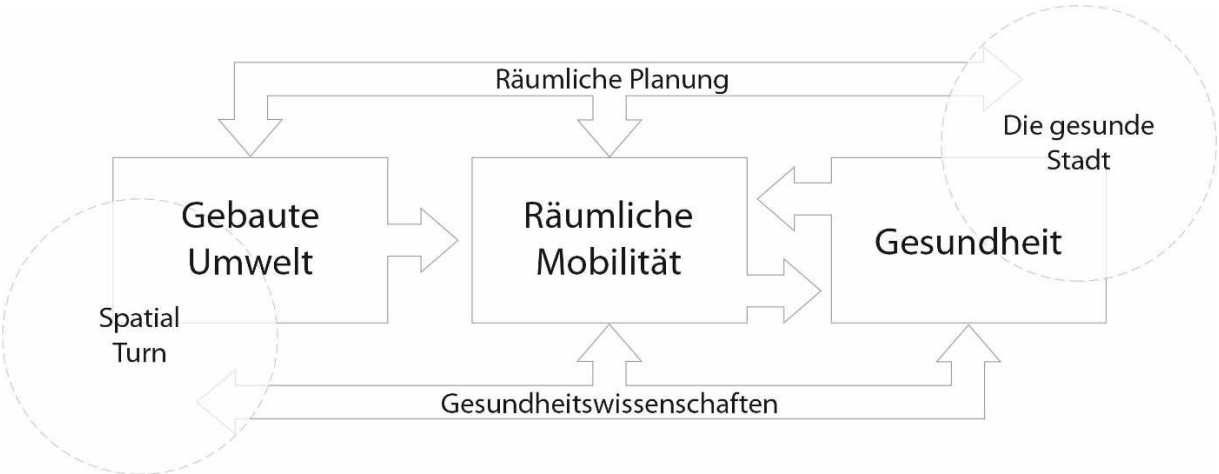


Abb. 1: Die Trias des Forschungszweiges mit disziplinären Zugängen (Kopal, 2022 nach Ohnmacht und Sauter, 2007).

3.1 Die gebaute Umwelt in den Gesundheitswissenschaften

Durch den Spatial Turn, also die stärkere Berücksichtigung räumlicher Kontexte in den Gesundheitswissenschaften und den Paradigmenwechsel vom Individuum zur Umwelt, nimmt die gebaute Umwelt ein breites Spektrum in den Gesundheitswissenschaften ein (Schwedes 2018; Andrews et al. 2012).

Die gebaute Umwelt aus Sicht der Gesundheitswissenschaften lässt sich gut in der Health Map von Barton und Grant betrachten. Die Health Map stellt ein humanökologisches Modell einer Siedlung dar und beschreibt die Determinanten von Gesundheit und Wohlbefinden im Wohnumfeld des Menschen. In diesem Modell sind unterschiedliche Bereiche des sozialen und wirtschaftlichen Lebens und der näheren Umwelt dargestellt, auch die gebaute Umwelt stellt in dem Modell einen Einfluss auf die Gesundheit dar (siehe Abbildung 2) (Barton und Grant 2006).

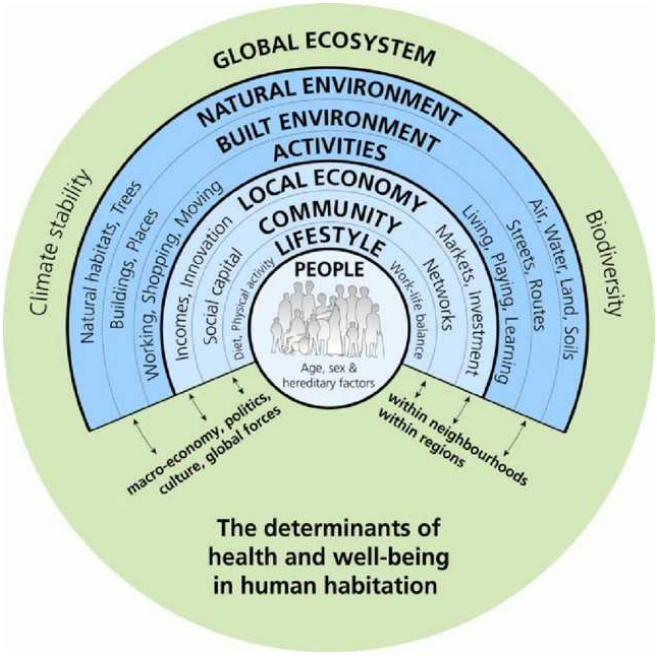


Abbildung 2: Health Map (Barton und Grant, 2006).

An dieser Stelle ist die Verzahnung zur räumlichen Planung erkennbar. Vereinfacht dargestellt besteht die gebaute Umwelt aus Siedlungsstrukturen und infrastrukturellen Vernetzungen. Die Entwicklung dieser Strukturen soll durch die räumliche Planung gesteuert werden, daher setzt sich die Disziplin der Gesundheitswissenschaften seit dem Spatial Turn auch intensiv mit Mobilitäts- und Stadtplanung auseinander (Andrews et al. 2012).

3.2 Räumliche Mobilität und Gesundheit

Ein weiteres Forschungsfeld innerhalb der Trias stellt die räumliche Mobilität dar. Die Wirkung der gebauten Umwelt und der individuellen Gesundheit auf die räumliche Mobilität bzw. körperliche Aktivität ist aktuell im Fokus vieler Forschungen. Die eigene individuelle körperliche Aktivität übt jedoch auch Einflüsse auf die Gesundheit aus, dies ist bereits empirisch belegt (Ohnmacht und Sauter 2007). Verschiedene Studien haben bestätigt, dass tägliche Bewegung die Lebenserwartung erhöht sowie das Risiko von Übergewicht und Herz-Kreislauf-Erkrankungen verringert (Powell et al. 2011). Auch die WHO empfiehlt tägliche Bewegung, um den Körper und seine Organe über das Herz-Kreislauf-System mit auseichend Sauerstoff zu versorgen (WHO Regionalbüro Europa 2010). Auf Grund dieser Tatsache gibt es zahlreiche Aktionspläne und Empfehlungen aus verschiedensten Netzwerken, um die physische und aktive Mobilität in der gebauten Umwelt zu steigern (sowohl auf individueller als auch auf kommunaler Ebene). Bereits in der Ottawa-Charta der WHO zur Gesundheitsförderung von 1986 ist die Rede von einer systematischen Erfassung der gesundheitlichen Folgen der Umwelt. Unter anderen ist hier auch konkret die Stadtentwicklung genannt im Zusammenhang mit der Sicherstellung eines positiven Einflusses auf die Gesundheit der Öffentlichkeit. Darüber hinaus ist auch die Raumplanung laut Charta in den Mittelpunkt der öffentlichen Aufmerksamkeit zu stellen, um eine gemeinsame Verpflichtung zur Gesundheitsförderung zu erreichen und zu fördern (WHO 1986). Die Ottawa-Charta war die erste, welche Handlungsstrategien und Handlungsfelder für eine

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

gesundheitsfördernde Gesamtpolitik nannte. Dieses Vorgehen ist heute fester Bestandteil in den Gesundheitswissenschaften und als Health in All Policies-Ansatz bekannt (AGGSE 2020). Somit soll die Gesundheit der Bevölkerung in allen Politikbereichen weiter integriert und die Einbindung gefördert werden (Baumeister et al. 2016).

Speziell im Bereich der Mobilitätsplanung ist verstärkt die Forschung und Praxis zur Entwicklung von einer autoorientierten zu einer nachhaltigen Fortbewegung zu beobachten. Die Förderung von nachhaltigen Fortbewegungsmitteln, wie des Rad- oder Fußverkehrs, haben positive Effekte auf die Gesundheit durch die erhöhte physische Aktivität und begünstigen den Ausbau von bewegungsfördernden Umwelten. (AGGSE, 2020) Daher sind auch in der Forschung zu Mobilität die Ansätze der Gesundheitswissenschaften aufgegriffen. Aus der Annahme, dass die gebaute Umwelt einen Einfluss auf die körperliche Aktivität und somit auch auf die räumliche Mobilität ausübt, ist das Konzept der Walkability in den späten 1990-Jahren im Rahmen der Verkehrsforschung in den USA entstanden (Kerr, 2014). Walkability ist als ganzheitliches und interdisziplinäres latentes Konstrukt zu verstehen, welches auf eine bewegungsfördernde Umwelt abzielt (Bucksch, 2014).

3.3 Mobilitätsverhalten im Kontext der Trias

Verkehr wird durch Mobilitätsbedürfnisse hervorgerufen und ist die Summe einer täglichen Vielzahl von Befriedigungen von Bedürfnissen. Die Art des Verkehrsaufkommens ist definiert durch einzelne Entscheidungen und das Mobilitätsverhalten (Steierwald et al. 2005). Die vorgestellten Konzepte und Veröffentlichungen im Forschungsstand basieren wie bereits erwähnt auf der Annahme, dass die gebaute Umwelt einen direkten Einfluss auf die physische Aktivität ausübt und dementsprechend im Umkehrschluss bewegungsfördernde Umwelten geschafften werden müssen. Daher fällt dem Mobilitätsverhalten besondere Aufmerksamkeit zu. Jedoch ist nicht ausreichend erforscht, ob sich das Mobilitätsverhalten wirklich ändert, wenn bewegungsfördernde Strukturen im Umfeld geschaffen werden. Bereits 2007 machten Ohnmacht und Sauter darauf aufmerksam, dass der Einfluss der gebauten Umwelt auf das Verkehrsverhalten umstritten ist. Dies lässt sich unter anderem mit der Breite der Disziplinen erklären, welche zu der Trias forschen. Somit sind unterschiedlichste Forschungsdesigns gegeben, welche verschiedene Verhaltensmerkmale untersuchen (Ohnmacht und Sauter 2007). Heinen, Steiner et al. stellten 2015 in einer Veröffentlichung zur gebauten Umwelt und Verkehrsverhalten heraus, dass zahlreiche Studien aufzeigen, dass Menschen in Quartieren mit einer hohen dichte und einer hohen Nutzungsmischung mehr zu Fuß gehen und weniger fahren als Menschen in Quartieren mit geringer Dichte und geringer Nutzungsmischung. Darüber hinaus gibt es auch Studien, welche die Annahme unterstützen, dass Personen, die in attraktiven Quartieren wohnen eher zu Fuß gehen und die Nähe zu Parks die körperliche Aktivität steigert. Allerdings sind die Beweise, dass diese Merkmale einen aktiven Einfluss auf das Mobilitätsverhalten haben, dürftig (Heinen et al. 2015). Ein weiterer Aspekt, welcher den Zusammenhang von gebauter Umwelt und Verkehrsverhalten beeinflusst, ist die „residential self-selection“. Dieser Ansatz nimmt an, dass die individuellen Verkehrsmittelpräferenzen die Wahl des Wohnorts und der Verkehrsmodi beeinflussen. Dies bedeutet, dass der Zusammenhang von gebauter Umwelt und Verkehrsverhalten auch auf die Präferenzen der Verkehrsmittel zurückzuführen sein könnte (Heinen et al. 2015).

4 KONZEPTIONELLER RAHMEN DER EMPIRIE

Basierend auf dem aktuellen Stand der Forschung zu der Trias wurde ein konzeptioneller Rahmen entwickelt, um sich der Frage zu nähern, welche die diskriminierenden Faktoren für ein aktives Mobilitätsverhalten sind. Hierzu wurde ein Modell aufgestellt, welches auf der Trias aufbaut und verschiedene Items bündelt. Über messbare Variablen können Aussagen zu den Verknüpfungen und Einflüssen innerhalb der Trias getroffen werden.

Den einzelnen Items liegen verschiedene Modelle und latente Konstrukte zu Grunde, auf die im Folgenden näher eingegangen werden soll. Insbesondere das Rahmenmodell zum Person-Umwelt-Austausch von Oswald und Wahl (siehe Abbildung 4), welches sich mit Prozessen des Person-Umwelt-Austausches befasst, ist hier zu nennen (Oswald und Wahl 2016).

Obwohl sich das Rahmenmodell auf Personen im höheren Alter bezieht, sind dennoch viele Aspekte auf die Forschung des vorliegenden Beitrags übertragbar. In dem Modell von Oswald und Wahl haben die Ressourcen seitens der Person und der Umwelt einen Einfluss auf Erleben, Belonging, Verhalten und

Agency. Die Zusammenhänge zwischen Verhalten und Ressourcen seitens der Person und der Umwelt finden sich auch in der Trias wieder: die Ressourcen seitens der Person werden im Modell der Trias (siehe Abbildung 1) insbesondere als die Gesundheit dargestellt und die Ressourcen der Umwelt als die gebaute Umwelt.

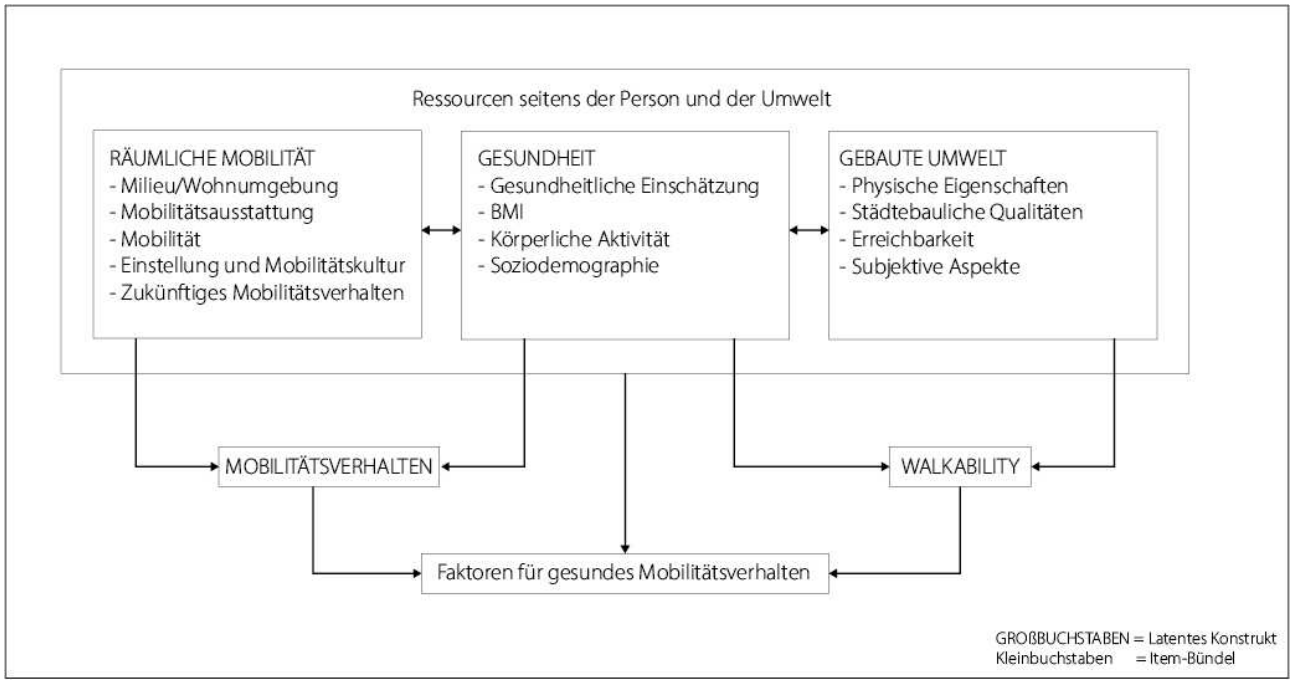


Abbildung 3: Modell „Faktoren für gesundes Mobilitätsverhalten“ (Kopal 2022).

Viele der vorangestellten Sachverhalte und Zusammenhänge sind nicht direkt messbar, daher werden latente Konstrukte aufgestellt, um diese Sachverhalte messbar zu machen. Ein latentes Konstrukt, welches bereits genannt wurde, ist die Walkability. Die Fußgängerfreundlichkeit der gebauten Umwelt bzw. einer bestimmten Umgebung ist nicht durch eine manifeste Variable direkt messbar. Dies wird über mehrere Variablen zur gebauten Umwelt und Erreichbarkeit erhoben.

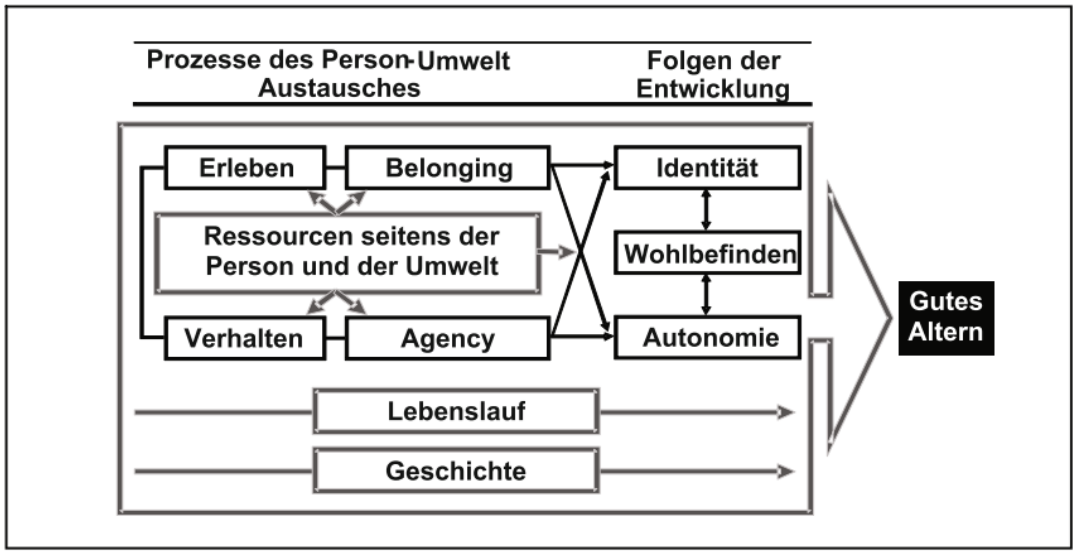


Abbildung 4: Rahmenmodell zum Person-Umwelt-Austausch im höheren Alter (Oswald und Wahl, 2016).

Des Weiteren kann das Mobilitätsverhalten ebenfalls über ein latentes Konstrukt messbar gemacht werden. Hierzu wurden Items zur Wohnumgebung, der Mobilitätsausstattung aber auch zu Einstellungen und Mobilitätskultur erfasst. Die Items bezüglich Einstellungen stammen aus dem PsyVKN, ein Fragebogen der Items zu Kontrollüberzeugungen, verkehrsmittelbezogenen Normen und Einstellungen beinhaltet. Der Fragebogen ist durch neun Jahre Forschungsarbeit theoretisch fundiert und empirisch validiert. Aus dem

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

PsyVKN sind acht psychologische Konstrukte mit 21 Items hervorgegangen, die teilweise auch in die Befragung des vorliegenden Beitrags eingeflossen sind. (Hunecke et al. 2022)

Die Erfassung der gebauten Umwelt ist ebenfalls durch ein latentes Konstrukt gegeben. Hierfür sind vor allem Items des deutschen Neighborhood Environment Walkability Scale (NEWS-G) eingeflossen. Der NEWS-G ist ein Fragebogen zur Messung von fußgängerfreundlichen Wohnumgebungen. Dort sind Fragen zu Wohngebäuden, Geschäften und öffentlichen Einrichtungen, Zugang zu Dienstleistungen, Straßen, Möglichkeiten zum Gehen und Fahrradfahren, Verkehrssicherheit, Sicherheit vor Kriminalität und Zufriedenheit in der Wohnumgebung gestellt. Der Fragebogen wurde 2002 in den USA von Saelens, Brian E.; Sallis, James F.; Black, Jennifer B. und Chen, Diana entworfen. Seit dem wurden dieser stetig weiterentwickelt und in verschiedene Sprachen übersetzt (Saelens et al. 2003; Sallis 2002).

Weitere latente Konstrukte, die sich aus der Grundlagenforschung der Trias für den Fragebogen ergeben haben, sind die räumliche Mobilität und die Gesundheit. In Abbildung 3 können die Item-Bündel zu den jeweiligen latenten Konstrukten abgelesen werden.

5 EMPIRIE

Aus dem theoretischen Konstrukt des Modells (siehe Abbildung 3) wurde die themenübergreifende Empirie mit entsprechenden Items und Verhaltensaspekten entwickelt. In dem Sample wurden 500 Personen ab 18 Jahren mit Wohnsitz in der Stadt Essen befragt. Der Fragebogen bestand aus insgesamt 57 Fragen zu folgenden Bereichen:

- Soziodemographie
- Gesundheitszustand
- Mobilitätsausstattung
- Aktive Bewegung
- Umfeldqualität
- Mobilitätsverhalten und Aktionsradius
- Einstellung und Mobilitätskultur
- Zukunftswünsche.

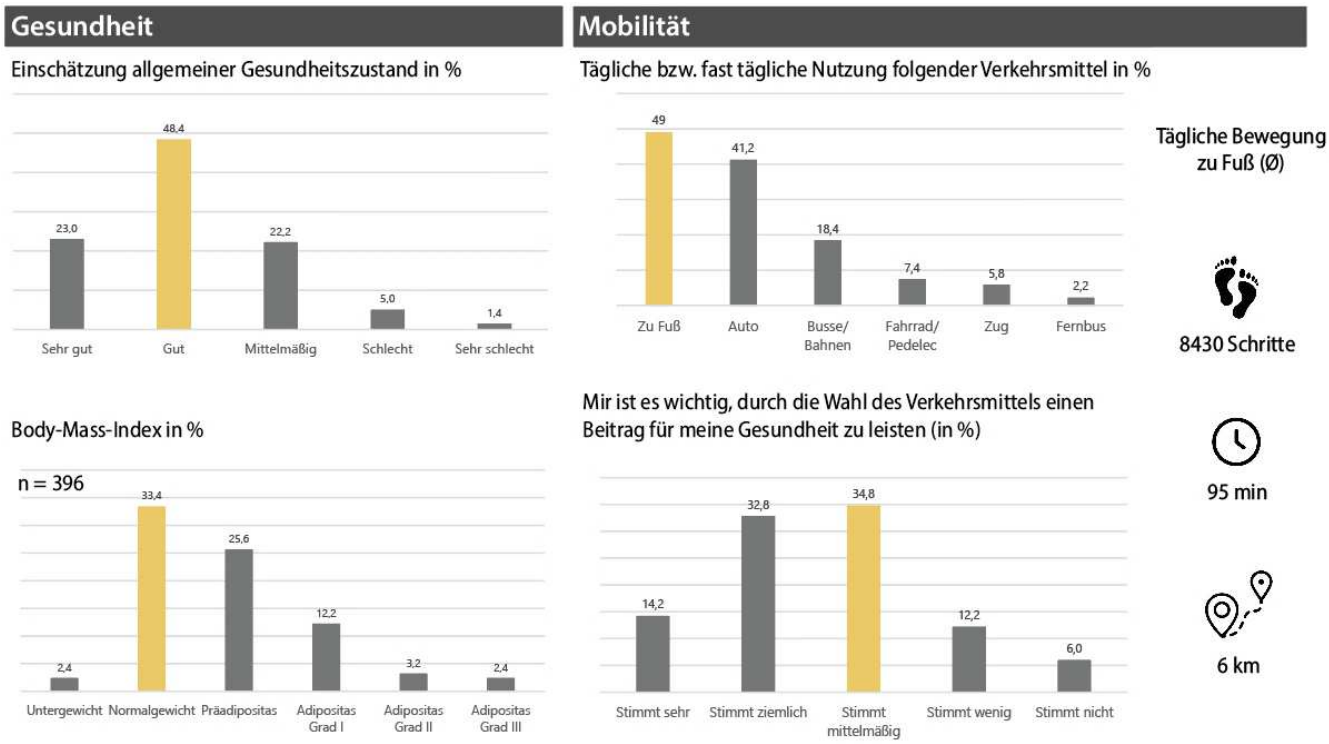


Abbildung 5: Übersicht der Stichprobe (imobis, 2022, Verwendung von Ressourcen von Flaticon.com).

5.1 Stichprobenbeschreibung

In diesem Abschnitt folgt eine prägnante Beschreibung der Stichprobe. Falls n ≠ 500, ist dies vermerkt.

Die Stichprobe besteht aus 61 % weiblichen und 39 % männlichen Personen mit einer Altersspanne von 18-79 Jahren. Der größte Anteil ist berufstätig (67 %), 29 % sind nicht berufstätig und die restlichen 4 % befinden sich in Ausbildung. 84 % der Stichprobe besitzen einen Pkw-Führerschein, in den Haushalten sind dementsprechend im Mittel 1,1 Autos und 1,4 funktionstüchtige Fahrräder vorhanden. Der allgemeine Gesundheitszustand wird von den meisten befragten Personen als „gut“ angegeben (48 %), gefolgt von „sehr gut“ mit 23 %, „mittelmäßig“ mit 22 %. „schlecht“ antworteten 5 % und 1 % der Befragten geben den allgemeinen Gesundheitszustand als „sehr schlecht“ an. Der errechnete BMI spiegelt dieser Bild wider, nach den Klassen des BMI sind nur 2 % untergewichtig, 33 % der Personen haben Normalgewicht, in die Kategorie „Präadipostias“ fallen 26 %. In die Kategorie „Adipositas Grad 1-3“ fallen 18 % der Stichprobe.

5.2 Kartengestützte Aktionsraumerfassung

Da die befragten Personen Fragen zu ihrer Wohnumgebung beantwortet haben, war vor allem eine kartengestützte Aktionsraumerfassung zentrales Messinstrument, um die Bewertung und Einflüsse der gebauten Umwelt verorten zu können. Somit konnten der Wohnort, Arbeitsort und Freizeitorte erfasst werden. Im Folgenden werden exemplarisch die Wohn- und Arbeitsorte dargestellt.

Bei der Verteilung der Wohnorte ist ein Nord-Süd-Gefälle zu erkennen (siehe Abbildung 6). In Anbetracht des Baldeneysees und dem Stadtwald lässt sich allerdings auch erkennen, dass der südliche Teil Essens (Fischlaken, Heidhausen sowie Kupferdreh) weniger bebaute Fläche mit Wohnraum zur Verfügung stellt und vorrangig als Naherholungsgebiet dient.

Der Großteil der befragten Personen wohnt in dem Stadtteil Frohnhausen, gefolgt von Rüttenscheid, Altenessen-Süd und Südviertel. Sowohl bei den Wohnorten als auch bei den Arbeitsorten (siehe Abbildung 6) ist erkennbar, dass sich die Angaben auf den nördlichen und mittleren Teil Essens konzentrieren. Etwa 14 % der befragten Personen arbeiten nicht in Essen, sondern in anderen umliegenden Städten des Ruhrgebiets wie Marl, Gelsenkirchen, Bochum, Herne, Duisburg, Mülheim oder Oberhausen. Einige der befragten Personen arbeiten auch in Düsseldorf oder Ratingen; in Abbildung 6 ist darüber hinaus erkennbar, dass vier Personen auf dem Gelände des Düsseldorfer Flughafens ihren Arbeitsort haben.

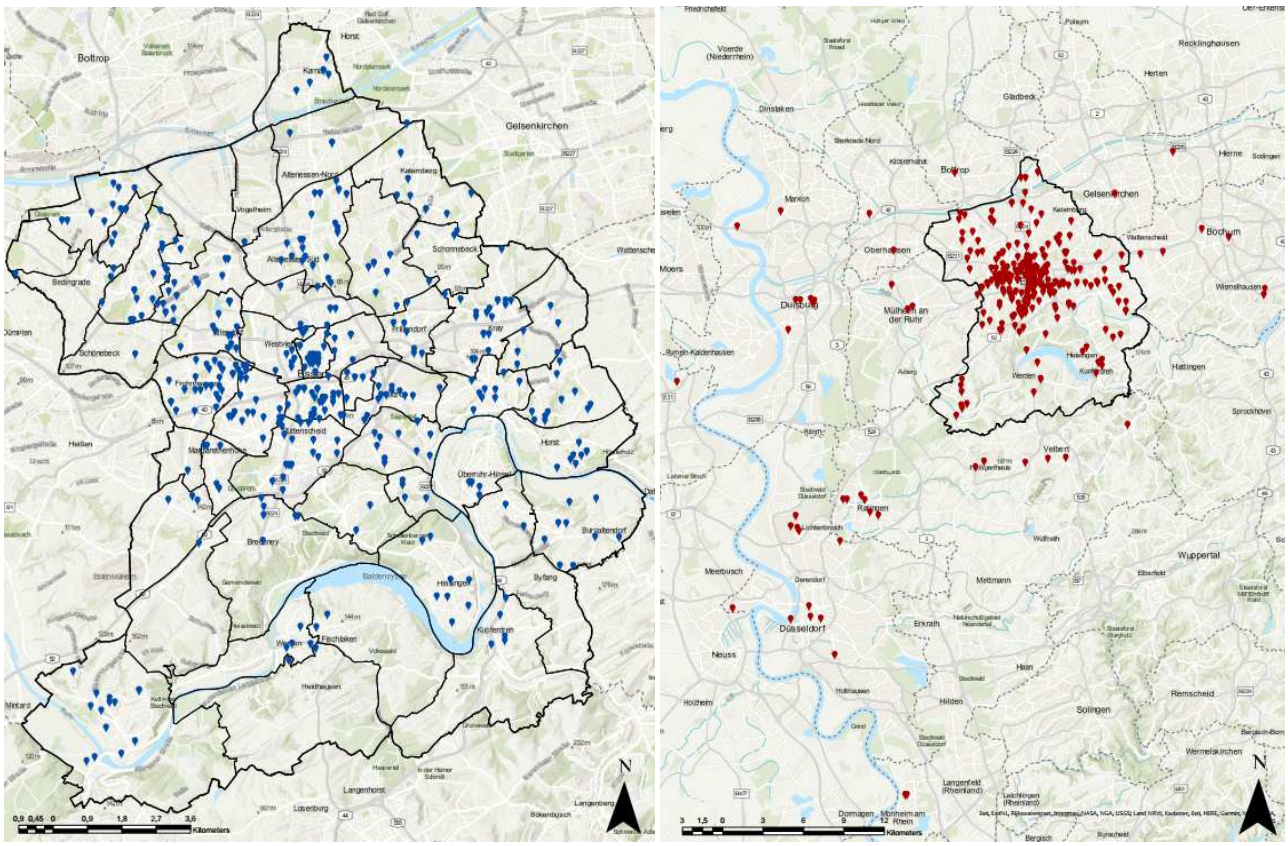


Abbildung 6: Wohnstandorte (links) und Arbeitsorte (rechts) der befragten Personen (imobis, 2022).

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

5.3 Subjektive Aspekte der gebauten Umwelt

Bezugnehmend auf das Modell aus Abbildung 3 sind in diesem Abschnitt exemplarisch deskriptive Statistiken zu den Verknüpfungen der gebauten Umwelt aufgeführt. Folgend sind Teilaspekte der subjektiven Walkability als Mittelwerte dargestellt und für die einzelnen PLZ-Gebiete der Stadt Essen dargestellt. Die Walkability ist ein latentes Konstrukt, dass aus mehreren Item-Bündeln wie subjektive Aspekte und physische Eigenschaften der gebauten Umwelt besteht.

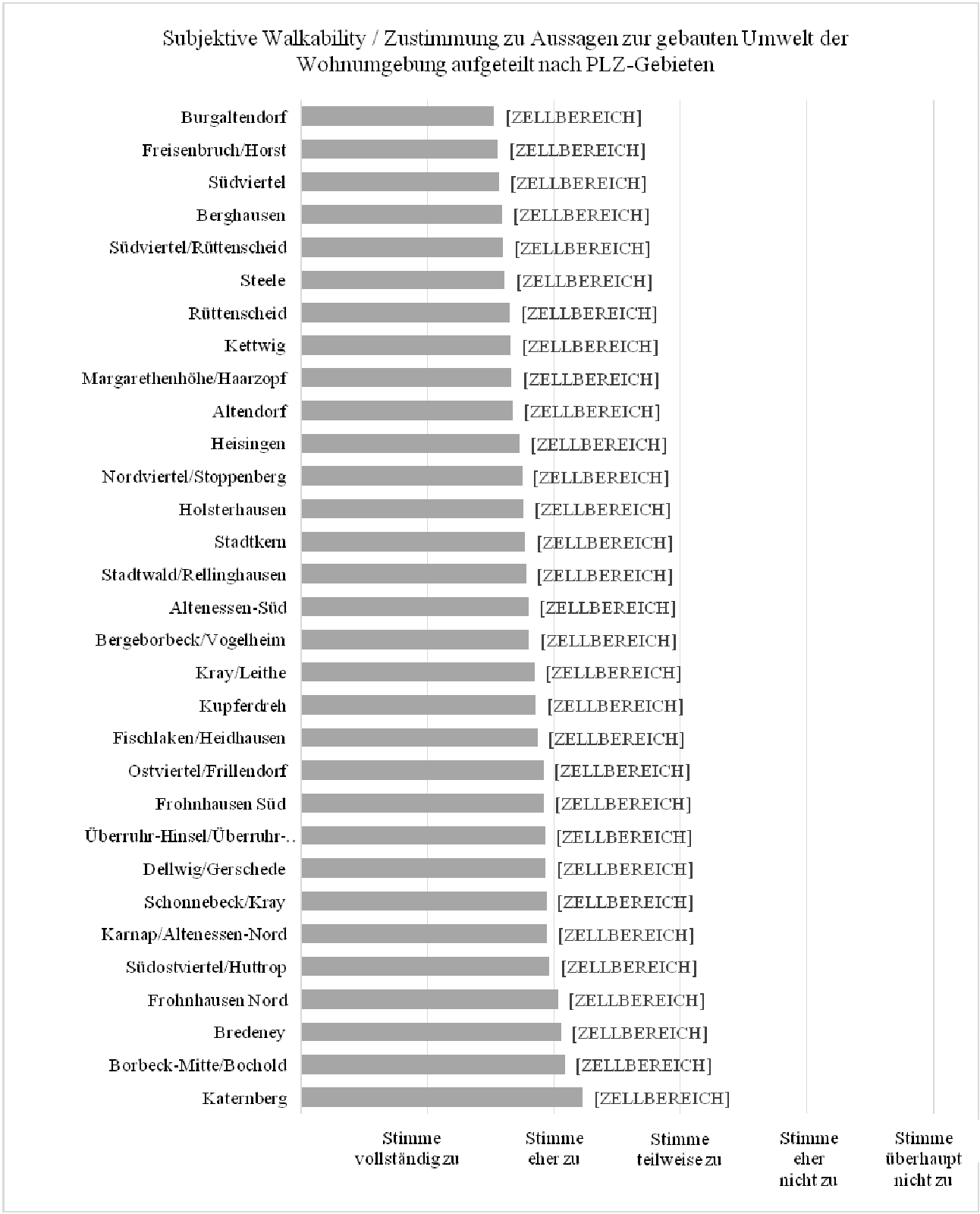


Abbildung 7: Subjektive Walkability nach PLZ-Gebieten dargestellt (imobis, 2022).

Infolge der themenübergreifenden Empirie ist es möglich, die gebaute Umwelt zu bewerten. Die subjektive Walkability hat eine Skala von 1 – 5, 1 ist der beste und 5 der schlechteste Wert. In Abbildung 7 ist zu erkennen, dass die subjektive Walkability in Essen von den befragten Personen überwiegend gut bewertet wurde. Die Spannweite liegt bei 1,53 – 2,23, der Mittelwert liegt bei 1,8. Die subjektive Walkability setzt sich aus Fragen zur Beurteilung der Gehwege, Fahrradwege, Grünflächen, Begrünung, Spielplätze, Sportanlagen, Sauberkeit und Attraktivität zusammen. In Abbildung 7 ist ein leichtes Süd-Nord-Gefälle erkennbar, die südlichen Stadtteile wurden besser bewertet als die nördlichen Stadtteile Essens. Diese Tendenz ist ebenfalls anhand der Bodenrichtwerte der Stadt Essen erkennbar, Bodenrichtwerte werden häufig als Indikator für Attraktivität genutzt (Der Obere Gutachterausschuss für Grundstückswerte im Land Nordrhein-Westfalen 2022). Darüber hinaus ist das Süd-Nord-Gefälle auch mit der infrastrukturellen Ausstattung und den städtebaulichen Qualitäten der Stadtteile übereinstimmend. 2017 hat das Institut für Stadtplanung und Städtebau eine Messung und Erfassung der Fußgängerfreundlichkeit von Stadträumen für das gesamte Stadtgebiet Essens durchgeführt, hierzu wurde ein Walkability-Index auf der Makro-Ebene errechnet und in einzelnen Stadtteilen auch Walkability-Indizes auf der Mikro-Ebene. Auch hier ist ein leichtes Süd-Nord-Gefälle erkennbar (Tran et al. 2017).

6 FAZIT UND AUSBLICK

Das Modell, um die Faktoren für gesundes Mobilitätsverhalten zu berechnen, zeigt anschaulich die Verknüpfungen innerhalb der Trias auf. Somit ist es möglich die interdisziplinäre Forschung der Trias zusammenzubringen, um die unterschiedlichen Ansätze der verschiedenen Disziplinen zu vereinen. Aufbauend auf dem Modell „Faktoren für gesundes Mobilitätsverhalten“ (siehe Abbildung 3) bietet die themenübergreifende Empirie die Möglichkeit die diskriminierenden Faktoren für ein aktives Mobilitätsverhalten im Spannungsfeld von Wohnumgebung, gebauter Umwelt sowie Einstellungen und Normen zu erfassen. Als erster Ansatz hierfür wurde die subjektive Walkability herangezogen und für die verschiedenen Stadtgebiete Essens berechnet. Zusammenfassend ist festzuhalten, dass in diesem Paper verschiedene Teilaspekte der Forschungsfelder innerhalb der Trias aufgezeigt und erste Einblicke in die aktuelle Forschungsarbeit gegeben werden konnten.

Im weiteren Verlauf der Auswertungen wird das Modell (siehe Abbildung 3) berechnet, indem die Item-Bündel zusammengefasst und die latenten Konstrukte berechnet werden. Anschließend soll ein Strukturgleichungsmodell Aufschluss über Faktoren für ein gesundes Mobilitätsverhalten geben. Darüber hinaus sollen Indikatoren bzw. Umgebungsvariablen für eine bewegungs- und gesundheitsförderliche Kommune abgeleitet werden, um die Gesundheit zu fördern und gleichzeitig das Klima zu schützen.

7 LITERATURVERZEICHNIS

AGGSE (Hg.) (2020): Empfehlungen für eine gesundheitsfördernde und nachhaltige Stadtentwicklung. Fünf Thesen der Arbeitsgruppe Gesundheitsfördernde Gemeinde- und Stadtentwicklung (AGGSE). Unter Mitarbeit von Christa Böhme. Deutsches Institut für Urbanistik (Difu). Online verfügbar unter https://difu.de/sites/difu.de/files/archiv/projekte/aggse_thesen_2020-03-09.pdf, zuletzt geprüft am 21.03.2020.

Andrews, Gavin J.; Hall, Edward; Evans, Bethan; Colls, Rachel (2012): Moving beyond walkability: on the potential of health geography. In: Social science & medicine (1982) 75 (11), S. 1925–1932. DOI: 10.1016/j.socscimed.2012.08.013.

Barton, Hugh; Grant, Marcus (2006): A health map for the local human habitat. In: The journal of the Royal Society for the Promotion of Health 126 (6), S. 252–253. DOI: 10.1177/1466424006070466.

Baumeister, Hendrik; Rüdiger, Andrea; Köckler, Heike; Claßen, Thomas; Hamilton, Jacqueline; Rüweler, Mareike et al. (2016): Leitfaden Gesunde Stadt. Hinweise für Stellungnahmen zur Stadtentwicklung aus dem Öffentlichen Gesundheitsdienst. // Hinweise für Stellungnahmen zur Stadtentwicklung aus dem Öffentlichen Gesundheitsdienst. Bielefeld: Landeszentrum Gesundheit Nordrhein-Westfalen.

Conrad, Kerstin; Oswald, Frank; Penger, Susanne; Reyer, Maren; Schlicht, Wolfgang; Siedentop Stefan; Wittowsky, Dirk (2018): Urbane Mobilität und gesundes Altern. Personen- und Umweltmerkmale einer generationengerechten Stadtgestaltung. Zur Arbeit der Forschungsgruppe autonomMOBIL. In: Rainer Fehr und Claudia Hornberg (Hg.): Stadt der Zukunft Gesund und nachhaltig. Brückenbau zwischen Disziplinen und Sektoren (Edition nachhaltige Gesundheit in Stadt und Region), S. 291–319. Online verfügbar unter https://content-select.com/de/portal/media/download_oa/5c7ba272-3580-4fb9-a0d6-686bb0dd2d03, zuletzt geprüft am 18.07.2022.

Der Obere Gutachterausschuss für Grundstückswerte im Land Nordrhein-Westfalen (2022): BORIS.NRW. Hg. v. Arbeitsgemeinschaft der Vorsitzenden der Gutachterausschüsse für Grundstückswerte in Nordrhein-Westfalen. Online verfügbar unter https://www.boris.nrw.de/borisplus/?lang=de, zuletzt geprüft am 29.07.2022.

Heinen, Eva; Steiner, Ruth L.; Geurs, Karst T. (2015): Special issue: built environment and travel behaviour. In: European Journal of Transport and Infrastructure Research 15 (1). DOI: 10.18757/ejtir.2015.15.1.3051.

Heinrich-Böll-Stiftung; VCD Verkehrsclub Deutschland e.V. (2019): Mobilitätsatlas. Daten und Fakten für die Verkehrswende. 1. Aufl. Lahr: Druckhaus Kaufmann.

Hunecke, Marcel; Heppner, Holger; Groth, Sören (2022): Fragebogen zu psychologischen Einflussfaktoren der Nutzung von Pkw, ÖPNV und Fahrrad (PsyVKN). In: Diagnostica 68 (1), S. 3–13. DOI: 10.1026/0012-1924/a000277.

Ohnmacht, Timo; Sauter, Daniel (2007): Gebaute Umwelt und körperliche Aktivität. Ein Literaturbericht. Hochschule für Wirtschaft Luzern. Luzern (ITW Working Paper Series, Mobilität 003/2007). Online verfügbar unter https://repository.difu.de/jspui/bitstream/difu/175616/1/DN0007.pdf, zuletzt geprüft am 04.05.2020.

Oswald, Frank; Wahl, Hans-Werner (2016): Alte und neue Umwelten des Alterns. Zur Bedeutung von Wohnen und Technologie für Teilhabe in der späten Lebensphase. In: Gerhard Naegele, Elke Olbermann und Andrea Kuhlmann (Hg.): Teilhabe im Alter gestalten. Aktuelle Themen der Sozialen Gerontologie (Dortmunder Beiträge zur Sozialforschung), S. 113–130. Online verfügbar unter https://link.springer.com/content/pdf/10.1007%2F978-3-658-12484-7.pdf, zuletzt geprüft am 17.02.2020.

Powell, Kenneth E.; Paluch, Amanda E.; Blair, Steven N. (2011): Physical activity for health: What kind? How much? How intense? On top of what? In: Annual review of public health 32, S. 349–365. DOI: 10.1146/annurev-publhealth-031210-101151.

Reyer, Maren (2017): Gebaute Umwelt und Alltagsaktivität: Walkability als Chance und Risiko für das Gehen Älterer im Alltag. Unter Mitarbeit von Universität Stuttgart.

Saelens, Brian E.; Sallis, James F.; Black, Jennifer B.; Chen, Diana (2003): Neighborhood-based differences in physical activity: an environment scale evaluation. In: American journal of public health 93 (9), S. 1552–1558. DOI: 10.2105/AJPH.93.9.1552.

Sallis, James F. (2002): Neighborhood Environment Walkability Scale (NEWS). Hg. v. J. F. Sallis. Online verfügbar unter https://drjimsallis.org/measure_news.html, zuletzt geprüft am 27.07.2022.

Schmidt, J. Alexander; Tran, Minh-Chau; Diekmeyer, Lisa; Kopal, Kerstin (2018): Walkability in der Praxis. Gesamtbericht. Walk-Audits in drei Städten in Nordrhein-Westfalen. Unter Mitarbeit von Paula Ruppert und Florian Fuchs. Essen.

Schulz, H.; Karrasch, S.; Bölke, G.; Cyrys, J.; Hornberg, C.; Pickford, R. et al. (2019): Atmen: Luftschadstoffe und Gesundheit – Teil I. In: Pneumologie (Stuttgart, Germany) 73 (5), S. 288–305. DOI: 10.1055/a-0882-9366.

Schwedes, Oliver (Hg.) (2018): Verkehrspolitik. Eine interdisziplinäre Einführung. 2. Aufl. 2018.

Steierwald, Gerd; Künne, Hans Dieter; Vogt, Walter (2005): Stadtverkehrsplanung. Grundlagen, Methoden, Ziele. 2., neu bearbeitete und erweiterte Auflage. Berlin, Heidelberg: Springer-Verlag Berlin Heidelberg.

Tran, Minh-Chau; Schmidt, J. Alexander; Nouri, Fatemeh (2017): Messung und Erfassung der Fussgängerfreundlichkeit von Stadträumen. Eine GIS-basierte Analyse gemischt genutzter Quartiersgebiete am Fallbeispiel Essen mit Hilfe des integrierten Walkability Audits auf Mikroebene (IWAM). Unter Mitarbeit von Alexandra Caetano, Justyna Luczak, Caroline Manz, Fatemeh Nouri, Marisela Soto Salas und Yeganeh Soudi. Hg. v. Institut für Stadtplanung und Städtebau. Universität Duisburg-Essen. Essen. Online verfügbar unter https://www.uni-due.de/imperia/md/content/imobis/messung_und_erfassung_der_fu%C3%9Fg%C3%A4ngerfreundlichkeit_in_essen_2017_xs.pdf, zuletzt geprüft am 23.09.2020.

WHO (1986): Ottawa-Charta zur Gesundheitsförderung. Ottawa. Online verfügbar unter http://www.euro.who.int/de/publications/policy-documents/ottawa-charter-for-health-promotion,-1986, zuletzt geprüft am 09.10.2018.

WHO (2019): Sustainable Cities. Health at the Heart of Urban Development. World Health Organization (WHO). Online verfügbar unter https://www.who.int/docs/default-source/documents/publications/sustainable-cities.pdf?sfvrsn=2accfb68_1, zuletzt geprüft am 20.07.2022.

WHO Regionalbüro Europa (2010): Bewegung und Gesundheit in Europa: Erkenntnisse für das Handeln. Hg. v. Nick Cavill, Sonja Kahlmeier und Francesca Racioppi. World Health Organization Regional Office for Europe. Wien. Online verfügbar unter http://www.euro.who.int/de/publications/abstracts/physical-activity-and-health-in-europe-evidence-for-action, zuletzt geprüft am 08.10.2018.

🏆 *reviewed paper*

Digital Public Art in Historical Urban Open Spaces: The Impact of New Technologies

Asmaa Saleh, Asmaa Hasan, Khaled Al-Hagla

(MSc. Candidate Asmaa Saleh, Architectural Engineering Department, Faculty of Engineering, Alexandria University, Alexandria, Egypt, asmaarsaleh@alexu.edu.eg)
(Lecturer. Asmaa Hasan, Architectural Engineering Department, Faculty of Engineering, Alexandria University, Alexandria, Egypt, asmaa.elsayed@alexu.edu.eg)
(Prof. Khaled Al-Hagla, Architectural Engineering Department, Faculty of Engineering, Alexandria University, Alexandria, Egypt, khagla@alexu.edu.eg)

1 ABSTRACT

For centuries, public art has been used to commemorate historical events, celebrate heroes, inspire citizens, decorate public spaces, and attract tourists. It represents the current cultural and social situation and aesthetic and artistic tendencies. Now, contemporary public art often ignores the "Do not touch" sign and encourages users to involve in shaping art pieces to their own preferences. In this process, digital public art (DPA) takes on a new role as a connector between people and art, and public space acts as the interaction context.

In the digital era, despite the blame attributed to new technologies for diminishing social contacts and degrading the identity of public spaces, today's application of new technologies with public art frequently produces astounding and surprisingly positive effects on people's feelings, perceptions, and behaviours. Digital public art can stimulate human senses while improving non-visual aspects of space.

The study's main concern is to redefine the role of public art in the digital era to cope with the changes in users' behaviour and the rapid changes in technology. In the context of historical urban spaces, the study looks into the relationship between three main pillars: digital public art, urban spaces, and users' behaviour. It investigates the role of new technologies in shaping the future of public art. It also reviews types of DPA in historical urban spaces and their impact on boosting user interactions and urban space identity. Finally, a comparative analysis study presents some DPA types for historical urban spaces to achieve the required interaction and identity.

Keywords: Digital public art, Digital era, Historical Public Spaces, identity, Users' behavior, Social Interaction

2 INTRODUCTION

Public art is not new; it goes back to ancient times. It has historical traditions and roots in different periods and cultures. It has taken multiple forms in various periods as it has been associated with its society (Fig. 1) (Senie, 2003). public art was introduced to the public as a religious and social art virtue (Post, 2011). However, as time goes by, the functions of public art have also expanded and evolved. It is a visual aid for public enjoyment by enriching the public's perception of those spaces (Miles and Mannion, 1997, Robinson, 1904).

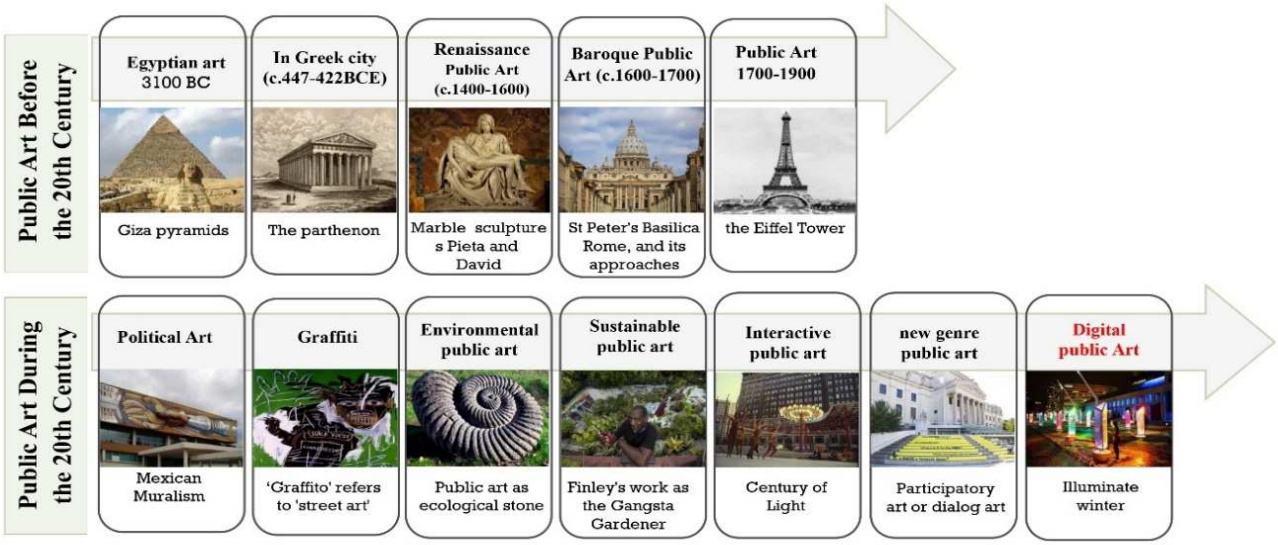


Fig. 1: The forms of public art through history.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Public arts need new carriers, materials, and languages to thrive in the age of new technologies, from static forms to dynamic and interactive forms (Wang, Hu and Rauterberg, 2012). This digital art combines technologies and smart materials to produce interactive artworks. It is an artistic configuration that attracts and motivates people to interact by moving it, moving through it, changing its sounds and lights, giving them a sense of ownership over the installation. Also, it generates a human-computer and human-human interactions in space. (Becker, 2004) (Ahmed, 2018, Ahmed, Jaccheri and M'kadmi, 2009).

The study investigates digital public art's role in historical urban spaces. Specifically, whether it can offer high levels of interactivity and identity, which are presented in interactive and participatory forms of installations.

3 THE ROLE OF PUBLIC ART IN URBAN SPACES

Public art gives public space identity and shape, making it more memorable (Moughtin, 2003). Lynch defines identity as "the ability to distinguish a place from others" (Lynch, 1984). It can develop a sense of place by creating a unique physical character and enhancing the links between communities and places; develop a sense of identity by helping people understand where they come from, particularly through historical connections (McCarthy, 2006); projecting an external image of a place; and develop a sense of community by revitalising poor-quality spaces and buildings with a sense of pride and ownership through involvement in the creative process (Hall and Robertson, 2001).

According to the literature analysis, public art researchers have discussed the values of public art to cities and public spaces. Their findings are primarily divided into three categories (Hall, 2003, Hall and Smith, 2005, Haus, Heinelt and Stewart, 2005, McCarthy, 2006, Miles and Mannion, 1997, Sharp, Pollock and Paddison, 2005):

(1) Aesthetic value: Public art improves the visual appearance of urban spaces.

(2) Economic value: Public art provides communities with competitive advantages and local uniqueness, which may attract investment, stimulate cultural tourism, and increase land use.

(3) Social and cultural value: Public art strengthens a sense of identity and place. It can foster social inclusion and link society with its history.

Public spaces with interactive public art provide new experiences in dealing with technology while meeting people's needs. Public art and urban spaces are interaction boosters and community expression tools, especially digital public art and historical urban spaces. This idea was evoked by Margareth Worth, who believes that "Art and design give way for telling the stories that remind communities of their foundations".

Material is a public art language that has evolved over several generations, from natural materials to smart materials (Dewey, 1934). The most recent materials used in public art installations encourage interactivity and participation, posing new issues for the innovative design process and how to include users.

4 DIGITAL TECHNOLOGY IMPACTS ON THE FUTURE OF PUBLIC ART IN URBAN SPACE

According to Hampton, a design that considers technology is paramount for the future of cities. As much as urban designers use trees, water, and other amenities to attract people to spend time in urban spaces and facilitate group interaction, it's advisable to start thinking about using other infrastructures. Considering how new technology and smart materials will fit into public places is a must to cope with the digital era (Project for Public Spaces, 2007). Compared to traditional public art, digital public art has four new features: interactivity, technologicalness, dynamism, and interestingness (Li and Luo, 2017).

Interactivity: Unlike traditional public art, which only provides a visionary impression, interactive public art will allow the audience to interact with the surrounding. Public art is becoming increasingly interactive, bringing more vitality to city spaces.

Technologicalness: It represents the basis for the realisation of digital public art. The use of virtual reality technology and mechanical control devices makes it possible for public art to create an interactive environment.

Dynamism: It has gotten rid of the rigidity and statics of traditional public art and has become more dynamic.

Interestingness: In interacting with modern public art, the audience will undoubtedly receive some feedback, most of which is interesting.

4.1 The contemporary types of digital public art in urban spaces

Digital public art is a type of artistic work or activity that integrates digital technology into the creative or presenting process. It belongs to the larger category of new media art (Mathew and Manohar, 2017, Paul, 2011). New media art refers to all forms of contemporary art made, altered, or transmitted using new media technology. This includes digital art, interactive art, virtual art, and works of art created using robotics, video games, biotechnology, 3D printing, and computer animation. New media art is a category that defies static categorisation as the form continues to expand and new media technologies are invented (staff, 2021).

The types of digital public art vary widely. Painting, drawing, sculpture, and music/sound art have all been affected by the impact of digital technology, while new forms, such as digital installation art and virtual reality have emerged (Fig. 2).

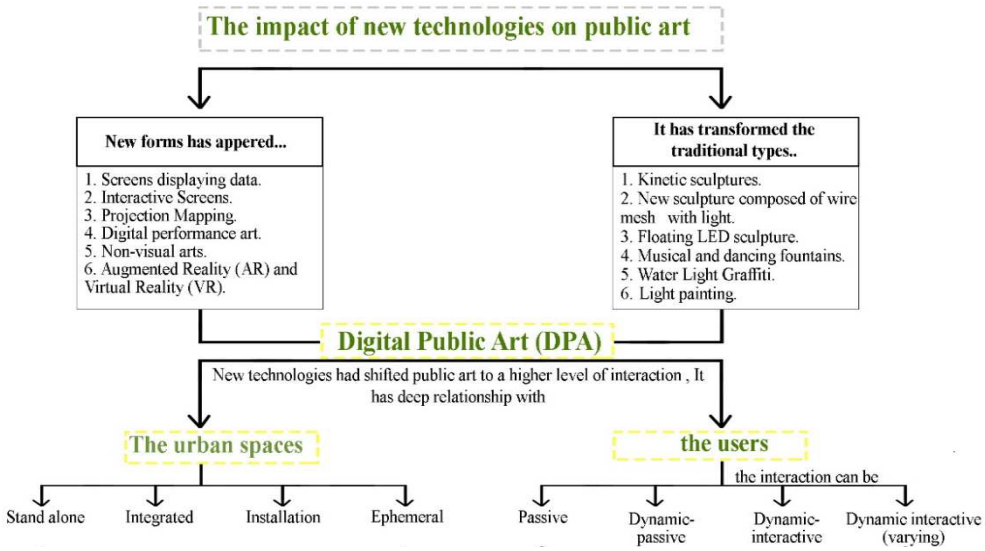


Fig. 2: The impact of new technologies on public art (contemporary digital public art classification).

4.2 The power of digital public art as placemaking in historical urban spaces (the identity)

In the digital age, some historical urban spaces face the threat of losing their identity and interactivity. The role of digital public art changed from a purely aesthetic phenomenon to a more and more recognised phenomenon for its contribution to "urban regeneration" (Hall and Robertson, 2001).

According to (Cant and Geography, 2006), placemaking uses design talents to develop images and enhance identity that reflect the historical and culture of a community. The urban planner Ronald Fleming (Fleming, 2007) was the first author to favour the term “placemaking” over “public art”. Placemaking has recently evolved into 'creative placemaking,' a movement focused on public art and creative activities in public spaces (Kent, 2009). Creative placemaking studies people's benefits from interacting with public art, focusing on citizen participation and social interaction. (McCarthy, 2006). It is highly related to the concept of a sense of place (Cant and Geography, 2006).

Digital Placemaking is the strategic deployment of technology to support and enhance community participation in public places. It is a collaborative practice intended to strengthen community connections. Digital art, in this context, can provide new relationships to a space or provoke new sensory experiences in a way that can also be dynamic and renewable. Having access to DPA in historical open spaces is a way to experience the past in modern ways. (Tomitsch, 2016).

4.3 The impact of digital public art on users' perception and interaction (the interactivity)

The new dynamic, interactive or participatory forms of DPA require the artists and designers to construct their work with a good understanding of human-system interaction (Hu, Wang, Funk, Frens, Zhang, Van Boheemen, Zhang, Yuan, Qu and Rauterberg, 2013, Wang, Hu and Rauterberg, 2012). It frequently positively affects peoples’ perceptions, emotions, and behaviour. People are encouraged to express their

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

presence, emotions, and feelings. Interactive DPA can stimulate human senses while also improving non-visual features of space (Urbanowicz and Nyka, 2012). It supports inclusion in the urban space, giving people more options for engaging with their public spaces and creating a personal identity for the individual and the city (Cartiere and Zebracki, 2015, Lossau, 2015).

The perception of DPA is acquired visually and psychologically, which indicates that an individual's impression of a specific artwork is influenced by various factors, such as cognition, values and beliefs, personal experience, and socio-cultural environment (Setiawan, 2010). It gives the public space a focal point and a purpose for people to have a new experience (Berg, 2009, Dovey, 2016, Hawkins, 2012). DPA encourages people to interact with it and become actors in urban performances (Urbanowicz and Nyka, 2016).

The relationship between interactive public art, users, and the environment, according to (Edmonds, Turner and Candy, 2004), can be static, dynamic-passive, dynamic-interactive, or dynamic interactive (varying).

(1) Static: The art object remains unmodified. The artwork itself does not respond to its surroundings.

(2) Dynamic-Passive: The art piece contains an inbuilt mechanism that allows it to change or be altered by an external factor such as temperature, sound, or light.

(3) Dynamic-Interactive: All of the characteristics of the dynamic passive category apply, with the addition that the human 'viewer' actively influences the changes in the art object.

(4) Dynamic-Interactive (Varying): Both 2 and 3 above apply, with the addition of a modifying agent that modifies the original specification of the art object. The agent could be a person or a computer program.

5 METHODOLOGY

This study is an exploratory study that is based on two main sectors. The first is a literature review presenting the impact of new technology on public art and illustrating the contemporary types of digital public art in urban spaces. It then investigates the role of digital public art in historical urban spaces, focusing on its impact on two aspects (users' interaction and the identity of urban space) (Fig. 3), considered later as the main criteria for the study. The second part presents five examples of historical urban spaces with different types of digital public art. Finally, a comparative analysis refers to the two main criteria mentioned above.

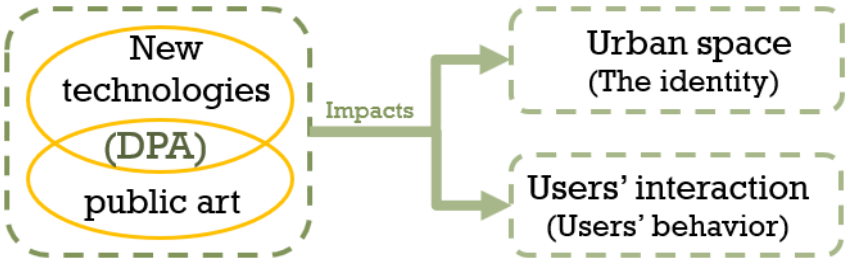


Fig. 3: The impact of DPA on historical urban space and users' interaction (the three main pillars of this study).

6 COMPARATIVE ANALYSIS

This comparative analysis includes five examples of public urban spaces worldwide with great historical backgrounds (Trafalgar Square in London, Central Business District of some countries, Plaza Mayor in Madrid, Giza Pyramids in Egypt, and Historic streets in London). These urban spaces already have various types of traditional public art (sculptures, fountains, historical buildings, and so on) from ancient times, reflecting the urban space's history. But now, they have undergone many renovations to cope with the digital era. New types of digital public art were added, presented in new technology which affect the existing public art or add new digital artworks. This comparative analysis aims to investigate the impact of digital public art on identity and interaction in these historic spaces.

6.1 Trafalgar Square, London.

Trafalgar Square is a well-known landmark in London, which has become a major tourist destination and a civic space open to the public. It has undergone many regeneration renovations to provide more attractions for visitors. The most recent redevelopment was in 2003 when the public space was pedestrianised. More

artworks were added. It included the fourth plinth and public art across the square. The square has four plinths with public statues or artwork. People sit on and play with a huge fountain (Fig. 4). It also has various public artworks, including Nelson's Column guarded by four lions. People sit on, touch, and photograph lion statues (Fig. 5). Many statues of famous people are in Trafalgar Square, although they are not interactive. (Escobar, 2014, Lossau, 2015, Searle, 2009).


Fig. 4: Public life around the fountain.(Balint). Fig. 5: People interacting with the lion statues (Balint).

6.1.1 London's Lumiere festival

From the 18th to the 21st of January 2018, London's most iconic landmarks were lighted, with more than 50 enormous sculptures, video mappings, and installations produced by influential artists and designers worldwide who utilise light as a medium (Fig. 6). Originally, this kind of celebration had a religious and spiritual meaning, to celebrate the end of the year’s dark period and the beginning of lighter days. Nowadays, the spiritual sense has given way to amusement and stupefaction (Porter, 2018) .






Fig. 6: Some of the most interesting installations during London's Lumiere festival in January 2018(Porter, 2018, urban75, 2018).

6.1.2 Please Feed the Lions

This is a stunning interactive sculpture created by artist and designer Es Devlin. The luminous, fluorescent-red paint finish sang out against the grey stone of Trafalgar Square, encouraging visitors to feed words to the open-mouthed lion via a touch screen mounted within a podium. The terms and selected poetry appeared on a monitor mounted in the lion’s mouth and projected up the full height of Nelson’s Column at night (Fig. 7) (Festival, 2018).


Fig. 7: Please Feed the Lions (Festival, 2018).

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Identity: This digital artwork keeps the identity of the open space and increases public awareness of the city's history. This kind of celebration had a religious and spiritual meaning, to celebrate the end of the year's dark period and the beginning of lighter days. Nowadays, the spiritual sense has given way to amusement and stupefaction.

Interactivity: The people are no longer passive participants in urban art. The square has a high level of interaction. Over the last few decades, the visitor has transformed from a passive spectator to a user who interacts with the object and contributes to the meaning-making process of art (Haus, Heinelt and Stewart, 2005).

6.2 In the Central Business District of some countries

Paul Virilio called the digital screens on high-rise structures "Electronic Gothic" like gothic architecture. It has an emotional and cognitive impact on city dwellers, like stained glass windows in gothic cathedrals. Looking at the world's most crowded cities, where most public space is covered with information surfaces based on capital, all seem the same. There are pictures in (Fig. 8) of Hong Kong, Tokyo, New York, and Las Vegas, where the perception of the urban place is almost identical. They are oblivious of any context; the selling image is the primary goal. Large digital displays are becoming ubiquitous in public spaces, but their potential for interactivity remains unrealised as they are mostly used to deliver content(Sökmenoğlu and Türkkan, 2009) (Dubois, Colangelo and Fortin, 2015).

Fig. 8: the perception of the urban place is almost identical (Sökmenoğlu and Türkkan, 2009).

Identity: These digital information screens are similar everywhere; The urban place perception is almost identical. They bring nothing except a sense of "placelessness." These digital information screens are not designed for specific urban spaces (Sökmenoğlu and Türkkan, 2009).

Interactivity: The viewer passively observes these urban screens. The art piece contains an inbuilt mechanism that allows it to change or be modified without being affected by its surroundings (Edmonds, Turner and Candy, 2004).

6.3 Plaza Mayor, Madrid.

Fig. 9: Madrid suspended above Plaza Mayor. Image by Joao Ferrand (Travel, 2018). Fig. 10: The fabric is lightweight and flexible—Echelman studio (Travel, 2018). Fig. 11: Public life around the colourful sculpture. Image by Joao Ferrand (Travel, 2018). To commemorate the 400th anniversary of Madrid's Plaza Mayor, American artist Janet Echelman suspended her latest woven artwork, "A colourful conversation with the past." Below it was the statue of Felipe III who oversaw the plaza's creation, to depict the space's history of violence and regeneration. (Fig. 9) (Alaimo, 2018).

Identity: The sculpture aims to commemorate the good evolution of culture and society over time (Fig. 11). "People have gathered in Plaza Mayor for almost 400 years to watch bullfights and Spanish Inquisition burnings. Today, we gather to debate concepts via art that investigates our understanding of time." Janet Echelman said.

Interactivity: The sculpture is made of lightweight, flexible fibre to twist and create one enormous piece that changes with wind and weather. It interacts with the environment more than with visitors. The structure becomes an eye-catching sea of colour at night when lights are projected onto it (Fig. 10).

6.4 Giza Pyramids and the temple of Philae in Egypt

Egypt has a lot of historical public spaces. These include the Giza pyramids, the temple of Karnak, and the Temple of Philae. In 1961 the government decided to develop the area of the Giza pyramids by performing the "Son et Lumiere" shows, recently called "sound and light" shows; light is used to illuminate the historical sites while a narrator or a voice through a space system tells the story of the place. Additional background music could be used.

Identity: the story and the lights give more perception of the site and tell the historical background of the public space, enforcing the sound of the identity of the place.

Interactivity: the show is passive. The changes in light and sound are pre-programmed without being affected by their surroundings.

Fig. 12: The memorable Giza Pyramids and the temple of Philae Sound and Light Show(Experts, 2022)

6.5 Historic streets in London "StreetMueum application"

Today, the various applications of mobile phone-based AR technology for guiding users through historic sites are constantly developing. The street museum is an augmented reality application developed by the Museum of London. It allows the user to browse historical photographs of various streets of London while walking through these streets using GPS or a map. The app recognises the location and overlays the historical photograph over the live feed of the current real world (Eccleston-Brown, 2010).

Identity: the application gives the user a sense of acquaintance with the place and deepens the historical background of the place. It allows users to see old London with new eyes (Fig. 13,14).

Interactivity: the application is a good tool for human-mobile interaction as the users can choose the street they want to explore, although this is limited by the number of old photos of some streets.

Fig. 13: iPhone shot of Carnaby Street in 1968 is aligned with today's perspective (Mohammed-Amin, 2010). Fig. 14: iPhone view of 1958 Carnaby Street with historical facts (Mohammed-Amin, 2010).

7 FINDINGS AND CONCLUSION

The following table shows the different levels of interactivity with digital public art in the selected examples. It shows that Trafalgar Square used passive and interactive types of digital public art to have a high level of interactivity. The times square and Giza pyramids used passive types with no interaction. The viewer passively observes. In Plaza Mayor, the interactivity of sculpture is higher with the environment than with the visitors. In StreetMueum application, there is no human-human interaction. It encourages human-mobile interactions.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

	Passive (Passive - passive)						Dynamic (Dynamic-passive)		Interactive (Dynamic- interactive)						
									Direct				Indirect		
	Media facades	Screens displaying data	Sound art	light painting	Projection-Mapping (on façades, walls, floors, stairs, or ceilings)	Kinetic sculptures with light	Installation changes with the weather conditions	Installation changes with the water conditions	Through touch: Interactive LED panels	Through gesture	Through sound monitors	Through movement sensors	Virtual reality With VR BOX	Augmented reality with Mobile applications	Interactive public Screens
Trafalgar Square in London.		√		√	√	√			√						√
CBD of some countries	√	√													
Plaza Mayor in Madrid.						√	√								
Giza Pyramids in Egypt.			√		√										
Historic streets in London.														√	

Table 1: the different levels of interactivity with digital public art in the selected examples.

The following table presents selected examples of historical urban spaces with different types of DPA. Examples are being analysed according to the types of public art and their impact on two main futures (interactivity and identity).

Historical urban spaces	Types of public art	Interactivity	Identity
Trafalgar Square in London	Massive sculptures. Video mappings. Interactive artworks	The square has high levels of interaction The visitors have transformed from passive spectators to users who interact with artworks.	It attracted more visitors and taught about the history of the place, but this kind of celebration had a religious and spiritual meaning. Spiritual meaning has given way to amusement and stupefaction.
CBD of some countries	Urban screens. Media facades	The public screens contain an internal mechanism that allows them to alter or be modified without being affected by their surroundings. The viewer passively observes these activities (Edmonds, Turner and Candy, 2004). There are no interactions.	These digital information screens are similar everywhere; The urban place perception is almost identical. They bring nothing except a sense of "placelessness." These screens are designed for commercial purposes only without engaging the space. (Sökmenoğlu and Türkkan, 2009).
Plaza Mayor in Madrid	Suspended fibre sculpture with light projection	The sculpture moves and changes with the wind and weather; when lights are projected onto it at night, it transforms into a colourful sea. The sculpture interacts more with the environment than with the visitors.	"For 400 years, people have gathered at Plaza Mayor to witness bullfights. Today, they get together to explore their sense of time via art" Janet Echelman According to the visitors' recorded video interviews, it is a cheerful and colourful sculpture regardless of the identity of the6 space.
Giza Pyramids in Egypt.	Sound and light Show with projection mapping.	Most of the digital public art in Egypt has no interactions. The viewer passively observes these activities (Edmonds, Turner and Candy, 2004).	The Sound Light shows take the spectators on a journey thousands of years back, bringing the Egyptian legacy back to life, and enhancing the identity (Experts, 2022).
Historic streets in London	Mobile application	An individual engagement using a smartphone app compatible with over 200 places in the capital by seeing a photo or painting of it in the past (Eccleston-Brown, 2010).	This application makes Old London more accessible. It strengthens the identity by helping Londoners discover the city's hidden past (Eccleston-Brown, 2010).

Table 2: Comparative analysis of the five examples

The analysis of the five examples shows that various types of digital public art have varying effects on the interactivity and identity of the historical urban spaces. Some types, such as light and sound shows, can enhance identity through passive interaction. They tell stories about the history of spaces in the same way that the StreetMueum app provides users with a feeling of identity, but it stimulates connection with new technologies.

Other types stimulate more interaction, but this reduces identity enhancement because it makes people feel cheerful and have fun without emphasising identity. Trafalgar Square has a high level of interaction, but its

spiritual meaning has given way to amusement and stupefaction. Other types, such as Times Square, destroy identity and diminish the sense of distinction and uniqueness. The perception of the square is nearly identical to other urban spaces. Also, in Plaza Mayor, the relationship between this sculpture and the square's identity is questionable, as it resembles other sculptures the designer used in other urban spaces.

This study tries to re-conceptualise the role of public art by merging digital technologies into our everyday lives. It speculated how digital forms of public art could promote interaction and construct or deconstruct the concept of identity in historical urban spaces. As seen through the five examples (Table 2), the digital public art interventions in the public spaces have the potential to influence the perception of space and attitude towards it, creating new identities.

Globally, digitalisation significantly impacts cities and how people interact with their spaces. It inspires and catalyses social engagement and participation with space elements and the surrounding environmental context. Digital interactive public art is one of the main tools for liveable cities and more functional spaces. However, some screens serve mainly commercial purposes, showing objects in different scales and proportions without considering the surrounding environment.

8 REFERENCES

AHMED, Salah Uddin: Interaction and Interactivity: In the Context of Digital Interactive Art Installation. 2018.

AHMED, Salah Uddin, JACCHERI, Letizia and M'KADMI, Samir:Sonic onyx: Case study of an interactive artwork. 2009.

ALAIMO, Carly:Gallery: Fantastical floating sculptures that will send your mind soaring. 2018.

BALINT, Wilhelm:Trafalgar Square in London.

BECKER, Jack: Public art: An essential component of creating communities. Washington, DC, 2004.

BERG: The Evolving Field of Urban Design. Vol. pp. 2009.

CANT, Sarah G J Social Morris, Nina J and GEOGRAPHY, Cultural: Engaging with place: artists, site-specificity and the Hebden Bridge Sculpture Trail. Vol. 7, (6) 6, pp. 863-888. 2006.

CARTIERE, Cameron and ZEBRACKI, Martin: The everyday practice of public art: Art, space, and social inclusion. London, 2015.

DEWEY, John: Art as experience. New York, 1934.

DOVEY, Kim: Urban design thinking : a conceptual toolkit. London ; New York, 2016.

DUBOIS, Jean, COLANGELO, Dave and FORTIN, Claude: Disrupting the City: Using Urban Screens to Remediate Public Space. Vol. pp. 2015.

ECCLESTON-BROWN, O:Old London seen with new eyes thanks to mobile apps. BBC. 2010.

EDMONDS, Ernest, TURNER, Greg and CANDY, Linda:Approaches to interactive art systems. 2004.

ESCOBAR, Maria Paula: The power of (dis) placement: pigeons and urban regeneration in Trafalgar Square. cultural geographies, Vol. 21, (3) 3, pp. 363-387. 2014.

EXPERTS, Digital:Sound & Light Egypt Show. 2022.

FESTIVAL, London Design: Please feed the lions. Vol. pp. 2018.

FLEMING, Ronald Lee: The art of placemaking: Interpreting community through public art and urban design. 2007.

HALL, T. Opening up public art's spaces: art, regeneration and audience. In: Miles, M. J. and N. Kirkham (ed.) Cultures and settlements. Bristol, Eng. ; Portland, OR: Intellect, 2003.

HALL, Tim and ROBERTSON, Iain: Public art and urban regeneration: advocacy, claims and critical debates. Vol. pp. 2001.

HALL, Tim and SMITH, Chereen: Public art in the city: meanings, values, attitudes and roles. J Interventions: Advances in Art Urban Futures, Vol. 4, pp. 175-179. 2005.

HAUS, Michael, HEINELT, Hubert and STEWART, Murray: Urban governance and democracy : leadership and community involvement. London ; New York, 2005.

HAWKINS, Harriet: Geography and art. An expanding field. Progress in Human Geography, Vol. 37, (1) 1, pp. 52-71. 2012.

HU, Jun, WANG, Feng, FUNK, Mathias, FRENS, Joep, ZHANG, Yu, VAN BOHEEMEN, Thom, ZHANG, Chenxi, YUAN, Qi, QU, Hongrui and RAUTERBERG, Matthias:Participatory public media arts for social creativity. 2013.

KENT, Fred: Project for public spaces. New York NY, Vol. pp. 2009.

LI, Liyuan and LUO, Mengxue: Study on Interactive Urban Public Art in the Background of Big Data. Vol. pp. 2017.

LOSSAU, Stevens, Quentin Julia: The uses of art in public space. 2015.

LYNCH, Kevin: Good city form. 1984.

MATHEW, Terence and MANOHAR, Sai: The first step study of Digital Art work and its impact on the Young People in Bangalore. International Journal of Advanced Research Methodology in Engineering & Technology, Vol. 1, (3) 3, pp. 210-211. 2017.

MCCARTHY, John: Regeneration of cultural quarters: public art for place image or place identity? Journal of Urban Design, Vol. 11, (2) 2, pp. 243-262. 2006.

MCCARTHY, John J Journal of Urban Design: Regeneration of cultural quarters: public art for place image or place identity? Vol. 11, (2) 2, pp. 243-262. 2006.

MILES, Malcolm and MANNION, Antoinette M: Art, Space and the City: Public Art and Urban Futures. 1997.

MOHAMMED-AMIN, Rozhen:Augmented reality: A narrative layer for historic sites. 2010.

MOUGHTIN, Cliff: Urban design: street and square. 2003.

PAUL, Christiane: New media in the mainstream. Vol. pp. 2011.

PORTER, L.:Lumiere London 2018 – The Incredible Festival of Lights Returns to London – Londontopia. . 2018.

POST, Chris W Art, scale, and the memory of tragedy: A consideration of public art in Pleasant Hill, Missouri. J Material Culture Vol. pp. 43-58. 2011.

PROJECT FOR PUBLIC SPACES:“What Is Placemaking?”. 2007.
ROBINSON, Charles Mulford: Modern civic art: or, The city made beautiful. 1904.
SEARLE, Adrian:Antony Gormley's fourth plinth is his best artwork yet. 2009.
SENIE, Harriet F: Responsible criticism: evaluating public art. Sculpture, Vol. 22, (10) 10, pp. 44-49. 2003.
SETIAWAN, Teguh:Role of public art in urban environment:: A case study of mural art in Yogyakarta city. 2010.
SHARP, Joanne, POLLOCK, Venda and PADDISON, Ronan: Just art for a just city: Public art and social inclusion in urban regeneration. Urban Studies, Vol. 42, (5-6) 5-6, pp. 1001-1023. 2005.
SÖKMENOĞLU, Ahu and TÜRKKAN, Sevgi: Digital Monumentality in/for Public Space. 2009.
STAFF, the MasterClass: What Is New Media Art? Definition and History of New Media Art. Vol. pp. 2021
TOMITSCH, Martin: Communities, spectacles and infrastructures: Three approaches to digital placemaking. Vol. pp. 339-347. 2016.
TRAVEL, Ammos:Madrid’s Plaza Mayor celebrates 400th anniversary with a colourful floating sculpture. 2018.
URBAN75: In photos: Lumiere festival 2018 – lights and interactive installations around central London. 2018.
URBANOWICZ, Katarzyna and NYKA, Lucyna:Media architecture: participation through the senses. 2012.
URBANOWICZ, Katarzyna and NYKA, Lucyna:Media architecture and interactive art installations stimulating human involvement and activities in public spaces. 2016.
WANG, Feng, HU, Jun and RAUTERBERG, Matthias: New carriers, media and forms of public digital arts. Culture and Computing, Vol. pp. 83-93. 2012.

🏆 *reviewed paper*

Emotion Sensing für (E-)Fahrradsicherheit und Mobilitätskomfort – das BMDV-Projekt ESSEM

Peter Zeile, Nina Haug, Céline Schmidt-Hamburger, Steffen Bengel, Nicolaj Motzer, Frank Otte, Tom Rath, Peter Klein, Martin Moser, Bernd Resch

(Dr.-Ing. Peter Zeile, Karlsruher Institut für Technologie KIT, Professur Stadtquartiersplanung STQP, peter.zeile@kit.edu)
(MSc. Nina Haug, Karlsruher Institut für Technologie KIT, STQP, nina.haug@kit.edu)
(MA Céline Schmidt-Hamburger, Karlsruher Institut für Technologie KIT, STQP, celine.schmidt-hamburger@kit.edu)
(MSc. Steffen Bengel, Universität Stuttgart, IAT, steffen.bengel@iat.uni-stuttgart.de)
(MSc. Nicolaj Motzer, Universität Stuttgart, IAT, nicolaj.motzer@iat.uni-stuttgart.de)
(Dipl.-Ing. Frank Otte, Stadt Osnabrück, Vorstand Umwelt und Bauen, otte@osnabrueck.de)
(Tom Rath, Bike Citizens, Director of Digital Business, Graz, tom@bikecitizens.net)
(Dr. Peter Klein, Head of Research & Innovation, Peter.Klein@uid.com, Ludwigsburg)
(MSc. Martin Moser, FB Geoinformatik – Z_GIS, martin.moser@plus.ac.at, Salzburg)
(Prof. Dr. Bernd Resch, Associate Professor & Head Geo-social Analytics Lab, Salzburg, bernd.resch@plus.ac.at)

1 ABSTRACT

Das Fahrrad nimmt in der Diskussion um postfossile Mobilitätsformen eine wichtige Schlüsselrolle ein und kann vor allem im Stadtverkehr eine bedeutsame Alternative zum motorisierten Individualverkehr darstellen. Fahrradfahren ist nicht nur umweltfreundlich, klimaschonend und kostengünstig, sondern auch förderlich für die persönliche Gesundheit. In der Realität legt sich dies im Modal Split vieler Städte immer noch nicht nieder. Vielfach wird der Umstieg auf das Fahrrad hin zur flächendeckenden Nutzung durch ein mangelndes Sicherheitsempfinden von Radfahrenden verhindert.

Das im mFUND-Programm des Bundesministerium für Digitales und Verkehr (BMDV) geförderte Verbundprojekt Emotion Sensing für (E-)Fahrradsicherheit und Mobilitätskomfort, kurz „ESSEM“, untersucht aus diesem Anlass heraus das subjektive Sicherheitsempfinden von Radfahrenden im Stadtverkehr. Mithilfe iterativer Erhebungen von umfeld- und körpernahen Daten mittels Sensoriktechnologien werden in den beiden Modellstädten Ludwigsburg und Osnabrück Stresspunkte im kommunalen Radverkehrsnetz identifiziert und analysiert.

Die gewonnenen Erkenntnisse sollen dabei helfen, Methoden und Handlungsempfehlungen für eine moderne, datengestützte Radverkehrsplanung zu entwickeln und die Fahrradinfrastruktur zukünftig angenehmer und sicherer gestalten zu können. Perspektivisch sollen innerhalb der dreijährigen Projektlaufzeit gemeinsam mit Industriepartnerinnen und Industriepartnern neben einem praxistauglichen Tool zum Bewerten von Fahrradinfrastrukturen mit Emotion-Sensing-Daten noch weitere Fahrradkomponenten (u.a. digitaler Rückspiegel) in der Produktentwicklung hervorgebracht werden.

In einer ersten Messkampagne wird in Kooperation mit dem Partner Bike Citizens ein partizipativer Ansatz verfolgt. Die Ansprache für die Akquise von Probandinnen und Probanden erfolgt in der bestehenden, aktiven Bike Citizens Fahrrad-Community. Die gleichnamige App zeichnet auf, welche Routen die rund 350 Probandinnen und Probanden in den beiden Modellstädten für ihre alltäglichen Fahrten nutzen, oder welche sie sogar erkennbar meiden.

Diese ersten Erkenntnisse bilden die Grundlage für die ab Sommer 2022 durchgeführten, mehrphasigen EmoCycling-Messungen, bei denen die messbare physiologische Stressreaktion der Probandinnen und Probanden lokal verortet und kartiert wird. Die Messungen werden im Projekt ergänzt durch standardisierte Fragebögen, welche im Zuge der Auswertung Aufschluss über persönliche Einflussfaktoren auf das Stressempfinden, wie zum Beispiel Alter, Geschlecht oder psychologische Merkmale geben. Die gewonnenen Erkenntnisse sollen dazu beitragen, mehr Wissen über die unterschiedlichen Typen an Radfahrenden für die Planung zu generieren.

Keywords: Infrastruktur, Fahrradverkehr, Sicherheit, Emotion Sensing, Prototypenentwicklung

2 EINLEITUNG

Von den Wegen zur Arbeit, Ausbildung oder Freizeitaktivitäten bis hin zur täglichen Versorgung - Mobilität prägt unseren Alltag und gehört in unterschiedlichem, sehr individuellen Umfang zu unserem sozialen Leben. Als Alternative zum Auto und Ergänzung zum ÖPNV und Fußverkehr erfährt vor allem die Fahrradmobilität eine steigende Relevanz. Nicht zuletzt durch das veränderte Mobilitätsverhalten während der Corona-Pandemie und der Möglichkeit des Pedelecs nimmt das Fahrrad besonders im Stadtverkehr eine Schlüsselrolle ein. Gleichzeitig entlastet Fahrradfahren die Umwelt und kann das persönliche Wohlbefinden

und die Gesundheit fördern. In der Realität legen sich diese Argumente für die Nutzung des Fahrrads im Modal Split vieler Städte allerdings immer noch nicht nieder.

Laut der Studie „Mobilität in Deutschland 2017“ des Bundesministeriums für Verkehr und digitale Infrastruktur (BMVI) verzeichnet der Anteil des motorisierten Individualverkehrs im Modal Split bundesweit mit rund 60 Prozent immer noch Zuwachs, wohingegen jedoch nur rund 11 Prozent aller Wege mit dem Fahrrad zurückgelegt werden (Follmer und Gruschwitz, 2019). Ein zentraler Grund, der der flächendeckenden Nutzung des Fahrrads im Weg steht, liegt im mangelhaften subjektiven Sicherheitsempfinden der Radfahrenden. Denn die Wahl des Verkehrsmittels hängt neben den Faktoren wie Komfort, Wegzeit und Kosten zu einem Großteil ebenso davon ab, ob Nutzerinnen und Nutzer die Mobilitätsform als angenehm oder unangenehm empfinden. So wird auch im „nationalen Radverkehrsplan 2020“ angegeben, dass Radfahrende, die sich besonders unsicher fühlen, auch weniger Fahrrad fahren (BMVI, 2022).

Für planende Städte und Gemeinden besteht zudem die Schwierigkeit, dass Stress auslösende und gefährliche räumliche Situationen wie zum Beispiel kritische Knotenpunkte und Führungsformen in der Realität oft nur schwer identifiziert werden können. Während nämlich bei statistisch relevanten Unfallhäufungen an einer Stelle entsprechende Maßnahmen ergriffen werden können, bleiben sogenannte Beinaheunfälle hingegen oft unerkannt, werden nicht in die Unfallstatistiken aufgenommen und bilden in der Praxis ein fortwährendes Hemmnis für unentschlossene Radfahrende. Die flächendeckende Nutzung des Fahrrads kann langfristig allerdings nur dann umgesetzt werden, wenn nicht nur die objektive, sondern auch die subjektiv empfundene Verkehrssicherheit von Radfahrenden mit der Umsetzung stressarmer, sicherer und qualitätsvoller Fahrradinfrastruktur erhöht wird.

3 STAND DER FORSCHUNG

Im nachfolgenden Kapitel werden die wichtigsten Grundlagen und Quellen für das im Projekt ESSEM vorgeschlagene Verfahren erläutert. Dabei geht es um das objektive und subjektive Sicherheitsempfinden von Radfahrenden, die unterschiedlichen Radfahrtypen und die Detektion von Stress mithilfe der EmoCycling-Methode.

3.1 Objektives und subjektives Sicherheitsempfinden

Mit dem Nationalen Radverkehrsplan 3.0 (BMVI, 2022) wird aktiv darauf hingewirkt, den Radverkehrsanteil in Deutschland in den nächsten Jahren kontinuierlich zu erhöhen und die Fahrradinfrastruktur auszubauen. Allerdings empfinden viele Menschen die Sicherheit im Radverkehr als unzureichend, was sie davon abhält, auf das Fahrrad als Verkehrsmittel umzusteigen.

Im Allgemeinen setzt sich die Sicherheit des Radverkehrs sowohl aus einer objektiven, als auch aus einer subjektiven Dimension, sowie deren Korrelation zusammen (Johannsen, 2013). Dabei beschreibt die objektive Sicherheit eine quantitative Betrachtung der tatsächlich eingetretenen Unfälle und stützt sich in der Regel auf die Veröffentlichung der polizeilichen Unfallstatistik. Bei der subjektiven Sicherheit handelt es sich hingegen um eine emotionale Betrachtung der Bedrohlichkeit einer Verkehrssituation durch die Verkehrsteilnehmerinnen und Verkehrsteilnehmer selbst (Fuller, 2005). Geprägt wird dieses subjektive Sicherheitsempfinden bei Radfahrerinnen und Radfahrern vor allem durch kritische Situationen, Beinaheunfälle oder Behinderungen im Verkehr.

Einige Radfahrexpertinnen und Radfahrexperten wie Thiemo Graf erachten deshalb die „Reduzierung von Stress“ im Radverkehr als einen wesentlichen Faktor zur Steigerung des Radverkehrsanteils (Graf, 2016). So erscheint es evident, dass nur, wenn eine Person das Fahrrad als sicher empfindet, sie es auch als Verkehrsmittel für ihre alltägliche Mobilität verwenden wird. Eine Schlüsselrolle nehmen dabei insbesondere solche Personen ein, die bislang wenig bis überhaupt kein Fahrrad fahren.

Aber nicht nur „exogene“ bzw. bauliche oder interaktive Einflussfaktoren beeinflussen das individuelle Mobilitätsverhalten. Auch variiert der Effekt äußerer Einflussfaktoren je nach persönlichen, „endogenen“ Merkmalen. Hervorzuheben sind hierbei das Geschlecht, das Alter, das Mobilitätsprofil (Menschen mit oder ohne Behinderung), Wegezwecke, Gewohnheit (Verkehrsmittel, Ortskenntnis) und psychologische Dispositionen (Schmidt-Hamburger, 2022).

3.2 Radfahrtypen

Es erscheint offensichtlich, dass das subjektive Empfinden von Sicherheit im Straßenverkehr aufgrund individueller Eigenschaften und Gegebenheiten der jeweiligen Person stark variieren kann. Eine Möglichkeit, das subjektive Sicherheitsempfinden zu analysieren ist es deshalb, Radfahrende in verschiedene, zuvor definierte Radfahrtypen zu kategorisieren.

Neben diversen anderen Modellen zur Unterscheidung verschiedener Radfahrtypen, lassen sich in der Kategorisierung nach Geller grundsätzlich vier Gruppen anhand ihres Radfahrverhaltens voneinander unterscheiden, die als eine Grundlage für die Datenerhebungen und Befragungen im Projekt ESSEM herangezogen werden.

Die charakteristischen Eigenschaften der vier Radfahrtypen „Die Starken und Furchtlosen", „die Begeisterten und die Souveränen", „die Interessierten aber Besorgten" und „Keine Chance, ganz egal wie" (Geller, 2009) sind in Tabelle 1 dargestellt. Die Zugehörigkeit zu einer dieser Gruppen kann sich – je nach Veränderung des Mobilitätsverhaltens und Lebenssituation – dynamisch verändern und ist bei manchen Personen nicht eindeutig zuzuordnen. Nichtsdestotrotz bietet die Einteilung in die vier Gruppen einen wichtigen Anhaltspunkt, um die Fähigkeiten, Wünsche und Bedürfnisse der verschiedenen Radfahrtypen analysieren zu können.

Radfahrgruppe	Die Starken und Furchtlosen (furchtlose Radfahrende)	Die Begeisterten und Souveränen (Alltagsradfahrende)	Die Interessierten aber Besorgten (Interessierte Radfahrende)	Keine Chance, ganz egal wie!
Eigenschaften	Nutzt Fahrrad immer, sicher und souverän	Fährt täglich Strecken, souverän aber mittleres Sicherheitsbedürfnis	Keine Alltagsmobilität mit dem Fahrrad; besorgt bezüglich der Sicherheit, aber dem Fahrrad gegenüber aufgeschlossen	In der Regel keine Fahrradnutzung
Fahrkönnen	Ausgezeichnete Beherrschung des Fahrrades	Selbstbewusst, teilweise defensiv wegen Sicherheit	Weniger souverän	Schlechte Kontrolle über das Fahrrad, fehlende Fahrpraxis
Stresstoleranz	Hoch	Mittel	Niedrig	Sehr niedrig

Tabelle 1: Eigenschaften der Radverkehrsgruppen nach Geller (Quelle: Verändert nach Graf, 2016)

Hinsichtlich der Radverkehrsförderung, und damit auch für das Projekt ESSEM, steht die Gruppe „Interessierte Radfahrende" im Fokus, da diese im Allgemeinen zwar gegenüber dem Fahrradfahren aufgeschlossen sind, jedoch bezüglich ihrer Sicherheit besorgt sind und das Fahrrad deshalb noch nicht für ihre täglichen Fahrten verwenden. Die Gruppen „Furchtlose Radfahrende" und „Alltagsradfahrende" bilden hingegen lediglich Randzielgruppen, da sie das Fahrrad bereits regelmäßig in der Alltagsmobilität nutzen. Selbstverständlich besteht hier jedoch die Motivation, diese auch weiterhin in der Nutzung des Fahrrads zu bestärken. Einen Sonderfall stellt die Gruppe „Keine Chance, ganz egal wie!" dar, für die das Fahrrad als Verkehrsmittel keine Option darstellt.

3.3 EmoCycling

Wenngleich der subjektiven Verkehrssicherheit zweifellos eine hohe Relevanz in Bezug auf die Förderung des Fahrradverkehrs beigemessen wird, so mangelt es dennoch weiterhin an praxistauglichen Strategien und Erfahrungen, um das subjektive Sicherheitsgefühl objektiv erfassen zu können. Im Planungsalltag der kommunalen Verkehrsplanung stellt sich das subjektive Sicherheitsgefühl von Radfahrenden deshalb bislang als eine nur schwierig quantifizierbare und vor allem auch kaum zu lokalisierende Größe dar. Auch im Nationalen Radverkehrsplan 3.0 (BMVI, 2022) werden hierzu keine handhabbaren Strategien genannt. Dabei muss die Operationalisierung des subjektiven Sicherheitsempfindens als ein entscheidender Faktor in der Radverkehrsförderung angesehen werden.

Die im Projekt verwendete Methodik des EmoCyclings findet ihren Ursprung in der 2009 von Christian Nold initiierten „emotionalen Kartografie". Ein wesentlicher Bestandteil stellte dabei ein eigens entwickeltes „Bio Mapping"-Gerät, das biostatistische Daten georeferenziert aufzeichnete und als Karte visualisiert dar (Nold,

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

2009). Damit konnte der Mensch und seine individuelle physiologische Reaktion erstmals als eine Art Sensor dienen und der Stress- bzw. Erregungszustand im urbanen Kontext aufgezeichnet werden. Nach einer Reihe anderer Forschungsarbeiten enthüllten Zeile et al (2016) die häufigsten Auslöser für Stressreaktionen bei Radfahrenden mithilfe von Wearables, Kameras und einer Smartphone-basierten Anwendung. Hauptsächlich wurde im Zuge dessen die spezifische Verkerssituation als Stressauslöser identifiziert, wie zum Beispiel Führungsformen, hohe Verkehrsaufkommen, gefährliche Überholvorgänge oder die Beschaffenheit des Straßenbelags.

Das Sensorarmband misst während der Fahrradnutzung die Vitaldaten, genauer die Hautleitfähigkeit und -Tempetarur, der Probandinnen und Probanden und synchonisiert diese mithilfe eines Smartphones mit den dazugehörigen GPS-Daten. Eine Stressreaktion wird in der Auswertung dann identifiziert, wenn die Hautleitfähigkeit ansteigt und die Hauttemperatur abfällt. Vereinfacht ausgedrückt sind diese Indikatoren einer negativen Erregung auch als „kalter Angstschweiß“ geläufig. Durch die Kombination mit einer Befragung der Probandinnen und Probanden nach dem Mixed-Methods-Ansatz kann dann spezifischer auf die identifizierten Stresspunkte eingegangen werden.

Bei der Erforschung von Stressphänomenen und deren schädlicher Auswirkungen auf den menschlichen Körper ist es nämlich vor allem relevant, als wie stark die jeweilige Person den erlebten Stress bewertet und somit auch empfindet. Diese subjektive Stressbewertung wiederum lässt sich durch Hinzunahme von Angaben über das Mobilitätsprofil, soziodemographische sowie soziopsychologische Annahmen weiter spezifizieren. Die endogenen Einflussfaktoren beziehen sich dabei auf individuelle demographische, sozioökonomische und soziokulturelle Attribute von Individuen und deren sozialer Umgebung, die die Wahrnehmung maßgeblich beeinflussen (Wermuth, 2005). Beispielhaft sind hier das Geschlecht, das Alter, die körperliche Konstitution, die Ortskenntnis oder auch die Vertrautheit mit dem Verkehrsmittel von Relevanz.

Weiter gibt es aus biopsychologischer Sicht Anhaltspunkte, dass genetische bzw. psychologische Prädispositionen Stressreaktionen verstärken bzw. abmildern können. Hierbei sind vor allem die Persönlichkeit, die Kontrollüberzeugung und die Risikobereitschaft herauszustellen (Schandry, 2016 und Kovaleva et al., 2012). Diese Daten werden mittels standardisierter Fragebögen vor den Sensormessungen erhboben und bei der Auswertung einbezogen. Erhofft wird sich dabei besonders vulnerable Gruppen in Bezug auf Stress zu identifizieren, um Kenntnisse über Hemnisse der Gleichstellung von Radfahrenden zu erhalten.[1]

Der Vorteil von Mixed-Methods-Ansätzen besteht dabei vor allem in der Kombination quantitativer Messdatenauswertungen mit qualitativen Umfragen und bietet zuverlässigere und umfassendere Ergebnisse als singulär angewendete Messtechniken. Denn die verwendeten Methoden können sich dabei ergänzen und ihre jeweiligen Mängel teilweise abmildern (Resch et al 2020).

4 ESSEM: PROJEKTZIELE

Das vorgestellte Projekt ESSEM befasst sich mit der Identifikation von Einflussfaktoren auf die subjektiv empfundene Sicherheit von Radfahrenden. Das Projekt hat zum Ziel, den Komfort und die Sicherheit von Radfahrenden zu steigern und damit einen Beitrag für eine nachhaltige und klimaneutrale Mobilität zu leisten. Mithilfe iterativer und sensorengestützter Erhebungen von umfeld- und körpernahen Daten nach einem EmoCycling-Mixed-Methods-Ansatz werden in den beiden Modellstädten Ludwigsburg und Osnabrück mit jeweils rund 350 Probandinnen und Probanden Stresspunkte in der lokalen Fahrradinfrastruktur identifiziert und analysiert.

4.1 Datengestützte Radverkehrsplanung

Mit den erhobenen Projektdaten sollen Mechanismen entwickelt werden, mit denen sich ausgehend von der zugrundeliegenden Infrastruktur, der Umwelteinflüsse, der genutzten Radausstattung sowie dem Radzubehör die Sicherheit, das Sicherheitsempfinden und der Mobilitätskomfort im Radverkehr bemessen lassen. Die gewonnenen Erkenntnisse sollen dabei helfen, Optimierungsbedarfe für (E-)Fahrradinfrastrukturen und -

[1] Vertiefend wird auf die Methodik im Beitrag „Stresstest Fußverkehr: Eine Studie im Rahmen des NRVP-Projektes „Cape Reviso” zur Messung des Stressempfindens Zufußgehender in Stuttgart“ von Céline Schmidt-Hamburger (2022) im Rahmen der REAL CORP 2022 eingegangen.

komponenten zu ermitteln. In den beiden Modellstädten Ludwigsburg und Osnabrück wird damit eine moderne, nutzerzentrierte und datengestützte Radverkehrsplanung gefördert und das Umweltsensitive Verkehrsmanagement (UVM) in Osnabrück weiter vorangebracht. Im Rahmen des Projekts soll langfristig ein innovatives, datenbasiertes und vor allem praxistaugliches Instrument entwickelt werden, mithilfe dessen städtische Fahrradinfrastrukturen überprüft und optimiert werden können.

4.2 Entwicklung fahrradbezogener Produkt- und Servicedemonstratoren

Darüber hinaus wird im Zuge des Projekts gemeinsam mit verschiedenen Industriepartnerinnen, Industriepartnern, Netzwerken und Verbänden ein Innovationsnetzwerk aufgebaut, im Rahmen dessen die datengestützte (Weiter-)Entwicklung fahrradbezogener Produkt- und Servicedemonstratoren aktiv gefördert werden soll. Hervorzuheben sind die Projektbeteiligten Bike Citizens, Porsche Digital und UID, die anhand konkreter Anwendungsfälle ihre Produkte und Services wie zum Beispiel das intelligente Fahrradnavigationstool und den digitalen Fahrradrückspiegel datengestützt und nutzerzentriert (weiter-)entwickeln.

5 ABLAUF UND ERSTE ERGEBNISSE DER DATENERHEBUNGSPHASEN

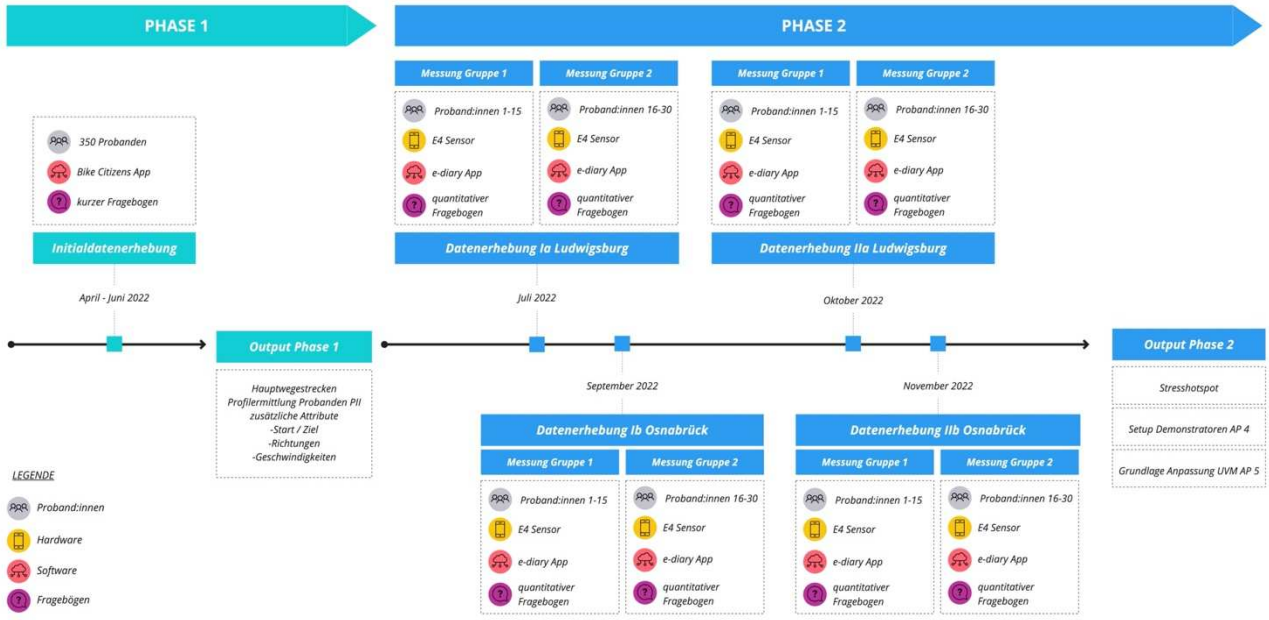


Abb. 1: Diagramm Ablauf Datenerhebungsphasen.

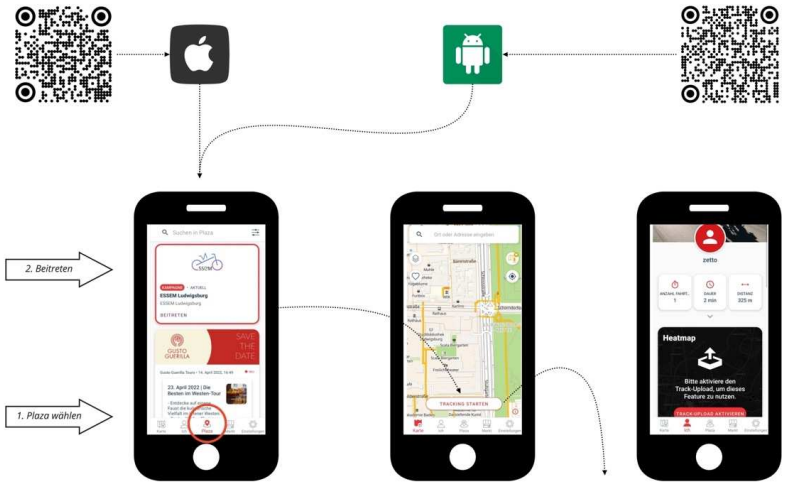


Abb. 2: Setting Initialdatenerhebung über die App Bike Citizens.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

5.1 Phase 1: Initialdatenerhebung

Im Rahmen der Initialdatenerhebung in der ersten Datenerhebungsphase erfolgt die Ansprache für die Akquise von Probandinnen und Probanden in Kooperation mit dem Projektpartner Bike Citizens. In der bestehenden, aktiven Fahrrad-Community der gleichnamigen App werden die Nutzerinnen und Nutzer über einen Banner mit kurzem Infotext dazu aufgefordert, sich am Projekt zu beteiligen. Über eine Verlinkung der Projekthomepage werden dann weitere Informationen zum Ablauf der Datenerhebungsphasen und den Projektzielen bereitgestellt.

Sobald die Nutzerinnen und Nutzer einwilligen, am Projekt teilzunehmen, zeichnet die App innerhalb eines festen Zeitraums auf, welche Routen die rund 350 Probandinnen und Probanden in den beiden Modellstädten Ludwigsburg und Osnabrück für ihre alltäglichen Fahrten mit dem Fahrrad nutzen. Zum Ende des Zeitraums werden die anonymisierten Datensätze ausgewertet und in einer Gesamtgrafik der Hauptwegenetze für die beiden Modellstädte kartiert. Die Daten der Initialdatenerhebung bilden die Grundlage für die ab Sommer 2022 durchgeführten, mehrphasigen EmoCycling-Messungen.

5.1.1 Ergebnisse der Initialdatenerhebung in Ludwigsburg

Mithilfe der von Bike Citizens entwickelten Analysefunktionnen lassen sich verschiedene fahrradverkehrsspezifische Aussagen aus den gesammelten Tracks der Nutzerinnen und Nutzer treffen. So ist es möglich, die Intensität in Bezug auf die Anzahl der Radfahrerinnen und Radfahrer im Netz zu ermitteln, sich die durchschnittliche Geschwindigkeiten pro Straßensegment anzeigen zu lassen, (forcierte) Wartezonen in Bezug auf ihre Häufigkeit zu identifizieren, den Aktionsradius der Teilnehmenden zu ermitteln sowie die Attraktivität des Straßensegments im Vergleich zum Gesamtnetz zu berechnen. Die Attraktivitätsfunktion identifitziert dabei bevorzugte und gemiedene Routen. Nehmen die Radfahrerinnen und Radfahrer einen Umweg in Kauf und meiden die kürzestete Route, so werden diese Abschnitte in Rot dargestellt. Beliebte Umwege erscheinen in grün. Die Liniendicke zeigt die Intensität an.

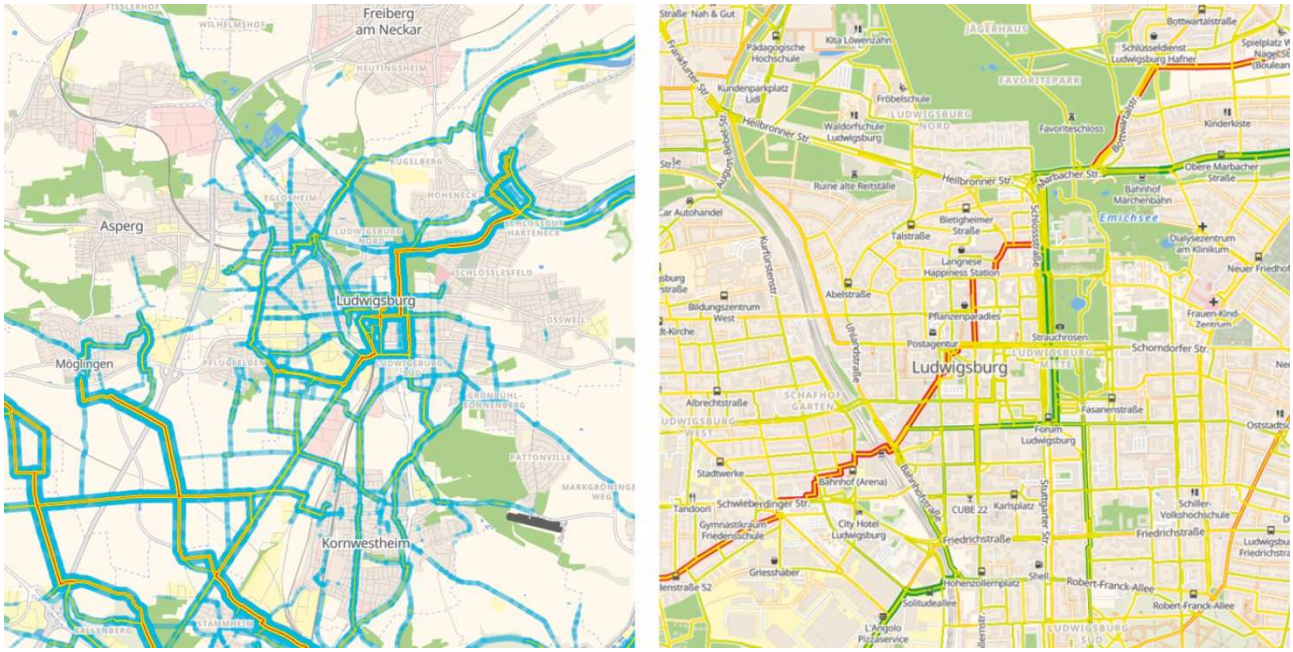


Abb. 3: Initialdatenerhebung in Ludwigsburg: Hauptwegenetz (links) und Attraktivitäten (rechts).

In Abbildung 3 sind diese Analysen gut zu erkennen: Auf der linken Seite ist das Hauptwegenetz abgebildet, das die Intensität in Form einer Heatmap über die Anzahl der Radfahrenden im Straßennetz ermittelt. Gut zu erkennen ist hier die Stuttgarter Straße als Hauptachse in Richtung Nord-Süd, entlang der barocken Parkanlage des Ludwigsburger Schlosses. Weiterhin lassen sich der Weg Richtung Neckar in östlicher Richtung sowie die Ausfallstraßen Richtung Westen als wichtige Achsen identifizieren. Auf der rechten Seite im Fokus „Innenstadt“ fällt bei der Attraktivitätsanalyse auf, dass viele Radfahrende aus der Innnenstadt den direkten Weg zum Bahnhof meiden und bevorzugt die orthogonalen Straßen nutzen. Demgegenüber steht die präferierte Nutzung der Radinfrastruktur entlang der Stuttgarter Straße, die häufig von Radfahrenden genutzt wird.

5.1.2 Ergebnisse der Initialdatenerhebung in Osnabrück

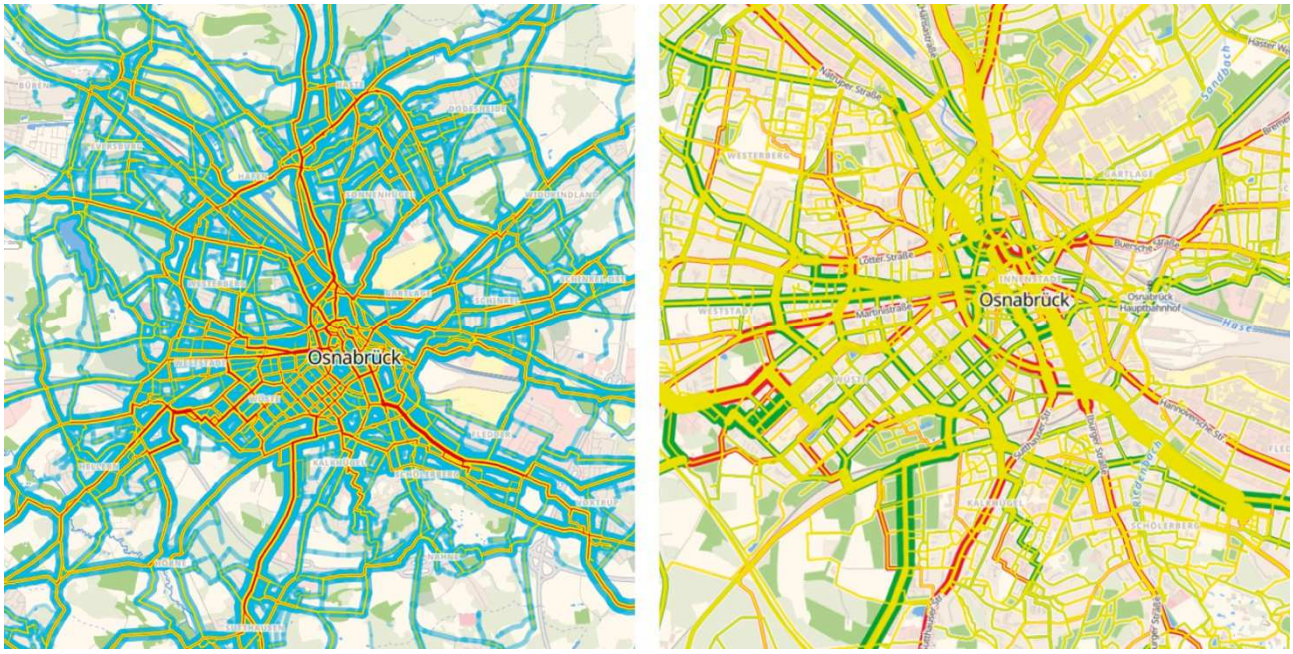


Abb. 4: Initialdatenerhebung in Osnabrück: Hauptwegenetz (links) und Attraktivitäten (rechts).

Auffallend in Osnabrück ist allgemein die intensive Nutzung der Wege in das Stadtzentrum. Im westlichen Bereich ist das vor allem die als Fahrradstraße markierte Katharinenstraße und die überwiegend auf Tempo 30 beschränkten Straßen des Stadtteils Wüste. Gemieden werden hingegen die unmittelbar parallel zur Katharinenstraße verlaufende, vom MIV geprägte Martinistraße im Süden und die Lotter Straße im Norden. Auch der südwestliche Innenstadtring wird von den Radfahrenden gemieden. Im Süden in Kalkhügel wird die Sutthauser Straße zugunsten des Burenkamp umfahren. Im Südosten ziehen die teilnehmenden Radfahrenden die Meller Straße der vierspurigen Hannoverschen Straße vor.

5.2 Befragungsprozess und Probandenauswahl Phase 2

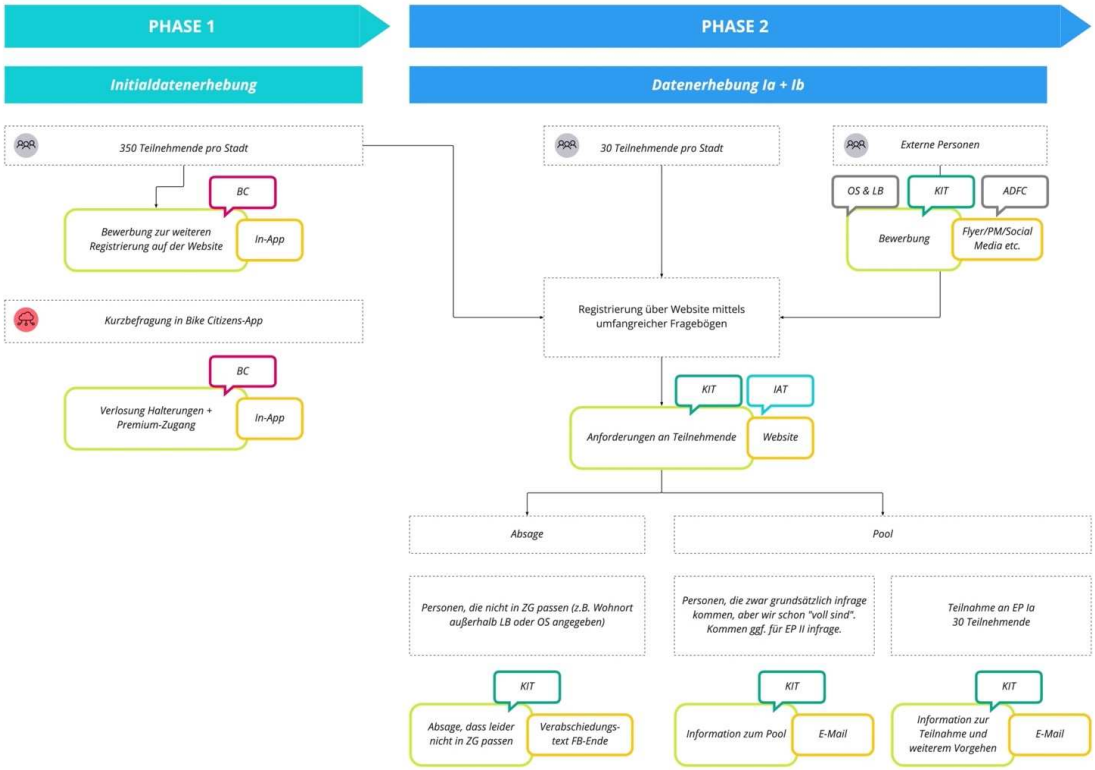


Abb. 5: Diagramm Ablauf Befragungsprozess.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Die sensorgestützten Daten der Erhebungsphasen werden ergänzt um standardisierte Fragebögen. Diese haben den Zweck, weitere Informationen über die Probandinnen und Probanden zu erhalten, die Aufschluss über deren spezifisches Mobilitätsverhalten und persönliche Dispositionen geben, die im weiteren Projektverlauf direkt in Zusammenhang mit dem gemessenen Stressempfinden gesetzt werden können.

Der entwickelte Fragebogen ist über die Plattform LimeSurvey zugänglich, mithilfe derer nach einem automatisierten Prozess in kurzer Zeit erste statistische Auswertungen generiert werden können. Die Dateneingabe der Probandinnen und Probanden erfolgt dabei anonymisiert. Um später die Fragebogendaten mit den Daten der sensorgestützten Messung in Zusammenhang zu bringen, sollen die Teilnehmenden im Verlauf des Fragebogens ein Pseudonym generieren, wodurch deren Anonymität gewährleistet wird.

Die Erkenntnisse aus den Fragebögen dienen darüber hinaus dazu, eine möglichst repräsentative Stichprobe für die sensorgestützten Messungen zu ziehen. Um die Teilnehmenden darüber zu informieren, ob sie als Probandinnen und Probanden für die Messungen ausgewählt wurden, haben die Teilnehmenden am Ende des Fragebogens die Möglichkeit, auf freiwilliger Basis ihre Emailadresse als Kontaktmöglichkeit anzugeben.

5.3 Phase 2: Emo-Cycling-Datenerhebungen

Beginnend mit Ludwigsburg wird ab dem Sommer 2022 die zweite Datenerhebungsphase in den beiden Modellstädten durchgeführt. Dazu werden für jede Stadt die 30 durch die Initialdatenerhebung und die standardisierten Fragebögen ausgewählten Probandinnen und Probanden in zwei Gruppen zu je 15 Probandinnen und Probanden eingeteilt und mit den Messinstrumenten ausgestattet.

5.3.1 Datenerhebungen Ia (Ludwigsburg) und Ib (Osnabrück)

Im Juli 2022 wird die Datenerheungs Ia in Ludwigsburg durchgeführt, im September 2022 startet analog dazu die Erhebungsphase Ib in Osnabrück. Der Erhebungszeitraum umfasst für jede Messgruppe jeweils zwei Wochen. Sobald die Erhebungsphase der ersten Gruppe beendet ist, werden die Messinstrumente an die zweite Gruppe übergeben.

Abb. 6: Setting Messungen.

Bei den Messungen werden die physiologischen Stressreaktionen der Probandinnen und Probanden nach der EmoCycling-Methode aufgezeichnet, lokal verortet und kartiert. Hierbei werden mit Empatica E4-Smartbändern körpernahe Daten (Hautleitfähigkeit- und Temperatur) aufgenommen, mithilfe eines Smartphones per GPS verortet und in der E-Diary-App gesammelt. Die Daten werden als gepackte Spatiallite-Datenbanken gespeichert, die Ergebnis-Daten mit den identifizierten Moments of Stress (MOS) als im maschinenlesbaren CSV-Format (vgl. Kyrakou et al. 2019, Texeira et al. 2019). Darin abgespeichert ist lediglich die X,Y Koordinate, der Unix-Zeitstempel sowie der evenutell vorhandene MOS-Score .

5.3.2 Erste Ergebnisse der Datenerhebung Ia in Ludwigsburg

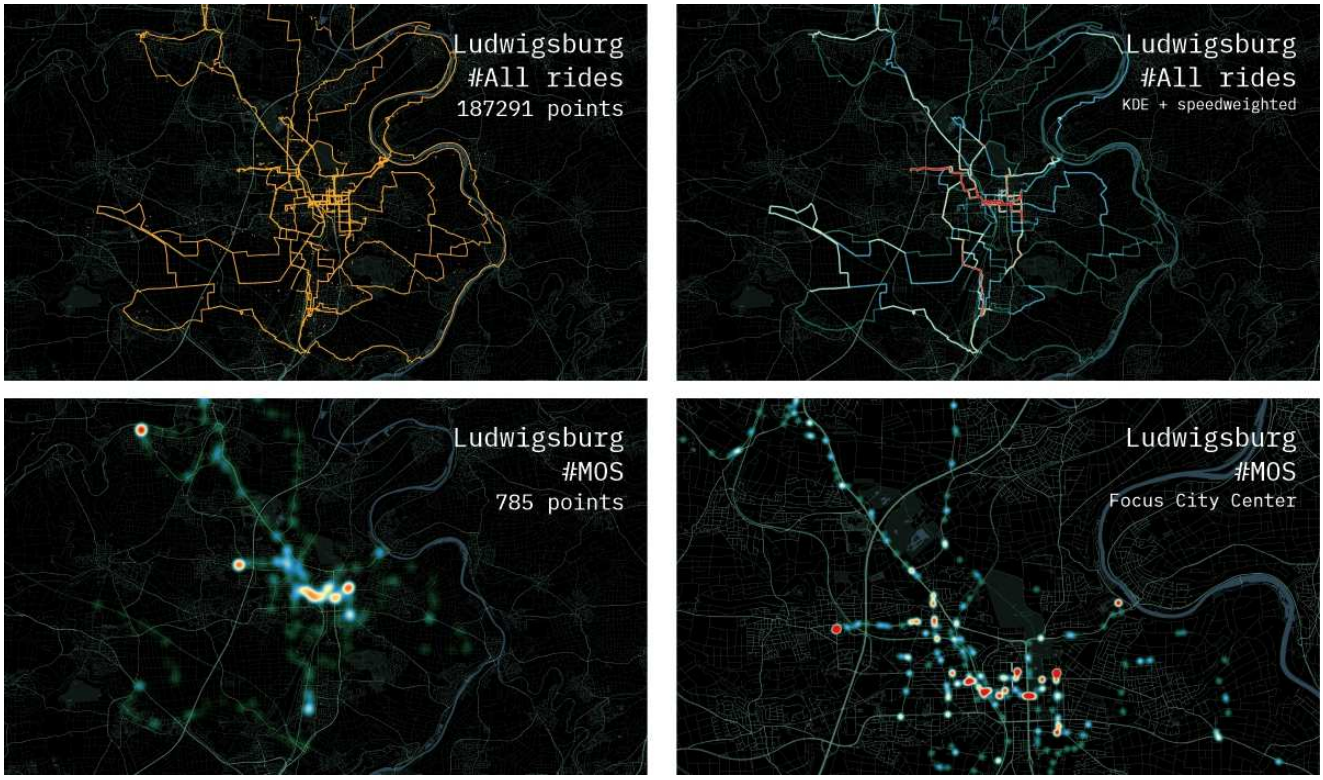


Abb. 7: Fahrradfahrten in Ludwigsburg, Dichte der Fahrten sowie Heatmaps der Stresspunkte innerhalb der Stadt in verschiedenen Detailschärfen.

Die ersten Ergebnisse aus der Erhebungsphase mit den ersten Probanden liefern von der technischen Seite her die erhofften Ergebnisse: Die Abbildung der Gesamtfahrstrecken, die Intensität der befahrenen Strecken als auch die Detektion der Moments of Stress können wir erwartet ausgewertet werden und zeigen erste Hinweise auf Situationen im Strassenraum, an denen Radfahrende während ihrer täglichen Fahrt Stress verspüren. Dieses Sammlung dauert noch den August an, zur Konferenz im November können hier genauerere Eergebnisse präsentiert werden.

5.3.3 Datenerhebung IIa (Ludwigsburg) und IIb (Osnabrück)

Um den Einfluss von jahreszeitlichen Wetterbedingungen auf die Datensätze möglichst gering zu halten, werden die Datenerhebung IIa und IIb in den beiden Modellstädten Ludwigsburg und Osnabrück im Herbst 2022 wiederholt. Die Erhebungsphasen finden mit dem gleichen Setting wie zuvor im Sommer statt und beginnen mit der Stadt Ludwigsburg (Datenerhebung IIa) voraussichtlich im Oktober 2022. Im November 2022 werden die Messungen dann mit der Datenerhebung IIb auch in Osnabrück wiederholt.

6 FAZIT UND AUSBLICK

Das vorgestellte Setup und die ersten Ergebnisse zeigen sich vielversprechend, sodass es realistisch erscheint, mithilfe von Mixed-Method-Ansätzen neue Perspektiven im Kontext des subjektiven Sicherheitsgefühls und Komforts beim Radfahren aktiv in Planungsprozesse und Demonstratorenentwicklungen zu integrieren.

Das Zwischenresumée des Erhebungsprozesses im Projekt zum Zeitpunkt der Initialdatenerhebung und der Datenerhebungsphase Ia in Ludwigsburg ist, dass ohne die direkte Einbettung der Kommune inklusive des entsprechenden Personals eine solche Langzeitstudie mit Probandinnen und Probandenakquise nicht zu stemmen ist. Dies mag einerseits an den jeweiligen Grundbedingungen einer Stadt liegen: Der radfahrspezifischen DNA, dem bestehenden Modal Split oder auch an der Topographie. So erscheint es evident, dass die Probandinnen und Probandenakquise in den beiden Modellstädten Ludwigsburg und Osnabrück mit unterschiedlichen Voraussetzungen gestartet sind. Andererseits konnten mit einer aktiven und umfassenden Pressearbeit in Osnabrück fast 300 Probandinnen und Probanden gewonnen werden. Trotz der direkten Ansprache vom Allgemeinen Deutschen Fahrrad-Club (ADFC) an seine Mitglieder in Ludwigsburg

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

lag hier jedoch der Anteil an potentiell Interessierten bei nur 10% der Teilnehmerinnen und Teilnehmer im Vergleich zu Osnabrück. Es ist daher festzuhalten, dass die Teilnahme an explorativen Prozessen – und damit auch deren Erfolg - ungemein durch die politische Legitimation von Seiten der jeweiligen Stadt unterstützt werden muss. Auch sollte frühzeitig durch einen Akquiseplan relevante Institutionen (Schulen, Kirchen, Verbände von Menschen mit Behinderung etc.), erfasst werden, um eine größtmögliche Diversität bei der Datenerhebung zu gewährleisten.

Nichtsdestotrotz stellt das hier vorgestellte Projekt eindrücklich die Potentiale von Kooperationsprojekten zwischen Wissenschaft, Wirtschaft, Kommunen und Verbänden heraus. Neben „klassischen" ortsbezogenen Diensten und Trajektorienermittlung von Radfahrenden versucht das Projekt im großen Maßstab erstmals über einen langen Zeitraum hinweg biostatistische Daten zur Stressdetektion zu erheben, um a) potentiell bestehende Stress-Hotspots zu identifizieren, b) mithilfe der Sensorik Fahrradkomponenten zu optimieren c) potentiell positive Auswirkungen durch Straßensperrungen für PKW im Rahmen des Umweltsensitiven Verkehrsmanagements auf das Stressempfinden von Radfahrenden zu detektieren, sowie d) mithilfe von Stress-Hotspots alternative Routenvorschläge für die Radfahr-Navigation zu erstellen (Emo-Routing).

Ein Fokus bei der weiteren Projektbearbeitung wird es sein, die Probandinnen und Probandenakquise verstärkt medial zu begleiten und bereits Interessierte durch eine eigens für das Projekt entwickelte ExperienceUser Journey weiter zu motivieren, aktiv am Projekt teilzunehmen.

7 DANKSAGUNG

Das Projekt ESSEM (Emotion Sensing für (E-)Fahrradsicherheit und Mobilitätskomfort) wird im mFUND-Programm des Bundesministerium für Verkehr und Digitale Infrastruktur (BMVI) unter dem Förderkennzeichen FKZ 19F2195A gefördert. Weitere Informationen sind unter http://www.essem-projekt.org verfügbar.

8 LITERATUR

BMVI: Fahrradland Deutschland 2030 – Nationaler Radverkehrsplan 3.0. Berlin, 2022. https://www.bmvi.de/SharedDocs/DE/Anlage/StV/nationaler-radverkehrsplan-3-0.pdf?__blob=publicationFile (Zugriff 28.Juni 2022)

FOLLMER, R.; GRUSCHWITZ, D.: Mobilität in Deutschland – MiD Kurzreport. Ausgabe 4.0. Studie von indas, DLR, IVT und infas 360 im Auftrag des Bundesministeriums für Verkehr und digitale Infrastruktur. 2019. http://www.mobilitaet-in-deutschland.de (Zugriff 27. Juni 2022)

FULLER, R.: Towards a general theory of driver behaviour. Accident Analysis and Prevention 37, S.461-472, 3. Mai 2005.

GELLER, R.: Four Types of Cyclists.Portland Bureau of Transportation. Portland, 2009.

GRAF, T.: Handbuch: Radverkehr in der Kommune: Nutzertypen, Infrastruktur, Stadtplanung, Marketing: Das Hygge-Modell, Ergänzung zur ERA (1. Auflage). Röthenbach an der Pegnitz: Les éditions Bruno im Hause Thiemo Graf Verlag, 2016.

JOHANNSEN, H.: Unfallmechanik und Unfallrekonstruktion. Springer Fachmedien. Wiesbaden, 2013.

KOVALEVA, A.; Beierlein, C.; Kemper, C.J.; Rammstedt, B.: Kurzskala zur Messung von Kontrollüberzeugung: Die Skala Internale-Externale-Kontrollüberzeugung-4 (IE-4). In: GESIS-Working Papers 19, 2012.

KYRIAKOU, K., RESCH, B., SAGL, G., PETUTSCHNIG, A., WERNER, C., NIEDERSEER, D., LIEDLGRUBER, M., WILHELM, F., OSBORNE, T., & PYKETT, J. (2019). Detecting Moments of Stress from Measurements of Wearable Physiological Sensors. Sensors, 19(17), 3805. https://doi.org/10.3390/s19173805

NOLD, C.: Emotional Cartography: Technologies of the Self. London, 2009

RESCH, B.; PÜTZ, I.; BLUEMKE, M.; KYRIAKOU, K.; MIKSCH, J.: An Interdisciplinary Mixed-methods Approach to Analysing Urban Spaces: The Case of Urban Walkability and Bikeability. International Journal of Environmental Research and Public Health. 2020.

SCHANDRY, R.: Biologische Psychologie (4. überarbeitete Auflage). Weinheim: Julius Beltz, S.324f., 2016.

SCHMIDT-HAMBURGER, C.: Stresstest Fußverkehr: Eine Studie im Rahmen des NRVP-Projektes „Cape Reviso" zur Messung des Stressempfindens Zufußgehender in Stuttgart Universität Bremen [Masterarbeit]. S.26f., 2022.

TEIXEIRA, I. P., RODRIGUES DA SILVA, A. N., SCHWANEN, T., MANZATO, G. G., DÖRRZAPF, L., ZEILE, P., DEKONINCK, L., & BOTTELDOOREN, D. (2020). Does cycling infrastructure reduce stress biomarkers in commuting cyclists? A comparison of five European cities. Journal of Transport Geography, 88, 102830. https://doi.org/10.1016/j.jtrangeo.2020.102830

WERMTUH, M.: Modellvorstellungen zur Prognose. In: Steierwald, G.; Künne, H.D.; Vogt, W.: (Hrsg.): Stadtverkehrsplanung: Grundlagen, Methoden, Ziele. (2. Auflage). Berlin: Springer. S. 243-295, 2005.

ZEILE, P.; RESCH, B.; LOIDL, M.; DÖRRZAPF, L.: Urban Emotions and Cycling Experience - Enriching Traffic Planning for Cyclists with Human Sensor Data. GI_Forum J. Geogr. Inf. Sci. S.204–216, 2016.

🏆 *reviewed paper*

Enabling Sustainable Freight Air Transport in the Adriatic Region through Development of ICT Platform

Panagiota Georgia I. Saranti, Yorgos J. Stephanedes, Dimitra V. Chondrogianni

(PhD Candidate, Civil Engineering Panagiota Georgia I. Saranti, University of Patras, Ypatias 1, Rio, 26500, psaranti@g.upatras.gr)
(Professor emeritus Yorgos J. Stephanedes, University of Patras, Ypatias 1, Rio, 26500, ystephanedes@upatras.gr)
(Dr. Civil Engineering, Architect, Dimitra V. Chondrogianni, University of Patras, Ypatias 1, Rio, 26500, dimitra.chondrogianni@g.upatras.gr)

1 ABSTRACT

Freight transport in the Adriatic area suffers from persistent organizational, operational and service barriers and the negative impacts of road transport. Multimodal interventions could reduce CO2 emissions and other impacts, including air and noise pollution, and road congestion. Integrated sustainable solutions can act to improve traffic flow and logistics, and management of goods and tourism supply. Multimodal optimization of road-sea combined transport can be augmented to include air modal share on existing and new routes for sensitive freight with emphasis on yearlong operations.

This paper adresses the need to improve and extend the availability of passenger routes to allow the potential for mixed cargo in the Adriatic with a case study in Italy-Greece transport. Such plans are hampered by the overlong (up to 15 hours) duration of air trips, which could reduce product quality within a few hours after harvest. Fast shipment and delivery of affordable fresh products, such as mozzarella and strawberries is essential, and would benefit from nonused passenger cargo. Fresh products could use available hold space, guaranteeing lower-than-conventional shipping time at affordable price.

The new service would establish new shipping options for fresh products, empowering Italian and Greek local producers. The service will be enabled through an integrated ICT platform that was developed to offer user access (e.g. to information on departure time, load space availability, goods allowed for transportation), and facilitate creation of new market opportunities for fresh producers.

The platform supports the identification of demand and supply (by creating accounts as seller or buyer) and the booking of transport. The platform end user (seller or buyer) can find the proper passenger carrier for shipping fresh products to the airport of origin. Platform design includes Operational (OR) and Non-Operational (NOR) requirements. For assuring traceability and location information, static and dynamic RFID tags and portable RFID readers, as well as GPS devices and/or tracking smartphones and supporting infrastructure were included.

Keywords: sustainable freight transport, fresh products, ICT platfom, air transport, demand and supply

2 INTRODUCTION

2.1 Freight transportation

The current boost in the world economy is partly due to developments and innovations in the transportation sector (Agbo et al., 2017). Freight transportation has been identified as a major contributor to the negative impacts arising from all logistics and industrial activities (Agbo et al., 2017). In view of this, researchers and individual organizations are putting up efforts in finding solutions to the problem. The introduction of multimodal, intermodal and co-modal freight transportation network systems was thought to be means by which the high cost and environmental pollutions from the freight transport sector could be reduced. The efforts can provide partial solutions to the undesirable consequences from the freight transportation sector. However, there exists more to be done, especially regarding reducing the pollutions from the road freight transport sector and this is a major concern to all governments globally. This has consequently led to national and international regulations and policies regarding industrial activities and their pollutions levels (McKinnon, 2016). Industries and researchers are finding better alternatives and strategies to avoid sanctions with regards to environmental and other sustainability issues (Agbo et al., 2017). Achieving economic, social and environmental sustainability is only possible through the integration of the various transportation modes. Interestingly, each transport mode has its own advantage comparatively.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

2.2 ICT based transport applications

The term “Information and Communications Technologies (ICT)” is often used ina broad sense to delineate a set of heterogeneous telecommunication and information technologies that allow for electronic communication, data collection and processing in distribution networks (Black and Geenhuizen, 2006). The extant literature offers different taxonomies regarding ICT adoption in practices. For instance, there have been studies where ICT has been classified into basic and advanced but the criteria for such categorization where not specified (Evangelista et al., 2010). Furthermore, both the works of Marchet et al. (2009) and Perego et al.(2011) classified transport-related technologies into four main types from a commercial“ company” perspective:

(1) transport management applications;

(2) supply chain execution applications;

(3) field force automation applications; and

(4) fleet and freight management applications.

Although offering useful insights, such categories present some overlaps. For instance some supply chain execution applications will have a module designed for transport management, a real-time tracking function in a field force automation application may well be part of a fleet and freight management application.

It is recognised that information and communication technology (ICT) functions like the nerve system of a multimodal transport chain and brings multiple benefits toorganisations by providing real-time visibility, efficient data exchange, and better flexibilityto react to unexpected changes during shipment (Prajogo and Olhager, 2012).Recent developments in the field of ICT such as cloud computing, social networking andwireless communication have further revolutionised the ways information is shared andsupply chains are structured.

2.3 Logistics of Fresh Produce

The development of fresh food e-commerce has provided comfort and convenience for consumers’ daily lives and has modified cold chain management drastically (Ruan and Shi, 2016). However, as foodborne diseases can have a wide influence and reach epidemic speeds of transmission (Gibson et al, 2019), monitoring and managing risks associated with the logistics of fresh produce must be addressed to ensure food safety (Nakandala, 2017). As fresh products are characterized by their short shelf life and perishability, the continued development of fresh food e-commerce also brings new opportunities and challenges to global sustainable development. To reduce produce losses incurred during transport and storage, certain logistic and technological requirements must be met, such as an otherwise controlled atmosphere and this has led to a rise in related costs (Ishangulyyev, et al., 2019).

As fresh products are perishable, their transit time must be strictly controlled. Many scholars have aimed to optimize the scheduling of fresh produce logistics. Cai et al. investigated the effects of freshness-keeping efforts on the supply chain of fresh products and characterized optimal producers’ wholesale price and distributors’ order quantity in decentralized and centralized systems. Blackburn et al. examined supply chain design strategies for perishable products by considering a product’s marginal value of time. Bogataj et al. studied the effects of time, distance, and temperature in a cold supply chain. Based on fresh produce characteristics, carbon-trading behavior, and external environmental factors (e.g., emergency events, weather), scholars have established transportation scheduling models and proposed optimal scheduling and pricing strategies (Mohammed and Wang, 2017).

Food supply chain challenges and opportunities are inherently complex. Each of these involves different levels of social and economic engagement and is characterized by multiple interactions and feedback loops (Nesheim et al., 2015). To cope with the rapidly growing population and the ever-increasing demand for high-quality fresh food, a more advanced transportation system for fresh food delivery is needed, particularly in urban areas (Hsu and Chen, 2014).

3 FRESH WAYS PLATFORM

3.1 FRESH WAYS concept

THE FRESH WAYS project addressed the need to improve and extend the availability of Puglia-Greece routes covered by passengers' airlines. It can be estimated that to reach internal Greek locations from Puglia region by ship, the travel time (port to port) goes from about 7 hours to more than 15 hours, to which it has to be added the time to reach internal destinations. Moreover, some destinations are very hard to reach in adequate time preserving quality of products, as fresh products have to be consumed even a few hours after their harvest in order to fully preserve their organoleptic characteristics. Fast shipment and delivery of fresh products, such as mozzarella on the Italian side and strawberries on the Greek side is essential but, at the same time, the products have to be affordable for the consumers.

On the other hand, airplanes on existing passenger airlines often travel with not fully or not at all used luggage space. In that case, fresh products can be loaded in the hold, utilizing the free luggage space and guaranteeing shipping times lower than when conventional methods are used. When an airplane starts its journey from Italy, there will be "offer" from the Italian side and "demand" from the Greek side. The roles are reversed when the airplane returns to Italy carrying Greek products.

The FRESH WAYS was designed to enhance the supply chain, but to also facilitate the creation of new opportunities in the market between the two countries. This action was accomplished through the development of an ICT platform that enabled the user access to the service (e.g. departure time, load space availability, goods allowed for transportation) and further allowing the execution of pilot actions.

3.2 Platform Demand and Supply

A new service that facilitates the shipment of fresh products between Italy and Greece was established in the FRESH WAYS project. This service empowers Italian local producers to effectively export and transfer their products with fresh value to Greek enterprises and empowers Greek local producers to effectively export and transfer their products with fresh value to Italian enterprises. More specifically, the service was enabled through an integrated ICT platform.

The services of the platform support the identification of demand and supply and the booking of the transport. These services are accomplished in four steps (figure 1). At first, the local producer is able to create a "producer account" and the enterprises will create a "consumer account." Every time that the producer has available products and wants to export them, he can use his account in order to record this offer as a "package" in the platform, providing within this package all the information related to the products and the time window that the products are available for transport. As a next step, the initial matching between supply (producer) and demand (consumer) is taking place, the producer is able to book the airline shipment of the fresh products via the platform, taking into account the agreed time window (day-and-time) of shipment. More specifically, the producer is able to declare his need of shipping his products using his account in the platform again, in order to book some hold space in the airline. Furthermore, the producer can decide on the way to transfer his products from the origin to the "airport-origin". He may choose to transfer his products on his own or to identify the optimal shipper via the platform. In the second case and given the required freight's time arrival at the airport, the producer will declare his need for shipment from his origin to the airport. Finally, the producer is able to book the shipment of his freight from the "airport-destination" to the final destination, where the consumer can finally receive the products.

Additionally, as an option to the end user (seller or buyer), the platform user is able to find the proper carrier for shipping his fresh products to the airport of origin in case the user cannot make the transfer themselves. Similarly, following the arrival of the products to the airport of destination, the user can identify the best carrier to reach the final destination. The core architecture focuses on matching demand and supply for freight transport before and after products are transported by passenger airlines and there are customized matching criteria that optimize the results from the proposed matching for the users.

More specifically, in order for the platform to exhibit traceability features and provide location information to the users, special equipment was used by the involved parties of the supply chain. The necessary equipment involves static and dynamic RFID tags and portable RFID readers, as well as GPS devices and/or smartphones with tracking capability and the supporting infrastructure. If the user selects one of the carriers proposed by the platform, the carrier is able to pick up the freight, place on it an RFID tag, and read the tag

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

with the portable RFID reader, thus recording the initial location of the shipment. The carrier can also activate the GPS device or smartphone for tracking his location consistently until arrival at the desired node/hub (e.g. airport) of origin, and for updating the platform accessed by the user. Then, the airport authorities that are equipped with compatible portable RFID readers are able to confirm the products' arrival.

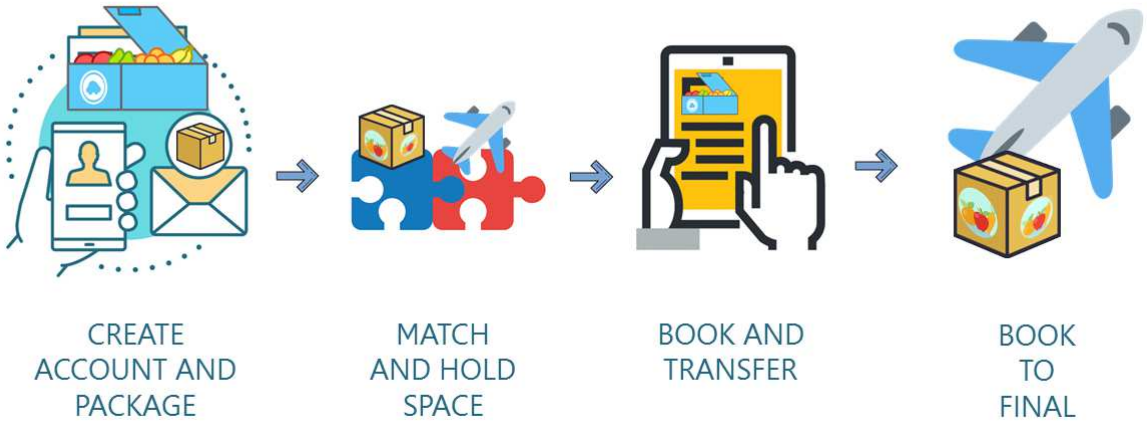


Fig. 1: Four Steps of the ICT Platform Demand and Supply

Customer Requirements
1 The platform must be able to register each client.
a. This will make the customer's future purchases easier. At first login it needs to enter its details in the user registration form.
b. Also, this way the manager has the information of each customer and it will be easier and faster for him to send the products.
2 After completing the form, each customer will be able to log in to the platform and be able to view and purchase any products they wish.
3 After completing the form, each customer will be able to log in to the platform and be able to add to the basket the products they wish to purchase.
4 Quick Product Search:
c. by type
d. by name.
5 Each client user can log out after visiting the platform.
6 The administrator should be able to add a new product to the platform.
7 The data is available - stored in a database on the computer.
8 The platform should be as fast as possible and run on windows.
9 The system can be installed on multiple computers.
10 The data can only be viewed by the administrator from the database with a special code.
11 Software function to be user friendly.
12 The products should be registered in such a way that the inventory manager can be informed daily.
13 Have a password containing digits and usernames.
14 Buttons have icons for convenience.
15 Automatically disconnect from the cart after 5second after ordering.
16 Each user has their own password.
17 The system should isolate and display errors without shutting down. If an error occurs, the system will try to correct it, otherwise the program maintainer will correct it.
18 The user tab contains e-mail, password, address, city, telephone.
19 Have product categories and specific products.
20 Details under the products.
21 Have a newsletter to better inform users.
22 If the customer does not make a connection the customer will not be able to place an order.
23 In case the customer adds a product to the cart:
a. be able to go back and add others and be able to delete products,
b. to add / remove products by selecting pieces,
c. change the price in this case,
d. the cart can be renewed,
e. empty cart,
f. and continue
24 The platform can change language.
25 Enable real-time chat
26 Be able to communicate with the platform administrator
27 Have a help desk

Table 1: Customer Requirements of the ICT platform

4 REQUIREMENTS ANALYSIS

For determining the system requirements, a study is carried out on the needs and requirements of the user and the data are mainly acquired from the feasibility study developed in the FRESH WAYS project. After all the use cases have been formulated and checked as well as the potential problems that may arise, a plan is

created for the design and implementation of the project. A key ingredient for a successful information system in any organization is for it to be user-friendly so, if it is easy to use, customers without special technological know-how can use it.

The recording of requirements is helpful for both those implementing it and for users completing the work requested by the client. Requirements are divided into Operational (OR) and Non-Operational (NOR). Operational requirements are those that describe what the system should do while non-Operational requirements are those that describe the properties that a system should have, for example usability, security, performance, legality and privacy. In order to better organize and serve the customers of a shop of local traditional and organic products it is necessary to implement an electronic platform with the following characteristics as described in Table 1, 2 and 3.

Operational Requirements
1 The platform must be able to register each client.
2 This will make the customer's future purchases easier. At first login it needs to enter its details in the user registration form.
3 In this way, the administrator has the information of each customer and it will be easier and faster for him to send the products.
4 After completing the form, each customer will be able to log in to the platform and be able to view and purchase any products they wish.
5 After completing the form, each customer will be able to log in to the platform and be able to add to the basket the products they wish to purchase.
6 Quick Product Search:
a. by type
b. by name.
7 After each visit to the platform, each client can log out.
8 The administrator should be able to add a new product to the platform.
9 The data can be stored in a database on the computer.
10 The platform should be as fast as possible and run on windows.
11 The system can be installed on many computers.
12 Data can only be viewed by the administrator from the database with a special code.
13 Software-friendly operation with help feature.
14 The products should be registered in such a way that the administrator can be aware of the stock on a daily basis.
15 Automatically disconnect from the cart 5second after ordering.
16 The system should isolate and display errors without shutting down. If an error occurs, the system will try to correct it, otherwise the program maintainer will correct it.
17 The user tab contains e-mail, password, address, city, telephone.
18 Have product categories and specific products.
19 Details of the products below.
20 Have a newsletter to better inform users.
21 If the customer does not make a connection, the customer cannot place an order.
22 In case the customer adds a product to the cart:
a. be able to go back and add others and be able to delete products,
b. add / remove products with item selection, and change the price in this case,
c. the cart can be renewed,
d. empty cart,
e. and continue
23 Enable real-time chat
24 Be able to communicate with the platform administrator

Table 2: Operational Requirements of the ICT platform

Non-Operational Requirements
1 The program should be as fast as possible and run on windows. (Efficiency)
2 It will work on many computers and will be administrator controlled. (Auditability)
3 Each user has their own password and username. (Security)
4 Buttons have icons for convenience. (Usability)
5 Have a password containing digits and usernames. (Security)
6 Will be able to move to any P/C regardless of hardware. (Portability)
7 Must have a help desk (Usability)

Table 3: Non-Operational Requirements of the ICT platform

5 ICT PLATFORM BASIC DESIGN- USE CASE DIAGRAMS

Users of the application are divided into Administrators and Standard Users. A single user can act as both a Buyer Role and a Seller Role. The Use Case Diagrams below show in detail all the actions that users of the application can take depending on the role they play. Note that the following use case diagram describes only the users that will transport their own products to the airport and back.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

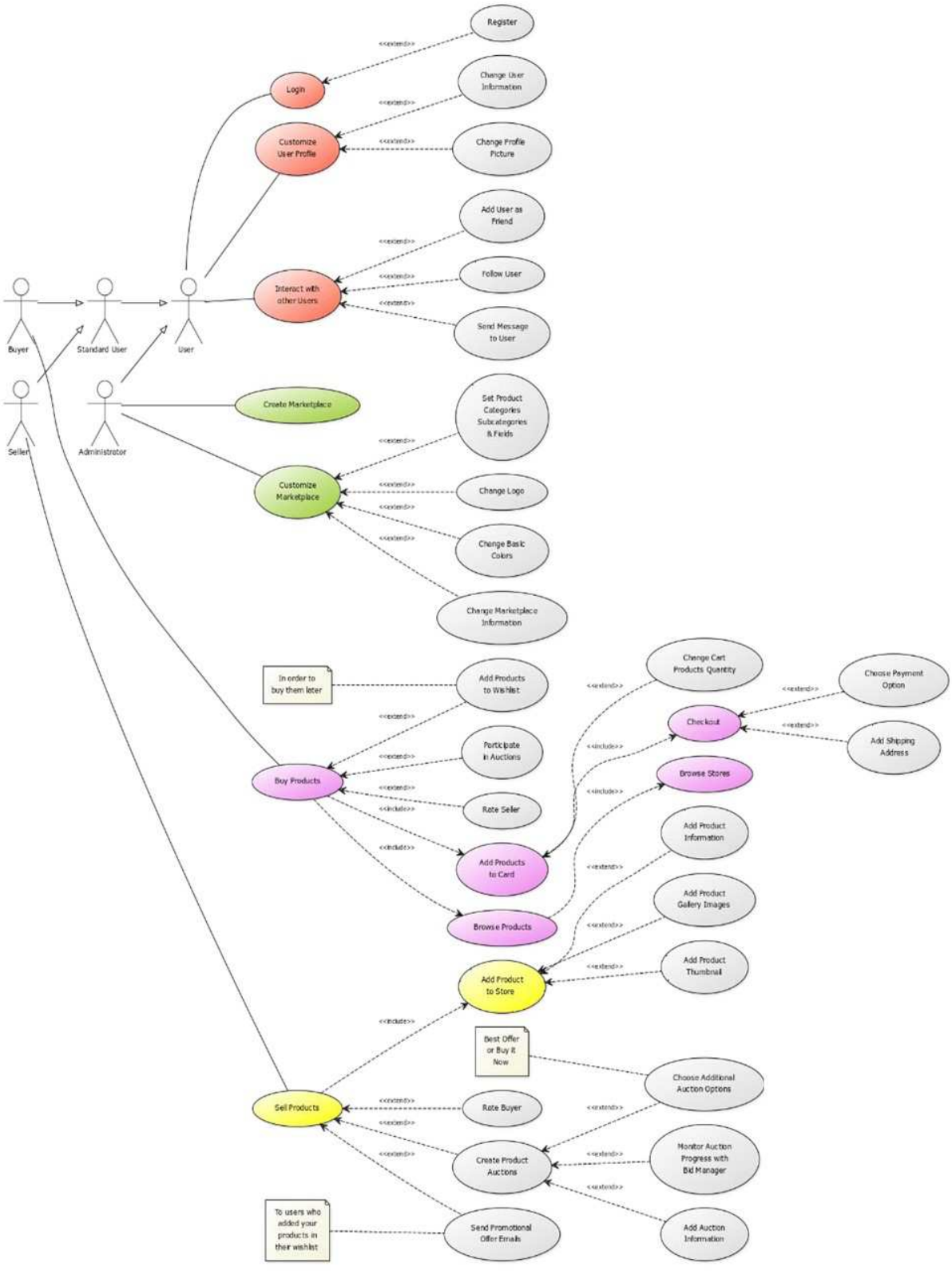


Fig. 2: Overall Application of ICT Platform User Chart (Overview)

6 CONCLUSION

Considering that the current freight transport system in the Adriatic area suffers the persistence of organizational, operational and service-related barriers, FRESH WAYS platform improves these services through its multimodal interventions, thus decreasing the negative impacts of road transport. Behavioral change of stakeholders and increase of their knowledge in green transport policies, relevant mentoring and

funding opportunities, sustainable freight transport and logistics and sustainable connectivity alternatives in Adriatic region through innovative educational approaches can play an important role.

Furthermore, the definition of the digital platform is a fundamental step to guarantee efficient data management, demand/offer matching and logistics, scalability, and traceability. In that regard, some requirements to be satisfied within the management of the whole FRESH WAYS process. The relation between some relevant aspects of some potential mid-term/long-term factors of this process and platform have to be noted in order to understand the impact of the technology enabling the design and implementation process on the macro environment.

Regarding data management, it has to be noted that the appropriate management of data can give an accurate and dynamic representation of demand and supply of fresh products. This issue is also recognised as a fundamental scope of action by the European Commission. Data management through a suitable ICT platform can be used to improve the users' experience and adapt business strategies, in order to foster existing market between the Project Regions and creating new opportunities. However, it is noted that current international policies (e.g. the EU Regulation 2016/679 on General Data Protection Regulation - GDPR) dictate that particular care is paid to data management and related responsibilities.

The scalability is also considered and important factor, since a flexible design of the digital architecture making use of the most recent solutions for access to microservices is a fundamental prerequisite for future extensions and for the inclusion of new services in future phases of the FRESH WAYS project. Furthermore the sustainability is also an important factor, since new technologies to enhance sustainable air transport such as biofuels, electrofuels and e-planes may be expected from progresses coming from on-going research. The FRESH WAYS project and the platform that was developed may offer intermediate steps toward sustainable air transport through the optimization of current resources. This can be implemented with current technology in order to increase the efficiency of air transport in the Adriatic Region with respect to carbon emissions.

The platform, that was created and put into operation, can be adopted and used multimodaly by different countries across the European Union, with minimal operations needed to be done in order to implement trading actions. Moreover, the project encourages related research and technology transfer to other EU countries that intend to innovate on the logistics sector intermodal and multimodal. By adopting innovative logistic technologies more and more small businesses of the agriculture sector could have additional competitive advantages, such as consistency of delivery time, safetyas well as low freight cost. Future studies could expand the scope of the research to include different transportation scerarios and needs to provide further insight.

7 ACKNOWLEDGEMENTS

The research was carried out within the project "FRESH WAYS – Cross-border mechanisms for Green Intermodal and Multimodal Transport of fresh products", funded under the INTERREG Greece-Italy 2014-2020 Cross-Border Cooperation Programme, Axis 3: Multimodal Sustainable Transport System.

8 REFERENCES

AGBO, A. A., Li, W., Atombo, C., Lodewijks, G., & Zheng, L. Feasibility study for the introduction of synchromodal freight transportation concept. Cogent Engineering, 4(1), 1305649, 2017.

BLACK, W. and Geenhuizen, M. ICT innovation and sustainability of the transport sector, European Journal of Transport and Infrastructure Research, Vol. 6 No. 1, pp. 39-60, 2006.

BLACKBURN, J.D., Scudder, G.D. Supply Chain Strategies for Perishable Products: The Case of Fresh Produce. Prod. Oper. Manag., 18, 129–137, 2009

BOGATAJ, M., Bogataj, L., Vodopivec, R. Stability of perishable goods in cold logistic chains. Int. J. Prod. Econ., 93, 345–356, 2005.

CAI, X., Zhou, X. Optimal Policies for Perishable Products When Transportation to Export Market Is Disrupted. Prod. Oper. Manag., 23, 907–923, 2014.

EVANGELISTA, P. and Sweeney, E. Technology usage in the supply chain: the case of small3PLs", International Journal of Logistics Management, Vol. 17 No. 1, pp. 55-74, 2006.

GIBSON, K.E., Almeida, G., Jones, S.L., Wright, K., Lee, J.A. Inactivation of bacteria on fresh produce by batch wash ozone sanitation. Food Control 2019, 106, 106747, 2019.

Hsu, C.I., Chen, W.T. Optimizing fleet size and delivery scheduling for multi-temperature food distribution. Appl. Math. Model., 38, 1077–1091, 2014.

ISHANGULYYEV, R., Kim, S., Lee, S.H. Understanding Food Loss and Waste-Why Are We Losing and Wasting Food? Foods 2019, 8, 297, 2019

MARCHET, G., Perego, A. and Perotti, S. An exploratory study of ICT adoption in the Italian freight transportation industry", International Journal of Physical Distribution & Logistics Management, Vol. 39 No. 9, pp. 785-812, 2009.
MCKINNON, A. C. Freight transport deceleration: Its possible contribution to the decarbonisation of logistics. Transport Reviews, 1–19, 2016.
MOHAMMED, A.; Wang, Q. The fuzzy multi-objective distribution planner for a green meat supply chain. Int. J. Prod. Econ., 184, 47–58, 2017.
NAKANDALA, D.; Lau, H.C.W.; Zhao, L. Development of a hybrid fresh food supply chain risk assessment model. Int. J. Prod. Res., 55, 4180–4195, 2017.
NESHEIM, M., Oria, M., and Yih, P. A Framework for Assessing Effects ofthe Food System, 1st Edn. Washington, DC: National Academies Press, 2015.
PEREGO, A., Perotti, S. and Mangiaracina, R. ICT for logistics and freight transportation: a literature review and research agenda, International Journal of Physical Distribution &Logistics Management, Vol. 41 No. 5, pp. 457-483, 2011.
PRAJOGO, D., Olhager, J. Supply chain integration and performance: The effects of long-term relationships, information technology and sharing, and logistics integration. International Journal of Production Economics, 135(1), 514-522, 2012.
RUAN, J., Shi, Y. Monitoring and assessing fruit freshness in IOT-based e-commerce delivery using scenario analysis and interval number approaches. Inf. Sci. 373, 557–570, 2016

🏆 *reviewed paper*

Enhancing Transit-Oriented Development Networks in South African Cities: Pathways for Sustainable Mobility and Access in the City of Johannesburg

Tshiamo Domingo, Tryson Gumbo

(Tshiamo Domingo, University of Johannesburg, Department of Town and Regional Planning, P.O Box 17011, Doornfontein, 2028, tshiamod13@gmail.com)
(Trynos Gumbo, Head of Department, University of Johannesburg, Department of Town and Regional Planning, P.O Box 17011, Doornfontein, 2028, tgumbo@uj.ac.za)

1 ABSTRACT

Transportation and spatial planning are inextricably linked. Transport networks and facilities have an immense influence on the spatial development of any city. Moreover, they determine the nature of the neighbourhood and the quality of life by directly influencing property market values. Transit-oriented development seeks to integrate urban spaces and bring people, amenities, and activities together with easy cycling and walking proximities to the excellent transit services. Consequently, successful transportation and spatial planning integration result in efficient transit-oriented development. This paper presents pathways for enhancing sustainable mobility and access through transit-oriented development networks in South African Cities. The paper adopts a case study research design wherein the impact of transit-oriented developments in the City of Johannesburg is presented and discussed. Quantitative and qualitative research approaches were deployed to gather relevant data, as well as specific questionnaires and interview guides. Preliminary findings reveal that transit-oriented developments have tremendous benefits and effectively transform neighbourhoods. There are still challenges associated with and hindering the integration of transit-oriented development and spatial planning in the City of Johannesburg. The paper concludes by recommending cities in South Africa and other developing countries adopt and implement transit-oriented development to achieve sustainable cities concerning efficient physical connectivity, mobility, and accessibility and to ensure climate-friendly and liveable cities. Lastly, transit-oriented development must be crystallised in city-wide developments in order to overcome contemporary mobility and access challenges in cities of the Global South.

Keywords: Transit-Oriented Development, Sustainable development, Spatial planning, Sustainable Mobility and access; City of Johannesburg.

2 INTRODUCTION

Since South Africa's democratic dispensation in 1994, various first and second-tier urban spaces have experienced rapid urbanisation. Thus, developing and enhancing the urban built environment to efficiently support sustainable transport is one of the overarching challenges for urban planning in most African cities (Gumbo et al., 2022). It is evident from previous scholars that the concept of land -use influences the traveling perception of citizens. According to prior researches, African cities have enhanced public transportation, boosted cycling and pedestrian activities, and reduced driving by integrating land-use planning with transportation planning. These implementations result from applying Transit Oriented Development (TOD) as an intervention and development principle for intensifying the urban built environment around public transit corridors and transportation nodes (Risimati & Gumbo, 2019). The TOD is an intervention that most developing countries in Africa should shift to its planning paradigm. This is because TOD is the vehicle that delivers sustainable mobility and access within the city. With that at hand this paper seeks to unpack how TOD concept is being codified within the inner city of Johannesburg, particularly this paper will utilise 400m radius from Park Station to further illustrate the concept of TOD as a point of case to support the study. The nature of TOD is to promote less driving and more cycling and walking, however, this paper outlines how TOD can be utilised as strategy to mitigate climate change. This paper highlights the ways in which the city of Johannesburg enhances the TOD networks in South African cities spaces, and how to further influences accessibility and sustainable mobility. Lastly the the paper provides feasible recommendations.

3 BACKGROUND

The concept of Transit-Oriented Development was codified by Peter Calthorpe in the late 1980's, other scholars had similar concept which contributed to the design of TOD existing today. The concept of TOD

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

became a headline for contemporary planning after the publications of "The New American Metropolis" by Peter Calthorpe in the early 1993. That was a steppingstone for the concept to be applicable for today's planning paradigm. TOD is sustainably driven, hence, Calthorpe perceived it as a neo-traditional chaperone to sustainable cities design. Beyond TOD's definition of built form, TOD was codified to meet communities needs and standards also it was an intervention to address innumerable societal challenges. As delineated by Nasri & Zhang (2014) the concept of TOD invigorates the development of vibrant and full cities designed to be concentrated on a transit facility. Since the codifying of the TOD, the concept invigorated growth of cities to be more compact and transit-supportive, the ideal of the concept was to integrate variety of residential real estate, commercial and amenities within a cycling and walking proximity of a transit station or stop and endorsing green and opening space and promote sense of community within urban spaces. TOD has been one of successful concept in urban planning which is a realistic concept to sustainable development. In the late 1989 the Board of Directors of the Bay Area Rapid Transit District (BART) conducted an intensive study on the possible high-rise housing on a TOD station. Housing units concentrated on a TOD was referred to as 'Transit-Based Housing" which were effectively influenced by the 'particular' transit. With that being surfaced the following session of the study is the 'literature review', the study reviews how TOD has been crystallised within the city of Johannesburg.

4 CONCEPTUAL SYNOPSIS

The TOD literature on European cities like Istanbul and Athens, amongst others, is widely cited as an inspiration for the development of TOD in most African cities, including Johannesburg (Cervero, 1996). These developed cities are most likely to be highly regarded among TOD researchers. They are highly regarded because they can integrate public transport and land use. However, to some degree, there might be a tendency to overestimate TOD's proliferation. Considering the wideness of the nation, the concept of TOD can be reluctant to the planning practice in these developed cities. For instance, according to Pettersson & Frisk (2016), there was intensive research conducted in Sweden regarding the implementation of TOD within the region of Skane; the research was conducted because the TOD concept was reluctant towards development. However, the study found that factors that make the concept difficult to achieve were the public transport accessibility development location, quality of public transport, and density.

TOD is one concept that is designed to mainly influence the use of public transit and develop a pedestrian-friendly urban environment. Over the years the concept of 'TOD' was referred to other various items including "transit-supportive development", "transit village", and "transit-friendly design". However, TOD is the most used popular term among these terms. In juncture, TOD generally provides an environment where citizens live within a walking proximity of a major transit station and essential amenities (Risimati et al., 2021). TOD is mainly premeditated to stimulate transit ridership and use of several different features. First and foremost, citizens who are living nearby transit, are most likely to be provided with the culmination opportunity to be well connected to the entire transit network. With that at hand, TOD aims to increase usage and transit ridership whilst providing vast access to economic opportunities, cultural facilities, and educational opportunities. Hence this study seeks to unpack ways to enhance TOD development at large in the city of Johannesburg. Interestingly, the study oversees the concept of TOD within the precinct of Park Station. The way the TOD concept is crystallised within Park Station influenced the study.

Moreover, TOD features, including design and mixed-use, aim to influence transit usage and thus reduce automobile trips for different purposes. This is primarily applicable to the city of Johannesburg. Recent studies indicate that a business-use zone consisting mainly of retail businesses strategically located between the station and residences is one of the essential factors in reducing automobile usage in transit-served neighbourhoods within Johannesburg. This planning concept is based on the principles of new urbanism. However, this planning concept adequately promotes rail-pedestrian trip-chaining. In addition, recent studies have adequately surfaced that a retail business land-use near amenities such as rail stations can invigorate the transit commute mode share by approximately 4% (Cervero, 1996). This paper also stresses that a well-designed, mixed-use, and concentrated development around transit notes can foster transit use around six times higher than comparable development away from transit. Also, this paper seeks to answer the question of how the city of Johannesburg can attain sustainable mobility by enhancing TOD.

4.1 Transit-Oriented Development

The present-day public transportation systems are well customised towards enhancing mobility within Johannesburg. In all epochs of life, the development of mobility infrastructure is essential. In light of this, the fourth industrial revolution era is convincing cities in South Africa to invest more in new innovative transportation systems to improve spatial development and connectivity. With that at hand, the city of Johannesburg metropolitan municipality is one of the leading Metropolitan cities in South Africa, with various innovative public transportation systems which adequately complement the transit-oriented development (TOD) (Risimati & Gumbo, 2019). Currently, the city is showing the ability to integrate public transport and the residential zones. The city has various informal and formal forms of public transportation, including high-speed trains (Gautrain) and rapid bus systems (Rea Vaya). The city also includes the traditional public transport systems that have been carrying the mass of the city (metro rail, Mega Bus, minibus taxis, Putco & metro bus). These are urban public transport essential to supporting the TOD in any given residential zones in Johannesburg city (Cervero & Dai, 2014). TOD has surfaced as one of the possible intrusions for sustainable urban mobility.

The implication of TOD with the city of Johannesburg has assisted in reshaping the quality of urban growth towards improved city accessibility and mobility, inflated sustainability, friendliness to pedestrians, and a high degree of human reciprocity. By definition, a TOD vicinity is a community that is a pedestrian-friendly built environment. The community will adequately have a central location of bus or rail stations that are relatively surrounded by high-density residential and mix-used commercial developments. The basic concept entails that TOD communities will, by default, have shorter proximity to amenities. In addition, Nasri & Zhang (2014) delineated that TOD communities are commonly located within 600m of a radius from a transit station or stop; this is a distance that is appropriately considered to be the scale of the pedestrian. Nasri & Zhang (2014) continues with an analogy that TOD urban spaces are built in urban forms unruffled by numerous TOD communities on transit lines. TOD is the model of dignifying transit by integrating urban land use with traffic. Nonetheless, TOD does not equate to a region where private automobiles are replacing public transit. Case in point, Doornfontein's vicinity in Johannesburg has an immense figure of TOD as much as the city of Johannesburg is a transit-oriented metropolis.

The Bus Rapid Transit (Ra Vaya) station and the companionship of midi-buses travelling along Bertrams Road between the Johannesburg stadium and the Caltex filling station make Doornfontein a viable alternative to driving. Many travellers opt for public transit commuting despite continued automobile ascendency. This paper emphasizes that TOD is adequately designed for non-motorized and motorized modes. This paper also recommends fostering pedestrian trips without tendencies to reject automobile traffic. This is feasible by designing street networks that allow safe and efficient interaction with all the transport modes. In addition to what is being delineated, the theoretical framework built for TOD definition consists of design, characteristics, expected benefits, and guidelines. With that being said, there are empirical elements for analysing TODs to observe how effective TOD is in improving transit ridership, encouraging more non-motorized travel, and reducing emissions. The scholar Robert Cervero conducted one study on TOD. The outcome was that TOD residents are around five times more likely to use transit to work. In addition, those who reside and work in TOD areas are about three times more likely to use transit to get to home or work compared to all residents within the vicinity of the city (Mu & de Jong, 2012). However, according to the study by this paper, the city of Johannesburg has neighbourhoods designed with TOD elements. For example, all the residents residing within Park Vicinity and the nearest neighbourhood, including Braamfontein, are well integrated with transit stations with fewer proximities to amenities and services. However, the TOD concept has been crystallised strategically within the area of Park Station. This is a catalyst for sustainable mobility within the city of Johannesburg.

4.1.1 Existing integrated public transportation infrastructure TOD

Strong (2017) sees that TOD can develop when existing and maintained public transport infrastructure such as rail or bus stations take action as a catalyst and leading market densification, and positively influencing land-use development. A fresh perspective from the study supports Risimati & Gumbo (2019) findings, due to the observations of South African cities. According to this paper South African cities development is purely based on the perspective of lucratively, thus the concept of TOD is on robust fundamentals of success. On the other hand, this will effectively find its path to sustainable mobility. Thus, Park Station is a

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

quintessential to this very study. In addition to Mu & de Jong (2012) vantage point, the design, planning and implementation is required to leverage and reposition the efficacy of the existing public transport infrastructural assets and channel them in attaining the new measures of prosperity and development. Moreover, Tabane et al. (2021) further underpins the study of Risimati & Gumbo (2021) that with the development of TOD projects funding information and cost and policy considerations, they provide leverage to decision makers to contemplate the sincere significant implementations and risks options. This is an integrated perspective that adequately surfaces a conventional focus and perception on the significant element that derives a successful business concept from the TOD concept of existing integrated public transportation. According to Strong et al. (2017) the development of TOD on existing integrated public transportation infrastructure rejuvenates the state of urban spaces, moreover, by virtue of the study area of the study, Park Station has revived the central business district (CBD) of Johannesburg. The transformative development from existing public transportation infrastructure also presents challenges aligned with regulation, planning and policy and the limitation of construction in an operational environment. This particularly means that the business case needs early and careful considerations to figure out if the ultimate value of the development is greater than the cost of implementation. To mitigate the risks and improve the feasibility toward the success of the TOD. This is because the concept of TOD can sometimes be reluctant towards implementation due to accessibility.

4.1.2 New integrated public transportation infrastructure TOD

TOD can call for radical development centred on existing integrated transport infrastructure that seeks to transform existing development, community, and environment. Strong et al. (2017) elucidated that an effective way of initiating TOD is through introducing a new integrated transport infrastructure at a primitive stage; this is a strategic way of stimulating the renaissance of previously inaccessible locations and contaminated field sites (brownfield sites). A new integrated public transport station it's a fresh perspective that can engender a ripple effect for the development throughout the vicinity of a city. Thus, in some cases, involved schemes incorporate land parcels altogether, forming a more significant new precinct through the influence of TOD. The development of TOD on a new integrated public transportation infrastructure requires an accurately calculated decision to make the development successful and to ensure sustainable mobility within a city. In addition, the requirements for the progressive development of TOD (building a station) incorporates well informed integrated approach, concrete significant upfront political structure, major investment from both private and public sectors, considerable leadership, and a large-scale planning process. The fundamental principle of TOD is to encourage transport infrastructural investment, this also impacts the market structure of the surrounding properties value, also this influences the sprawl of development and provides more accessibility and value to the precinct. Moreover, Thomas et al. (2018) also sees the initiative of TOD as a portal that opens up for new development opportunities and practices sustainable development at large. Commonly it is known that the TOD concept focuses on the strata of public transport infrastructure investments as first, effective discussion in regard to parallel land-use movement that permits an increased density that will equally develop a supplementary viable process. According to this paper, incorporating land-use policies decisions and public transport investment in regard to the projected mobility metrics in coordinated strategy in the process of developing TOD into new integrated public transportation infrastructure can lead to a success path (Thomas et al., 2018).

5 STUDY AREA

Geographically, the City of Johannesburg is within the heart of Gauteng province, South Africa. However, the core focus of the study is interest in the Park Station precinct. The Study area is strategically located in region F of the city of Johannesburg Metropolitan Municipality. The study utilized a 400m radius of walking proximity from the Gautrain Rapid Rail Link station for this study. The geometry dynamics of the study area include Smit Street, De Villiers Street, Hospital Street, De Korte Street, Rissik Street, Koch Street, Simmonds Street, King George Street, and Wanderers Street. In terms of spatial location, the Johannesburg Park Station precinct is well positioned to be in the centre heart of Johannesburg, with which it is well functionally integrated. The area surrounding Johannesburg Park Station Precinct is tremendously predominated by commercial land use in nature.

With the arrival of the Gautrain, there was a better projection of Park Station in terms of spatial transformation. The transit node involved the redevelopment in accomplishing residential and commercial land use at a higher density. The predominance of commercial land use established the area to have a high degree of business services and real estate, insurance, the high profile of finances and communication sectors, storage, and transport. With that at hand, one can perceive high-density luxury residential growth within the cycling and walking proximity to Gautrain station. This could be for high-income earners at Randburg, Midrand, and Sandton. This concept is convenient for their affordability. The TOD concept at Park station has effectively increased the opportunities for hotels, retail stores, restaurants, and conference facilities within Park Station Node. The fact that Park Station is within the inner city of Johannesburg, the transportation system is decentralising from the inner city to the peripheral, and it is planned with the concept of a co-centric model of planning. This ensures that Park Station caters for all income classes with its market forces and inclusionary housing. The following figure 1 represent the map of Johannesburg park station with the radius of 400m.

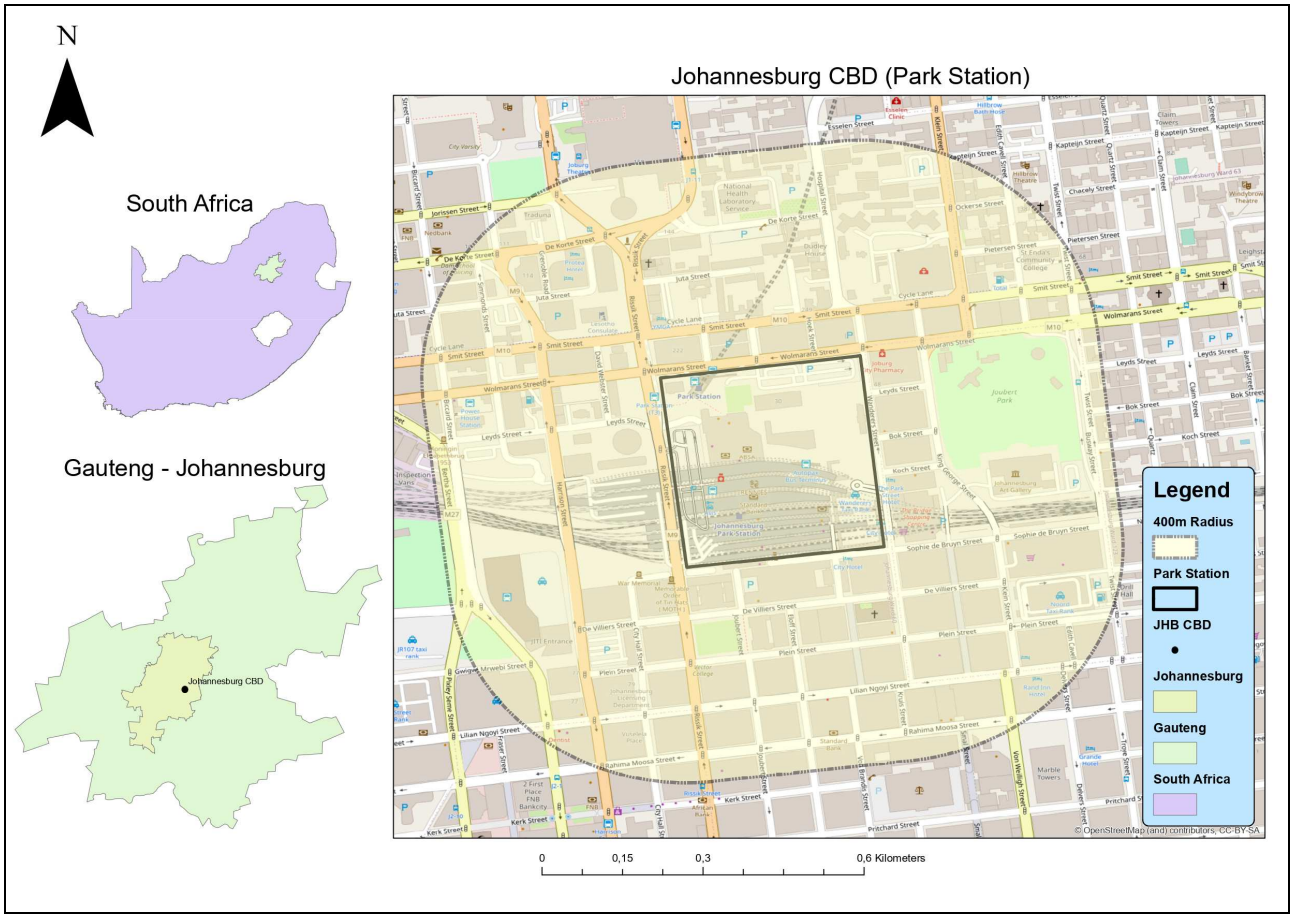


Fig. 1: Johannesburg Park Station Map

The above is the map (see figure 1) showing Park station, this map is following the logic of the study. Therefore, the radius of 400m is the appropriate proximity which the study also supports. The study also discovered commuters due to different groups of income, low-income groups are likely to walk more than 500m to Park station. Commuters also have surfaced that the reason in line with that issue it's because the precinct is populated. With that being elucidated, the urban functionality and the status quo will be discussed further on research findings. The following section will elucidates how the data was collected.

6 RESEARCH METHODOLOGY

An exploratory research design was adopted to assess Park Station's spatial distribution pattern from the 400m radius of walking proximity from the Gautrain Rapid Rail. The study also utilized the mixed method research design, as it was adopted where quantitative data and qualitative data analysis were utilised. For the accuracy of the study, various research instruments were deployed in the study. The key informant interviews were effectively utilized to further accumulate information for this particular study. For this study,

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

interviews were semi-structured and blended using open-ended questions to discuss other transit-oriented development Pathways for sustainable mobility and access in the City of Johannesburg. Ten interviews were carried out with different daily commuters of Gautrain residing within the 400m radius of walking from the Gautrain Rapid Rail with a positive response. Five interviews were conducted with the officials from different departments in the city of Johannesburg.

These informants provided insightful information for the study about the various transport modes that park stations in Johannesburg have, from informal and formal public transport to support further the TOD to provide complete access to the city of Johannesburg. Most significantly, the core focus of the study was acknowledged by the daily commuters residing within a radius of walking from the Gautrain Rapid Rail. These commuters answered positively to the question: of how the city of Johannesburg enhances the TOD to further provide sustainable pathways for sustainable mobility and broader access to the city of Johannesburg. This study adopted subjective/purposive sampling due to the informed commuters and officials' respondents through the interviews, documented studies, and observations. Moreover, these tools were utilised to gather data from various sources. In addition, the study utilised secondary information that was acquired from ginormous databases including Francis and Tailor, Google scholar, Science direct and Sage.

7 RESEARCH ANALYSIS AND FINDINGS/RESULTS

The City of Johannesburg is venturing into its new contemporary spatial plannings aligned with the 2040 Growth Development Strategy, including the Johannesburg Spatial Development Framework 2040. These are strategic policies that are well based on transport-oriented developments. The city of Johannesburg has a high-profile city plan, including its corridor of freedom roped to interchanges. The city has spatial plans focused on mixed-use development, which adequately support the TOD city-wide (Mbatha & Gumbo, 2019). These equally provide configurations of the future city incorporating well-planned transport arteries. The main objective of the spatial policies is to commit to and reduce private motorised transport and provide vast alternative means such as pedestrians' walkways, bus lanes, and cycling. In addition, the study has also surfaced that 90% of the officials of the City of Johannesburg, Gautrain, and Metrorail provided positive feedback about integrating the transport modes provided in Park station precinct. The officials provided that the northernmost Gautrain station is adjacent to Metrorail's Johannesburg Park station, which has overridden the transport system within the inner city of Johannesburg. Since the Gautrain station assimilates Gaubus stations which include pickup points expanding the modes of public transportation within the inner city.

There was a strategy of the city of Johannesburg to enhance the transport systems to be more reliable and cost-efficient. Interestingly, the commuters residing around Park Station also had vital positive feedback from Questionnaires and interviews towards integrating public transport as they have specified that they travel easily to workplaces and amenities. The Park Station is approximately 100m to Gaubus station and Gautrain station, accommodating commuters to walk between the stations easily. Likewise, the city of Johannesburg is diverse, incorporating all the different levels of income. About 70% of commuters are facing the challenge of Metrorail (PRASA) hiccups since it's not operating in recent days due to looting and financial constraints from PRASA. There has been a disadvantage to the low-income commuters living near Park station. Metrorail has the following station in Johannesburg: Centurion station and Johannesburg Park station. However, it also has stations at Pretoria and Kempton Park. In addition, Metrorail has subordinating stations within the city's urban nodes.

The study has found that Metrorail has been a pillar transport to many commuters as a fund by the study. 80% of Metrorail commuters agree on integrating the following system to the park station: Metro bus and BRT. This will dispense benefits to the commuters of both transport systems. Through clear observations, the BRT only utilises well-serviced and intensely busy routes. In addition, BRT also uses routes potentially connecting other locations, including the City of Tshwane and the City of Ekurhuleni. The commuters have also highlighted that the BRT transport reaches significant sites around the CBD and these locations incorporate their workspaces. However, these commuters utilise the BRT through the connectedness of the transport systems. Thus, they suggest that BRT and Metro buses be closer to Park Station as part of enhancing transit-oriented development networks in Johannesburg. This was a significant finding for the study since it answers the people's statement of the study. However, 20% of the commuters are not pleased with the routes BRT, GauBus, and Gautrain use because they do not reach their desired places, such as their workstation. These commuters are reluctant to accept the idea that the transport system in the city of

Johannesburg is not well integrated. 80% of the commuters who reside closer to Park Station value the integration of the transport system concept due to how the system is convenient to them. Through how the data was collected the findings answered the research question on how can TOD be enhanced in South African cities and provided sustainable mobility and access in the City of Johannesburg. How transit-oriented networks can be enhanced? With that at hand, the following section seeks to answer the research question on how can the City of Johannesburg enhances the TOD networks in South African cities spaces, and how to further influences accessibility and sustainable mobility.

7.1 How to enhance TOD networks in South African cities?

This section seeks to discuss pathways which the South African cities including the city of Johannesburg are indulging on. The City of Johannesburg is committed to deliver sustainable mobility and continue to enhance accessibility through its spatial transformation.

7.1.1 Spatial integrated systems

The integration of spatial system is an exclusive planning framework which seeks to incorporates all the possible zonings. For accurate results, the aid of GIS is always applicable to further recognises zonings that should be relevant. The integration of spatial system is a framework that seeks to correct the exclusionary land-use patterns that were implemented by apartheid. However, integration of the spatial systems in South African city network is needed since it will improve the efficacy of the spatial planning since spatial integration systems seeks to locate residential development closer to economic opportunities, employment opportunities and exploit surplus bulk infrastructural capacity to reduce the cost of development. The spatial integration systems also promote social cohesion on social dimensions it can also increase the accessibility within the city for low-income residents to services, facility and opportunities. The spatial integration conveys the cultural and economic opportunities for diversity within the city. Most significantly it designates the levels of connectivity between the different geographical scale of transport systems. Moreover, Spatial integration is encouraged positively by the present of efficient physical, administrative bodies and function status quo between areas and the absents of political controversies.

7.1.2 Integration of the electronic payment systems

Covid-19 pandemic have escalated the concept of cashless societies at a global scale. The practice of electronic payments in retails and other services was enhanced even on transport sectors. The system of “pay as you go” is a traditional way that was introduced through cash transactions. This is the same system that South African cities can indulge on using for electronic payments. Moreover, the city of Johannesburg can enhance their payments methods on their transit nodes including Ra Vaya, Metrobus, Metrorail, Gaubus and Gautrain to accept immediate payment through cell phone or tag devices through tapping their devices through terminal payments to avoid long queues of cash and cards transections. Also, the city of Johannesburg can influence and rope other private entities of transport nodes into the system such as Starbus, Putco and Megabus to venture in and integrate their system of electronic payment systems. The “Payment Systems in Public Transport” concept is grounded on what is known to be “four-party model payment” this model comprises responsibilities of allotting bank also acquiring bank are clearly divided in the card payment transection process. The public transport operator is also observed as a service provider that accept rapid payments that equally channelled to an acquiring bank for transport provided. Therefore, the integration of the electronic payment systems on the transit nodes on city of Johannesburg will enhance transport availability and rapid transportation since the payments systems will be centralised. This means all the transport nodes will use one integrated payment model. The commuter will be eligible to use their device to make payments in all various transport mode. Moreover, integrating block-chain technology in the “fund’s system” will further ensure all the information happening on the system from registration to transactions is made anonymous and secure.

7.1.3 Development of station hubs

The development of a new station hub is ideal. This a fresh perspective that can further stimulates the economy Gauteng at large. Certainly transportation sector always present immense economic opportunities in urban spaces. This paper encourages transit station at Soweto township. Developing an immense public transport station at Soweto can influences the surrounding real estate values particularly in housing sector.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

However, this can also rope in some risk such as pushing away some other groups due to property values in Soweto. Although this has also great benefits to all groups since there will be an increment of employment opportunity. Nonetheless, the great capacity of transport will have positive influence to the low-income group in this current cripple economy. Development of a new hub station comes vast feasible benefit including mitigate of climate crisis, accessibility, sustainable smart mobility, development of retail development and implementation of place making concept. Despite the traffic congestion that might be possible in Soweto, this development can further decentralises resources from the inner city to the peripheral of the city, it will also provide excessive frequency of transport services in respect to locations in Gauteng and South Africa as a region. A rail station can accommodate immense group of travellers at a comfortable and safe curtesy. This station can utilises smart transfer solutions for calculated decisions and the future of the station. Smart transfer solutions are exclusively independent on an effective design of the station, integrated, and multidisciplinary approach is proficient way. It is commonly known that railways links cities, regions and districts, railway also thrives in dynamics of departures and arrivals. Thus, in a global scale studies have shown that the railway is an embraced alternative for sustainable transport which thrives to improve the quality of life in urban spaces.

7.2 Pathways sustainable mobility and access

7.2.1 Policy and legislative frameworks on TOD

Sustainable mobility is still one of the overarching challenges that global cities are facing. The city of Johannesburg has also implemented positive reinforcement in terms of its policies to thrive in sustainable mobility. However, the concept of new urbanism and transit-oriented development are vastly evident within the urban spaces of the city of Johannesburg. With that being said, the city of Johannesburg is still reinstating its Spatial Development Framework 2040 (SDF) to further transform its spatial spaces to be sustainable and integrate transport systems. The discourse of this policy seeks to also invest on transport infrastructure to influence smart mobility. In addition, by virtue nature the concept of TOD seeks to merge development and investment in a close proximity to transit infrastructure. Accessibility in the city of Johannesburg can be assessed to various opportunities and activities by utilizing several transport modes in both qualitatively and quantitatively measures. In this case of point, the BRT (Ra Vaya) has enhance the accessibility of the city of Johannesburg.

7.2.2 Implications for Sustainable mobility and access

Transport sector is one the factors that influences the human activity within the city of Johannesburg hence the transport well-being robustly depends on characteristics and performance. Since the city mobility systems connect places and people while it presents significant social and economic added value and enhancing the quality of life, the city of Johannesburg seeks to integrate the transport systems which there is a potential success on this concept due to transport and spatial elements that are already in place. The city of Johannesburg has a vast high profile transport infrastructure that is significantly providing immense accessibility. With various transport modes that are currently available within the city spaces (see figure 2) there has been improvement of accessibility and sustainability within the city of Johannesburg.

The above map denotes the transport modes that are available within the city of Johannesburg as they impact the accessibility and sustainable mobility positively. However, the city of Johannesburg has vast transport infrastructure that also caters for other transport notes of the joint transport private entities such as Megabus, Putco, Starbus etc. With that being delineated, the inner city of Johannesburg comprises of diverse land-use, thus the following section seeks to unpack the function ability found in the inner city (Park Station).

7.3 Park Station urban function status quo

The inner city of Johannesburg is found within the region F, this region also consists of industrial and residential zones that can be found on the south of the city. Region F has dual characteristics, it is commonly known to be the host of both high-income and low-income communities including Berea and Bertrams catering for low income and wealthier suburbs of Parktown in the north of the city. Moreover, region F also consist of wealthy vicinities in the south of the city in Bassonia, Glenvista, and Mulbarton. The region F is one of the focused regions in the city of Johannesburg with well serviced road infrastructure, this region has access to M1 that joins the inner city with the Southern suburbs whilst the M2 joins the inner city with the

industrial zone of the city. Moreover, due to the chosen study area, Park station node has a significant function as an intermodal public transport hub. Park Station is within the city centre; thus, it represents a gateway to the city's peripherals for various commuters, also Park station is known to be the gateway for commuters from other countries from Africa including other cities locally (Mbatha & Gumbo, 2019).

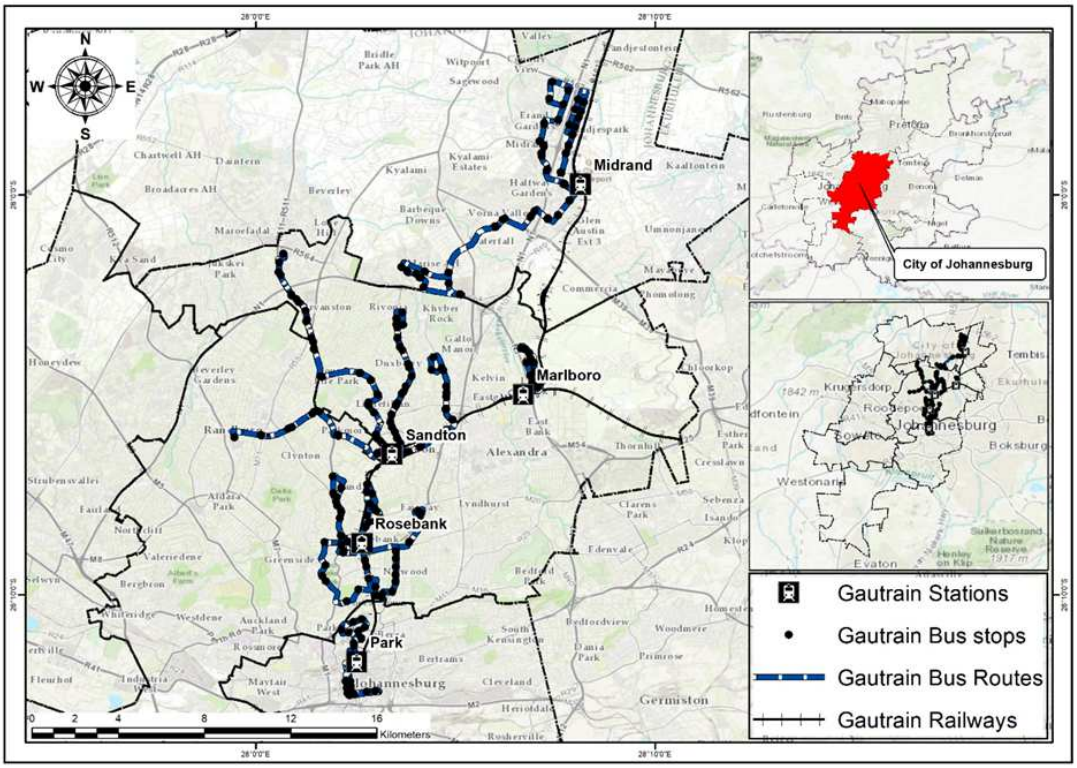


Fig. 2: Johannesburg transit Map

The Buses and Metro Rail services at Park Station are for regional transport services, intra-city transport as well as the inter-city. The Park station is accessible in all directions, this can be the mobility spines of De Korte street, Smit Street and De Villiers Street. These streets are all within short proximity to M1 highway. Park Station is the anchor of accessibility to the inner city; however, it also stipulates access to Braamfontein, a well-recognised high-density precinct that has undergone the incubation process of city regeneration. Braamfontein vicinity spatially supports the transit-oriented development since it also hosts a multiplicity of government departments including higher educational facilities (Wits university), local retail businesses, vast student accommodations, municipal and financial institutions. Due to Braamfontein's urban functionality, there are lots of people within the vicinity including various commuters through the area which results in more pressure on the capacity of service delivery and its quality (Risimati et al., 2021).

7.3.1 Land uses

The research site is in Johannesburg's suburban area to accommodate a broad range of land uses. Park Station is a sub-place due to its characteristics of a mixture of high-density land uses. According to the suitability of the study, this study utilised the 400m radius for its accuracy and rigour. Moreover, the intensity of land uses varies as they range from a nucleated by primarily commercial land uses in the south of sub-place. This has derived spatial planning from concentrating amenities and services, including educational facilities, parking spaces, governmental offices, and other diversified land used towards the north. The study supports TOD due to spatial planning and transformation; for reliability and validity, the Johannesburg Park Station sub-place falls within the eastern quadrant of Johannesburg and incorporates mixed land uses, commercial buildings, health care amenities, and educational facilities. With the high intensity of land uses in the vicinity of Park Station, it also has high volumes of people crossing the area for various motives. In addition, the study also discovered that within the 400m radius, there is no park or green space radius of chosen research. It is commonly known that Park Station is a protuberant transport main terminal in the city of Johannesburg, South Africa, and the Southern African Development Community (SADC). Park Station is a terminal known to dispense metro rail platforms, taxi ranks, and bus stations strategically located in walking proximity to the park station precinct. The study also noted that the BRT and

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Gautrain Park station bus routes are significant distributors and feeder routes within the area of Johannesburg at large (Tabane et al., 2021).

7.3.2 Property trends

Within the radius of 400m of Park Station, various property trend strata show mixed results. Subsequently, the development of Gautrain integration with Park Station was predicted to enhance the real estate and property markets. This was more biased towards the residential and retail properties. Considering that the study is within Braamfontein's boundaries, this has been advantageous to Braamfontein in the aspect of property development through the city regeneration projects by the private sector. According to Risimati et al. (2021), in mid-2006, Braamfontein was successfully transformed into a fully fleshed arts and cultural and commercial precinct. In addition, the precinct became an entertainment vicinity supported by a vibrant student population from the University of Johannesburg and Witwatersrand University. The city of Johannesburg prioritized the setting of Braamfontein with students' accommodations, art galleries, restaurants, and street-scale strips of malls offering fashion. The other border of the study area is Joubert Park. The properties of Joubert park also show a distinct trend. As elucidated, Joubert Park is within the sub-place, just outside the study area. The Residential properties in Joubert are decaying, forming a degrading Joubert precinct, with numerous residents occupying these decaying buildings. These decaying buildings are influential to the TOD at Park Station; however, the city of Johannesburg has city regeneration programmes that object to reviving these decaying buildings and rejuvenating them with adequate urban infrastructure.

8 POLICY IMPLICATIONS AND LESSONS LEARNT

The municipal system Act 32 of 2000 delegates all the South Africa local municipalities to effectively develop and produce a well-functioning Integrated Development Plan (IDP) that regulates the initiatives of the development. IDP delineates all the future terms period, thus it also addresses the challenges such as the city performance measurement systems, spatial planning, risks mitigations and management, and economic development. With that being elucidated, it is evident that the government of South Africa has prioritised the enhancement of transport systems throughout the strategic policy instruments and mega projects investment. Nonetheless, the city of Johannesburg is venturing on new spatial plans of development that are more aligned with the 2040 Johannesburg Spatial Development Framework and Growth and Development Strategies. These are policies that are found during the study. Also, the policies are strategically aligned with transit-oriented development with prominent public transport networks (Risimati & Gumbo, 2019). The city of Johannesburg successfully acknowledged numerous public transport corridors, including future public transport nodes, development opportunities, and consolidated development initiating from the corridors integrating peripheral urban spaces such as Soweto, linking it with the inner Sandton city. This transition includes the existing public transport modes Metrobus, Metrorail, GauBus, Rea Vaya, and Gautrain. Moreover, the public transport corridors will adequately operate as transit-orientated corridors capable of transporting numerous colossal commuters from one point of the city to the other with ease at an efficient cost.

Other public transport corridors will integrate public transportation with housing development, optimize investment, provide new employment opportunities, and provide social amenities. On the other hand, the city dimensions will consist of high-profile planning practices of transport arteries, and the corridors of freedom will be incorporated into the city's interchanges (Mbatha & Gumbo, 2019). The outcome is that the public is advantaged with vast alternative means that are cost-effective and reliable. This includes extrapolated bus lines, rail lines, cycling ways, and pedestrian walkways. With that all being said, TOD as a policy concept has been metastasizing globally with the aid of international conferences, policymakers, and scholars endeavouring to transfer the idea to various cities and other countries.

9 RECOMMENDATIONS

This paper investigated ways to enhance transit-oriented development networks in South African Cities and Pathways for sustainable mobility and access in the City of Johannesburg. The findings collected suggestions from commuters and other interested parties about the TOD in Johannesburg. One of the recommendations included integrating available transit nodes within the inner city to accommodate low-income commuters further since Metrorail is not currently operating due to unfortunate circumstances and financial constraints.

Moreover, this paper supports the recommendation since integrating these modes will be interchanged in the city, allowing Johannesburg to make convenient policy adjustments. Furthermore, integrated public transit allows TOD to dispense significant intermodal integration and mobility options. This can be crystallised in congested vicinities in the CBD. Integrating the transit modes can allow diversity in transportation; for instance, old age and youth will be able to utilize multiple modes of transport. This paper strongly recommends the place-making concept. Placemaking can enhance public safety and improve the sense of place and transport through active development throughout the day and evening with eyes on the street. This concept can also improve the safety of pedestrians and promote pedestrian-centric areas within Johannesburg since the city of Johannesburg is venturing into new spatial development plans that are more aligned with the 2040 Johannesburg Spatial Development Framework and Growth and Development Strategies. The policies should rope in sustainable urban planning to reinstate a sustainable development approach to urban planning. Since TOD is channelled on denser density than low-density development, Sustainable urban development in TOD can reduce the need to convert open spaces and natural cover land-use into development.

10 CONCLUSION

This paper pursued to uncover the mobility innovations and the spatial transformation visions drafted by the city of Johannesburg to enhance the TOD networks in Johannesburg and find Pathways for sustainable mobility and access in the city. This paper also acknowledges most contributing factors to city conditions such as population dynamics, current economic opportunities, and political systems to enable the study to contribute knowledge about the city. The city of Johannesburg is accumulated by an endless list of challenges, including urban decaying, informal settlement, and traffic congestion. However, the city is leading the development and academic affiliations in the country. With that being said, this paper concludes that TOD is the vehicle to deliver sustainable development to South African cities and provide resilient, intelligent, sustainable mobility. On the other hand, this paper has surfaced that TOD can be a mechanism South African cities can utilise to metastasize the concept of place-making. Also, it has surfaced by the study that public transport corridors can accommodate cogent public transit with housing development.

11 REFERENCES

Cervero, R. and Dai, D., 2014. BRT TOD: Leveraging transit-oriented development with bus rapid transit investments. Transport Policy, 36, pp.127-138.

CoJ (City of Johannesburg). 2011. Joburg 2040: Growth and Development Strategy. Johannesburg: CoJ. 2020. Integrated Development Plan. Johannesburg: CoJ.

Gumbo Trynos; Moyo Thembani; Ndwandwe Bongumusa; Risimati Brightnes; Mbatha Siphiwe (2022) Urban Public Transport Systems Innovations in the Era of the Fourth Industrial Revolution: Perspectives, Reflections and Conjectures, Springer Nature Switzerland AG, https://link.springer.com/book/10.1007/9783030987176

Gumbo Trynos and Moyo Thembani (2020) Exploring the Interoperability of Public Transport Systems for Sustainable Mobility in Developing Cities: Lessons from Johannesburg Metropolitan City, South Africa, Sustainability, 12, 5875; 1-16; https://doi:10.3390/su12155875

Mbatha, S. and Gumbo, T., 2019, April. Establishing the state of spatial integratedness of innovative public transport systems in Gauteng, South Africa. In REAL CORP 2019—IS THIS THE REAL WORLD? Proceedings of 24th International Conference on Urban Planning, Regional Development and Information Society (pp. 319-327).

Moyo, T.; Mbatha, S.; Aderibigbe, O.; Gumbo, T and Musonda, I (2022). Assessing Spatial

Variations of Traffic Congestion Using Traffic Index Data in a Developing City: Lessons from Johannesburg, South Africa. Sustainability, 14, 8809; 1-16. https://doi.org/10.3390/xxxxx

Mu, R. and de Jong, M., 2012. Establishing the conditions for effective transit-oriented development in China: the case of Dalian. Journal of Transport Geography, 24, pp.234-249.

Nasri, A. and Zhang, L., 2014. The analysis of transit-oriented development (TOD) in Washington, DC and Baltimore metropolitan areas. Transport policy, 32, pp.172-179.

Risimati, B. and Gumbo, T., 2019. Mapping the spatial integration of motorised and non-motorised transport infrastructures: A case study of the city of Johannesburg. Proceedings of the REAL CORP.

Risimati, B., Gumbo, T. and Chakwizira, J., 2021, September. Innovative Initiatives Usage to Improve Efficiency in the City of Johannesburg Public Transportation. In CITIES 20.50–Creating Habitats for the 3rd Millennium. Proceedings of REAL CORP 2021 (pp. 715-726). Competence Center of Urban & Regional Planning.

Strong, K.C., Ozbek, M.E., Sharma, A. and Akalp, D., 2017. Decision support framework for transit-oriented development projects. Transportation research record, 2671(1), pp.51-58.

Tabane, I.T., Gumbo, T., Musakwa, W., Moyo, T. and Mbinza, Z., 2021, September. Assessing the Efficacy of Spatial Planning and Development System in Improving Living Conditions of the Society. In CITIES 20.50–Creating Habitats for the 3rd Millennium: Smart–Sustainable–Climate Neutral. Proceedings of REAL CORP 2021, (pp. 77-87). CORP–Competence Center of Urban and Regional Planning.

Thomas, R., Pojani, D., Lenferink, S., Bertolini, L., Stead, D. and van der Krabben, E., 2018. Is transit-oriented development (TOD) an internationally transferable policy concept? Regional Studies, 52(9), pp.1201-1213.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

🏆 *reviewed paper*

Evaluation of COVID-19 Related Measures using Ordered Logistic Regression Analysis based on a Survey of Tourism-Related Offices in the Nishimikawa Region, Aichi Prefectur

Mingji Cui, Hiroyuki Shibusawa

(Asst. Prof. Mingji Cui, Toyohashi University of Technology, 1-1 Tempaku Toyohashi Japan 441-8580, cui.mingji.iq@tut.jp)
(Prof. Hiroyuki Shibusawa, Toyohashi University of Technology, 1-1 Tempaku Toyohashi Japan 441-8580, hiro-shibu@tut.jp)

1 ABSTRACT

COVID-19 has had an unprecedented impact on the tourism industry. The Go To Travel (overnight travel discount and regional common coupons campaign), which was implemented in Japan from July 2020 to stimulate demand in the tourim industry, was canceled at the end of 2020 because of the spread of infection again. Repeated outbreaks of infection and state of emergencies highlight the difficultly in balancing human health and economic activities during the COVID-19 pandemic. This study aims to clarify the economic impacts of the pandemic and evaluate the implementation of related economic support measures on the tourism industry. Based on a questionnaire survey of tourism-related offices in the Nishimikawa Region of Aichi Prefecture, it examines the economic impacts on the sales amount of tourism-related industry, evaluated the effects of the Subsidy Program for Sustaining Businesses (SPSB) and Go To Travel (by the national government) and Coupon Campaigns for shopping and restaurants (by municipalities) using ordered logistic regression analysis. The findings show that the impact of COVID-19 on business office sales is most severe for the accommodation industry, with a 62% decrease at the time of the survey compared to 2019. In addition, SPSB and Go To Travel campaigns are relatively highly evaluated by accommodation and tourism servise offices, while Coupon Campaigns for shopping and restaurant coupon campaigns are relatively more effective in the restaurant and retail offices. In additon, the results show that the larger the offices annual sales, the more effective the Coupon Campaigns, indicating that since consumers use premium coupons to purchase goods and services that are more expensive than usual, the effect of policy implementation would be biased toward business offices that provide relatively expensive goods and services

Keywords: policy effectiveness, economic impacts, questionnaire survey, tourism industry, COVID-19

2 INTRODUCTION

Though the mobility restriction measures for individuals have been effective in temporarily reducing the number of coronavirus positive cases, they have seriously impacted the economy, particularly the tourism industry. Japan has experienced six waves of coronavirus infection spread, and it is now in the midst of its seventh (MHLW, 2022). According to the Japan Tourism Agency's Statistical Survey on Overnight travel, the number of overnight travelers in Japan decreased by 44% in 2020 and 46% in 2021 compared to 2019 (Japan Tourism Agency, 2022). Consequently, tourism-related industries such as tourism services, restaurants, and retail (especially the accommodation sector), have experienecd serious financial difficulties. Furthermore, a number of small- and medium-sized enterprises (hereinafter SMEs) have been forced to close their offices or are bankrupt due to serious business deterioration (MIYAKAWA et al., 2021).

Consequently, the government implemented a "Subsidy Program for Sustaining Businesses (hereinafter SPSB)" with an annual budget 5.5 trillion yen as the source of funds (METI, 2020). In addition, after the lifting of the first state of emergency, the government conducted "Go To Travel," a travel and tourism promotion campaign by subsidizing expenses of overnight travel and shopping to stimulate the demand of domestic tourism (Japan Tourism Agency, 2020). However, the campaign was canceled due to an outbreak of infections at the end of 2020.

Various studies have assessed the economic impact of COVID-19 (KHALID et al., 2021, YAGASAKI et al., 2021, HANAFIAH et al., 2021) and the effectiveness of related measures. A study evaluating the short- and medium-run effects of the infection prevention and economic policies showed that the business suspension request in the state of emergency decreased firm sales by 10% points, whereas the business continuation subsidy helped firms survival prospects by 19% points (KAWAGUCHI et al., 2021). In addition, Hoshi et al. (2021) revealed the relationship between a firm's creditworthiness and its likelihood of applying for subsidies. They found that firms with low credit scores before the COVID-19 pandemic were more likely to apply for and receive the subsidies offered by the Japanese government in 2020. This is related to the size of the company—larger companies with good financial condition can sustain their operations without applying

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

for subsidies, while smaller and less creditworthy companies are more likely to apply for subsidies. Furthermore, while the Go To Travel campaign is considered effective in attracting visitors from distant regions (MATSUURA et al., 2022), Tamura et al (2022) highlight how the travel stimulus measures have resulted in an increase in the number of infections. With the unprecedented long-term effects of the pandemic, policy implementation that cannot be referred to by previous experience will be optimized through iterative evaluation and feedback, which requires supporting evidence in all the processes of policy assessment. Therefore, a questionnaire survey is an effective method for providing objective and visual data of actual situations for developing and evaluating economic support measures.

This paper aims to determine the actural situation of economic impacts and policy effectiveness in COVID-19, based on a questionnaire survey of tourism related offices in the Nishimikawa Region of Aichi Prefecture. It has several sections. (1) It summarizes the impact of COVID-19 on Japan's tourism industry with changes in overnight travelers, the declaration of a state of emergency, and the economic support measures, providing policy-relevant data that will be employed in the analysis of this study. (2) It describes the summary and basic statistical analysis of a survey of tourism-related offices, showing differences in the impact on business sales and the policy evaluation by sector. (3) The relationship between business offices' evaluation points for policy implementation (dependent variable) and the type of business, size, and impacts of COVID-19 (independent variable) are analyzed using ordered logistic regression to conduct a comprehensive evaluation of policy effectiveness and discussion of policy implications.

3 COVID-19 IMPACTS ON TOURISM INDUSTRY AND RELATED MESURES

3.1 COVID-19 impacts on the tourism industry in Japan

Figure 1 shows the number of positive cases of coronavirus and the change rate of overnight travelers compared to 2019. In additon, it highlights the timing of COVID-19 related measures implemented in Japan. After the first case of infection reported on January 16, 2020, it faced the first wave of outbreaks from the end of March to May 2020. Subsequently, the first state of emergency was declared on April 7, 2020 to restrict people from going out, gathering, and holding events. Due to the refraining from nonessential outings and movements, overnight Japanese tourists decreased by 79% and foreign tourists by 98% by May 2020 compared to May 2019. Furthermore, subsequent trends indicate that the first state of emergency had the most severe impact on the tourism industry. Presumably, people were more anxious about the risk of infection in the early stages of the pandemic which affects their economic activities and livelihoods. (MIYAKI, 2021).

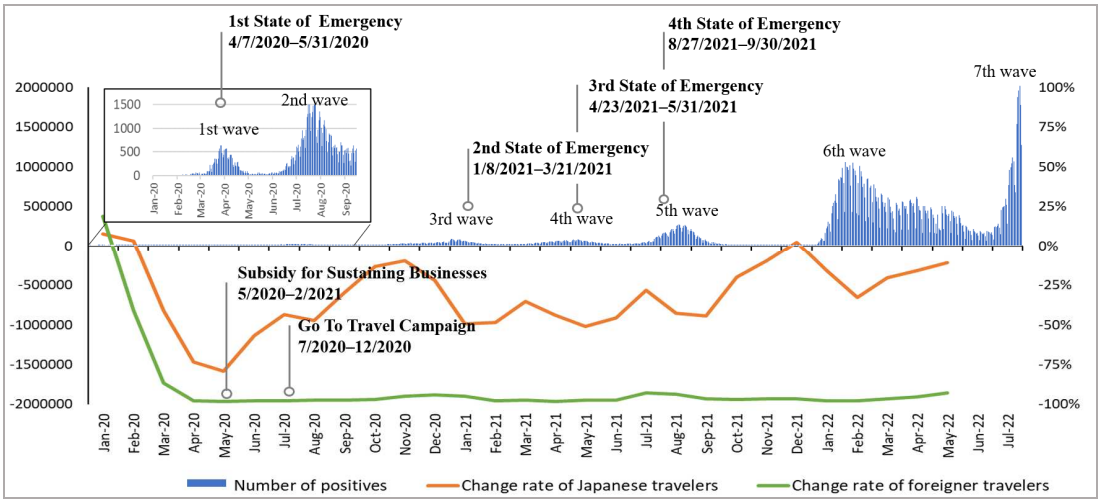


Fig. 1: Number of infections and the Change rate of Overnight Travelers compared to 2019

3.2 Measures to support the operation of business offices

The state of emergency restricted people from nonessential outings and called for business enterprises in certain areas, such as restaurants, movie theaters, department stores, and theme parks, to cooperate in shortened hours operation or closures. To support those SMEs and sole proprietors whose sales have decreased due to such restrictive measures, the government launched various economic support programs to

facilitate the continuation or revitalization of their businesses. Table 1 shows the main measures implemented in 2020 and 2021. (1) The most versatile subsidy program was the SPSB. It targeted SMEs and sole proprietors whose monthly sales decreased by over 50% compared to the same month in 2019, without limitations on the way of using the subsidy. The subsidy amount was set in two categories, with a maximum of 2 million yen for SMEs and 1 million yen for sole proprietors. Consequently, the same amount of subsidy is applied to all businesses in the same category, irrespective of the size of the business. (2) The government also provided Rent Subsidy for Business to reduce the burden of land and building rent costs of offices that were facing a decrease in sales due to the state of emergency. (3) Another subsidy program is the Employment Adjustment Subsidy, which partially subsidizes the employer's payment of timeoff benefits to employees during the period of closures. (4) The government established various loan programs for SMEs and sole proprietors. For example, it lent up to 300 million yen without interest to business offices whose sales had declined by 20% or more, and at a lower interest rate to business offices whose sales had declined by 15%. In addition, for business offices whose sales had declined by 5% or more, it subsidized the guarantee fee for the loan. Furthermore, the government provided profitability improvement support, such as creating profitability improvement plans and subsequent regular monitoring.

Measures	Implementation period	Details
(1) Subsidy Program for Sustaining Businesses (SPSB)	May-1, 2020 –Feb-15, 2021	-Target small and medium-sized enterprises (SMEs) and sole proprietors whose sales decreased by more than 50% compared to 2019. -Subsidy amounts: for SMEs: Up to 2 million yen; for sole proprietors: Up to 1 million yen
(2) Rent Subsidy for Business	Jul-14, 2020 –Feb-15, 2021	-Target Medium-sized enterprises with capital of less than 1 billion yen, SMEs and sole proprietors, whose sales decreased by more than 50% or sales in any three consecutive months have decreased by more than 30% compared to 2019. - Subsidy amounts: follows a particular calculation method, for companies: up to 1 mullion yen; for sole proprietors: Up to 0.5 million yen
(3) Employment Adjustment Subsidy	Apr-1, 2020 –Sep-20, 2022	-It is a subsidy that partially subsidizes the employer's payment of time-off benefits to employees. -A company whose sale is decreased by more than 5% compared to 2019. - Subsidy amounts: follows a particular calculation method, for SMEs: Up to 2/3 of the time-off benefits, for others: Up to 1/2 of the time-off benefits
(4) Loans for Cash Management	Apr-1, 2020 –To present	-Provide interest-free or low-interest loans -Provide guarantee fee assistance -Provide profitability improvement support, such as profitability improvement plan and regular monitoring

Table 1: Main measures to support the operations of business offices in 2020 and 2021

3.3 Measures for individuals to stimulate tourism demand and consumption

Table 2 shows the measures for stimulating tourism and consumption by the national, prefectural, and municipal government. The Japan Tourism Agency supported the continuation of employment and business of the tourism industry and implemented the Go To Travel campaign in July 2020 to stimulate the tourism demand. The government subsidized travel expenses to promote domestic travel and formulated the New Travel Etiquette for accommodation facilities and travelers to ensure infection prevention.

In addition, prefectural governments implemented tourism promotion campaigns and issued premium coupons. Aichi Prefecture implemented the LOVE Aichi Campaign to subsidize a portion of travel expenses, and the Aichi Travel e-Money Campaign, which rewards a portion of travel expenses as shopping points. As cross-prefectural travel was restricted to prevent the spread of the infection, these measures were designed to stimulate travel within the prefecture by limiting users to Aichi Prefecture residents only.

Implementation Entities	Measures	Period	Details
Nation	Go To Travel Campaign	Jul-22, 2020 –Dec-28, 2020	- Discounts 30% of travel expenses, up to 14000 for overnight travel and 7000 for 1 day travel. - Travelers and accommodations should follow the New Travel Etiquette, which is a set of infection prevention manual.
	Regional common coupons	Jul-22, 2020 –Dec-28, 2020	- Coupons associated with the Go To Travel Campaign. - Coupons amount: 15% of travel expenses
Aichi	LOVE Aichi Campaign	Intermittently conducted four times, from Jul-20, 2020.	- In 2020 and 2021, the campaign only targeted travellers from Aichi prefecture. - Discounts 50% of travel expenses, up to 10000 for overnight travel and 5000 for 1 day travel.
	Aichi Travel e-Money Campaign		- Returns up to 7,000 yen worth of points per person per trip
Municipalities in Aichi	Premium Coupons for Shopping or restaurant	from Jul 2020, depends on each municipality	- The shopping or restaurant coupons worth 6,000 to 10,000 yen are available for 5,000 yen. And the premium amount varies from each municipality.

Table 2: Major measures by individuals to stimulate tourism or consumption

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Municipalities are issuing premium gift coupons subsidized by the national government to promote local economies that have been severely impacted by the pandemic. These can be used in exchange for goods and services above the purchase amount of the coupon, and the premium rates of the savings amount vary between municipalities.

4 QUESTIONNAIRE SURVEY OF NISHIMIKAWA REGION

A questionnaire survey was conducted among tourism-related business offices in the Nishimikawa Region of Aichi Prefecture to determine the actual impact on the tourism industry and the effects of the policy implementation.

4.1 Survey area

Aichi Prefecture is known as Japan's manufacturing prefecture. In recent years, Aichi Prefecture has strived to promote tourism by taking advantage of regional resources, launching the "Aichi Tourism Strategy 2016–2020" and the "Aichi Tourism Strategy 2021–2023," expanding divisions in charge of tourism, developing tourism plans, and establishing regional tourism associations. However, since 2020, the number of tourists has decreased significantly, and efforts to revitalize the tourism industry have become a part of the tourism strategy. As shown in Figure 2, Nishimikawa region runs through the center of Aichi Prefecture and consists of 10 municipalities. Major tourist resources include Aichi Plateau National Park, Mikawa Bay National Park, Hongu Mountain Prefectural Natural Park, and the hometown of Tokugawa Ieyasu. Tourist facilities such as amusement parks, camping facilities, tourist farms, and fishing are scattered around the area, with natural and historical cultural resources attracting visitors from nearby regions.

4.2 Overview of the survey

Table 3 provides an overview of the questionnaire survey. There are various definitions of tourism-related business offices; however, for the purposes of this study, they were defined as travel services, accommodation, restaurants, and retail businesses that are recognized as contributing to the promotion of regional tourism. The Nishimikawa Wide-area Tourism Promotion Committee opened a tourism information website "Nishimikawa Gurutto Navi" in 2016 to promote wide-area tourism through interregional cooperation. This survey covers all business offices registered on this website, excluding facilities with free admission, such as natural parks, temples, and other free tourist spots.

Items	Details
Survey period	November 29, 2021 - December 19, 2021
Survey Target	A total of 751 survey forms were distributed to the offices of accommodations, restaurants, retail stores, and tourism service etc. which are listed on the 'Nishi-Mikawa
Survey method	Distribution and collection by post
Questionnaire contents	Basic information of business offices (8 questions) Measures for preventing the spread of infection (1 question) Impact on business activities and sales (3 question) Effect of COVID-19 related measures (2 question) Expected support measures in the future (1 question) Free description (1 question)

Table 3: Overview of the questionnaire survey

4.3 Result of survey

4.3.1 Collection number of the questionnaires

Among the 824 questionnaires distributed, 751 were received by the offices, and 73 were returned for nonresponse. The 73 nonresponses included 53 cases of "closure" or "with unknown operation status," 11 cases of "address unknown" and 1 case of "business open only during the summer." Therefore, further investigation is required to determine whether the closure or unknown operation status of these 53 offices is due to the impact of COVID-19.

A total of 212 questionnaires were collected, with a response rate of 28.2%. Since it includes the public facilities which are ineligible for subsidy programs and were temporarily closed under the direction of the local government during the state of emergency, this study excludes them from the analysis. Accordingly, the final number of responses for analysis is 179, with 23.8% of distributed number.

Figure 3 shows the number of questionnaires distributed and collected by business type. The offices of restaurant sector had the highest number (80), followed by retail (38), accommodation (33), the tourism service (18), and others (10). Here the tourism service sector includes the offices that operate tourist spots such as amusement parks, theme parks, tourist farms, camping spots, clam digging spots, and fishing spots, etc. In addition, the others include offices that predominantly engaged in the manufacture and sale of handicrafts and souvenirs.

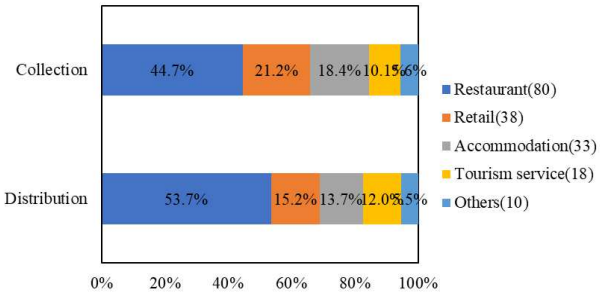


Fig.3: Percentage of Questionnaires Distributed and Collected by Business Type (n = 179)

Figure 4 (a) shows the number of employees by business type. The vertical axis indicates the number of responses by sector. In all se ctors, small-scale offices with 1–4 employees accounted for the largest proportion, totaling 105 (58.7%). The restaurant and retail sectors have a relatively large number of small-scale offices, while the tourism service, accommodation, and others have a certain percentage of offices with 20 or more employees. Figure 4 (b) shows the annual sales amount in 2019 before the COVID-19 pandemic. Offices with sales between 10 and 30 million yen had the highest number of responses, accounting for 56 (31.3%), followed by those with sales of 5–10 million yen (30 [16.8%]), 30–50 million yen (25 [14.0%]), and under 5 million yen (18[10.1%]). The number of offices with the sales amount under 50 million yen accounted for 72% of the total.

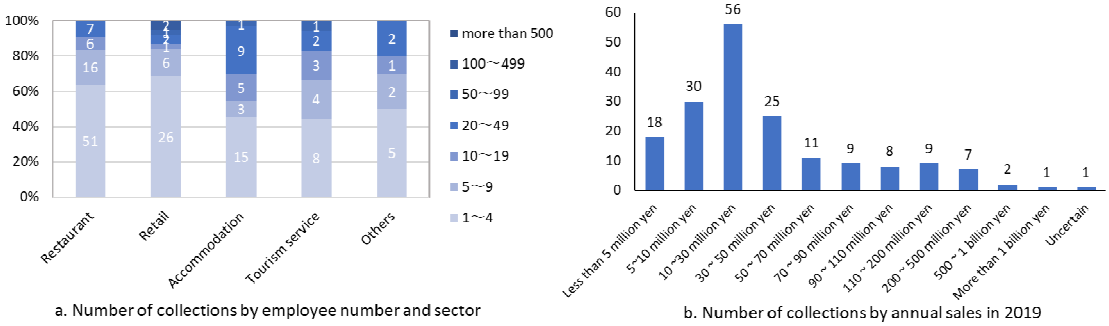


Fig. 4: Number of Collections by Employee Number (a) and Annual Sales in 2019 (b; n = 179)

4.3.2 Impact on sales amount and business operation

Respondents were requested to set the percentage of quarterly sales in 2020 and 2021, assuming that the quarterly sales amount in the period in 2019 was 100%. Figure 5 shows the average decrease rate in quarterly sales amount in 2020 and 2021 compared to 2019. The vertical bar shows the decreased rate in each business type, while the line graph indicates the average level of total sectors. The accommodation sector has been the most seriously affected, with sales decreasing 66% in the first quarter (April–June) of 2020, when the first state of emergency was declared. The sales recovered in the second half of 2020 with the implementation of Go To Travel; however, they began to decline again in 2021 and down 62% at the time of the survey.

The tourism service sector declined significantly in the first quarter of FY2020 and has subsequently recovered above the overall average level. Presumably, many neighborhood tourists are visiting them since tourist service business offices, such as theme parks, tourist farms, camping and fishing, are mainly outdoor spots where the risk of infection is relatively low. Regarding the restaurant and retail sector, a decrease in sales was observed for the entire COVID-19 period; however, there was no significant change in the period of infection spread or the period of Go To Travel.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

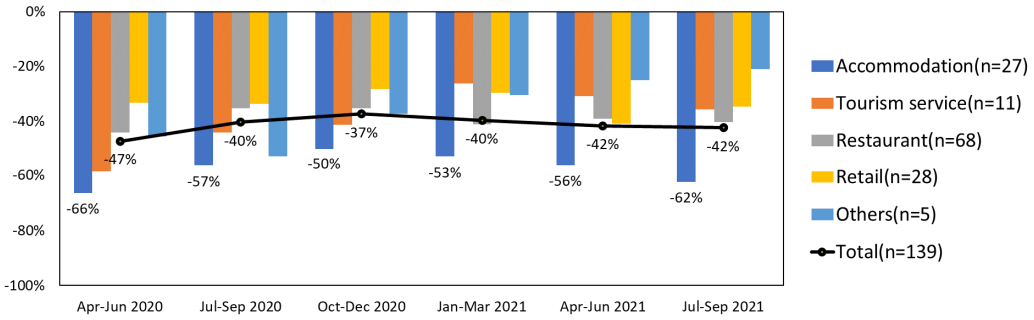


Fig. 5: Economic impacts on the business offices by business type (n = 139)

The survey investigated the impacts on business activities, such as closure and difficulty in bearing fixed costs, by classifying the impacts into five levels: “very severe (5 points),” “somewhat severe (4 points),” “undecided (3 points),” “not very severe (2 points),” and “not severe at all (1 point).” Figure 6 highlights the results of the impact on business activities. No significant differences were found in the number of responses at each level.

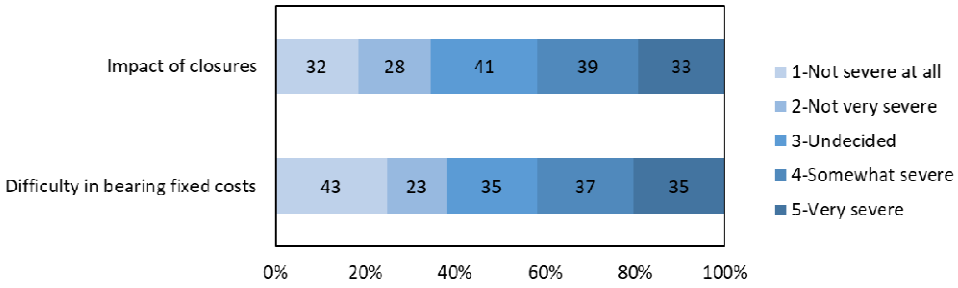


Fig. 6: Number of Respondents at Each Level of Impact (n = 173)

4.3.3 Evaluation of policy effectiveness by business offices

To measure the effectiveness of the government’s economic support measures, each business office who applied to the measures was asked to rate the measures they applied on a 5-point scale of “very effective (5 points),” “somewhat effective (4 points),” “undecided (3 points),” “somewhat ineffective (2 points),” and “completely ineffective (1 point)” regarding their effectiveness in maintaining or recovering business activities. On the other hand, if the offices have not applied for the measures, answer "no application". Figure 7 shows the number of respondents with application for the measures by each evaluation point and without application. Compared with other subsidies, the largest number of offices applied the SPSB, accounting for approximately half of the total. Furthermore, the evaluation points were relatively high, accounting for 90% of the applied offices.

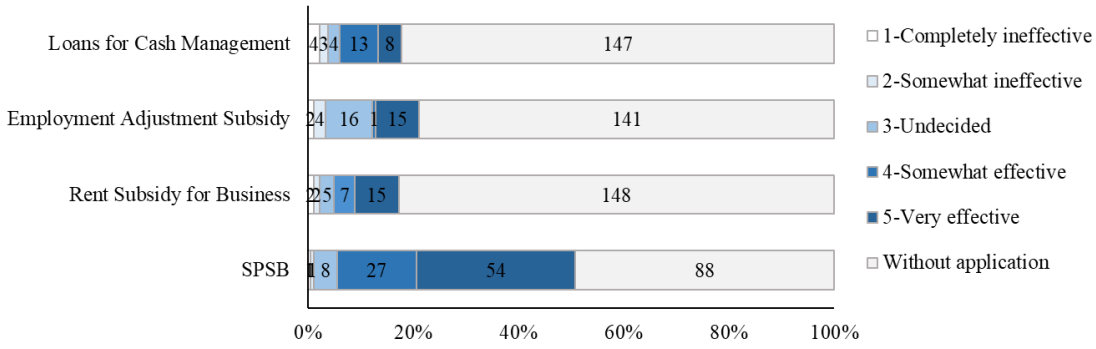


Fig. 7: Number of Respondents by Evaluation Points for Applications and Without Application for the Measures (n = 179)

For the tourism and consumption stimulation campaigns, respondents were also requested to rate the campaigns on a 5-point scale in the same way. Figure 8 shows the average rating points for tourism and consumption stimulation campaigns by business type, and the line graph shows the overall average level. It is evident from the line graph that the shopping and restaurant coupon campaigns conducted by

municipalities were rated the highest, while the prefectural LOVE Aichi Campaign and Aichi Travel e-Money Campaign were rated comparatively low. By industry, Go To Travel was comparatively highly effective in the accommodation sector, and shopping and restaurant coupons by the municipalities were effective in the restaurant and retail industries.

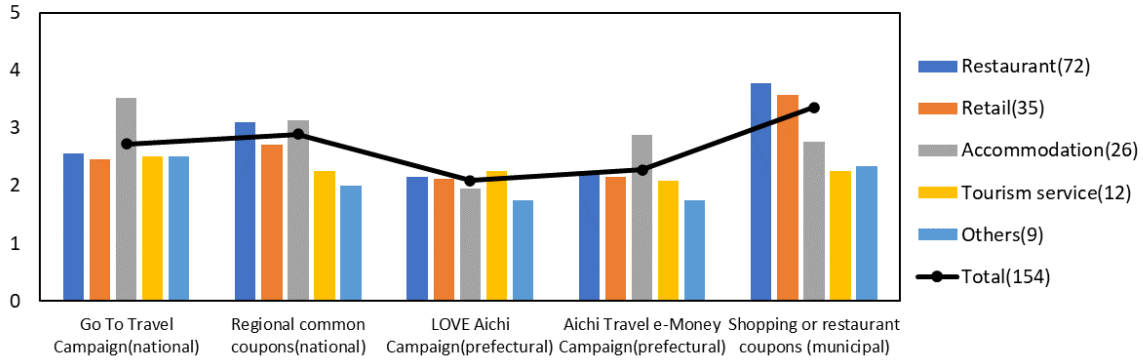


Fig. 8: Average Rating Points for Tourism and Consumption Stimulation Campaigns by Business Type (n = 154)

5 ORDERED LOGISTIC REGRESSION ANALYSIS OF COVID-19 RELATED MEASURES

5.1 Overview of variables

We qualitatively and quantitatively extracted the business attributes (such as business type, employee number, annual sales amount, etc.) and the value of impacts by COVID-19 (such as change rate of sales, impact of closure, difficulty of paying fixed cost, etc.) and measures related factors (such as with/without subsidy application, premium rate of coupons by municipality) which are assumed to affect the evaluation points of COVID-19 related measures, to quantitatively analyze the influence factor of measures. Since the evaluation points of measure effectiveness by business offices (dependent variable) are on an ordinal scale and the independent variables also include categorical data (ordinal and nominal scales), we used ordinal logistic regression analysis to estimate the contribution and significance probability of each factor and added a systematic discussion of the results.

This study analyzes the effectiveness of SPSB, a subsidy program that received the highest number of points in the survey, the main tourism stimulation campaign GoTo Travel, and the travel, shopping, and restaurant coupon campaigns by municipalities, which is highest rated by business offices.

Type	Variables	Description of variables		Obs	Mean	Std. dev.	Min	Max
Independent variables	rest	Businese types (Figure3)	Restaurant	80	-	-	-	-
	retail		Retail	38	-	-	-	-
	accm		Accommodation	33	-	-	-	-
	tous		Tourism service	17	-	-	-	-
	others		Others	10	-	-	-	-
	emp	Number of employee (Figure4)		178	12.7	33.4	2.5	299.5
	sale2019	Annual sales of 2019 (million yen, Figur4)		175	62.3	126.0	2.5	1000
	cr_sale	Average change rate of sales during COVID-19 (%, Figure5)		139	-41.5	24.4	-91.7	56.7
	imp_cost	Difficulty in bearing fixed costs (Figure6)		173	3.0	1.5	1	5
	imp_cls	Impact of closures (Figure6)		173	3.1	1.4	1	5
	app_SPSB	With/Without application of SPSB (1/0, Figure7)		178	0.5	0.5	0	1
	prm_r_Coup	Premium rate of coupon_municipality (%, Table2)		178	131.6	52.3	20	200
Dependent variables	p_SPSB	Evaluation points of SPSB by offices (Figure7)		91	4.5	0.8	1	5
	p_GoTo	Evaluation points of GoTo by offices (Figure8)		132	2.7	1.5	1	5
	P_Coup	Evaluation points of coupon_municipality by offices (Figure8)		141	2.9	1.4	1	5

Table 4: Basic statistics of variables

Table 4 shows the basic statistics of the variables used in the analysis. Values that required specific calculations to be incorporated as independent variables are presented here. (1) Since, the number of employees and annual sales of 2019 was asked in several ranks in the questionnaire survey, as shown in Figure 4, the average of the beginning and ending values for each rank was used in the analysis as an

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

independent value. However, for the last rank, the values written in the questionnaire were used as is. (2) For the value of the average sales change rate during the COVID-19 period, the average of the change rate for the periods of 2020 and 2021 shown in Figure 8 was calculated for each business office. (3) For the value of the premium rate of coupon issued by the municipality, we adopted the premium rate of coupons for the municipality in which each office is located.

Considering that using all the independent variables listed in Table 4 simultenously, in addition to multicollinearity, often cannot provide enough combinations between categories for analysis, we used the forward stepwise method to select variables with p-value = 0.05 as the criterion. Stata/SE 17.0 (Lightstone Corp.) was used for the analysis.

5.2 Results of ordered logistic regression analysis

The odds ratio estimated for each independent variable category indicates the odds of moving into the next highest policy rating point category for a one-unit change in the independent variable, or for the base category. That is, a category with an odds ratio above 1.0 indicates a higher policy rating point compared to the base category.

Table 5 shows the results of the analysis with the SPSB effectiveness evaluation points as the dependent variable. The tourism service sector has the highest contribution to the SPSB compared to the base category of retail trade, followed by the accommodation and restaurant sectors. In addition, there is a significant relationship with the category of number of employees (emp), indicating that offices with a larger number of employees are evaluated lower in the effectiveness of SPSB from the offices. This finding aligns with the study conducted Hoshi et al (2021) which states why the lower creditworthy companies with smaller size are more likely to apply for subsidies. Furthermore, compared to offices where there was absolutely no impact of the closure on business activities (base category of imp_cls), those that were impacted provided a lower evaluation of the policy's effectiveness. Therefore, even with the support of the businesses sustaining subsidy, they were forced to close their businesses due to the spread of pandemic. Compared to offices that had no impact on bearing fixed cost burdens (base category of imp_cost), those that had such an impact evaluated the policy more positively, indicating that they utilized the subsidies to cover fixed costs for operating their business, such as rent and labor costs.

Variables		p_SPSB as dependent variable					
		Odds ratio	Std. err.	z	P	95% conf. interval	
Business type	retail	1 (base)					
	rest	5.87 *	4.67	2.23	0.026	1.235	27.904
	accm	55.64 *	64.76	3.45	0.001	5.682	544.751
	tous	137.82 *	226.23	3.00	0.003	5.522	3,439.749
	others	3.90	5.10	1.04	0.299	0.299	50.747
emp		0.95 *	0.25	-2.13	0.033	0.899	0.996
cr_sale		1.03	0.02	1.88	0.06	0.999	1.060
imp_cls	1	1 (base)					
	2	0.02 *	0.03	-3.01	0.003	0.002	0.270
	3	0.36	0.41	-0.89	0.375	0.039	3.398
	4	0.07 *	0.08	-2.44	0.015	0.009	0.597
	5	0.06 *	0.07	-2.49	0.013	0.006	0.543
imp_cost	1	1 (base)					
	2	22.28 *	26.51	2.61	0.009	2.163	229.406
	3	38.97 *	47.04	3.03	0.002	3.658	415.166
	4	13.14 *	13.41	2.52	0.012	1.777	97.146
	5	21.87 *	23.63	2.85	0.004	2.629	181.884
/cut1		4.55	1.52			-7.536	-1.573
/cut2		3.83	1.34			-6.448	-1.203
/cut3		2.00	1.20			-4.350	0.355
/cut4		0.40	1.20			-1.944	2.752
Log likelihood							-64.857176
Pseudo R2							0.1928
n							80

Table 5: Analysis results of p_SPSB as dependent variable. Reference categories **: significant at the 1% level, *: significant at the 5% level

Table 6 shows the analysis results of effectiveness of Go To Travel and coupon campaigns implemented by municipalities.

Regarding the results of Go To Travel, no significance was found with the other categories except for the business type. Compared to the base category of accommodation, the odds ratios for the other sectors were smaller than one, indicating that the evaluation points for the effectiveness of Go To Travel are relatively negative for the offices of the other sectors.

Regarding the results of the coupon campaign, the contribution of restaurants and retail business offices to the campaign evaluation is higher than that of accommodations. In addition, although the results are not significant with the number of employees, they were significant with the annual sales in 2019 (sale2019), with the larger sales offices evaluating the campaign more positively. This indicates that customers typically use discount coupons to spend at offices with higher prices than usual. Furthermore, change rate of sales in COVID-19 pandemic (cr_sale) results with an odds ratio greater than one. This demonstrates that the smaller the impacts in sales of business offices, the higher the evaluation points of the campaign tended to be, which infers that the implementation of the campaign positively affects the sales recovery. Finally, significance was also found with the coupon premium rate (prm_r_Coup), with a 1% increase in the premium rate resulting in a 1.011 times increase in the probability of shifting the evaluation points to the next higher stage of the campaign.

Variables		p_GoTo as dependent variable						P_Coup as dependent variable					
		Odds ratio	Std. err.	z	P	95% conf. interval		Odds ratio	Std. err.	z	P	95% conf. interval	
Business type	accm	1.000	(base)					1.000	(base)				
	rest	0.311 *	0.16	-2.29	0.022	0.114	0.844	7.752 **	4.045	3.93	0.000	2.788	21.554
	retail	0.239 *	0.15	-2.35	0.019	0.073	0.789	5.054 **	3.090	2.65	0.008	1.525	16.752
	tous	0.226 *	0.17	-2.03	0.042	0.054	0.950	0.216	0.195	-1.7	0.089	0.037	1.264
	others	0.343	0.32	-1.14	0.255	0.055	2.161	0.189	0.177	-1.78	0.075	0.030	1.180
emp		0.997	0.01	-0.32	0.747	0.981	1.014	0.988	0.009	-1.31	0.190	0.969	1.006
sale2019		1.002	0.00	1.02	0.308	0.998	1.005	1.005 *	0.002	2.09	0.037	1.000	1.009
cr_sale		1.004	0.01	0.5	0.619	0.988	1.021	1.022 **	0.008	2.67	0.008	1.006	1.038
app_SPSB	0	1.000	(base)					1.000	(base)				
	1	1.230	0.47	0.55	0.584	0.586	2.582	3.576 **	1.380	3.3	0.001	1.679	7.619
prm_r_Coup		-	-	-	-	-	-	1.011 **	0.004	3.07	0.002	1.004	1.018
/cut1		-1.940	0.69			-3.299	-0.581	0.184	0.757		-2.242	-1.299	1.667
/cut2		-1.133	0.68			-2.473	0.207	1.108	0.754		-1.341	-0.370	2.586
/cut3		-0.394	0.68			-1.718	0.930	2.584	0.787		0.025	1.042	4.126
/cut4		0.991	0.68			-0.341	2.323	4.601	0.858		1.839	2.919	6.282
Log likelihood		-162.13764						-156.80106					
Pseudo R2		0.0316						0.1658					
n		106						123					

Table 6: Analysis Results of p_GoTo and p_Coup as dependent variables. Reference categories **: significant at the 1% level, *: significant at the 5% level

5.3 Discussion

The results of the analysis show the following policy findings.

(1) The larger the number of employees, the lower the policy effectiveness of the SPSB was evaluated. As shown in Table 1, SMEs were granted up to 2 million yen and sole proprietors were granted the up to 1 million yen regardless of the size of offices. Accordingly, while the relatively small offices can utilize the subsidy as funds to improve the business conditions of the offices affected by the pandemic, for SME offices, the amount may be insufficient to sustain the business activities that were severely impacted by COVID-19. In addition, since the subsidies were targeted at offices with a 50% or more decrease in sales without limiting the use of the subsidies, the small business office and sole proprietors may receive more income by applying for the subsidy without an effort to restore business that impacted by COVID-19. This indicates the importance of including further requirements in the subsidy program, such as the size of business offices and the impact level of COVID-19 on business activities.

(2) Regarding Go To Travel, the accommodation offices evaluated the policy higher than other sectors, showing that it was comparively effective in recovering the economic impact on the accommodation industry in the Nishimikawa region. However, a comparison of the change in Japanese overnight travelers in Figure 1 and the decrease in accommadation offices' sales in Figure 5 shows that during the Go To Travel period, a -10% decrease in Japanese overnight travelers in Figure 1, while the decrease in sales of accommodation in Figure 5 is -50%. Therefore, the subsidized overnight travel expenses by Go To Travel lead people to travel

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

to popular tourist sites or regions with a flourishing tourism industry, and compared to such areas, the effect of stimulating tourism by the campaign is not relatively significant in the Nishimikawa region.

(3) The results indicate that the municipal coupon campaign was effective in revitalizing the local economy. However, business offices with higher annual sales had higher evaluation points for the campaign. This indicates that a higher amount of spending is possible than the purchase price of the coupon, and tended to be spent at stores providing relatively higher-priced goods and services. In addition, the offices located in municipalities that issue coupons with higher premium rates were more highly evaluated in the campaign. However, increasing the premium rate dose not necessarily result in more effective measures. The higher the premium rate, the more consumers tended to purchase expensive goods and services that they could not normally consume, which may have caused a bias in the effectiveness of the campaign. This indicates the importance of complementary measures to support small local restaurants, souvenir stores, and stores, for example, by offering rewards for using coupons at small offices.

6 CONCLUSION

This study examined the economic impact of the COVID-19 pandemic based on the results of a questionarre survey of tourism-related offices in the Nishimikawa Region of Aichi Prefecture. In addition, it statistically analyzed the policy effects of the measures such as the government subsidy program SPSB, GoTo Travel campaign for tourism stimulation, and municipal premium coupon campaigns, using ordinal logistic regression analysis. The results show that the impact of COVID-19 on business office sales is most severe for the accommodation offices, with a 62% decrease at the time of the survey compared to 2019 (much lower than the national average level). SPSB and Go To campaigns are relatively highly evaluated by accommodation and tourism servise offices, while shopping and restaurant coupon campaigns are relatively more effective in the restaurant and retail offices. In addition, the results show that the larger the offices annual sales, the more effective the campaign, indicating that customers typicaly use discount coupons to spend at business offices with higher prices than usual and it is required the complementary measures to support small local restaurants, souvenir stores, and stores.

This is an empirical study to clarify the actual economic impact and policy effects to provide evidence-based knowledge for economic revitalization measures. As a limitation of this study, policy effects were analyzed on the basis of evaluation points from the perspective of business offices, which may potentially include subjective factors of respondents. Therefore, while further investigation is required to determine how the subsidy program actually had an effect on business continuity and sales recovery, the findings of this study are considered to provide evidence on the actual status of policy implementation based on the supply-side perspective. Furthermore, continuous observation is required as the spread of COVID-19 and its impact on economic activity remains ongoing.

7 REFERENCES

HANAFIAH, Mohd, Hafiz, BALASINGAM, Ann, Selvaranee, NAIR, Vikneswaran, RAZIFF, Mohd: Implications of COVID-19 on Tourism Businesses in Malaysia: Evidence from a Preliminary Industry Survey. Asia-Pacific Journal of Innovation in Hospitality and Tourism (APJIHT), Vol. 10, Issue 1, pp. 81-94, 2021

HOSHI, Takeo, KAWAGUCHI, Daiji, UEDA, Kenichi: The Return of the Dead? The COVID-19 Business Support Programs in Japan, Crepe Discussion Paper No.100, Center for Research and Education in Program Evaluation (CREPE), The University of Tokyo, http://www.crepe.e.u-tokyo.ac.jp/results/2021/CREPEDP100.pdf, pp.1-63, 2021. Accessed 15, July 2022

Japan Tourism Agency: Go To Travel Program Related Information, https://www.mlit.go.jp/kankocho/page01_000637.html, 2020. Accessed 15, July 2022 (in Japanese)

Japan Tourism Agency: Statistical Survey on Overnight travel, https://www.mlit.go.jp/kankocho/siryou/toukei/shukuhakutoukei.html, 2022. Accessed 15, July 2022 (in Japanese)

KAWAGUCHI, Kohei, KODAMA, Naomi, TANAKA, Mari: Small business under the COVID-19 crisis: Expected short- and medium-run effects of anti-contagion and economic policies. Journal of The Japanese and International Economies, Vol. 61, pp. 1-13, 2021.

KHALID, Usman, OKAFOR, Luke, Emeka, BURZYNSKA, Katarzyna: Does the size of the tourism sector influence the economic policy response to the COVID-19 pandemic? Current Issues in Tourism, Vol. 24, Issue 19, pp. 2801-2820, 2021.

MATSUURA, Toshiyuki, SAITO, Hisamitsu: The COVID-19 pandemic and domestic travel subsidies. Annals of Tourism Research, Vol. 92, pp. 1-14, 2022.

Ministry of Economy, Trade and Industry (METL): Application and Payment of Subsidy Program for Sustaining Businesses, https://www.meti.go.jp/covid-19/jizokuka-info.html, 2020. Accessed 15, July 2022 (in Japanese)

Ministry of Health, Labour and Welfare (MHLW): About New Coronavirus Infections, https://www.mhlw.go.jp/stf/covid-19/kokunainohasseijoukyou.html, 2022. Accessed 15, July 2022 (in Japanese)

MIYAKAWA, Daisuke, OKIWA, Koki, UEDA, Kozo: Firm exit during the covid-19 pandemic: Evidence from Japan. Journal of the Japanese and International Economies, Vol. 59, pp. 1-17, 2021.

MIYAKI, Yukiko: Diversification of Anxiety Caused by Prolonged COVID-19 Pandemic, Based on the Second Declaration of State of Emergency, Life Design Report2021.1, Dai-ichi Life Institute of Economics, https://www.dlri.co.jp/pdf/ld/2020/wt2101f.pdf, pp.1-5, 2021. Accessed 15, July 2022.

TAMURA, M., SUZUKI, S., YAMAGUCHI, Y.: Effects of tourism promotion on COVID-19 spread: The case of the "Go To Travel" campaign in Japan. Journal of Transport & Health, Vol. 26, pp. 1-7, 2022.

YAGASAKI, Noriko: Impact of COVID-19 on the Japanese travel market and the travelmarket of overseas visitors to Japan, and subsequent recovery. IATSS Research, Vol. 45, pp.451-458, 2021.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

🏆 *reviewed paper*

Experimental Governance for Sustainable Cities and Climate Action – Case Study ANN (A New Normal) RADAR Hamburg

Jörg Knieling, Jens Bley, Kay Hartkop, Anna Wildhack

(Prof. Dr. Jörg Knieling, HafenCity University Hamburg, Henning-Voscherau-Pl. 1, D-20457 Hamburg, joerg.knieling@hcu-hamburg.de)
(Jens Bley, HafenCity University Hamburg, Henning-Voscherau-Pl. 1, D-20457 Hamburg, joerg.knieling@hcu-hamburg.de)
(Kay Hartkopf, HafenCity University Hamburg, Henning-Voscherau-Pl. 1, D-20457 Hamburg, joerg.knieling@hcu-hamburg.de)
(Anna Wildhack, HafenCity University Hamburg, Henning-Voscherau-Pl. 1, D-20457 Hamburg, joerg.knieling@hcu-hamburg.de)

1 ABSTRACT

In response to the challenges of climate change and other environmental and structural problems, different new forms of urban governance have been developed and tested throughout European cities. Urban Living Labs constitute one form of experimental governance, whereby urban stakeholders develop and test new technologies and ways of living to address the challenges of climate change and urban sustainability. Characteristics of Urban Living Labs in the sense of experimental governance are temporal limitation, spatial selectivity and problem-orientation.

Staging urban experimentation requires an evidence-based process to identify suitable urban target locations for urban testbeds. The research project ANN (A new Normal) RADAR addresses this challenge. Through a data-driven evidence base, it aims at identifying areas that have a particular demand and provide ample context for experimental interventions. The underlying research question is in how far experimentation strategies for sustainable urban development and climate mitigation can benefit from digitalisation by enriching the political decision-making process of identifying potential urban testbeds with analysing, processing and visualising available data. This paper describes the ANN RADAR approach and methodology, reflects experiences from pilot application and discusses issues relevant for further research.

Keywords: living lab, experimental governance, sustainable city, climate mitigation, digital tool

2 EXPERIMENTAL GOVERNANCE AND SUSTAINABLE CITIES

In recent years, European cities have tested new forms of urban governance to respond to the challenges of climate change and other environmental problems. They are embedded in efforts of sustainability transition to foster cities' capability to reach climate neutrality and the global Sustainable Development Goals by accelerating policy change and implementation in related fields of action like mobility, energy or housing.

Experimental sustainability transition focuses on the role of timely and spatially limited experiments to overcome implementation restrictions for game-changing innovations. Cities are complex, multi-actor and multi-level systems that have the tendency to hinder and slow-down the creation and implementation of innovations by multiple factors (non-innovative setting). The experiment as a method of innovation management overcomes these barriers by offering calculated risk, reversibility and low costs. The success and benefit of experiments offer the chance to let the invented social practices become the "new normal" which then can be rolled out throughout the city and even furthermore. (e.g. Evans et al. 2016; Kronsell and Mukhtar-Landgren 2018)

As methodological framework for experiments Urban Living Labs (ULL) have been applied in cities. They constitute one form of experimental governance, whereby urban stakeholders develop and test new technologies and ways of living to address the challenges of climate change and urban sustainability (Bulkeley and Castán Broto 2013, Kronsell and Mukhtar-Landgren 2018). Characteristics of ULL in the sense of experimental governance are temporal limitation, spatial selectivity and problem-orientation, e.g. test a new solution for urban sustainability transition for a limited time in a selected part of a city or quarter. By reflecting on and learning from experiments, urban living labs create the basis for mainstreaming new solutions on a broader scale. Experiments are therefore often seen as a way of establishing niches, i.e. fringe spaces for emerging technologies or alternatives to current methods of governance (Schot and Geels 2008).

Experimental governance and related transition management (or experimental sustainability transition) are part of the transition theory framework (Grin et al. 2010; Geels 2002; Geels and Schot 2007). In the multi-level-model of transition management (see Fig. 1) experiments insert innovation in the regime structure. Together with local pioneers they are seen as change agents and drivers of social innovation and transition towards sustainability. They operate in niches or as part of the existing regime (political-administration

system, business sector, academia). In the context of the experimentation approach the goal is to analyse these niche actors, their contributions to sustainable cities, and success factors and restrictions for their pioneering ambitions and activities, as well as to provide a transparent basis for the co-design of urban futures together with transition pioneers.

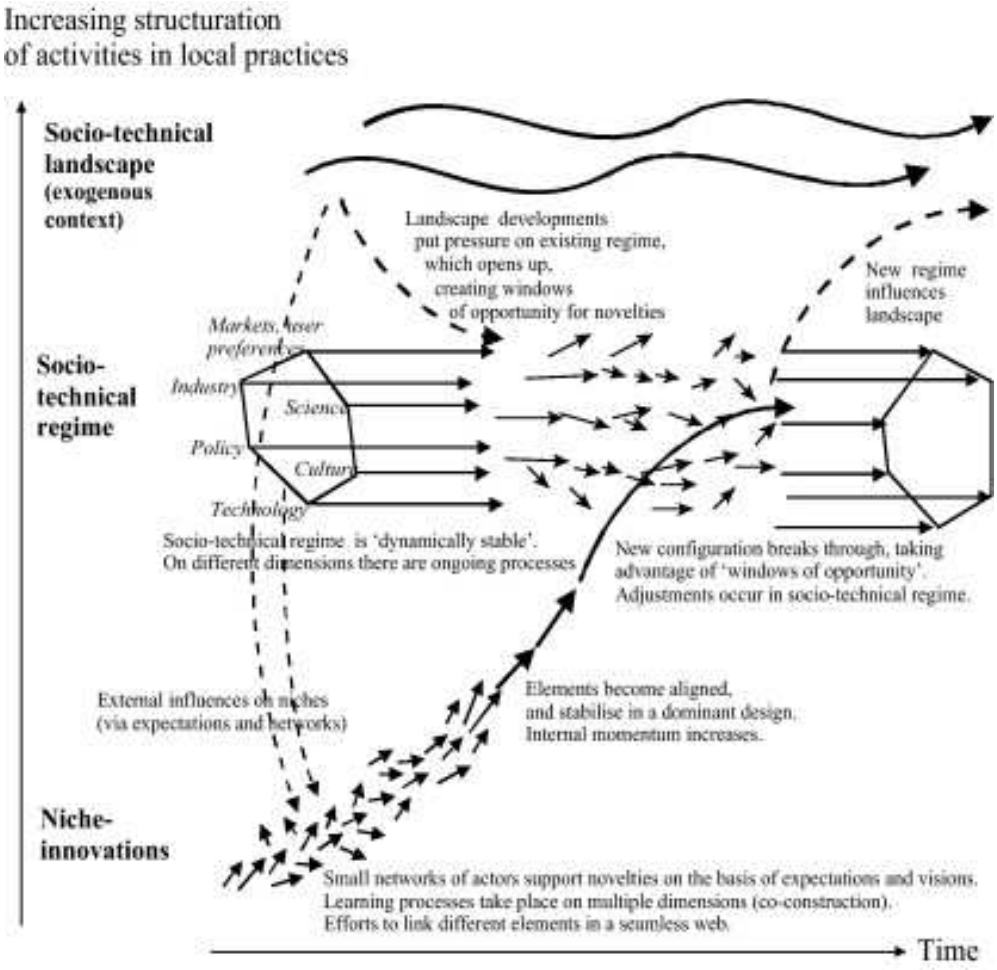


Fig. 1: Multi-level perspective on transitions, adapted from Geels (2002: 1263)

Establishing successful strategies within the urban sustainability transition requires transdisciplinary approaches that foresee the engagement of different stakeholders in the urban environment (Wittmayer and Loorbach 2016). Engaging the public is seen as an essential factor for achieving sustainable urban development (UN-Habitat 2020), because complex problems are best solved when the different groups who can affect it or are affected – the stakeholders in the sense of Freeman (Freeman 2010) – work together in partnership. Moreover, consulting stakeholders is an instrument to collect information for evidence-based policymaking. Their views, practical experience and data will help deliver higher quality and more credible policy initiatives and evaluations (European Commission 2021).

3 URBAN LIVING LABS AND EXPERIMENTATION

In various urban sustainability sectors, cities have been developing pilot projects and 'Living Labs' in the spirit of urban experimentation to explore innovative approaches and then, based on initial evaluation, upscale, replicate or make permanent interventions resulting in a new and more sustainable practice. Not only does this provide testbeds for experimenting with new technologies and social innovations, but it also facilitates the building of awareness and acceptance of such interventions amongst citizens and other stakeholders. The European Network of Living Labs (ENoLL), an umbrella organisation for living labs around the world, defines them as "user-centred open innovation ecosystems based on a systematic user co-creation approach, integrating research and innovation processes in real-life communities and settings. Living Labs are both practice-driven organisations that facilitate and foster open, collaborative innovation, as well as real-life environments or arenas where both open innovation and user innovation processes can be studied as subject to experiments and where new solutions are developed." "Living Labs are real-life test and

experimentation environments that foster co-creation and open innovation among the main actors of the Quadruple Helix Model, namely: Citizens, Government, Industry, Academia." (openlivinglabs.eu/aboutus)

Living labs emphasise innovation by engaging user and stakeholder perspectives in developing public services. They take a radically different approach to innovation than the top-down routine associated with traditional public administration (TPA) and New Public Management (NPM), adhering instead to a network approach based on integration of stakeholders, problem solving by collaboration and joint implementation efforts. (Fuglsang and Hansen 2022)

4 STAKEHOLDER PERSPECTIVES IN URBAN INNOVATION

Urban Living Labs have been becoming increasingly important in developing and testing responses to the social, environmental and economic challenges present in contemporary urbanism (Vallance et al. 2020). In Urban Living Labs, engaging citizens and other stakeholders are essential components and can be found in any characterisation of the key elements in the literature (ENoLL; Hossain et al. 2018; Leminen et al. 2015). In contrast to many other forms of innovation, living labs involve heterogenous stakeholders such as academics, developers, business representatives, citizens, and users, as well as various public and private organisations in living lab networks (Hossain et al. 2018). Living Labs thus assume the Quadruple Helix conception of innovation theory.

The Quadruple Helix framework is an iteration of the more established Triple Helix theory of innovation through the interaction between industry, government and university partners. The Quadruple Helix model adds a fourth sphere that more explicitly recognises the coproduction role of the public or other civil society actors (Carayannis and Campbell 2009). For Carayannis and Campbell, leading proponents of the Quadruple Helix model, this represents a more democratic approach to innovation. It also more easily allows for the outcomes of these interactions across institutional boundaries to be conceived as forms of social rather than just technological or business innovation (Vallance et al. 2020).

Because attention to stakeholders is so important, stakeholder analysis becomes important (Bryson 2004). There are different methods for identifying and analysing the relevant stakeholders (ENoLL, Rees et al. 2009, Bryson 2004). The simplest and most widely used method for identifying relevant stakeholders is the “Stakeholder Power/Interest-Matrix” (Ackermann and Eden 2011). This matrix can be found in many guidelines for stakeholder engagement, e.g. in EU-funded research projects (e.g. AREA 21, REPAiR, Cities4People, mySmartLife, Move21, see Tatum et al. 2020, Lange and Knieling 2020; Fischer et al. 2020). Once the relevant stakeholders have been identified and categorised, strategies for action can be developed on this basis. The different ways stakeholder engagement can occur can be described in five levels of participation: inform, consult, involve, collaborate and empower (Bammer 2019). Where the involvement of relevant stakeholders in living labs goes beyond information and consultation, active participation and co-creation are described as relevant elements of living lab experience (Hossain et al. 2018).

Although this is a vital first step in any participatory exercise, stakeholders are often identified and selected on an ad hoc basis without applying any structured methodology. The reasons for this are complex and range from a lack of resources and knowledge to concern about the results (Bryson 2004). In any way, non-systematic actor analysis and selection have the risk to marginalise relevant groups, bias results and jeopardise long-term viability and support for the process (Rees et al. 2009: 1933).

Which method is used for the stakeholder mapping, who the key stakeholders are and what roles they take on (Ståhlbröst et al. 2015; Westerlund and Leminen 2011; Arnkil et al. 2010) depends on each specific project setting. For ANN RADAR, however, the systematic identification of the relevant stakeholders needs to take into account the Quadruple Helix model and an engagement strategy based on this to implement an Urban Living Lab successfully.

Against the background of the described methodological framework the underlying research question is in how far experimentation strategies for sustainable urban development and climate mitigation can benefit from digitalisation by enriching the political decision-making process of identifying potential urban testbeds with analysing, processing and visualising available data. The following section provides insights into the ANN RADAR research.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

5 ANN (A NEW NORMAL) RADAR

Chronéer, Ståhlbröst and Habibipour (2019) have identified key components of Urban Living Laba such as governance models, financing and business models, a physical representation that takes place in a real-life setting in the city context, an innovation to experiment with partners and end users, including citizens, public and private actors, and academic institutions (i.e., a quadruple helix), and approaches for engaging different stakeholders and collecting data.

Staging urban experimentation requires an evidence-based process to identify suitable target locations. The project ANN (A new Normal) RADAR addresses this core challenge. Through a data-driven evidence base, it helps to identify areas that have a particular demand and provide ample context for experimental interventions and to support with the evaluation of their effectiveness. The underlying research question is in how far experimentation strategies for sustainable urban development and climate mitigation can benefit from digitalisation by enriching the political decision-making process of identifying potential urban testbeds with analysing, processing and visualising available data that relate to the aforementioned key elements of urban living labs.

ANN RADAR is designed as an instrument for experimental transition processes in cities and urban districts. It accumulates indicators from multiple dimensions including localised strategies, transformational goals and paths, urban data, as well as stakeholder and citizens engagement for the identification of best suited city areas for urban testbeds for sustainability and climate mitigation action. Guiding initial use case scenarios for ANN RADAR are European calls for urban experimentation, such as for New European Bauhaus pilot regions; German federal and state funding for thematic experimentation in the areas of solar energy, energy efficiency and mobility; as well as city and district initiatives for urban experimentation. Strategic climate action plans embedment, citizens and stakeholder engagement approaches, urban data evidence, (social) inclusiveness, replicability and scalability are at the core of the scenarios.

The project follows a collaborative and participatory methodology mixed with state-of-the-art digital formats for integrating data and rapid innovation technologies, initially in the City of Hamburg. The mayor's office, the district coordination office, climate coordinators and other stakeholders in Hamburg are part of the co-design and the experimental governance approach. The methodology draws on research and practices in experimental transition processes, living labs and urban testbeds, as well as stakeholder and citizens engagement.

The increased demand for sustainable urban development spawned a wealth of activities from developing climate plans to planning climate mitigation actions. All of these provide information, be it concepts and plans or structured data from experiments and operations. This information provides a valuable source of data which ANN RADAR leverages to assess climate actions, understand status and impact of urban testbeds as well as the maturity of experimentation and experimental governance in municipalities and selected geographic areas. Alongside, ANN RADAR taps into sources of data from the local authorities and the open data available for the respective locations.

As an example, ANN RADAR uses solar potential data (estimate of PV electricity harvesting from rooftops) from Hamburg's geo portal to assess the percentage of households' electricity consumption (average consumption for households of a specific size - according to the BDEW, federal association of energy and water management) which could be harvested from PV installations on the respective building for its inhabitants.

In one of the scenarios larger buildings (a minimum of 20 households) with 80-120% of photovoltaic (PV) coverage potential (meaning 80-120% of households' yearly electric energy consumption could be harvested from PV) in underprivileged areas (ideally buildings with subsidised housing) are considered as the most promising areas for a sustainability testbed taking into account the "social" leverage and the return on investment (ROI) for the respective measures. Social inclusiveness is one of the key attributes in the aforementioned scenarios.

To assess the public resources (e.g. financial, personnel) information about ongoing initiatives can be used to identify sources for funding as well as the availability of personnel to support new initiatives and provide knowledge about specific areas as well as stakeholder networks. In the case of Hamburg special development areas (RISE: Rahmenprogramm Integrierte Stadtteilentwicklung - framework for integrated urban development) are an example of such areas which provide an opportunity to leverage available public

resources. Since these specific areas have been established due to the need for inclusive social development in the selected areas it emphasises social development as an important factor for the selection of testbeds. In the ANN RADAR initial test scenario, a socially challenged inner city quarter with high solar potential for urban experimentation is identified within the context of the "New European Bauhaus" programme. The detailed examination of that specific quarter in return also advanced the prototypical approach by helping to identify urban data segments that are trans-local in their relevance, such as the social and cultural infrastructure and the aforementioned zoning in the framework of integrated urban planning.

Urban testbeds in the presented scenarios can be described as socio-economic entities which have to be assessed from various viewpoints, such as the structure of the built environment, e.g. like the number and average size of parcels, as well as social status of households in an area. These provide the "physical" parameters and factors to be considered, which are usually provided by the city. For the success of urban testbeds, several other, "softer" factors, like citizen and stakeholder engagement, strategies and plans for sustainable development as well as public resources play an important role. To provide a holistic view of these different perspectives a key instrument of ANN RADAR is a Balanced Scorecard (BSC) which tries to capture these different viewpoints in a structured and standardised way.

Based on the state of research, own experiences and the explorative approach of the project on urban testbeds, the ANN RADAR approach is based on four BSC dimensions: Strategy & Plan, Stakeholders, Public Resources, Urban Data.

"Strategy & Plans": This dimension assesses whether an area is being managed with a strategic vision and if this vision is linked to actionable plans. During recent years many municipalities started to budget for climate mitigation actions as well as climate adoption. This led to the development of action plans (e.g. SUMP, SECAP) which describe the actions and their impact on the area and the climate (usually reduction of GHG emissions). To assess the intent and political, as well as governmental support for climate actions these plans provide a valuable source of information starting from a general vision down to specific climate actions, including the intended impact and required investments. Hence this dimension provides insights into the ability and willingness to execute the defined climate strategies and the associated measures. An extensive analysis has been undertaken to deconstruct the local climate strategies and plans into scorecard criteria. These include the existence and measurability of transformational goals and paths regarding our prototypical urban experimentation thematic areas solar potential, energy efficiency and mobility, monitoring processes in place and experience with model quarters and urban testbeds.

"Stakeholders": This dimension offers insights into the structure and the management of the stakeholder ecosystem, the experience gathered and the ability to manage a diverse group of stakeholders to gain acceptance and commitment. It assesses past experiences with stakeholder management, setting up binding agreements with stakeholders and involving diverse stakeholder groups (quadruple helix) in long term development processes.

"Public Resources": This dimension explores which assets the public sector could offer as a contribution to an urban testbed. It could comprise real estate, personnel to support testbed development, as well as funding sources to make investments or subsidise testbed development. Public resources are a crucial part of the experimental governance readiness for municipalities and districts to engage and permit urban experimentation.

"Urban Data": This dimension assesses the ability to support data driven evaluation of the physical potential (e.g. number of inhabitants, size of buildings/areas) as well as constraints (regulations) and opportunities for the testbeds under consideration. For example, the total area available for PV installations on rooftops provides insights regarding the maximum PV energy harvesting potential from rooftops. Besides physical properties, social and ecological indicators provide valuable information to evaluate the feasibility to successfully implement a testbed.

The Balanced Scorecard integrates all four dimensions which build additional layers of ANN RADAR (see Fig. 2) and can be adjusted and combined as needed for a specific scenario, e.g. application for EU funds or investments from local budgets in urban testbeds to initiate climate actions.

Adding the physical potential to the picture a holistic view on the feasibility and suitability of an urban testbed for a given scenario can be provided. This integrated view could guide the selection process and supports an evidence-based process to establish urban testbeds.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

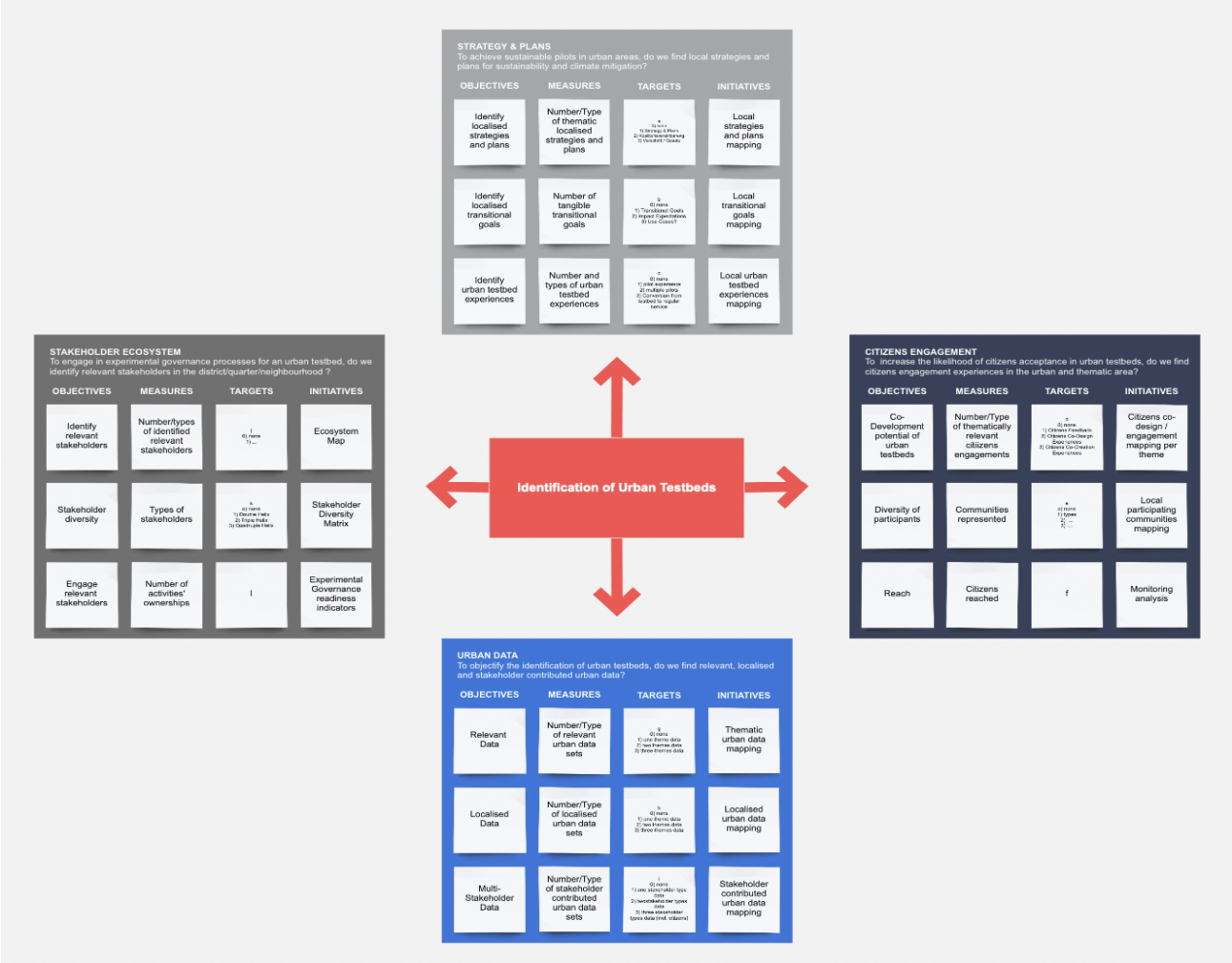


Fig. 2: Balanced Scorecards – excerpt and early-stage design

The Balanced Scorecard results will be one element of the ANN RADAR-Dashboard (see Fig. 3). Here the key dimensions for identifying suitable urban experimentation locations are shown with a geo-located reference. Data layers depicting contextual geo-located information including social monitoring results, social and cultural infrastructures, existing model quarters, urban testbeds and funding zones for integrated urban developments, can be viewed and discussed in connection with co-evaluated balanced scorecards for local climate mitigation and sustainability strategies and plans, stakeholder engagement, public resources for experimental governance readiness and urban data availability. Physical sustainability potentials can be assessed to the level of building blocks, both in summary and in detail.

Most of the data used by ANN RADAR is publicly available and can be accessed through the urban data platform or the geo-portal of the city of Hamburg. However, some of the data is not publicly available or easily accessible (e.g. number of households per building, roof top solar potential). The reasons being manifold like license/ownership restrictions, data privacy concerns or commercial interest in the data. To overcome these obstacles a strong data competency and data awareness needs to be established in the public administration and the government. This should cover legal as well as technological and data analytics capabilities to provide as much raw data as possible as open source whilst additionally offering data insights through accessible tools for all interested parties, be it citizens, businesses, NGOs, academia or government organisations. This will require political and legislative support to ensure reliable and secure access to the data sustainably. Besides availability and accessibility of the data, data literacy will become ever more important to facilitate data and evidence driven societal consensus on key questions around sustainable urban development. Consequentially, a two pronged approach, providing data and insights as well as enabling data retrieval and interpretation, is needed to capture the full value of open and free access to urban data.

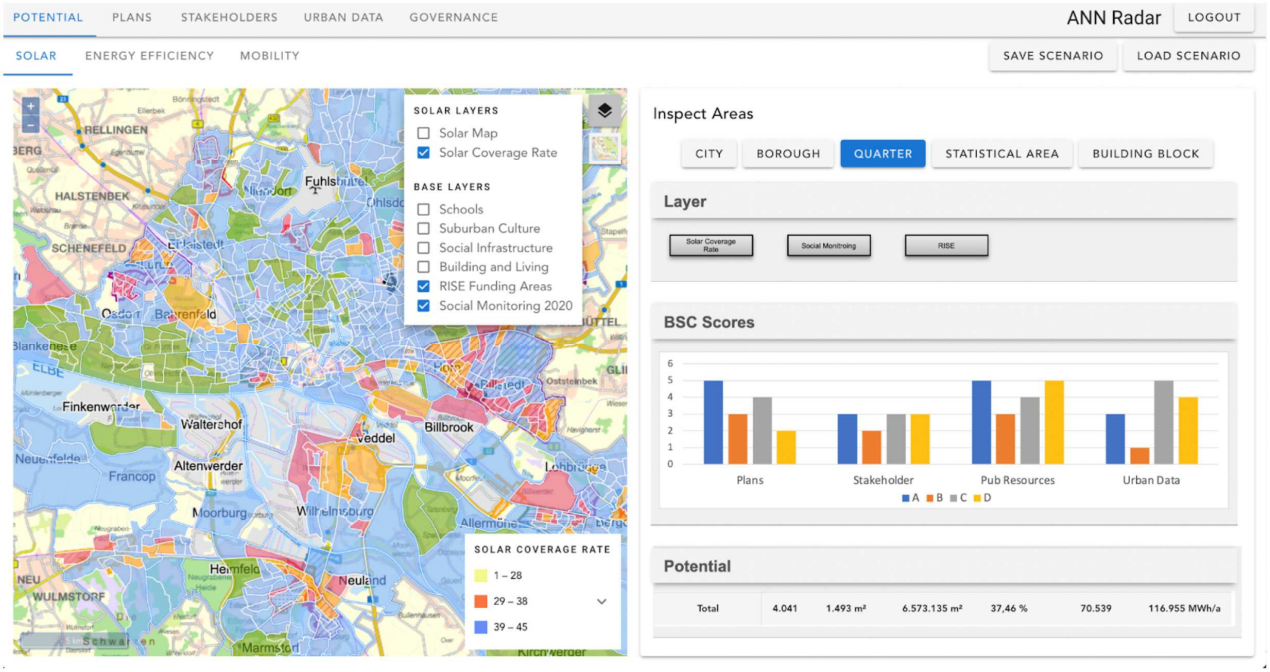


Fig. 3: ANN RADAR Prototype Dashboard for the co-evaluation process of identifying suitable locations for urban experimentation

6 REFLECTIONS

The approach and methodology of ANN RADAR aims at supporting the decision-making process for urban experimentation for sustainability and climate action in the context of location-based experimental governance and co-creation with citizens and stakeholders. From our point of view just inclusion in sustainability action can be achieved by informed, broad and inclusive participation of citizens and diverse stakeholders. An example is manifested in the Malmö Commitment (2022), which "positions local and regional governments at the centre of the global response to today's challenges, by encouraging sustainable approaches, innovation, adaptability, participation, and inclusiveness in policy-making to tackle the current climate emergency and by embedding social equity at the core of their local sustainable development". Digitalisation enhances data-driven, evidence-based and transparent participation which leads to a more just and equitable participation in decision-making processes. Such urban data evidence-based and transparent decision-making is at the intersection of digitalisation and sustainability, and as such this 'third way' of a socially embedded digital agenda, and is understood as a contribution to a European perspective of sustainable digitalization.

Putting ANN RADAR in the wider context of digitalization it can be seen as an example for leveraging (open) urban data for sustainable urban development. Since raw data usually cannot be easily understood it is necessary to process, aggregate and present the data in an accessible and digestible way. The widespread approach of many municipalities to provide geo-data portals is a first step towards this goal. However, leveraging Artificial Intelligence and Big Data exploration methods offers a further opportunity to capture the full value of urban data by turning raw data into insights and finally stories which can transform into actions. This approach would allow municipalities to leverage the rich urban data available for transparent, evidence based sustainable urban development.

In its research ANN RADAR has developed and applied a methodology to aggregate, annotate, visualise and evaluate urban data in regard to key dimensions for identifying suitable urban experimentation locations. In this phase, the prototype has been introduced in an iterative co-design process to stakeholders engaged in pre-selecting urban testbeds in the initial ANN RADAR scenarios of European, national and state funding calls. Stakeholders include the mayor's office of Hamburg, the district coordination office, climate actions management of selected boroughs and climate action and sustainability consultancies that are deeply engaged in local climate action planning, as well as citizens and stakeholder engagement processes.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Besides technological challenges of the ANN RADAR approach, experimental governance is confronted with restrictions resulting from personnel shortages in local administration. Experiments need additional administrative capacity to provide a suitable environment. In competition with routine tasks that have to be fulfilled anyway, experiments have difficulties to gain the necessary priority in the internal agenda setting. Thus, there is the fundamental finding that experiments need additional funding to compensate additional costs and personnel resources. Furthermore, the extra-benefit of experiments for local sustainability transition needs to be communicated to motivate politicans and administration to take the effort and risk.

In next steps of the ANN RADAR research on experimental governance, it is planned to extend the scope of the thematic sustainability areas beyond the initial three areas to gain further knowledge in how far the methodology is transferable on different policy areas and in how far such a multi-thematic approach contributes to experimentation platforms as conceptualised by Rehm et al. (2021). Furthermore, the analysis and deconstruction of the local climate plans as one significant input for the balanced scorecard toolkit will be supported by artificial intelligence. Here the aim is to explore how far artificial intelligence can support the analysis of local climate strategies and plans with their transformational goals and paths in the context of changing local, national and international urban agenda frameworks on sustainability and transformation. Such an approach is foreseen to enhance the usability of ANN RADAR in various urban and regional functional areas for stakeholders without the means or expertise to aggregate and input the core information for the balanced scorecards as one of the key elements of the ANN RADAR process.

The ANN RADAR research will be reflected with the help of iterative evaluation in the varying contexts of different functional urban areas' sizes and complexities and against the ongoing discussion of the key elements of urban experimentation, including conceptual considerations on evaluating smart city approaches (e.g. Rodrigues et al. 2022), and research regarding the development from a quadruple helix to a quintuple helix perspective. Here, an important question will be in how far the expert driven process of data-collection and processing for experimental governance can be connected with formats of citizen participation or if this approach holds the tendency of excluding citizens or at least parts of the citizenship.

Note:

ANN RADAR is a third-party funded research project (ICLEI Action Fund) and as such it is part of a network of projects throughout Europe that use a combination of private and open-source data to drive environmental action in their respective cities. The project started in 2020, it is focused on transition processes in three selected sectors, renewable energies, energy efficiency and mobility.

7 REFERENCES

Ackerman, F.; Eden, C.: Strategic Management of Stakeholders: Theory and Practice, Long Range Planning, Vol. 44, Issue 3, pp. 179-196, 2011, DOI: 10.1016/j.lrp.2010.08.001

Arnkil, R.; Järvensivu, A.; Koski, P.; Piirainen, T.: Exploring Quadruple Helix Outlining user-oriented innovation models, Final Report on Quadruple Helix Research for the CLIQ project, under the Interreg IVC Programme, Työraportteja 85/2010 Working Papers, Tampere, 2010.

Bammer, G.: Key issues in co-creation with stakeholders when research problems are complex, Evidence & Policy, Vol. 15, Issue 3, pp. 423–435, 2019, DOI: 10.1332/174426419X15532579188099

Bryson, J. M.: What to do when Stakeholders matter. A Guide to Stakeholder Identification and Analysis Techniques. Public Management Review, Vol. 6, Issue 1, pp. 21–53, 2004.

Bulkeley, H.; Broto, V. C.: Government by experiment? Global cities and the governing of climate change. In: Transactions of the Institute of British Geographers, Vol. 38, pp. 361-375. 2013.

Carayannis, E.; Campbell, D.: 'Mode 3' and 'Quadruple Helix': Toward a 21st century fractal innovation ecosystem, International Journal of Technology Management, Vol. 46, Issue 3/4, pp. 201-234, 2009.

Evans, J., Karvonen, A.; Raven, R.: The Experimental City. London and New York: Routledge by Taylor & Francis, 2016.

European Commission: "Better Regulation" toolbox. 2021, https://ec.europa.eu/info/sites/default/files/br_toolbox-nov_2021_en_0.pdf (accessed 10/08/2022)

Fischer, J.; Alimi, D.; Knieling, J.; Camara, C. 2020. Stakeholder Collaboration in Energy Transition: Experiences from Urban Testbeds in the Baltic Sea Region. Sustainability, Vol. 12, Issue 22, p. 9645, 2020.

Freeman, R. E.: Strategic Management: A Stakeholder Approach, New York: Cambridge University Press, 2010.

Fuglsang, L.; Hansen, A. V.: FramingImprovements of Public Innovation in a Living Lab Context: Processual learning, restrained space and democratic engagement. Research Policy, Vol. 51, Issue 1, pp. 2-12, 2022. DOI: https://doi.org/10.1016/j.respol.2021.104390

Geels, F.: Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study, In: Research Policy, Vol. 31, pp. 1257-1274, 2002.,

Geels, F. W.; Schot, J.: Typology of sociotechnical transition pathways. Research Policy, Vol. 36, pp. 399-417, 2007.

Lange, K.; Knieling, J.: EU Smart City Lighthouse Projects between Top-Down Strategies and Local Legitimation: The Case of Hamburg, Urban Planning, Vol. 5, Issue 1, pp. 107–115, 2020, DOI: 10.17645/up.v5i1.2531

Grin, J.; Rotmans, J.; Schot, J.: Transitions to Sustainable Development, New Directions in the Study of Long-Term Transformative Change, New York: Routledge, 2010.

Hossain, M.; Leminen, S.; Westerlund, M.: A systematic review of living lab literature. Journal of Cleaner Production, pp. 976-988. 2018.

Knieling, J.; Lange, K.: Smart Guidance: Governing the Urban Energy Transition. In: Droege, P. (ed.), Urban Energy Transition. Renewable Strategies for Cities and Regions. pp. 513-524. Amsterdam/Oxford: Elsevier, 2018.

Kronsell, A.; Mukhtar-Landgren, D.: Experimental governance: the role of municipalities in urban living labs. European Planning Studies, Vol. 26, Issue 5, pp. 988-1007, 2018.

Leminen, S.; Habib, C.; Westerlund, M.: Living Lab as Innovation Platforms: The Key Constructs. Research Day. Conference proceedings 2015. https://issuu.com/enoll/docs/276089123-enoll-research-day-conference-proceeding (accessed 10/08/2022)-

Malmö Commitment: https://worldcongress.iclei.org/malmo-commitment/, May 2022

Rees, M. S.; Graves, A.; Dandy, N.; Posthumus, H.; Hubacek, K.; Morris, J.; Stringer, L. C.: Who's in and why? A typology of stakeholder analysis methods for natural resource management. Journal of Environmental Management, Vol. 90, pp. 1933–1949, 2009.

Rehm, S.-V.; McLoughlin, S.; Maccani, G.: Experimentation Platforms as Bridges to Urban Sustainability. Smart Cities, Vol. 4, pp. 569–587. 2021. https://doi.org/10.3390/smartcities4020030 (accessed 10/08/2022)

Rodrigues, N.; Vale, M.; Costa, P.: Urban experimentation and smart cities: a Foucauldian and autonomist approach. Territoriy, Politics, Governance, Vol. 10, Issue 4, pp. 549-567, 2022. https://doi.org/10.1080/21622671 .2020.1777896

Schot, J.; Geels, F. W.: Strategic niche management and sustainable innovation journeys: theory, findings, research agenda, and policy. In: Technology Analysis & Strategic Management, Vol. 20, Issue 5, pp. 537-554, 2008.

Ståhlbröst, A.; Bergvall-Kåreborn, B.; Ihlström Eriksson, C.: Stakeholders in Smart City Living Lab Process. Americas Conference on Information Systems (AMICIS). Puerto Rico, USA. August 13-15, 2015.

Tatum, K.; Cekic, T.; Landwehr, A.; Noennig, J.; Knieling, J.; Schroeter, B.: Co-creation of Local Mobility Solutions: Lessons from the Mobility Lab in Hamburg-Altona. In: Müller, B.; Meyer, G. (eds.), Towards User-Centric Transport in Europe, No. 2, pp. 16-27. Berlin, 2020.

UN-Habitat (2020): Building Participatory Accountability Systems for City Policies: Handbook, https://unhabitat.org/sites/default/files/2021/06/210618_ _building_participatory_accountability_systems_for_city_policies.pdf (accessed 10/08/2022).

Vallance, P.; Tewdwr-Jones, M.; Kempton, L.: Building collaborative platforms for urban innovation: Newcastle City Futures as a quadruple helix intermediary. European Urban and Regional Studies, Vol. 27, Issue. 4, pp. 325-341, 2020.

Wittmayer, J. M.; Loorbach, D.; Governing Transitions in Cities: Fostering Alternative Ideas, Practices, and Social Relations Through Transition Management. In: Loorbach, D.; Wittmayer, J.M.; Shiroyama, H.; Fujino, J.; Mizuguchi, S. (eds.): Governance of Urban Sustainability Transitions, pp. 13–32. Tokyo: Springer, 2016.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

🏆 *reviewed paper*

Exploring Neighbourliness and Social Cohesion in Two Residential Gated Developments in Johannesburg, South Africa

Vuyiswa Letsoko, Kammila Naidoo, Trynos Gumbo

(Vuyiswa Letsoko, University of Johannesburg, Department of Urban and Regional Planning, Cnr Siemert & Beit Streets, Doorfontein, 0184, Johannesburg, South Africa, 2028, vuyisway@uj.ac.za)
(Prof. Kammila Naidoo, University of Johannesburg, Department of Sociology, 5 Kingsway Ave, Rossmore, Johannesburg, 2092 kammilan@uj.ac.za)
(Prof. Trynos Gumbo, University of Johannesburg, Department of Urban and Regional Planning, Cnr Siemert & Beit Streets, Doorfontein, 0184, Johannesburg, South Africa, 2028, tgumbo@uj.ac.za)

1 ABSTRACT

The growth of privatised residential territories through the concept of 'gating' has become a global phenomenon and a distinct feature of the urban landscape of cities. There has been much debate around their existence. Justifications for these developments have been largely associated to the fear of crime, the expressed need for a defensible space, ineffective security provisions by government institutions, a search for an enhanced residential lifestyle and inadequate municipal service provision and governance. In the South African context, it has been argued that they have generated a "neo-apartheid" and serve as a façade, concealing the elitism and privilege that they offer residents. Similarly, questions have been raised around the benefits of living in a gated community, including whether or not they nurture or limit social cohesion among their residents. Current literature and studies on gated communities tends to focus on their physical form and function with little emphasis on the internal dynamics that take place within such developments. Given the growth and popularity of such developments in South African cities, the paper employs a qualitative approach using in-depth interviews with residents of two gated communities in Greenstone Hill to examine how living in a gated community influences daily social interactions among neighbours. The findings of the study identified four key themes that influenced social cohesion in the gated developments. Furthermore, contrary to expectations, interview data revealed that gated communities are socially diverse living spaces allowing for interactions of individuals from various cultural, religious, racial and class backgrounds which is unique given South Africa's legacy of apartheid that has resulted in the persistence of residential segregation and mono-racial communities. The implications of the study are that these developments provide platforms for different races, classes, and cultures to unlearn past prejudices which has key implications in the process of re-building and uniting the country and its communities. The paper makes recommendation for gated communities to be viewed from a different perspective that focuses on their potential to contribute to social change and cohesion in the era of democracy.

Keywords: neighbourhood cohesion, neighbourliness, social cohesion, residential gated communities, South Africa

2 INTRODUCTION AND CONTEXTUALISATION

The growth of privatised residential territories through the concept of 'gating' has become a global phenomenon and a distinct feature of the urban landscape of cities. Gated developments, more commonly known as gated communities, originate from the United States; however, these developments, in various forms, have since proliferated in cities of many other developed and developing countries. Gated communities are privatised physical locations whose access is restricted by walls, fences, gates or booms that detach their communities from their surrounds (Liu and Song, 2017). Within the geographical scholarship and urban studies literature, increased attention to gated communities has spawned the development of a corpus of 'critical' literature documenting the global spread of the phenomenon. Global pressures of globalisation and the evolution of capitalist and neoliberal forces of "privatism" have been largely associated with their growth and popularity in the twenty-first century (Pow, 2014). Other justifications for these developments cited in literature include the fear of crime, the expressed need for a defensible space, ineffective security provisions by government institutions, and search for an enhanced residential lifestyle and inadequate municipal service provision and governance outside the gates (Landman, 2003; Lemanski et al., 2008; Roitman, 2011, Tanulku, 2012).

In the context of South Africa, "gating" presents a unique challenge given the country's' legacy of apartheid. They are critiqued for generating a 'neo-apartheid' in the city where segregation takes place not only on the grounds of race but also on the economy of space and market ethos (Ramoroka and Tsheola, 2014). Here,

division based on status, exclusivity and social class takes centre stage, facades of privilege and elitism are dividing social groups. and the city is divided into "civilised zones and savage zones" (Santos, 2007). These developments have transformed the social, economic and political context of our South African cities by re-ordering and re-organising the micro-society of space (Landman, 2012) and have consequently re-defined the spaces in which communities interact. Gated communities have also been greatly critiqued in literature for becoming sources of segregation, social divergence and the breakdown of society. Additionally, it can be argued that these gated communities are a paradox as they thrive in a country rooted in the tenets of ubuntu and social cohesion in an effort to undo the injustices resulting from colonial and apartheid rule and nation-building at multi-levels of society. Furthermore, these developments have been greatly critiqued for constructing undemocratic spaces that tend to weaken social cohesion and community building. In a country such as South Africa, that formally encourages inclusion and equality, it is important to research spatial practices that appear to contradict such values and principles. Various scholars in literature (Pow, 2015) suggest that there is a tendency for urban researchers to focus on the visual form and topology of gating without paying close attention to their underlying functions and diverse social meanings and symbolism. Some scholars (Low, 2003; Salcedo and Torres, 2004) have however mentioned that gated communities have the potential to promote social integration and impact society positively by providing employment for surrounding communities and allow for social mixing that can result in opportunities for social interaction between different social groups, therefore diminishing the scale of segregation. As research develops in this field, there is much interest about the community behind the gates. In fact, the term 'gated community' incites enquiry about what type of "community" is being referred to in this expression and how they (gated developments) build their "community". There remains a lack of research on the internal socio-spatial configurations, complex realities and social life of their inhabitants. The paper aims to address this gap by exploring neighbourliness and social cohesion in two socially diverse residential gated communities in Greenstone Hill, Johannesburg South Africa. The intention is to understand how gated living influences residents' everyday social interactions and relations among their neighbours.

3 LITERATURE REVIEW

3.1 Neighbourliness and Social Cohesion

Neghibourliness and social interactions in the neighbourhoods are a part of everyday life for all citizens of contemporary urban societies. Various concepts have been employed to investigate social interactions within residential areas in different parts of the globe namely: social capital (Putnam, 1993,1995,2007), neighbouring (Flilpovic, 2008;Guest and Wierzbicki, 1999) and sense of commuity (Lupi and Musterd, 2006). This study employed the concept of social cohesion to unpack the neighbourly relations and interactions that occur in the everyday lives of residential gated community residents. The concept of social cohesion is very broad and has also been regarded as a "quasi-concept" (Bernard 1999; Jenson 2002; 2010) due to its ability to be retrofitted in various diciplines and factors such as community development, nation-builing, societal well-being and diversity to mention a few (Bidandi, Roman, Davids and Khaile, 2021). That is, it can take on different conceptual meanings as well as practices in relation to its contextual needs and demands. It has been a subject of global importance and debated by academic and policy makers since the late 19th centruay. From an international perspective, social cohesion emerged out of literature of social capital and was introduced as one aspect of social cpatial (see Putman 1993, 2001). Since then the concept has been widely used in the international policy environment and also embedded within forums such as the Organisation for Economic Cooperation and Development (OECD), the European Union (EU), the World Bank, the Club of Rome and the Canadian federal government since the 1990s (Barolsky,2016).

Due to the broad nature of the concept, there is no single defintion that applies to it. For instance, Putnam (2000) defined social cohesion as the "glue" that binds individuals together and permits the pursuit of collective goals. On the other hand, Forrest and Kearns (2000) affirm that it is the need for a shared sense of morality and common purpose and a social order that indicates the quality of social relations and interactions within communties or families or a sense of belonging to a place. Forrest and Kearns (2000) were also very influential in applying the concept to the neighbourhood scale and identified five key dimensions in defining social cohesion namely: common values, social order and social control, social solidarity, social networks, place attachement and identity. These are the dimensions that were adopted in this study. In the context of South Arica, social cohesion is particularly important to address the scourge of a socially divided society.

Lukhele (2018) explains that this is because social cohesion at neighbourhood level allows for the social fabric of communities to hold together despite specialised roles, economic inequality and differences in social status and class. Palmary (2015) points to the fact that social cohesion in South Africa is laregly treated as being synonymous with nation building and is primarly focused at the national scale instead of the local/community level which is mostly common in the way it is referred in international literature. She explains that in South Africa social coheison is "seen as precisely a response to, and remedy for, the effects of a racist and otherwise exclusionary past" (ibid, 2015:64). Additionally, the term was intially aligned to the arts, culture and heritage sectors from 2004 onwards. However its ideological roots are also located within the "African humanism" and "Ubuntu" framework (see for example Mbeki, 1996; Tutu, 2000; Mbembe,2011).

3.2 Residential Gated Communities: Definitions, Typology and Social Implications

Internationally, literature pertaining to gated communities has its origins in the USA and can be traced back to the master-planning of retirement housing developments during the 1970s (Bodnar and Molnar, 2011; Breetzke, Landman and Cohn,2014). It was not until the late 1990s that these developments also gained popularity in South African cities/ Since then these developments have taken centre stage in most new developments in these cities. not only in South Africa but globally and have become a key feature of the 21st century (Landman, 2010). The justifications for such developments, outlined in literature (Nasution and Zahrah,2015; Ramoroka and Tsheola, 2014; Landman, 2002; Breetzke et al,2014; Tibbalds, 2001; Lemanski, 2004; Blakely and Snyder, 1998) is the fear of crime, for providing an improved quality of life, as well as the need for privacy, exclusivity and convenience. Moreso, Lemanski (2004) highlight that these developments are also born out of not-in-my-backyard mentalities. Therefore, one can refer to these gated communities and developments as defence mechanisms and a way to relive fear of the outside "world", similar to the walls and motes during the medieval times to restrict trespassers from access (Micthell,1995; Landman,2010).

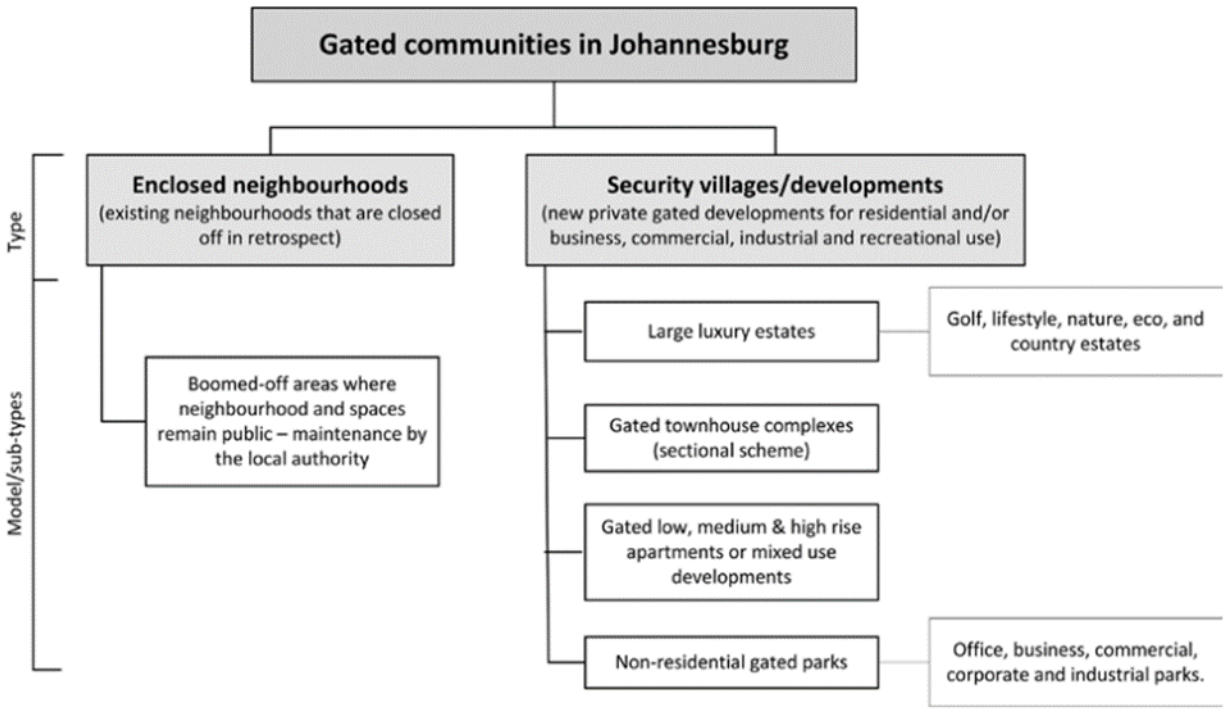


Fig 1: Gated communities in Johannesburg Typology (Source: Landman and Badenhorst, 2012)

Although, Obeng-Odoom, El Hadary and Jang (2014) argue that even though these walls exist some residents of such developments have expressed still feeling insecure as a result of crime which could take place within the walls. Another issue relating to this in accordance with Landman (2000) is response times for emergencies as police and other emergency departments need to access through these gates in order to reach a house within these gated developments. Gated developments have been defined as being "residential areas with restricted access such that normally public spaces have been privatised" (Blakely and Snyder, 1997:1). Similarly, Landman (2010) perceives gated communities as being physical locations that have walls

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

or fences which have detached them from their surrounds and also have gates/booms which restrict access into these locations and as a result the public spaces within these developments are privatised. From this definition the key characteristics of these type of developments can be identified as having physical barriers and walls with gates or security-controlled entrances which are privately managed. Furthermore, Iiesanmi (2012) outlined other classifications for gated communities as having technological barriers (surveillance cameras, alarms and swipe access); manned barriers (security guards); physical features (speed humps and signage); and natural surveillance ("eyes on the street"). Blakely and Snyder, (1997) have outlined that the three main categories of gated communities are security zones, elite communities and lifestyle communities. Although different countries have developed different terms and forms for these, they all find themselves within these categories. For example, in China they are state-led private neighbourhoods, in the USA they are common interest developments and in the Middle East they are referred to as traditional gating (Iiesanmi, 2012). In South Africa, gating takes place in both new and existing developments and according to Landman and Badenhorst (2012) the typology of gated developments in Johannesburg is categorised in the following way (see Fig 1):

Contemporary South African cities are bounded spaces. This is attributed to the fact that settlement and building fortification and segregation have a long history given the country's colonial and apartheid legacy dating back to the military forts and 'laagers' of Cape Town castle and the Group Area Act of 1950 (Landman,2010). The principles of apartheid were focused on the segregation of space based on race and thus "produced a set of practices concerned with boundaries between categories that it conceived" (ibid:53). Gated communities in South Africa have been critiqued for upholding this 'border mentality' in the post-apartheid state, as gated spaces reproduce such boundaries defining who belongs and who doesn't and utilising various strategies to demarcate separate territories. In addition, racism, exclusivity, power and more are concerns surrounding gated communities. Motivations for moving into gated developments in South Africa have revolved around crime and the desire to be free from the anxieties associated with city life (Hook and Vrdoljak, 2002; Ballard, 2004; Durington and Slover, 2006; Lemanski, 2006; Ballard and Jones, 2011). The governance of these private developments is managed privately through a residence association or body corporate which control administration and rule enforcement within these developments (Roitman, 2005). The social behaviour and the regulations regarding construction are guided by a code of conduct that has been formulated by the residence association (Roitman, 2005).

Gated communities have been vilified as vessels of segregation such that the residents of gated enclaves have been often characterised as "anti-social urban elites" (Pow,2015:477) who turn their back on society and lead gated minds and gated lives and in the South African context, have a racist fear of difference (Lemanski, 2004; Brunn, 2006). In fact, Mantey (2017) argues that the term 'gated community' should be replaced by gated estate, as gated developments with a high sense of community among its residence does not necessarily result from frequent neighbourly interaction but instead from the "design and aesthetic uniformity" (ibid;153). Furthermore, Walks (2010) outlines that these gated enclaves represent a process of 'civic secession' whereby residents wall themselves off from the problems of contemporary society, thus avoiding responsibility for the plight of others whether within or outside the gates. Contrary to the above, some scholars (Lang and Danielson 1997; Blandy and Lister 2005; Serife 2007) believe the sense of community and social ties are higher in gated enclaves than in non-gated developments due to the similarity of income and interests among residents. Thus, they are providing a premise for weakened social ties with people outside the gates within surrounding communities. The suggested effects that gated communities have on society in general from a social, spatial, political and economic perspective as well as the various dilemmas they perpetuate, makes them a significant area of research. Housing is at the core of social life, more specifically with reference to "how and where people are housed" (Stone and Hulse, 2007:1). Li et al, (2012) note that different types of neighbourhoods have different experiences in terms of neighbourliness, and it has been noted that very little is known about the link between different typologies of housing, housing design, urban form and social cohesion. Similarly, research on gated communities and their effect on social cohesion and neighbourliness in the experiences of the residents appears to be minimal.

In literature, gated communities are said to have various social advantages that have a positive effect on the social interactions and cohesion of their communities. These include the safe, clean and private space they offer their residents (Tanulku, 2011), the communal leisure amenities (Kenna, 2010) and the exclusivity they provide (Hook and Vrdoljak, 2002). In fact, Blandy and Lister (2005) in their study of gating in England

found that it is because of reasons related to those previously mentioned, that social interaction and neighbourliness in gated communities is higher than in comparison to a non-gated community. Furthermore, heightened security also provides a platform for residents to feel more at ease in their communities and often leads to increased interaction and sense of community, compared to residential areas with less security (Lemanski et al.,2008). The size of the gated community is also said to have an influence on the social functions as those that have large number of homes are more likely to have facilities such as club houses and swimming pools that can facilitate social interaction (Grant and Mittlesteadt, 2004). Additionally, larger gated communities such as Steyn City are incorporating increased mix of land uses and social infrastructure within gated communities in such a way that outcomes of such practices could be the greater withdrawal of gated community residents among communities outside the gates.

4 METHODOLOGY

The research forms part of the findings of a larger PhD study concerning social interactions within residential gated communities in Johannesburg in the post-apartheid era. By critically focusing on the lived experiences of residents of gated communities, this study adopts a phenomenological approach to understand resident's everyday experiences of neighbourliness and social cohesion within a gated community. At its most basic, phenomenology can be defined as an "approach to research that seeks to describe the essence of a phenomenon by exploring it from the perspective of those who have experienced it" (Neubauer, Witkop and Varpio, 2019:91). The research is designed as a qualitative study. This approach is best suited for the study as it allows the researcher to delve into the lived experiences of individuals, exploring certain feelings and emotions that are difficult to quantify (Creswell,2007). It employed in-depth semi structured interviews with eighteen residents residing in two residential gated communities in Greenstone Hill, Johannesburg and sampled using purposive and snowball sampling techniques. The locality of these two residential gated communities that were the focus of the study are depicted in the figure below (shaded in red and yellow).

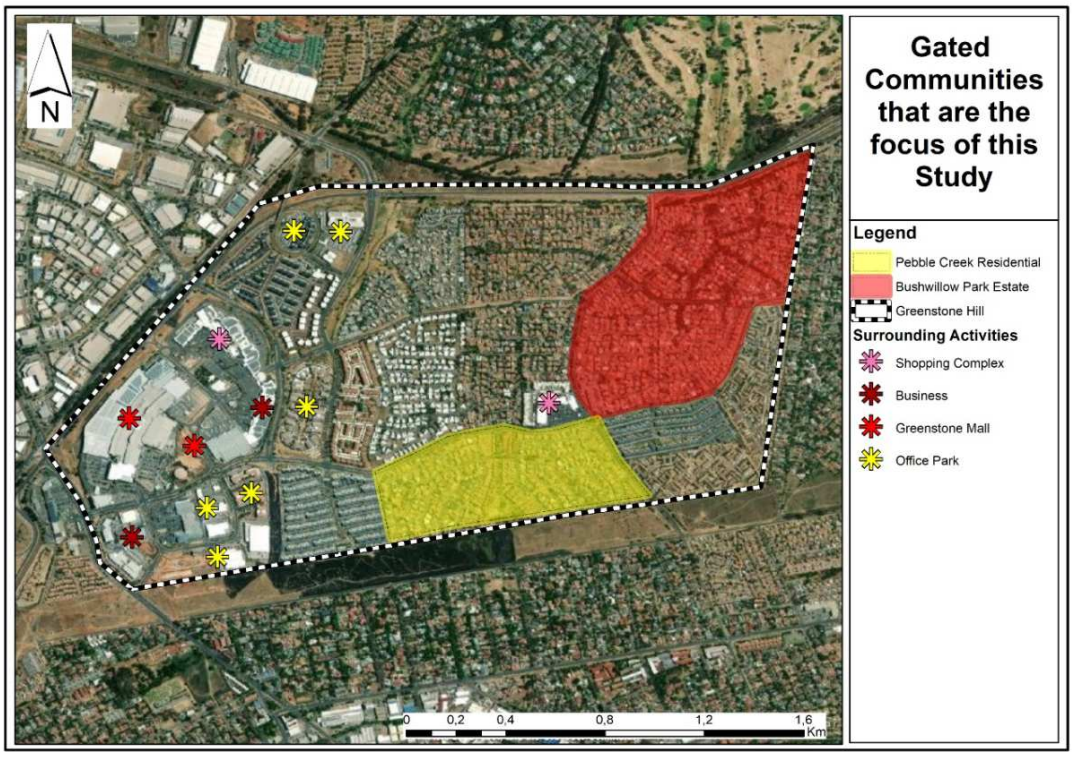


Fig. 2: Residential gated communities' locality and housing typologies

The types of gated communities that are in Greenstone Hill can be seen in the images below.

Greenstone Hill is a residential suburb located in the north-east of the City of Johannesburg within Region E. Although the history of this residential suburb is not well documented, it is new and was initially green belt land which was transformed into the spatial expressions of privately driven city building. The area is commonly referred to as Greenstone and is a diverse space made up of secured business parks, warehouse

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

complexes, shopping malls, townhouse complexes and gated residential communities with free-standing houses.




Name of gated development	Type of gated development	Housing typology in gated development
Bushwillow Park Estate	Freehold houses and sectional title units	Houses and townhouses
Pebble Creek Residential Estate	Freehold houses and sectional title units	Houses and townhouses

Fig. 3: Housing typology in Pebble Creek Estate and Bushwillow Park Estate, Johannesburg

5 RESULTS AND DISCUSSION

Whilst the common idea is that elites are self-sufficient and do not require "street-level interpersonal relations and neighbourhood networks to meet their basic needs" (Harvey, 1985:262), people, including the elite in society, do not live in complete isolation from one another and their social lives are not immune to external influences and social networks. As such, people's lives are linked and there is a form of interdependency between people and communities. An important consequence of social networks is that potential for people within them to act as a group to pursue shared goals by means of collective action. Neighbourly relations constitute part of our everyday life, and these informal social relations can either impact positively or negatively on social cohesion in a residential setting (Ruonavaara, 2021). In this sense, neighbours are members that residents interact with primarily because of the commonality of place of residence; in the context of the study this is the gated community. This section outlines results and presents the discussion based on the data collected to address the main purpose of this study.

5.1 Neighbourhood diversity and social interactions

Social interactions are a core part of what brings people together and are at the centre of community cohesion. In the context of a neighbourhood these social relations are commonly referred to as neighbourly relations that have been theorised as friendly distance comprising of mundane everyday social activities that neighbours engage in, such as borrowing tools, asking for help or visiting one another (Redshaw and Ingham, 2017). From observations and interviews with residents, social interactions within the gated communities range from superficial interactions to, in some instances, more deep social connections and friendship links. These superficial interactions were a result of what Van Eijk (2012) refers to as "chance

encounters" i.e., bumping into other neighbours in the common areas, driveways, etc. where brief forms of interaction occur. This is captured in the interview excerpt below from an interview with one of the residents

"I mean most interactions amongst neighbours here start with a general wave, like hi and bye and in most cases it ends there or sometimes you can become good friends like one of our neighbours but mostly the interaction happens or rather starts in the driveway when someone is jogging by. also in the parks…there you obviously greet others to show that you are a decent human being. Some people are just generally rude though, so even if you want to greet or whatever you can already see from their body language that they have no interest in even that little hi or bye of yours and just makes you not greet them at all…so it depends really."

The interview excerpt above provides an example of how initial interactions are usually brief among neighbours, the potential for these to develop into meaningful relationships and friendships is possible based on the willingness to engage. Interestingly, the above narrative also indicates that even these chance encounters can be negatively impacted by the experiences of the first interaction and indicates the link between social interaction and non-verbal behaviour. To this end, Arqoub and Alserhan (2019:308) statement can be appreciated that "our body speaks words, sentences, phrases, and punctuation" and this can either lead to positive or negative communication and interaction experiences. Additionally, this also indicates the relationship between chance encounters and the values of good neighbouring. Diversity in the gated community can take various forms namely: mixing of household types and tenures; occupations, income levels, race, ethnicities, birthplaces, languages and religious and cultural backgrounds (Wang and Kemeny, 2021; Talen, 2008). The consensus for a long time since the conception of gated communities in the US was that they were home to the white elite in society (Blakely and Snyder, 1997). However recent literature (Chipkin, 2012; Ballard, Jones and Ngwenya, 2021) on gated communities has indicated that trends of a growing black middle class has led to a diversity behind the gates and there is a greater racial integration within these spaces. This was particularly the case in the two gated communities. The residents' experiences with diversity were generally positive and gave hope for a democratic South Africa. This is evident in the interview excerpt below:

"People of my generation… my matric year was when Mandela was released. So, I grew up properly during apartheid, South Africa…even in my university years, the university I went to was largely a non-white University, a lot of black students, lots of Indian students, etc. But there were, you know, maybe a handful of white students. So, the first time I got to experience white people was in the workplace, and in the residential complex that I stayed in. The reason I mentioned that is because I think where you live, actually provides a platform for engaging with people of different cultures, especially in the context of South Africa. So, for example, for a black person who lives in a township the chance of him living next to someone of a different race is zero, right? But a black person, I mean, my neighbour who's an attorney… grew up in Soweto… I've gotten to learn a lot about him and what he's done and where he comes from and his history etc, because we live in a community of this nature. So, I think people generally…embrace it. Because it is what South Africa is all about. It's diverse. I think that it [the gated community] certainly does offer a positive platform for you to cross those divides and get to know who your neighbours are and what they're about and what their history is, where they come from, problems growing up."

5.2 Neighbourhood trust and community attachment

Previous studies have conceptualised two primary forms of social trust namely: generalised trust and particularised trust (Freitag and Traunmüller, 2009; Uslaner, 2002; Yamagishi and Yamagishi, 1994). The latter refers to trust that supersedes one's immediate familiarity and the former relates to trust that is Whilst most residents associated their community with high levels of trust, their explanations fell within these two categories, and this was related to the nature of the relations they had with their neighbours i.e. intimates (friends, partners, and family), strangers (whom we know, and with whom we share, very little), and acquaintances (people we know a bit about and with whom we share a little) (Ruonavaara; 2021). Particularised trust was expressed for neighbours who were considered friends or family and the nature of these intimate relationships allowed for the exchange of intimate knowledge and emotional vulnerability.

"Yes I would definitely say I trust my next door neighbours, we have become really good friends and they have been there for us when we went through some really tough personal stuff…we also occasionally leave

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

the key with them if we are away for long periods of time so they can feed our pets and just check that all is in order…their older daughter even babysits our kids from time to time."

Behaviours such as leaving the doors of the house unlocked during the day and night, leaving a car parked outside the gate unattended and unlocked with valuables in the car and leaving kids' bicycles in the driveway all indicated a generalised sense of trust in the community. This sense of trust was augmented by the sense of security that the gated communities provided for them. One of the research participants expressed that

"…I might not be the best friends with my neighbour…I would like to think that if anything were to happen that was suspicious on my property that they would at least give me a heads-up you know…I would do the same for them" (Interview with a research participant).

This shows that the trust in the community is also established by exercising reciprocal care. Furthermore, such expectations arose from those residents with whom they have acquainted themselves, however such expectations were not tendered towards neighbours they had very little contact with and considered to be strangers, but to people they know a bit about.

5.3 Neighbourhood attachment and identity

In the gated community, place attachment occurs both at the individual (residents) and group levels (neighbours). At the individual level, residents expressed having personal connections to the gated community and these connections are also the reason why they have decided to be part of the Homeowners Association (HOA). Additionally, one of the participants expressed that they once have considered moving to another gated community, however

"the kids are really, really attached to this community, I recall we once thought we would move and we have that informal talk with our kids and they were not pleased at all, but it makes sense because this is home to them, their first home in fact as they have been here since birth and have all their friends here"(Interview with research participant).

This was a common theme regarding attachment to the community, especially among the white residents in both gated communities. At a group level, people feel attached to a place where they have shared meanings through shared historical experiences, values, symbols, and culture. The shared meanings that were present in the conversations with the participants in the study were fourfold:

Firstly, the shared community commitment and devotion to safety and security, this relates to previous discussions on how residents defined their community as being a safe and secure community and the commitment thereof.

Secondly, the emphasis on family values and estate living facilitating family life. For instance, one of the other participants of the study shared the following

"I guess what also binds us is that a lot of the people in the estate are family orientated; there are a lot of families here…even those who are renting, you find, are mostly families and I think that is a value I share with my neighbours." (Interview with research participant).

Similarly, another participant of the study defined the culture of the community as one rooted in

"family values and people are just really wanting a space to enjoy family life".

Thirdly, the shared value of protecting property assets and investment by way of preserving and maintaining an aesthetically pleasing environment. Residents expressed that by virtue of people choosing estate living, it also indicates a shared sense of respect for preserving the urban environment within the gated communities as a research participant explained:

"so people who live here generally abide by the rules, not always but most times, right, and I think that sense of respect for the rules and the law is what connects us as people but also makes us want to live in this space…one submits to this order and control and that's a choice you make" (Interview with research participant).

This order and control also leads to an increased attachment to the gated community for residents as it reinforces safety.

5.4 Covid-19 and experiences about community and neighbourliness

The data was collected during the peak of Covid-19 and this specific temporal context allowed for a nuanced insight into social life within gated communities at the time of a global pandemic. One of the participants indicated the impact of Covid on social cohesion in the gated community. She mentioned the following:

"If there was ever a time to actually feel that sense of ubuntu, it is definitely now. I mean this pandemic has really shown us that there we are all human…whether black, white or blue and that in times like these we need to come together and fight this thing [referring to Covid] together…people in our community WhatsApp group are so supportive of one another, I mean one lady was even sending over hot meals to people who tested positive with Covid and couldn't cook for themselves, others delivered medication to one another and people are just generally more helpful…perhaps it is because we have a common battle to fight and it's not just here in Pebble Creek but also just all over South Africa."

The narrative above extracted from one of the interviews echoes the sentiments of the majority of the participants of the study who expressed the communal love and support that was shared, especially during the initially stages of the lockdown. The above narrative aligns to recent research on Covid-19 and social solidarity that indicate that people generally come together in times of crisis (Lalot, et al.,2021). Furthermore, the fear, trauma and necessity of common coordinated responses during the beginning of the pandemic led to increased perceptions of everyone "being in the same boat" regardless of previous divisions between social groups (Muldoon, 2020).

5.5 Socially exclusive practices and limitations of neighbour relations

There were some participants in the study who indicated that they generally did not interact much with their neighbours. For instance, one research participant indicated that they felt that large luxury estates were not an ideal "sociable environment for young people and best suited for families, and people are focused on being more permanent and long term here so you find a lot more older people living here" (Interview with research participant) based on the fact that there were very few young single people that are her age that she could relate to. She suggests that other gated developments in Greenstone Hill such as the Acacia complex (sectional title schemes) houses more young people to whom she could perhaps relate much better. She does however indicate that developments such as the Acacia complex were "unstable" given the high number of tenants in comparison to luxury estates, hence her decision to choose to live in the current gated community. This also indicates that safety is a big determinant in the decision-making processes of where some gated community residents reside as opposed to their social connections.

Non-involvement was explained through two factors, suburban lifestyle and common apathy. Suburban lifestyle, "bowling alone" (Putnam, 1995), was centred around the working and school days, running nuclear family in the evenings, spending leisure time either at home or outside your own neighbourhood. Most social networks were not spatially defined and not neighbourhood based. Most respondents said their social contacts and friendship links were outside the gated community. The biggest group that had very few social contacts in the gated communities were the black residents. Another one of the participants of the study for example explained that while her children have made friends in the gated community, she did not consider anyone in the community as her friend although she knew her neighbours, but she did not socialise with them (Interview with research participant). Residents´ professional lives were outside the community, and children went to school in other areas. Social contacts were born in these environments. Both gated communities also had limited leisure time activities, and there were no places to meet other people (in comparison to the new gated developments that provide lifestyle centres, gyms etc.). For the active age people, social communities were not place based. And for many socialising happened through social media and the internet.

One of the key limitations of social cohesion in the gated community were issues pertaining to race. Interviews revealed that the participants judged other groups mainly on preconceived impersonal experiences and their historical and cultural perceptions of the "other". In fact, many of the prejudices and stereotypes that emerged mirrored conversations in the broader South African society. For example, one of the residents noted the following:

"…there's a level of comradeship across the community, however…I think that is affected by more of the macro issues in the broader community of South Africa…we need a lot of questioning, and a lot of

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

comfortableness. I think, you know, that has ripple effect…so I would say there is trust, but I think it's hard to balance with a lot of social influence and mistrust that is going on in the broader society".

It became clear that race was a conditioning factor for deep connections and that the global and political climate can spill over to micro-communities. In the context of the study, stereotyping and prejudice mainly took place at a group level as opposed to an individual level and was mainly captured in the subtle comments that were embedded in the conversations with the participants. This further amplifies the need for a bottom-up approach when it comes to social cohesion in the country and that such processes are key in addressing the psychological traumas of the country's history to enable greater expressions of democracy and neighbouring at the micro-scale of society.

6 RECOMMENDATIONS AND IMPLICATIONS FOR POLICY

In South Africa, social cohesion is seen as a project of nation-building, whereas globally the concept is more localised. This means that the policy context largely focuses on social cohesion at a national scale (i.e the draft policy on Social Cohesion and Nation Building drafted by the SADAC) with very little attention given to the neighbourhood experiences of social cohesion. This approach over-emphaises the ability for national policy to trickle down into the community and households of South Africans which is a potentially dangerous assumption, given that the remnents of apartheid still remain in the society and efforts to unite communties and to allow for a greater acceptance of diversity still fall short. The neighbourhood is the micro-unit of society. If there are challenges with achieving social cohesion at that micro-scale, that leaves little hope for waves of change at a national level. In fact, the study also revealed that local governments and muncipal authorities know very little about the social environment that is provided by gated developments. This laissez-faire approach to the management of social space within the city undermines the neighbourhoods importance in fostering and nurturing social cohesion. While literature suggests that neighbourhood and territorial ties remain largely insignificant in the digital era, the Covid-19 pandemic brought into focus the importance and value of phycial social interactions in communities. It is reccomended that local government in the approval of these developments, require a drafted social cohesion strategy that will be implemented and follwed by the Homeowners Associatiions of gated developments to ensure that there is an investment into the social life within these spaces which is not only important from a social cohesion perspective, but also valuable for a communties well-being.

7 CONCLUSION

This study provided an insight into the community that exists within residential gated community and brough to light the expereirences of neighbouring, within this context through the subjective experiences of the residents. While the purpose of this research was not to provide a generalisation of experiences within all gated developments in the country, it highlighted the challenges and opportunties presented by neo-liberal urban settings for social cohesion and its contributions to the country's nation-building project. Furthermore, the experienced mundane realities of these residents in a diverse surrounding, negotiating everyday contacts with racial, cultural, economic groups other than their own, also contributes to the understanding of the post-apartheid community which is important, given the legacy of segregation the country has endured over the years. The willingness and openness of the gated community residents to get along with neighbours from other social groups reinforced the challenges of multiracialism or non-racialism in society in general. Thus, the gated community may be interpreted both as a micro-product and as a reflection of the broader atmosphere in contemporary South Africa. Racial identities and post-apartheid changes are influencing the re-negotiating of identities among individuals in different race groups. At the same time, the thoughts and attitudes of residents can illustrate the more common mentality in South Africa. The complexity between the apartheid legacy, individual and group identities and the post-apartheid experiences develop multifaceted conditions and mechanisms of being involved, negotiating social contacts and socialising in the neighbourhood context.

8 REFERENCES

Barolsky, V. (2016). Is social cohesion relevant to a city in the global South? A case study of Khayelitsha Township. South African Crime Quarterly No 55

Bernard, P.(1999). "Social Cohesion: A Dialectical Critique of a Quasi-Concept." http://www.omiss.ca/english/reference/pdf/pbernard.pdf

Bodnár,J. & Molnar, V.(2011). The struggle to belong: Dealing with diversity in 21st century urban settings. Are There Gated Communities in Post socialist Eastern Europe?, International RC21 conference Session 7: Gated Communities from a Global Perspective, Amsterdam, 7-9 July 2011. Viewed 20 May 2016, http://www.rc21.org/conferences/amsterdam2011/edocs/Session%207/7-1-Bodnar.pdf

Breetzke,G.D., Landman,K.& Cohn, E.G.(2014). Is it safer behind the gates? Crime and gated communities in South Africa, Journal of Housing and the Built Environment, June 2013, vol.29,p123-139.

Filipovic, M. (2008). Influences on the sense of neighborhood: Case of Sloviania. Urban Affairs Review 43(5): 718–732.

Forrest,R.& Kearns, A.(2001)."Social Cohesion, Social Capital and the Neighbourhood," Urban Studies, vol. 38, no. 12, pp. 2125-2143.

Ilesanmi,A.(2012). The roots and fruits of gated communities in Lagos, Nigeria: social sustainability or segregation?, Sustainable Futures: Architecture and Urbanism in the Global South, Kampala, Uganda, 27 – 30 June 2012., http://sfc2012.org/ilesanmi.pdf

Jenson, J.(2002). "Identifying the Links: Social Cohesion and Culture." Canadian Journal of Communication 27(2). [online] https://www.cjc-online.ca/index.php/journal/article/view/1289/1309Jenson,

Jenson,J.(2010). Defining and Measuring Social Cohesion. OECD ilibrary. https://www.oecd-ilibrary.org/content/publication/9781848590724-en.

Neubauer,B.E, Witkop, C.T., Varpio, L.(2019). How phenomenology can help us learn from the experiences of others. Perspect Med Educ.8(2):90-97. doi: 10.1007/s40037-019-0509-2.

Grant, J.&Mittlelsteadt, L.(2004). Types of Gated Communities. Environment and Planning B: Planning and Design, vol 31, pp913-930.

Guest,.A.M, &Wierzbicki,. S.K.(1999) Social ties at the neighbourhood level: Two decades of GSS evidence. Urban Affairs Review 35(1): 92–111.

Landman, K. (2000). Gated Communities and Urban Sustainability: Taking A Closer Look at The Future, 2nd Southern African Conference on Sustainable Development in the Built Environment: Strategies for a Sustainable Built Environment, Pretoria,23 – 25 August 2000. Viewed 17 May 2016, http://researchspace.csir.co.za/dspace/handle/10204/2823

Landman,K.(2010). Gated communities: utopian vision or necessary evil?,Essays Innovate, Viewed 26 May 2016,http://www.up.ac.za/media/shared/Legacy/sitefiles/file/44/1026/2163/8121/gatedcommunitiesutopianvisionornecessaryevil.pdf

Landman,K.(2012). Gated communities in South Africa: Tensions between the planning ideal and practice, Town and Regional Planning, Vol.61

Landman, K.& Badenhorst, W.(2012).The impact of gated communities on spatial transformation in the Greater Johannesburg area. University of Witwatersrand.

Lemanski, C.(2004).A new apartheid? The spatial implications of fear of crime in Cape Town, South Africa, Environment and Urbanization, October 2004,vol.16,no. 2,p 101-112.

Mbeki, T.(1996). "I am an African." https://www.mbeki.org/2016/06/01/i-am-an-african-speech-by-president-thabo-mbeki-8-may-1996/

Mbembe, A.(2011). "Democracy as a Community Life." In The Humanist Imperative in South Africa, edited by J. de Gruchy, 187–194. Stellenbosch: African Sun Media

Nasution,A.D.,& Zahrah, W.(2015). The Space is Not Ours, the Life of Public Open Space in Gated Community in Medan, Indonesia, Procedia - Social and Behavioral Sciences,Vol.202,p144-151.

Obeng-Odoom F, Eltayeb ElHadary YA, Jang HS.(2014). Life within the Wall and Implications for Those Outside It: Gated Communities in Malaysia and Ghana. Journal of Asian and African Studies. Vol;49(5):544-558. doi:10.1177/002190

Palmary,I.(2015). "Reflections on social cohesion in contemporary South Africa." Psychology in Society 49, 62-69.9613495649

Pow, C.P.(2015). Urban dystopia and epistemologies of hope. Progress in Human Geography. 2015;39(4):464-485. doi:10.1177/0309132514544805

Putnam, R.D. (1993) The prosperous community: Social capital and public life, in Blaire, K, Almjeld, J & Murphey, R (eds) Cross currents: Cultures, communities, technologies. Boston: Wadsworth (pp 249-257).

Putnam, R. (2000). Bowling alone: The collapse and revival of American community. Simon & Schuster.

Putnam, R. (2001) Social capital: Measurement and consequences. Canadian Journal of Policy Research, 2(1), 41-51.

Ramoroka,T. &Tsheola,J.(2014). Gated-communities and the privatization of public spaces in urban South Africa: Democratic social integration or exclusion?, Journal of Geography and Regional Planning,June 2013,vol.7,no.4,p 58 -68.

Roitman, S. & Phelps, N.(2011). Do Gates Negate the City? Gated Communities' Contribution to the Urbanisation of Suburbia in Pilar, Argentina, Urban Studies, December 2011, vol.48,no.16,p3487-3509.

Ruonavaara, H., & Kouvo, A. (2009). Neighbour relations in contemporary society: A survey of ideas and a blueprint for a framework for investigation. Paper presented at the ISA Housing Assets, Housing People conference, Scotland.

Tibbalds, F. (2001). Making people-friendly towns: improving the public environment in towns and cities, 2nd edition. Spon Press: London.

Tutu, D. (2000). No Future without Forgiveness. Johannesburg: Penguin/Random House

🏆 *reviewed paper*

Exploring the Challenges and Opportunities of Farm School Infrastructure in Kwa-Zulu Natal, South Africa

Nischolan Pillay

(Lecturer Nischolan Pillay, Durban University of Technology, nischolanp@dut.ac.za)

1 ABSTRACT

South Africa is a country that has a rich history of segregation of races driven by a minority government. Through the ill system of apartheid, several aspects of human life became intolerable, one of which was the education system. The introduction of the Bantu Education Act of 1953 indoctrinated African learners by educating them to perform menial tasks and manual labour, becoming subservient to the white minority. This "knee on throat" system further oppressed Africans, making it difficult to progress and preserving the idea of education being a privilege and not a right. The act played out at various "black" schools in South Africa, especially farm schools, which created an economic benefit for the farmers. The farm school became a factory to create a new labour force, whose parents were smoke screened to believe paid education would benefit their children. In 1994, a new dawn for all the people of South Africa promised hope and freedom. The government promulgated laws that would benefit citizens' human rights and allow those who needed them the most. The redress of education policies aimed at giving all South Africans a fair opportunity for education; however, this is seldom the case in most of the country's impoverished rural and farm schools. The government, through legal frameworks, aims to convert schools on commercial farms to normal state-owned and managed institutions, removing the dependence on the farm owners. However, this process has been arduous, and the farmers' kick has been great to the extent that children and teachers are restricted from entering the premises. Regular intervention by police and government officials assists; however, this is not long-term management of deep-seated problems. Although the government has taken many steps in the right direction, at the very core, farm schools still suffer from infrastructural issues that are so profoundly entrenched in the buildings that it is difficult to dismantle. Perhaps, like most of South Africa, the apartheid regime is built in brick and mortar. These farm schools, in most instances, do not comply with the basic regulations of the South African Schools Act of 1996. However, these schools continue to operate and educate students across the country. Using a phenomenological paradigm and a qualitative approach, this research uses semi-structured interviews conducted at two farm schools in Kwa-Zulu Natal, South Africa, to gather rich data from participants. This study is limited by cost and time. The researcher used a purposive sampling technique to identify four participants who were probed on different aspects of the farm school infrastructure and experiences working and using the facilities. This research aims to understand the challenges and opportunities that farm schools offer. Findings from the data reveal that although farm schools have several infrastructural challenges, the staff and community adapt the use of these buildings to suit the needs of the activities, albeit with challenges. The researcher proposes adaptive reuse of the infrastructure to suit a school's programme and provide space for a community.

Keywords: South Africa , Adaptive reuse, Infrastructure, Rural, Farm Schools

2 INTRODUCTION

South Africa is well known for its past policies of segregation. This segregation created various societal and infrastructural ills that persist even to this day, with no resolution date. One such problem is the farm schools that the apartheid regime has left behind. These schools played a vital role in indoctrinating black people and creating a labour force for the farmers. These schools were initially envisioned to keep the children of farm workers out of trouble and soon became a factory for new workers. This reality persists even today, merely because the school remains in the vicinity of the farm, making the future vision for the learners cloudy, further binding them to the system of farm labourers like their parents. These problems are further compounded by ownership of the infrastructure years after the apartheid regime was dismantled, making it difficult for communities to contribute to the ongoings of the school actively—something which is an everyday occurrence outside of these spaces.

Schools play a critical role for scholars, the community, and society. Therefore it is essential to recognise the power of a school as it shapes the future societies and communities. Schools, in general, have played a role far beyond their primary purposes, to an extent where they have become the central civic spaces in neighbourhoods. Schools support a community's social and economic well-being, which directly impacts the

members of such spaces. Communities and schools are two entities that must work together to drive their societies forward.

This research aims to explore the challenges and opportunities of farm schools in South Africa. The research is essential as it touches on the actual problems affecting communities and their schools, such as alcohol and substance abuse, mindset, lack of recreational facilities, lack of income and other societal and infrastructural issues. The study examines farm schools to conclude the problems these communities face.

3 RESEARCH METHODOLOGY

3.1 Context of the Study

This study utilised a qualitative case study design at two farm schools in Kwa-Zulu Natal Province, South Africa. Both schools are within 30km of a major town. Kwa-Zulu Natal is known for its high number of rural and farm schools and has the highest concentration of such schools, 6036 in total (Galal, 2021). Therefore, the study area holds value in the South African context. The schools chosen for this study are located in two districts previously under the farmer's control; however, during the transition into democracy, these have since moved to the control of the Department of Education. Although, one school is still under the ownership of the farmer. These schools are significant as they previously served the workers of sugar cane farms and still do. Due to the sensitivity of the information, the Kwa-Zulu Natal Department of Education required that the names of the institutions and staff members be kept confidential and anonymous.

3.2 Sampling and participants

For this study, a purposive sampling method was chosen. Due to time and cost implications, the study is limited to two farm schools in rural Kwa-Zulu Natal. The study is further limited to schools categorised as Quintile 1, Primary Schools, which indicates that the schools are non-fee bearing due to the high unemployment and illiteracy rate in which the schools are located. Farm schools, in general, are limited to the primary level allowing the researcher to study these specifically. Within the cases, four participants, two from each school, formed part of the study. This research fits into a more extensive study being conducted by the researcher, and the results of this study are conclusive for the aims of this paper. However, the small sample indicates the vast infrastructural issues plaguing education in many parts of the country.

3.3 Instruments and Data Collection

This study aimed to gather data in two forms. The first instrument was through a literature review of articles published in the past ten years on farm school infrastructure. Although there were several sources of information, none of the articles was solely focused on the infrastructure in particular. Therefore, this research aims to fill that gap by exploring the infrastructural issues of farm schools. The second instrument used was semi-structured interviews with four participants. Magnusson and Marecek (2015) state that semi-structured interviews allow the researcher to gather rich data from participants as the conversation flows, giving the researcher the freedom to probe deeper into different aspects. This open-ended approach allows the interviewee the freedom to discuss topics interrelated to the subject at hand. In the case of this study, semi-structured interviews were conducted and lasted between 30 and 60 minutes. All respondents spoke fluent English. Thus, the interviews were conducted in English only. All interviews, with permission of the interviewees, were recorded and transcribed verbatim for further analysis. Participants were probed into the issues of the school's infrastructure, community usage, and maintenance. Different themes emerged as the researcher probed, and these results are discussed within this paper.

3.4 Data Analysis

In terms of the semi-structured interviews, a phenomenological paradigm was used. As the basis of the study, the researcher wanted to understand the lived experiences of the interviewees concerning their daily interaction with the farm school infrastructure. Therefore, the approach is inductive. The interviews were voice recorded and transcribed for analysis. The raw data was then analysed in search of meaning and the relation of meanings to each other. The analysis sought to understand the complexity of meanings through the lived experience of participants rather than a quantifiable ratio. Therefore, the interview analysis was a long process searching for patterns which eventually became themes from which meaning is derived.

4 ORIGINS OF THE FARM SCHOOL

4.1 Bantu Education

To understand and contextualise the origins of the farm school, it is critical to understand the political history of how it developed and why it continues to exist. Before 1948, the schooling system in South Africa allowed all races to attend the same schools (Morris and Hylsop, 1991, cited in Bryant et al., 2019). However, after the National Parties' victory in 1948, racial segregation became an underpinning law that would entrench the division in the physical landscape and the minds of South Africans (Molokoe and Ndandani, 2014). It was not until 1953 that South Africa saw the promulgation of one of the cruellest educational laws in the world, the Bantu Education Act No. 47 of 1953 (Khumalo, 2022). Naidoo & De Beer (2022) observe that the Bantu Education Act created a separate system for black learners under the control of the Department of Bantu Education. Beckmann (2022) adds that the Bantu Education system departed from the stance of white supremacy, making it seem as though non-whites are somewhat inferior to their white counterparts. It is important to note that this notion of supremacy and difference eventually drove the separation of races which is perpetuated even in current times. In its infancy, the Bantu Education Act sort to keep the education of the different races apart; however, it gradually ingrained a sense of inferiority and hierarchy for the white minority.

Molokoe & Ndandani (2014) observe that the Bantu Education Act was tactfully crafted to guarantee that the black majority became subservient to the white minority. Khumalo (2022) exerts that the white minority received quality education while the other races, particularly blacks, received inferior education. Tsoaledi (2013, cited in Bryant et al., 2019) professes that the Bantu Education system is an inferior type of education that paralyses and marginalises the majority racial group in the country. At this point, it becomes clear that Bantu Education sort to cripple the majority black population by feeding them an ideology of inferiority. It must be understood that the apartheid government not only did this to keep the black majority from gaining power but to create the manual labour force to drive their economic growth. Molokoe and Ndandani (2014) state that Bantu Education was more politically grounded than educationally to bind the black majority employees to the white minority farm employers. Furthermore, this type of education was effectively only primary level, making it extremely difficult for the farmer workers and their children to progress beyond the confines of a farm, restricting them to manual labour (Beckmann, 2022). This well-thought-out system bound the black majority to farms as labourers, brick walling them from further work opportunities. In some instances, the churches viewed the Bantu Education system as a significant problem and sort to educate the black majority within church schools; however, even this was short-circuited by the apartheid government and these institutions were instructed to follow the Bantu Education Act (Khumalo, 2022). Beyond the auspices of this absurd law, funding to farm schools was kept at a minimum, nearly as much as one-fifth of white schools (Bryant, Berry and Cevik, 2019). This approach by the apartheid government was the final nail in the coffin for black education under its authority. The Bantu Education Act has left a lasting impact on the lives of the majority of black people in South Africa, as the country moves from racial segregation to class segregation. Although this system is abolished, the physical remnants are left behind in the infrastructure of farm schools which continue to operate today albeit, with severe inadequacies.

4.2 The infrastructure of Farm Schools

From the previous section, it is clear that the Bantu Education Act intended to lock black people to farms and their employers, keeping the labour force strong and forthcoming. In this instance, the farm school became a factory for new workers. Bantwini and Feza (2017) posit that the farm school intended to keep the children of farm workers busy with primary education while their parents/relatives worked the farm. In this sense, the need to provide education was not a primary driver for the farmer. However, children became a problem which hindered the production of the farm. Hence, a 'school' was created within the confines of a farm. Molokoe and Ndandani (2014) observe that students attended school in barns or other general four-cornered buildings. This observation is constant over the landscape of South Africa where these schools occur. Bantwini and Feza (2017) observe that most farm school buildings are dilapidated and uninspiring, which comprise one long block of classrooms with small windows and lack verandahs. Draga (2017) cites a study by Carol Weinstein in 1979, which concluded that there is a strong link between infrastructural factors and improved educational outcomes; factors such as lighting, ambient temperatures, and air quality play a vital role within learning environments. Farmers did not build schools to provide quality education but saw it as

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

an escape from the problems the children created for the workforce. Therefore, the infrastructure provided could never serve the purpose it was forced to provide. Molokoe and Ndandani (2014) further state that farm schools were the poorest under the apartheid regime. Their infrastructure physically shows it even years after the democratic dispensation, some of which still do not have piped water or electricity or are dilapidated beyond habitation (Draga, 2017).

Perhaps it is essential to point out Article 26, Right to Education of the Universal Declaration of Human Rights. General comment no. 13 states the need for education's availability, accessibility, acceptability and adaptability, alluding to the dire need to provide fair education. Drilling down deeper into the availability of education, the commentary reads: "all institutions and programmes are likely to require buildings or other protection from the elements, sanitation facilities for both sexes, safe drinking water, trained teachers receiving domestically competitive salaries, teaching materials, and so on; while some also require facilities such as a library, computer facilities and information technology"(U.N. Committee on Economic, 1999). Clearly, the committee fully understands the need for proper facilities on the ground to provide an education comparable to the first world countries. Although these basic needs are well noted, it took many years for the policy to be implemented in South Africa. Only in 2013 was a policy framework for the norms and standards for school infrastructure promulgated through the South African Schools Act, 1996 (Act No. 84 of 1996) – Regulations relating to minimum uniform norms and standards for public school infrastructure. The policy can be seen as groundbreaking as it set the minimum standards for a fully operational school considering basic human rights. The policy sought to abolish schools built with non-compliant materials and to provide clean water, sanitation and electricity which had not previously benefitted from these services; by 29 November 2016; Non-complying schools must be brought into compliance regarding water, sanitation, electricity, perimeter fencing, classrooms, and electronic connectivity by 29 November 2020; libraries and laboratories by 29 November 2023 and all other norms, e.g. sports, recreational facilities and universal access by 31 December 2030 (Draga, 2017). Insofar as policy, the South African government has made concerted efforts to tackle the problem of lacking school infrastructure; however, years of deep entrenching of apartheid systems will need dismantling to resolve the issues of infrastructure and mindset in these spaces.

4.3 Community engagement within the setting of a school

For many, the thought of classrooms filled with children learning, writing, talking and laughing comes to mind when thinking of a school. For others, this could bring back memories of the playground or the library, perhaps first friendships or awry moments. Be it as it may, the mind's perception of a school is social and inclusive of people. Schools play an essential role in society as it nurtures them to fulfil their purpose within the structures of communities. The position of a school is not an isolated instance; it has deep roots in the community it serves (NEEDU, 2018). The school, in any context, is a place of meeting and engagement for the students and the community. Perhaps the common proverb: " It takes the whole village to raise a child" bears testament to the importance of the community towards learning and the school. According to Barrett et al. (2019), community engagement works in a multi-faceted manner; the physical school spaces can be used intensely by the community and the students as teachers within the community outside the confines of a school. The school becomes a critical space for the activities of the communities it serves. Perhaps this is more dominant in rural schools, where the school is often the only public building or, in most instances, the only building that supports community functions. Woods, 2006 cited in Hemming, 2018 suggests that the rural school plays an essential role in a community by hosting events, bringing parents together, building community networks through school friendships, heritage through a generation that has passed through the school and symbolising youthfulness of the village. It is important to note that a school is central to rural places and plays a vital role in the development of the community.

5 RESEARCH FINDINGS

This research sought to explore the opportunities and challenges of farm schools in the context of South Africa. The literature reviewed sets the scene of the background and the formation of farm schools in the country; this is starkly different from any other country in the world and therefore has challenges unique to this context. Although farm schools occur primarily in rural parts of the country, farm schools have specific issues that are not always present in rural schools or the former Bantustans. The author explores the issues so tightly related to farm schools to explore the challenges and opportunities of the infrastructure.

5.1 Socio-Economic issues

Similar issues were encountered between the two schools that formed the case studies for this research. It is critical to note that both schools are on private farmland and are classified as farm schools. Both schools are classified as Quintile one schools, meaning that the school services a community with a very low literacy rate and high unemployment. Of the two schools, one school is still under the farmer's ownership; this school is considered a Section 14 school. Section 14 schools are those which have been built on private land for public schooling.

5.1.1 Financial Implications

Introspecting the reality of these farm schools, not much has changed from the apartheid regime. The farm schools studied in this research are to this day servicing the children of farm workers. Perhaps, this way, it can be interpreted that although apartheid has been removed, the physical infrastructure perpetuates a similar schooling system. Through the interviews, the researcher found that the community consisted primarily of people who worked on farms, especially sugar cane cutters. This job entails cutting sugar cane in the harvest season after the sugar cane has been burned for eventual processing at a sugar mill. This job is menial with minimal payment and is seasonal. Therefore, it is clear to understand the socio-economic category of the people that live in this area. One of the interviewees termed the workers as being "below the bread line."

The communities are plagued with socio-economic issues. Firstly, a stable income for the workers is almost non-existent in either of these communities. Sugar cane farming, a seasonal harvest, leaves the workers with income only in some parts of the year. For the other parts, workers and community members rely on social grants to get by. The two interviewees, staff at the schools, noted that the school could not meet their registration targets. Children would come late in the year from other areas, usually in April, because their parents would work on contract on the farms. This situation causes significant problems with school funding. The Department of Education provides funding based on registration numbers; unfortunately, for both schools, the funding is usually not enough to provide for the additional students and negatively affects the feeding scheme at the schools. The two interviewees stated that the food was insufficient to feed all the learners on some occasions, and some rationing had to be applied. The knock-on effect of apartheid-created society lives on in these communities, and the opportunity for a better life for these communities cannot even be imagined.

5.1.2 Social Ill's

In both communities, all the interviewees stated the problem of alcohol abuse from the community members. The problem of alcoholism does not end with the workers but is also evident in children who consume alcohol. The interviewees stated that the children in the community see their future in their parents; "to cut sugar cane and drink alcohol." Children as young as six years old are consuming alcohol in these areas, which gives an impression of the social ills often the product of poverty. When probed further, interviewees constantly attributed this behaviour to the lack of social activities or facilities in the area. Both communities have no space where they could do sports or other recreational activities, but the school and, in both instances, are short of appropriate.

5.1.3 Literacy and Mindset

The severe lack of education in these communities is seen as problematic by the interviewees. When probed further, they cited issues such as technology illiteracy, lack of soft skills, mindset and general arrogance. One interviewee stated that children do not have any birth documents. When assisted in creating these documents with the Department of Home Affairs, they realised the parents were not identifiable. These issues are deep in a past of oppression, where identity did not mean much because it was so easily stripped away. One interviewee stated that literacy and technology access were significant hurdles in the community. The mere fact that a community member cannot create a curriculum vitae and apply for a job via the internet is problematic. The interviewee stated that implementing systems to help students with these challenges will significantly benefit the community. Lastly, all the interviewees noted that the students and community members alike did not see a future for themselves, almost arrogantly. The interviewees reduced this to an issue of mindset and lack of education and proposed that some mentoring occur within the community.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Most of the issues found through the interviews were common in the literature. The interviews paint a picture of how the physical infrastructure has perpetuated the principles set out by the apartheid government – indoctrinating the workers into a system of manual labour and then using the schools to create more labour, breaking the future of the younger generation of these places.

5.2 Infrastructural Issues

Given the history of South Africa, infrastructure generally has a severe bearing on the apartheid government. A space and place-based introspection can give total opposites like the two sides of a coin. In South Africa, public infrastructure in the big cities and suburbs is world-class, rivalling even some first-world countries. However, on the other side of the same coin is the stark difference in infrastructure when driving into the country's rural areas. One can be plagued by the lack of roads and essential services such as potable water and electricity in these areas. Fortunately for some of these places, a school is the only piece of public infrastructure stretching thin to service the community. In this section of the research, the author uses a thick description of the infrastructure and the issues described by the interviewees.

The two cases in this study are identified as farm schools. However, there are some slight differences. The first school (School A) was built by Indians and is classified as a state-aided Indian school, although the South African Government now aids it. This school was built to be a school; however, its initial planning did not include other facilities such as administration blocks or other allied facilities—the author terms this school as a "formal" school. The classrooms are full-sized and large enough to comfortably fit at least 40 learners. The second school (School B) was not built to be a school. Rather the buildings were purposed to become a school-the author term this school as an organic school. Initially, this included one large building, big enough to accommodate at least 60 learners. Other buildings on the site were tacked on to accommodate more learners; this includes four mobile classrooms.

5.2.1 The South African Schools Act

According to the South African Schools Act, 1996 (Act no. 84 of 1996), Minimum uniform norms and standards for public school infrastructure schools must have minimum education areas, education support, and administration areas. Furthermore, ablution facilities must be provided as per the National Building Regulations of South Africa. The act speaks of the school placement; it should be located in an area with basic services and suitable topography; its location should be adjacent to uses that are not detrimental to the ongoings of the school, such as shebeens. The act advocates for universal design and inclusivity. The policy states that classrooms for Grade R (Pre-School) should have a maximum of 30 learners, and all other classrooms should have a maximum of 40 learners, all of which must allow for at least 1m2 per student, 2m2 for differently abled and 7m2 for the teachers. All schools must have a library and laboratories if the science subjects are offered and must provide sports and recreation facilities. All schools must have adequate perimeter fencing and a security guard. All schools must have electronic connectivity that is in good working order.

5.2.2 School A

School A is small and has five classrooms. Initially, the school had only three classrooms. However, a donation to the school allowed for two more classrooms and an administration area. However, the school does not fully comply with the minimum norms and standards, making it illegal in some ways. The school does not contain a comprehensive planning programme, only a few buildings are available, and these are used as dual spaces. Although classrooms are provided for teaching and learning, these do not meet or follow the minimum requirements. At School A, classrooms support more than 40 learners at a time. Furthermore, these classrooms are used as multi-graded spaces, which means that two schooling grades are being taught in the same space, which is less than ideal. The severe lack of classrooms has a negative bearing on the students as well as staff. The load for a single teacher is double the usual, and students can easily be distracted by this change from grade to grade. To make matters worse, the school is placed in an unserviced area within 1km of a tavern; this results in problems for everyone involved and again contravenes the minimum norms and standards. The ablution facilities provided for students and teachers are non-water borne and illegal. Minimal attempts at improving these facilities have been made; more pit latrines have been installed. The school has no running water, no sewer system, and runs on an electrical supply that is not stable. The school has a make-shift library that runs out of a make-do administration block, which is less than desirable but concerted

efforts by staff to have some facility. The school has a sports field but does not have the funds to maintain it, the grass has grown over head height, and there are simply no efforts being made to tame it. Recreation facilities are non-existent. The school has some perimeter fencing. However, there are areas which a wholly open. The school has no electronic connectivity, and staff need to go to the nearest town to send an email. Although the school lacks the absolute basics to operate, the staff members are making do with what is available with very little financial support. The problem is compounded by the fact that this school is a non-fee school, which means there are no additional funds. This situation makes the maintenance of the school extremely difficult; most of the time, the school relies on sponsorships to conduct maintenance.

5.2.3 School B

School B is small and has only three built classrooms and four mobile classrooms. Initially, the school had one large building, which was around 60m2. This building is now being used as one classroom and supports multi-graded teaching. This space is also used as a church on weekends for the community. The school has an administration block, a repurposed classroom built years after the initial large building on the site. The school also has a Grade R block, a repurposed building barely supporting early childhood development needs. The rest of the school is made up of mobile classrooms. However, the entire school is multi-graded, again taking strain on staff and students. Ablution facilities are well provided for and use rainwater tanks as a water source. There is no municipal sewer line, but a septic tank is used. The school has no electrical supply, and the staff rely upon the district office to engage with electronic communications. A library facility is non-existent in this school. The school does have a sports field, but no other recreation facilities are present at this school. The school has a security guard and fencing, which is well maintained. General maintenance of this school is non-existent and is compounded by the fact that the farmer still owns the school buildings. The farmer has not allowed the school the opportunity to maintain or extend the school in any manner; this attitude is the same as under the apartheid regime – a total dominance in order to benefit themselves. The staff member mentions, “We cannot even cut the grass here without being stopped.”

6 RECOMMENDATIONS

Through this research, it becomes clear how the school buildings still indoctrinate the communities they serve. These schools have mainly remained the same and still, to this day, without any effort, lock the farm workers and their children into a dreamless future. However, several opportunities within these spaces can be promulgated to assist the communities with the various problems. Below, the author makes a few recommendations that can be utilised to assist the communities and the schools.

6.1 Ownership

Although the control of the school has moved over to the department of education, the physical infrastructure in both the case studies still belongs to the farmers on which the schools sit. It is recommended that the Department of Education purchase these buildings to control the spaces fully. The mere fact that ownership sits with the farmer creates exclusionary criteria for the community. How does the community fully engage with something they feel does not belong to them? Ownership also creates community assets and responsibility. The interviewees mentioned the lack of many facilities. In School A, for instance, a sports field is available. However, it is not maintained. The community can conduct a simple grass-cutting exercise to revitalise this existing asset. This way, ownership for their benefit is achieved, which can negate the issues of alcohol abuse, mindset, literacy and other problems within the communities.

6.2 Community engagement

Community engagement is a necessary tool in the development of communities. When communities come together, resilience forms to make that community strong. The communities role in terms of the school is an absolute necessity. This idea of community engagement in the school is more than evident in the literature. The authors are pretty explicit about the benefit, especially in areas with little to no resources. The school is central to the community and serves a civic purpose beyond its primary use; it would be somewhat naïve to think that a school’s only purpose is to be a school. In the case of the communities studied, the schools have the infrastructure, although not perfect, to provide essential spaces for community engagement.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

6.3 Adaptive Reuse

What is clear from this study is the adaptive reuse of buildings that have been provided. In both schools, the infrastructure is not perfect. However, the buildings have been adapted in some way to serve the purposes of a school. For example, School B has a large 60m2 building that has been adapted into a classroom, and School A has adapted a classroom into an administration office. The ability for spaces to change their capacity, performance and function are critical for the success of these farm schools; this can be done with the existing infrastructure. The spaces provided are not ideal. However, these spaces can be made available for community activities. In the example of School B, the large 60m2 becomes a church on weekends. Although the staff members may complain that the infrastructure is unsuitable, the space adapts to the need as and when it occurs. The author recommends that the school staff and the community work together to use the spaces to benefit both parties.

7 CONCLUSION

Although this study presents preliminary results of a more extensive study, several key issues are tabled. Through the literature, the author presents how the farm school came into existence. This phenomenon is particular to South Africa and is directly linked to the Bantu Education Act and the need to create labourers for several farms across the country. The author cannot emphasise the radical destruction these farm schools have created in these societies over the years. The legacy of apartheid is well and alive in the infrastructure of these places. Perhaps this was the intention that prevailed even after regime change. The mere fact that a farmer still controls the school and uses forceful or obstructive techniques is absurd even today. However, the power must be placed back in the hands of the people. This situation can only be resolved if the school staff and community collaborate to uproot the deep-seated problems. The recommendations can assist communities in changing the mindset of the learners, introducing them to a world beyond that of the sugar cane plantation and alcohol. The author sincerely hopes these societal and infrastructural issues reach the right minds and implement strategies promulgated to move beyond the apartheid regime's confines.

8 REFERENCES

BANTWINI, B.D. and FEZA, N.N. (2017) 'Left behind in a democratic society: A case of some farm school primary schoolteachers of natural science in South Africa', International Journal of Leadership in Education, 20(3), pp. 312–327.

BARRETT, P. et al. (2019) The impact of school infrastructure on learning: A synthesis of the evidence. 1st edn. Washington D.C: World Bank Publications.

BECKMANN, J. (2022) 'Thoughts on the Impending Third Epoch of School Education Policy in South Africa', in Towards the Next Epoch of Education. Sofia: Bulgarian Comparative Education Society, pp. 65–71.

BRYANT, K.C., BERRY, J.R. AND CEVIK, S. (2019) 'A South African High-Needs School: A Case of Context Driven by History.', International Journal of Educational Leadership Preparation, 14(1), pp. 113–127.

DRAGA, L. (2017) 'Infrastructure and equipment', in Veriava, F., Thom, A., and Hodgson, T. (eds) Basic education rights handbook: Education rights in South Africa. Braamfontein, South Africa: Section27. Available at http://section27. org. za/wpcontent/uploads/2017/02. 1st edn. Johannesburg: Section 27.

GALAL, S. (2021) • South Africa: number of schools by sector | Statista, Number of schools in South Africa in 2019, by sector. Available at: https://www.statista.com/statistics/1262871/number-of-schools-in-south-africa-by-sector/ (Accessed: 23 May 2022).

HEMMING, P.J. (2018) 'Faith schools, community engagement and social cohesion: A rural perspective', Sociologia Ruralis, 58(4), pp. 805–824.

KHUMALO, S.S. (2022) 'Critical analysis of Bantu Education Act of 1953 and implications on COVID-19 pandemic in black schools: A social justice perspective', Social Sciences, Humanities and Education Journal (SHE Journal), 3(2), pp. 260–271.

MAGNUSSON, E. AND MARECEK, J. (2015) Doing interview-based qualitative research: A learner's guide. 1st edn, Doing Interview-Based Qualitative Research: A Learner's Guide. 1st edn. Cambridge: Cambridge University Press. doi:10.1017/CBO9781107449893.

MOLOKOE, K. AND NDANDANI, M. (2014) 'Challenges and issues facing the education system in South Africa', in Legotlo, M.W. (ed.) Farm Schools in South Africa: issues and challenges. 1st edn. Pretoria: Africa Institute of South Africa.

NAIDOO, S. AND DE BEER, Z.L. (2022) 'International Perspective on Managing Racial Integration in Secondary Schools', in Towards the Next Epoch of Education. Sofia: Bulgarian Comparative Education Society, pp. 33–40.

NEEDU (2018) Schools and Communities working together to improve quality education: Some lessons from schools that work. Polokwane: Department of Education.

U.N. COMMITTEE ON ECONOMIC, S. AND C.R. (CESCR) (1999) 'General Comment No. 13: The Right to Education (Art. 13 of the Covenant)'. United Nations Geneva.

🏆 *reviewed paper*

Exploring the Feasibility of Intergenerational Co-Living based upon the Perspective of Inclusive City

Yong-en Zhang, Tzu-Ling Chen

(Yong-en Zhang, University of Taipei 1, No. 101, Sec. 2, Zhongcheng Rd., Shilin Dist., Taipei City, u10750006@go.utaipei.edu.tw)
(Supervisor Tzu-Ling Chen, University of Taipei 1, No. 101, Sec. 2, Zhongcheng Rd., Shilin Dist., Taipei City, skylight@mail2000.com.tw)

1 ABSTRACT

Due to globalisation nowadays, the flow of population, information, and goods has not only diversified the city but also intensified the living style within the city. An inclusive city has been proposed and advocated by UN-Habitat, where everyone, regardless of their economic means, gender, race, ethnicity, or religion, is enabled and empowered to fully participate in the social, economic, and political opportunities that cities should offer. With advanced technology and health care, cities have confronted serious issues with ageing. The social isolation problem of elders has been gradually valued and regarded as an important issue. Intergenerational co-living might be a possible approach for solving both elder landlords and the youth working population and further establishing inclusiveness within the city.

Therefore, the study attempts to explore the feasibility of intergenerational co-living based on the perspective of an inclusive city. As we all know, the basic living styles among the elders and the young are quite different. In addition, most elders might own real estate ownership due to the high housing price in the city while most of the young working population might not be able to own or afford high rent in the city. Intergenerational co-living might be a possible solution to deal with elder landlords to rent out the idle room with lower rent to the youth to acquire company and even health care.

In the beginning, the study will review the past literature regarding the concept of inclusive city and the successful case studies of intergenerational co-living. To select an appropriate study area, the study will then utilise suitability analysis to search for potential sites. The criteria include the population composition, the real estate market, and the location of the university. The composition of intergenerational co-living is the elder and the young, while the young could be separated into college students and the working population. Due to this being a preliminary study, we will then focus on exploring the feasibility of intergenerational co-living between the elders and college students.

Afterward, the study will apply surveys to explore both the demand from the elders and the young population on the topic of intergenerational co-living and the structural equation model (SEM) will then be applied to explore the relationship between the elders and the young. The purpose of the study is to provide policy recommendations for promoting intergenerational co-living in Taiwan.

Keywords: structural equation model, suitability analysis, inclusive city, intergenerational co-living, statistics

2 LITERATURE REVIEW

2.1 Inclusive City

The urban environment is an important centre of political, economic, and cultural development. Recently, emerging technologies especially in communication, transportation and globalisation accelerate the circulation of groups, information, and culture, that change the lifestyles in the urban environment directly or indirectly and strengthen connections. However, it has also become the source of differentiation and the basis of exclusion in society (UN-Habitat, 2004; Stren, 2001). In 2000, UN-Habitat proposed the "Inclusive City", which is defined as "a place where everyone, regardless of their economic means, gender, race, ethnicity, or religion, is enabled and empowered to fully participate in the social, economic, and political opportunities that cities have to offer. Participatory planning and decision making are at the heart of the inclusive city." (Asian Development Bank, 2017). In 2015, the United Nations released the 17 Sustainable Development Goals (SDGs), of which the 11th goal is "Sustainable Cities and Communities" and reveals that cities and human settlements should be inclusive, safe, resilient, and sustainable by improving the living environment of disadvantaged groups. As a result, many countries, local governments, and scholars have realised the importance of inclusiveness, and have begun to discuss some related areas like inclusive growth, inclusive urban design, and inclusive city assessment (Liang et al. 2021 ; World Bank, 2016 ; Espino, 2015 ; Dani & Haan, 2008 ; Westendorff et al., 2004).

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

However, due to the lack of a complete and systematic definition, framework, and execution of an inclusive city, it is difficult to have appropriate policies to implement the goals that an inclusive city wants to achieve. In addition, social exclusion is still a widespread issue (World Bank, 2013). The people who have been excluded who belong to all categories: gender, race, class, ethnicity, religion, and disability status, are prone to be stigmatised and stereotyped because of their unique differences and are treated unequally and there is little chance for them to change status. Among them, advanced age, a stage that many will go through, has also become one of the groups that suffer from social exclusion. Elderly people over the age of 65 are prone to major changes in their lifestyles and interpersonal relationships due to factors such as retirement, chronic diseases, and loss of important relatives and friends, and gradually become physically and psychologically weak. It is difficult to maintain participation in social activities, or expanding new friendship contacts (Smith, 2021).

With the daily progress of society, the rapid development of medical technology, and the change in people's ideas, the birth rate, and death rate have decreased year by year, while the proportion of the elderly population has increased significantly. The ageing society has become a major issue in the world. According to the definition of the World Health Organisation of the United Nations, in 1993, the proportion of my country's population over the age of 65 reached more than 7%, becoming an ageing society. In 2018, it exceeded 14% and became an ageing society. In just 25 years. ageing, was much faster than in other developed countries. According to the analysis by experts through population estimation, it is expected that the proportion of the population over the age of 65 in Taiwan will reach 20% by 2025, making it a super-aged society, and urban-friendly architectural design for the elderly is more imperative (Institute of Architecture, Ministry of the Interior, 2018). On the other hand, according to the statistics of the Ministry of Finance, about 30% of the houses in the country are owned by people over the age of 65 (Statistics Department of the Ministry of Finance, 2020). According to the summary analysis of the results, the elderly living alone increased from 14.3% to 15.6%, and the proportion of only living with a spouse or common-law partner also increased from 19.5% to 21%. The increasing number of elderly people living alone year by year may cause problems such as the inability of immediate treatment of accidents of the elderly at home, the disconnection between life and society, and the cluttered and unattended home environment, which are urgent issues to be solved today (Yang Huiru, 2005).

2.2 Intergenerational co-living

The concept of "co-living" originated in the 1960s with the Danish scholar Bodil. The idea began to take shape after Graae wrote the report "Children Should Have One Hundred Parents." According to the concept in the article, in 1967 about fifty families came together to form an organisation, the Sættedammen, which is currently the world's first group of co-housing communities. In addition to the independent space of the bedroom, the community has a larger number of public facilities for the general community, so that the residents living in the communal house have a strong sense of community, can actively participate in community affairs, and residents can also take care of each other, taking care of children, sharing childcare, gardening and other work. At dinner time twice every Monday, residents will also take turn in cooking, sharing cooking work and sharing meals, as welll as at the weekly community meetings. Members of the community will also take care of the overall management of the community through joint efforts. Thus they liive and engage in activities that foster a sense of community. Generally speaking, the decision-making of the community comes from the consensus of the members - the opinions of all residents of the community are adopted, and decisions are made based on membership agreement (Wu Cihua, 2017).

After that, the concept of co-living has gradually become popular, as the proportion of elderly people increases year by year. Inter-generational co-living has also been proposed and implemented. Its ancestor can be traced back to the Mediterranean port city of Alicante in Spain. In the early 2000s, the local municipal government built a "senior village" specially tailored for the elderly. Although the living environment is excellent, the elderly living in them still feel lonely and isolated from society. At that time, nearly half of the young people in Spain were unemployed. Even if the university was free of tuition fees, the young people could not find part-time jobs, making their food, clothing, housing, and transportation expenses a problem. Therefore, the government decided to recruit young people to live there. In 2003, the "Municipal Project For Intergenerational Housing and Community Services" was launched. The selection is based on conditions such as experience and love and patience. After establishing its effectiveness, some universities have

implemented the "Programa Vive Y Convive" intergenerational co-living programme, using the resources hidden in the two major groups of the elderly and young people - young people have the physical strength and spare time, and the elderly have a house. These are resources for the two generations to live together and take care of each other, to protect both parties. In addition of being managed by the university as an intermediary, students and the elderly sign a contract to ensure that both parties abide by their commitments. From the perspective of society, cross-generational houses can use land resources more effectively, which is also in line with economic principles (Liu Yijun, 2019).

3 RESEARCH DESIGN

3.1 Research area

Considering the benefit of the needs of the elderly, this study takes Taipei City as the preliminary research scope, and then divides "intergenerational co-living" into three different needs of "youth", "elderly" and "housing", and sets the screening conditions; In the research, the "silver" part obtained information on the age and proportion of household heads in each district in the first quarter of 2011 in Taipei City through the information provided by the real estate information platform of the Ministry of the Interior. The third quantile of each mile in Taipei City was used as the boundary, and then compared with other conditions. In the "House" part, the positioning statistics are based on the number of rented houses in the first quarter of 2011. The first 25% of the number of rented houses are taken and then compared with the above screened out ones. The 59 village do not overlap. The "youth" part is based on college students who are the main rental demanders. The research scope is narrowed down to the "village" level by screening the conditions of whether they are close to the university. Quantitative analysis to explore the feasibility assessment of localised intergenerational co-living. Therefore, in this study, Minhui Village, Daan District will be taken as the final research field to conduct a feasibility analysis.

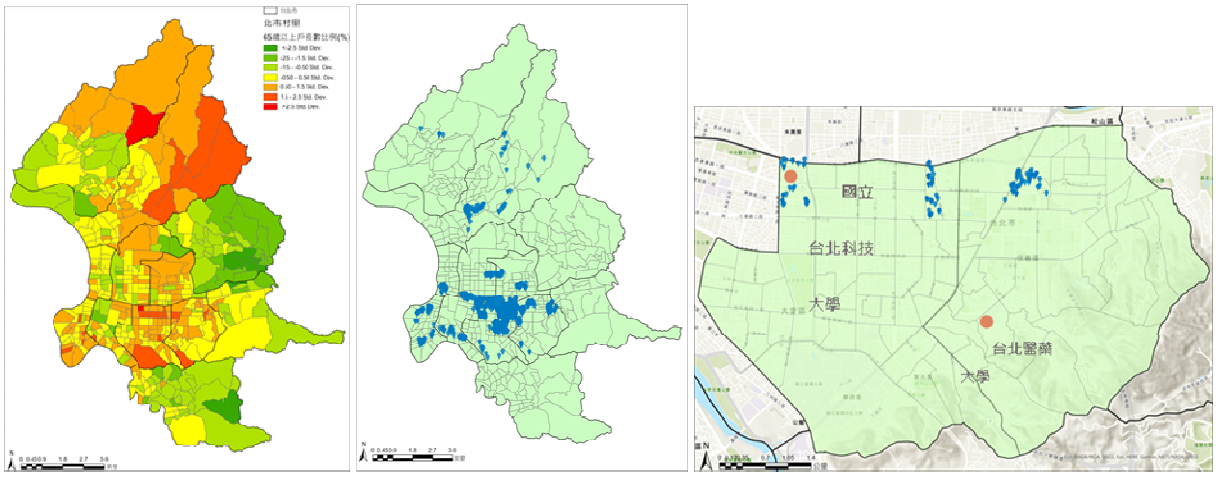


Fig. 1: Heads of households of Taipei City in 2021 (left). Fig. 2: The number of housing rentals in Taipei City in 2021 (middle). Fig. 3: Location relationship with the nearest university (right).

3.2 Survey design

This research hopes to understand the willingness of the elderly and young people to intergenerational co-living by distributing online questionnaires to the elderly over 65 living in Minhui Village, Daan District, as well as students of Taipei University of Technology. The content design of the questionnaire can be divided into four parts, including basic personal information, the expected benefits of participating in the intergenerational co-living, the price you are willing to pay for participating in the intergenerational co-living process, and the factors that will reduce participation in the intergenerational co-living; The seven-point scale is used to ask questions, with seven different grades: strongly agree, agree, somewhat agree, average, somewhat disagree, disagree, and strongly disagree, to explore the respondents' agreement on the narrative questions.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

4 CONCLUSION

In this study, a total of 187 recovered data were collected from the elderly questionnaire, of which 18 were invalid questionnaires, and a total of 166 valid questionnaires; a total of 160 recovered data were collected from the youth questionnaire, of which 2 were invalid questionnaires. There were 158 valid questionnaires.

4.1 Descriptive statistical analysis

The sample structure of the questionnaire for the elderly in this study, in terms of gender, is dominated by women, accounting for 60.84%. In terms of age, it is mostly in the range of 65 to 70 years old, accounting for 81.33%. Employment status is mainly retired, accounting for 77.11%, while those in employment and unemployed account for 21.69% and 1.20% respectively. The distribution of average monthly income is relatively even within the range of 10,000 to 20,000 yuan (30.12%). and is slightly higher than other ranges. The respondents live mostly with their family members or relatives, accounting for 92.77%. The housing type is mainly self-owned houses, accounting for 90.96%. The respondents who are willing to participate in intergenerational co-living account for 78.92%, and those who are unwilling to live together accounted for 21.08%.

Item	Options	Times	Percent	Item	Options	Times	Percent
Gender	Male	65	39.16%	average monthly income	Under $10,000	34	20.48%
	Female	101	60.84%		$10,000-$20,000	50	30.12%
Age	65-70	135	81.33%		$20,000-$30,000	37	22.29%
	71-75	26	15.66%		$30,000-$40,000	20	12.05%
	76-80	3	1.81%		$40,000-$50,000	14	8.43%
	81-85	2	1.20%		Over $50,000	11	6.63%
	Over 86	0	0.00%	living situation	alone	9	5.42%
marital status	Unmarried	13	7.83%		With families or relatives	154	92.77%
	Married	136	81.93%		With friends	3	1.81%
	Widowed	14	8.43%	Dwelling type	Own	151	90.96%
	Divorced	3	1.81%		Rent	14	8.43%
Have child or not	Yes	153	92.17%		Other	1	0.60%
	No	13	7.83%	Physical conditions	Disabled	2	1.20%
Employment status	Retired	128	77.11%		Part disabled	29	17.47%
	Employed	36	21.69%		Normal	135	81.33%
	Unemployed	2	1.20%				
Willing to join intergenerational co-living or not	Yes	131	78.92%				
	No	35	21.08%				

Table 1: Times and Percentage of Part I

	I expect the occupants to provide company (including chat and entertainment)		I expect the occupants to accompany when I go out (including walking, shopping, and attending gatherings)		I expect the occupants to assist in daily life care (such as assistance with housework)		I expect the occupants to help maintain the home environment		I expect the occupants to provide special talents (such as playing an instrument or teaching painting)	
	Times	Percentage	Times	Percentage	Times	Percentage	Times	Percentage	Times	Percentage
Strongly disagree(1)	0	0%	0	0%	1	0.76%	0	0%	0	0%
Disagree (2)	1	0.76%	1	0.76%	2	1.53%	1	0.76%	4	3.05%
Slightly disagree (3)	3	2.29%	7	5.34%	1	0.76%	2	1.53%	8	6.11%
Neutral(4)	21	16.03%	13	9.92%	19	14.50%	8	6.11%	48	36.64%
Slightly agree (5)	47	35.88%	38	29.01%	40	30.53%	45	34.35%	31	23.66%
Agree (6)	46	35.11%	52	39.69%	46	35.11%	58	44.27%	30	22.90%
Strongly agree (7)	13	9.92%	20	15.27%	22	16.79%	17	12.98%	10	7.63%
Descriptive analysis										
Average	5.320610687		5.473282		5.450382		5.587786		4.801527	
Standard deviation	0.98658054		1.083642		1.124645		0.90188		1.179438	
Standard error of the mean	0.086197942		0.094678		0.098261		0.078798		0.103048	
Confidence(95%)	0.17053232		0.18731		0.194397		0.155892		0.203868	

Table 2: Times, Percentage, and Descriptive Analysis of Part II

The second part of this questionnaire is a continuation of the question "Want to participate in the intergenerational co-living". In the first part, the total number of respondents is 131, and the interview is conducted with a seven-level Likert scale, with options ranging from 1 to 1. 7 which are strongly disagree, disagree, somewhat disagree, average, somewhat agree, agree and strongly agree, so as to understand why the elderly need more assistance in the intergenerational symbiosis. In the analysis, it was found that among

the various items of assistance that the elderly expect from intergenerational symbiosis are as follows: the residents who are expected to assist in maintaining the home environment have the highest demand, with an average of 5.59; for shopping and attending gatherings the average is 5.47. The lowest demand is for those who expect the occupants to provide special talents (such as performing musical instruments or teaching painting); the average is only 4.80, between ordinary and somewhat agreeable.

This part is a continuation of the second part, hoping to understand what kind of assistance the elderly are willing to give. In the third part of the questionnaire, the elderly are the most willing to provide their past knowledge and experience, with an average of 5.53; while the willingness to provide their own connections and to provide rent relief is second, with an average of 5.23. However, in the standard deviation, the option of providing personal connections is greater than the option of providing rent reduction or exemption, indicating that the elderly have a large gap in their willingness to provide their personal connections; the lowest willingness is to adjust the layout and decoration of the interior space, with an average of 5.21.

	I am willing to offer rent relief		I am willing to provide knowledge and experience		I would like to provide my connection		I am willing to adjust the layout and furnishings of the space	
	Times	Percentage	Times	Percentage	Times	Percentage	Times	Percentage
Strongly disagree(1)	0	0%	0	0%	0	0%	0	0%
Disagree (2)	2	1.53%	0	0%	0	0%	0	0%
Slightly disagree (3)	2	1.53%	2	1.53%	6	4.58%	6	4.58%
Neutral(4)	21	16.03%	14	10.69%	25	19.08%	24	18.32%
Slightly agree (5)	54	41.22%	45	34.35%	44	33.59%	49	37.40%
Agree (6)	43	32.82%	53	40.46%	45	34.35%	41	31.30%
Strongly agree (7)	9	6.87%	17	12.98%	11	8.40%	11	8.40%
Descriptive analysis								
Average	5.229008		5.526718		5.229008		5.206107	
Standard deviation	0.957279		0.905778		1.004336		0.990086	
Standard error of the mean	0.083638		0.079138		0.087749		0.086504	
Confidence(95%)	0.165467		0.156566		0.173601		0.171138	

Table 3: Times, Percentage, and Descriptive Analysis of Part III

	I'm worried about the incompatibility with the occupants' personalities		I'm worried about the difference in schedule with the occupants		I'm worried about the difference with the living habits of the occupants		I'm worried about feeling uncomfortable with the changes in the furnishings		I'm worried about sharing bathrooms and kitchens with others		I'm worried about the lack of integrity of the occupants	
	Times	Percentage	Times	Percentage	Times	Percentage	Times	Percentage	Times	Percentage	Times	Percentage
Strongly disagree(1)	0	0%	0	0%	0	0%	1	0.60%	0	0%	0	0%
Disagree (2)	0	0%	0	0%	1	0.60%	0	0%	0	0%	0	0%
Slightly disagree (3)	6	3.61%	4	2.41%	3	1.81%	3	1.81%	7	4.22%	5	3.01%
Neutral(4)	20	12.05%	20	12.05%	20	12.05 %	58	34.94 %	32	19.28 %	26	15.66 %
Slightly agree (5)	65	39.16%	50	30.12%	46	27.71 %	45	27.11 %	47	28.31 %	38	22.89 %
Agree (6)	51	30.72%	59	35.54%	59	35.54 %	46	27.71 %	46	27.71 %	61	36.75 %
Strongly agree (7)	24	14.46%	33	19.88%	37	22.29 %	13	7.83%	34	20.48 %	36	21.69 %
Descriptive analysis												
Average	5.403614		5.584337		5.626506		5.024096		5.409639		5.584337	
Standard deviation	0.996837		1.015991		1.052683		1.055731		1.13923		1.085215	
Standard error of the mean	0.07737		0.078856		0.081704		0.081941		0.088421		0.084229	
Confidence(95%)	0.152762		0.155697		0.16132		0.161787		0.174583		0.166306	

Table 4: Times, Percentage, and Descriptive Analysis of Part IV

In the fourth part, regardless of whether the respondents are willing to participate in the intergenerational symbiosis, they will fill in this part, so that they can fully understand the doubts of the elderly about the

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

implementation of the intergenerational symbiosis. According to the compilation of this study, it is found that the elderly are most worried about the difference in living habits with the residents in intergenerational co-living, with an average of 5.63; secondly, they are worried about the lack of integrity of the residents and the difference in the living habits of the residents. The average is the same. It is 5.58, but in terms of standard deviation, the option of worrying about the lack of integrity of the occupants is slightly larger than the option of worrying about the difference in the living routine of the occupants. Among the options that feel uncomfortable with changes in home furnishings, the average number is the lowest (5.02), which is the item that the elderly are least worried about.

4.2 SEM

In the structural equation, the questions in the second and third parts of the questionnaire are mainly used for analysis, and the questions will be re-divided into “willingness to intergenerational co-living”, “rewarding from young/old people”, and “personal willingness to pay.” "Three aspects are discussed, and finally the feasibility of co-living between youth and elderly is drawn from these three aspects.

1. Questionnaire for the elderly

The "intergenerational co-living willingness" dimension of the elderly questionnaire includes two variables: expecting the occupants to provide company (including chatting and entertainment) and expecting the occupants to accompany them to go out (including walking, shopping, and attending meetings). The "Benefits from youth" dimension includes three variables: the expectation that the occupant can assist with daily life (such as assisting with housework, safety monitoring), the expectation that the occupant can assist in maintaining the home environment, and the expectation that the occupant can provide special talents (such as performing musical instruments or Teaching painting). "Personal willingness to pay" includes four variables: willingness to provide rent reduction, willingness to provide past knowledge and experience, willingness to provide one's own contacts; and willingness to adjust the layout and decoration of the interior space. The structural equation constructed by it is as follows:

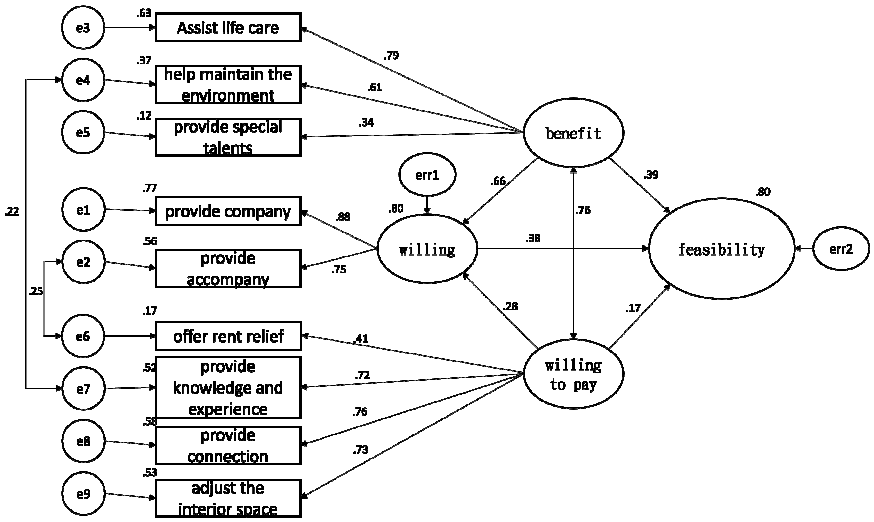


Fig. 4: Structure of SEM

Standardized regression coefficients, also known as "factor loadings", represent the direct effects of latent factors on measurement indicators, and values between 0.50 and 0.95 indicate that the basic fit of the model is good. If it is larger, the greater the variation of the index variable can be explained by the facet (>0.6 is acceptable, and >0.7 is the ideal value), and the variable index can more effectively reflect the characteristics of the facet to be measured. In order to confirm that the research model of the elderly is consistent with the questionnaire data, the following indicators can be used to illustrate the overall fitness of the research model of the elderly. For the results of each fitness index, the chi-square value is 25.041, the degree of freedom is 22, the p value is 0.295 and greater than 0.05 indicates that it is not significant, and the RMSEA 0.032 is lower than 0.05, indicating that the model error is low and the model has excellent adaptability. The Fit Index (GFI) is 0.962 higher than 0.9 and the Adjusted Fit Index (AGFI) is 0.922 higher than 0.9, the Fit Index (NFI) is 0.943 higher than 0.9 The Fit Index (IFI) is 0.993 higher At 0.9, the indicator is suitable.

item	modle data	standard	up to standard or not
CMIN	25.041	The smaller the better	—
DF	22	The smaller the better	—
P-value	.295	>.05	Yes
CMIN/DF	1.138	Preferably between 1 to 3	Yes
RMR	.043	<.05	Yes
RMSEA	.032	<.08(good) <.05(excellent)	Yes
GFI	.962	>.90	Yes
AGFI	.922	>.90	Yes
NFI	.943	>.90	Yes
RFI	.907	>.90	Yes
IFI	.993	>.90	Yes
TLI(NNFI)	.988	>.90	Yes
CFI	.922	>.90	Yes

Table 5: Modle data and standard of SEM

Through the analysis of the above coefficients and fit indicators, it can be seen that the model of the elderly has a certain degree of fit, and for the elderly, the willingness to intergenerational co-living, the benefits from youth, and the personal contribution willingness will all affect the feasibility of intergenereational co-living. Among the three, the influence of benefit from youth is the most significant, followed by willingness to intergenerational co-living, and finally the personal contribution willingness; in addition, benefit from youth will also affect the willingness of intergenerational co-living, while benefit from youth and personal contribution willingness affects each other. It shows that the elderly pay more attention to the project of benefit from youth. If it can meet the related needs of the elderly, it can greatly enhance the willingness of the elderly to participate and personal contribution willingness, and then promote the feasibility of intergenerational co-living.

5 REFERENCES

Asian Development Bank. (2017). ENABLING INCLUSIVE CITIES Tool Kit for Inclusive Urban Development.

World Bank. (2013). Inclusive Matter.

World Bank. (2015). World Inclusive Cities Approach Paper.

World Bank. (2016). Inclusive Cities and Access to Land, Housing, and Services in Developing Countries.

A.A. Dani, & A. de Haan. (2008). Inclusive States: Social Policy and Structural Inequalities: World Bank Publications.

N.A. Espino. (2015). Building the Inclusive City: Theory and Practice for Confronting Urban Segregation: Taylor & Francis.

Emma Garland. (2018). Learning from Intergenerational Housing Projects in the USA.

Danni Liang, Martin De Jong, Daan Schraven, & Lili Wang. (2021). Mapping key features and dimensions of the inclusive city: A systematic bibliometric analysis and literature study. International Journal of Sustainable Development & World Ecology, 1-20. doi:10.1080/13504509.2021.1911873

Nantes'Renoue. (2022). Nantes'Renoue. Retrieved from https://www.nantesrenoue.com/

Benjamin J. Smith. (2021). Exploring student discourses: Would intergenerational cohousing be possible?

Richard E. Stren. (2001). Thinking about Urban Inclusiveness.

UN-HABITAT. (2001). The State of the World's Cities, 2001: UNCHS (Habitat).

UN-Habitat. (2004). THE STATE OF THEWORLD'S CITIES 2004/2005.

D.G. Westendorff, United Nations Research Institute for Social Development, Swiss Agency for Development, Co-Operation, Switzerland. Direktion für Entwicklungszusammenarbeit und Humanitäre Hilfe, & Schweiz. Direktion für Entwicklung und Zusammenarbeit. (2004). From Unsustainable to Inclusive Cities: UN Research Institute for Social Development.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

🏆 *reviewed paper*

Exploring the Network Accessibility in the Airport Regions of India: Case Study of Bagdogra Airport, West Bengal

Shalvi Sharma, Sewa Ram

(Research Scholar Shalvi Sharma, Transport Planning Department, School of Planning and Architecture, New Delhi, India, sshalvisharma@gmail.com)
(Prof. Dr Sewa Ram, Transport Planning Department, School of Planning and Architecture, New Delhi, India, drsewaram@gmail.com)

1 ABSTRACT

Transportation network development is considered to be one of the keys to modernization and development. Airports are emerging as new hubs of development. Airport corridors are the upcoming economic corridors being a connection between the airport and the host city through highways, expressways, and railways, where infrastructure is planned with more public involvement. At a regional scale, Aerotropolis is an extrapolation of the airport city, to the surroundings, where the reciprocation of the airport city can be seen in terms of amenities, services, industries, residences, and thematic and logistic spaces. For linking the airport for better access, an efficient road network is inevitable in the country. Connectivity measures are an indicator of the performance of airline networks, airports and regions which allow policymakers and industry professionals to benchmark and monitor the network performance against that of other airports, airline networks and regions and plan the regions accordingly. This paper seeks to derive the landside connectivity for the road network of different tiers of airports in their influence area and identify the regions that are most and least accessible in the Indian scenario. In order to explore connectivity and accessibility, the regions are ranked on the basis of some of the indices such as alpha, beta, Gama, Konig no. etc. Further, the study comprehends the case study of Bagdogra Airport, Siliguri, being the least accessible region as per the landside connectivity.

The study of landside connectivity includes a GIS-based analysis of links and nodes with the help of graph theory and centrality indices. Results derived indicates the impact of airport connectivity in the identified influence area of the region, the centrality indices increase with a decrease in distance from the airport. The results also indicate the emergence of important nodes and links, probing towards the need for comprehensive planning for new airport regions for better accessibility and induced development of the region.

Keywords: centrality, Regional Connectivity, Graph Theory, Accessibility, Airport Region

2 INTRODUCTION

As they are not silos, airports are essential to transport hubs working in multilayered local, state, national, and international transport networks. Therefore, facilitating airport accessibility is essential for the whole value chain. Whether travelling for business or recreation, a journey never concludes at the airport. (Plan, 2010)

Connectivity by air may play an essential part in boosting local economic development and supporting the long-term growth objectives of the economy at the national level. Air connectivity helps the incorporation of a nation into the global economy by improving the flow of products and services, as well as people, ideas, expertise, as well as financial investments. Because of this, air connectivity confers immediate benefits on those who make use of aviation services and broader benefits on the economy as a whole as a result of the favourable effects it has on productivity and economic performance. As a result of these beneficial effects, governments should make an effort to study the impact of their policies on air connectivity and the factors that contribute to better air connectivity results.(Jagoda Egeland International Transport Forum, 2018).As a result, as we respond to the difficulties of deteriorating road congestion and its influence on travel time and travel time reliability, the availability of mass transportation to connect airports throughout the world will become increasingly vital. (Hambarde, 2018)

For a very considerable time, the size of the air transport industry has doubled every fifteen years, growing faster than the bulk of other industries. Since 1960, the demand for passenger and freight services has grown along with technological development and corresponding investment. This increase in air travel compares favourably with the global GDP, the broadest measure of global output, which increased by more than five times in real terms over the same time period.“Asia/Pacific continued to be the most active region, making

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

up 35% of all revenue-based traffic followed by Europe and North America, each with 26% and 22%" (Industry High-level Group, 2019). The International Air Transport Association (IATA) predicts that by 2030, “India would surpass both China and the United States as the third-largest air passenger market in the world”. The Indian government has been attempting to build more airports in order to handle the increased aviation traffic. India had 153 operating airports as of the year 2020. India plans to have between 190 and 200 operational airports by FY40. (IBEF, 2021). In order to maximise airport benefits, feeder connectivity to airports must be investigated associated with air transportation statistics and the requirement for airport connectivity.

3 NEED FOR STUDY

The National Civil Aviation Policy 2016 was published by the Ministry of Civil Aviation (MoCA), Government of India, in order to improve regional connectivity through financial assistance and infrastructure development (NCAP 2016). The Regional Connectivity Scheme (RCS) for improving underserved air connections includes the Regional Airport Development Scheme for India (UDAN), which is a regional airport development programme. To encourage inclusive national economic development, employment creation, and the development of air transport infrastructure in all areas and states of India, the mission is to make air travel more accessible and more inexpensive. The possible RCS airports have been chosen based on the following characteristics, which are, first and foremost, a distance of at least 150 kilometres from the closest operating airport (with a few exceptions), The demographic profile, the industrial profile, the passenger demand, and the market potential all play a role. Potential for tourism at the airport and in the surrounding area, The quality of the airport's current runway and terminal, The requirement for new land purchases as well as financial expenditures, Access to other means of transport, such as highways and trains, as well as competition from these other modes(Anon., 2022). The rationale behind keeping the distance from operational airports at 150 kilometres is that there are very few airports in India that are closer together than 150 kilometres, and for a distance of 150 kilometres, travelling by road is much more advantageous in terms of time, cost, and convenience than flying, with the exception of areas that have topographical challenges such as hilly regions.. (Partner, 2004)

To better support the infrastructure of airports, it is necessary to improve other network connection infrastructures, which serve as the airports' primary support system. These shifts in the connectivity of the road network have led to the development of city areas surrounding airports. Authors such as Kasarda have placed an emphasis on airport-linked productivity, aviation-oriented agglomeration economies, and changes in connectivity indices. It is necessary to identify the changes in various factors related to connectivity and accessibility in the emerging airport-oriented regions in India, following the UDAN scheme that has been proposed and is currently being implemented in India. This is necessary in order to include such identified phenomena in policies that are linked to upcoming airport regions. Because air travel serves time-sensitive markets, ground access to airports must be efficient, and airport-related criteria must be updated on a regular basis. As a result, there is an urgent need to prioritise the integration of specialised transportation services in many additional Indian cities in order to establish a long-term solution(Gaonkar, 2013) (De Jong et al., 2008).

4 LITERATURE REVIEW

Such analysis is crucial to examine since it provides the insights required to develop measures to increase airport competitiveness. For example, these metrics can show how well an airport serves as a connecting hub in a certain origin-destination market in contrast to competitor hubs. Furthermore, connectivity parameters enable governments, terminals, and flights to track network performance over time and evaluate the impact of different policies to maintain or improve network performance. Because of this, connectivity measurements are frequently utilised as input for larger strategic airport and airline planning. Regional economic connectivity indicators can assist policymakers by analysing travel times to reach a specific proportion of global GDP or population from a predetermined location.(Matsumoto et. Al.2008).

In fact, academic studies have proposed a wide range of connectivity indicators that account for both direct and indirect connection in airline networks. Some are based on network topology and complex network theory, while others are based on the operational characteristics of airline hub-and-spoke networks or on findings from social science studies.(Burghouwt & Redondi, 2013)

4.1 Defining Airport regions

Dr. John Kasarda, an American urban economist and sociologist, emphasizes the significance of airports in transforming urban form in the twenty-first century, much as motorways, railways, and seaports did in the twentieth. He believes that the fourth revolutionary wave of transportation and communication will have the greatest impact on business location and the new proclamation of survival of the fastest with supply chain logistics and other time-sensitive economic activity, emphasising airport proximity as gateways and for movements of capital, materials, and information.Kasarda defines an Aerotropolis as a metropolitan sub-region centred on an airport. A typical metropolis has a core business district and commuter-linked suburbs, he argues. (Perera & Development, 2019)

Airport-related theories have been defined by several authors, including Airport Region, Airport Corridor, Aerotropolis, and Airea. An airport area is a developing aerotropolis in which the airport is linked to the host city and other industrial and logistical centres by road and rail networks. While other authors have proposed the development of an airport corridor between the airport and the host city. Airport corridors are characterised as a connection between the airport and the host city via motorways, expressways, and railways, with increased public engagement in infrastructure planning. Aerotropolis is a reproduction of airport city in terms of services, industry, homes, themed and logistic areas.(Correia & De Abreu E Silva, 2015)

4.2 Connectivity Measures

Sociological importance of connectivity measurements is obvious, as is the need for suitable connectivity metrics that account for both types of connectivity. Indicators of connectivity are applied to evaluate the performance of airline networks, airports, and regions. They enable policymakers and industry professionals to analyse and monitor network performance relative to other airports, airline networks, and regions, and to create regions accordingly.(Burghouwt & Redondi, 2013)

Accessibility has been a crucial criteria for measuring a network's spatial interconnectivity and evaluating travel prospects in transportation network development. Accessibility incorporates network metrics like connection and node accessibility. Several ways highlight a transportation network's connectedness and nodal accessibility. Hansen (1959) defined accessibility as "the potential for interaction and provided a potential-based approach to evaluate accessibility in cities". Garrison (1960) presented "graph theoretic principles to study the topological accessibility of a transportation network utilising accessibility indices (beta index, association number, alpha index, gamma index) and node accessibility indices (i.e., Shimbel index and nodal degree)". Transportation research uses graph theory-based network accessibility measurements. The objective of graph-based evaluations is to statistically evaluate the spatial distribution of travel opportunities based on travel times, distance, theoretical accessibility model, or structural-based approaches including spatial syntactic research. (Chen et al., 2014)

Some sites are more accessible than others, implying that there are disparities across the locales. Therefore, accessibility represents geographical inequality. Hence, the concept and idea of accessibility is based on two fundamentals: The first is the location, in which the relativity of areas/zones is assessed in relation with the transport infrastructures, which provide the means to facilitate movement. Each area/zone has a set of peculiar characteristics, such as its population or extent of economic activities. The second factor is distance, which is determined by the physical or geographical segregation among various areas/zones. Transportation must exist between two areas in order for there to be a distance between them. A network is a structure comprised of interconnected links. Several network-based indicators have been established to analyse the transport network, and these indicators may be categorised as measures of connectedness, cyclic property, and efficiency. Understanding the network structure has traditionally been of interest only to geographers, who consider the spatial form of the road network to be a crucial factor in regional development. In recent years, there has been a great deal of interest in comprehending the topology of transport networks that connect places in geographic space and contribute to the creation of new settlements as a result of enhanced connectivity (Sreelekha.M.G, 2016).

There are two linked geographical categories that are applicable to accessibility issues. The first category is topological accessibility, which deals with quantifying accessibility in a network of nodes and links (a transportation network). It is considered that accessibility is a quantitative property that only applies to specific components of a transportation system. The second form is contiguous accessibility, which includes

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

assessing accessibility throughout a surface. Accessibility, also known as isochrone accessibility, is a measure of how well-connected various locations are across a given distance, given that geography is considered continuous. (Rodrigue, 2020).

Following these conditions, the indicators suggested for computing landside connectivity in the airport region are distance-based and topology-based on a system of nodes and linkages. According to various studies, the airport is related to changes in connectivity indices in the region served by that airport. Several research on discovering airside connectivity indices utilising the hub and spoke paradigm have been conducted(Jose & Ram, 2018).

5 OBJECTIVES OF THE PAPER

This research work attempts to determine the landside connectivity in the influence area of airport through nodal perspectives. The objectives of the paper therefore are –

(1) To formulate the methodology for computing landside regional connectivity of different tier of airports.

(2) To identify the regions on the basis of regional airside and landside connectivity in airport region.

(3) To delineate a region on the basis of change in connectivity for the selected airport region.

(4) To determine the change in degree of centrality of the selected nodes in the identified region.

6 FORMULATION OF METHODOLOGY

In order to identify the change in connectivity indices in regions of India, India has been divided geographically into four regions firstly based on airside connectivity indices using the hub and spoke concept. (Amal Jose, 2019) The author has already classified and ranked the 36 airports based on hub and spoke concept following the air connectivity indices such as Ranking based on Different tier of airports Participation Coefficient, Z-Score, *Hubbing Potential Index* ($H.\ P.\ I.$) and *Inter Community Coefficient* ($I.\ C.\ C.$). to evaluate airside connectivity at sub community as well as inter community level. (Amal Jose, 2019). Further to explore the landside connectivity, the categorized four regions have been chosen in order to rank airports on the basis of node and link-based connectivity parameters. In order to compute landside connectivity indices region wise, the extent of region has been buffered for radius of 150 km, 70km, 46 km for catchment area for different hierarchy of airports (Tier I, Tier II, Tier III). The indicators chosen for the analysis are, settlements including census towns and statutory towns acting as nodes in the airport region, and links are national highway, state highway and major district roads. Further in order to rank, the indices computed are Alpha Index,Beta Index, Gama Index, Konig Number using ArcGIS software.

6.1 Identification of regions on the basis of landside airport connectivity- Discussion

In order to identify the airport region on the basis of connectivity, the study area selection has been done on the basis of airside connectivity as well as landside connectivity. In order to compute landside connectivity, 36 airports of different tier of airports and 4 different regions have been identified using the ranking based on Different tier of airports, Participation Coefficient, Z-Score, Hubbing Potential, Potential Index, Inter community coefficient. In Region 1 that is the Northern Region, New Delhi, Jaipur and Lucknow having the highest ranking among all the eight airports. In Region2, that is the central India, Mumbai, Ahmedabad and Pune has the highest-ranking airports. In Region 3 that is the North east region, Kolkata, Guwahati and Bagdogra ranks the highest. In Region 4, Bangalore, Hyderabad and Chennai ranks the highest. (Amal Jose, 2019)

In order to further examine the connectivity indices in the 4 airport regions, some of the measures as defined in the Graph theory has been applied. Graph theory basically converts the transport networks into a matrix in which Edges are defined as Line segment (link) between locations, for example: roads, rail lines, etc. and Vertex are defined as impostant locales on the transportation network that is of interest (node), for example: cities, towns,public places, etc. The connectivity measures that are applied are Alpha Index, Beta Index, Gamma Index and Koenig No. These measures have been computed using QGIS, network analysis tool to convert the road network into Planar Graph. These indices have been defined as:

(a) "Beta Index. Measures the level of connectivity in a graph and is expressed by the relationship between the number of links (e) over the number of nodes (v). Trees and simple networks have Beta value of less than one". (Arlinghaus, 2001)

(b) "Alpha Index. A measure of connectivity which evaluates the number of cycles in a graph in comparison with the maximum number of cycles. The higher the alpha index, the more a network is connected". (Arlinghaus, 2001)

(c) "Gamma Index. A measure of connectivity that considers the relationship between the number of observed links and the number of possible links. The value of gamma is between 0 and 1 where a value of 1 indicates a completely connected network and would be extremely unlikely. Gamma is an efficient value to measure the progression of a network in time". (Arlinghaus, 2001)

(d) "Koenig number (or associated number, eccentricity). A measure of farness based on the number of links needed to reach the most distant node in the graph". (Arlinghaus, 2001)

	Airports	Passengers FY 2019-20	Ranking based on passenger traffic	Tier of Airports	Beta Index	Alpha	Gamma Index	Konig No.(Shortest path length of farthest node)
Region-1	**New Delhi**	67,301,016	I	I	1.93	0.48	0.65	178
	Jaipur	5,031,561	III	II	1.58	0.30	0.54	96
	Lucknow	5,433,757	II	II	1.60	0.37	0.59	78
	Chandigarh	2,445,202	V	III	1.65	0.41	0.62	51
	Patna	4,525,765	IV	III	1.53	0.36	0.59	52
	Varanasi	3,010,702	VI	III	1.43	0.30	0.56	69
	Ranchi	2,485,293	VII	III	1.33	0.24	0.51	45
	Allahabad	414,064	VIII	III	1.31	0.24	0.52	52
Region-2	**Mumbai**	43,873,329	I	I	1.63	0.39	0.49	165
	Ahmedabad	11,432,996	II	II	1.42	0.27	0.53	83
	Pune	8,085,607	III	II	1.54	0.33	0.56	63
	Raipur	2,119,417	VI	III	1.33	0.31	0.57	48
	Goa	8,356,240	IV	II	1.48	0.41	0.62	93
	Indore	2,918,971	V	II	1.36	0.23	0.50	77
	Nagpur	3,061,548	VII	III	1.14	0.13	0.44	48
	Surat	1,515,557	VIII	III	1.33	0.23	0.50	72
Region-3	**Kolkata**	22,015,391	I	I	1.36	0.21	0.48	170
	Guwahati	5,457,449	II	II	1.20	0.13	0.43	120
	Bagdogra	3,197,168	III	III	0.94	0.00	0.36	78
	Imphal	1,506,435	V	III	0.88	-0.04	0.33	51
	Agartala	1,285,860	IV	III	0.67	-0.14	0.33	53
	Dimapur	192,899	VI	III	0.50	-0.29	0.25	60
	Shillong	30,502	VII	III	0.67	-0.14	0.33	75
Region-4	**Bangalore**	32,361,666	I	I	1.59	0.31	0.47	214
	Hyderabad	21,651,878	III	I	1.41	0.25	0.51	200
	Chennai	22,266,722	II	I	1.38	0.19	0.47	168
	Cochin	9,624,334	IV	II	1.23	0.13	0.46	89
	Vizag	2,681,283	VII	III	1.19	0.69	0.81	59
	Vijayawada	1,130,583	VIII	III	1.18	0.71	0.83	41
	Trivandrum	3,919,193	V	III	1.12	0.12	0.33	54
	Bhubaneswar	3,672,246	VI	II	1.28	0.39	0.60	56

Figure 2 Landside Connectivity Indices, (computed by author)

As per the connectivity indices for landside connectivity in various airport regions it is found that Region 1 As a metro hub, New Delhi ranks first in landside connectivity followed by Lucknow in Tier II and Chandigarh in tier III type of airports. In Region II as a metro hub, Mumbai ranks first in landside connectivity followed by Ahmedabad in Tier II and Surat, Raipur in tier III. In Region As a metro hub, Kolkata ranks first in landside connectivity followed by Guwahati in Tier II and Siliguri in tier III. In Region 4, as a metro hub, Bangalore ranks first in landside connectivity followed by Cochin in Tier II and Vijayawada in tier III type of Airport. For the identified four regions, Region 1 has the highest landside and airside connectivity values followed by region 2, region 4 and region 3.

Various researches have stated that airport influences the landside connectivity in a region over a period of time and in order to explore the same, measures of centrality has been computed. In order to investigate the most accessible and connected settlements as nodes in the airport region, the decadal change in accessibility parameters have been assessed with respect to road network. For the study, Bagdogra airport has been selected from the north east region, which is the region 3 as categorized in the Figure 2. In order to analyze the impact of airport on landside connectivity in the region, North-east has been considered in order to look at the change in connectivity parameters impacted by the provision of airport connectivity to the least accessible regions. Since road and rail facilities are inadequate in the region, therefore viable means of

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

transportation in the North-Eastern states is by air. In UDAN scheme as well, impetus has been given to North-east Region for improving the regional air connectivity in the region.

7 CASE STUDY: BAGDOGRA AIRPORT, SILIGURI

The Bagdogra region of Siliguri in northern West Bengal, India, is site to Bagdogra Airport, a customs airport. Siliguri is the city that the airport serves. At the Indian Air Force's AFS Bagdogra, it is run as a civil enclave. Additionally, it serves as a gateway airport for other North Bengal area hill stations, including Darjeeling, Gangtok, Kurseong, Kalimpong, and Mirik. Each year, thousands of visitors use this airport. The airport serves as a significant transportation centre for the area, and in 2002, the Indian central government granted it restricted international airport status with limited international operations. The airport served 3.2 million passengers in 2019–20, a rise of 11.2% from the prior year, ranking it as India's 17th busiest airport. (Anon., n.d.)

Siliguri is strategically located with easy access to Nepal, Bangladesh and China. That is not all. The critical Siliguri Corridor marks the 60 km long and 22 km “Chicken Neck” connecting the rest of India with the north eastern states.

Conferring to the airport serving the North Bengal region, in order to compute the change in accessibility in the Bagdogra airport region, the study area identified consists of 4 districts which has been delineated by applying Voronoi polygon tool in QGIS, then applying intersection tool so as to demarcate the area with respect to district boundary. The demarcated area consists of districts namely Uttar Dinajpur, Jalpaiguri, Koch Bihar, Darjeeling.

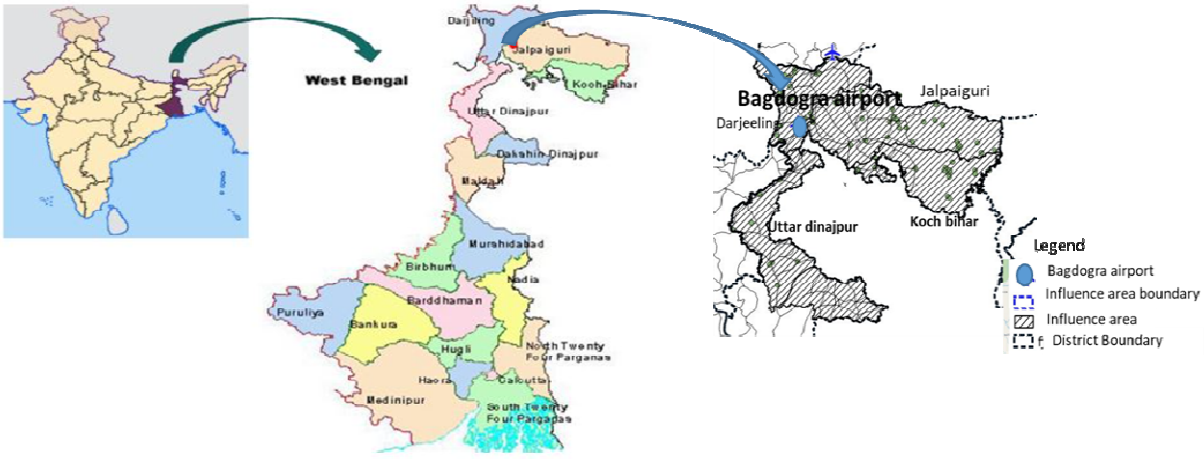


Figure 3 Study Area: Location of Bagdogra Airport and its region (Not to scale)

District	Population 2001	Population 2011	Area of the district	No. of census towns 2001	No. of census towns 2011	No. of statutory towns 2001	No. of statutory towns 2011
Darjeeling	1609172	1846823	3149sq.km	4	24	4	5
Jalpaiguri	3401173	3872846	6227sq.km	13	35	3	4
Koch bihar	2479155	2819086	3387sq.km	4	12	6	6
Uttar dinajpur	2441794	3,007,134	3140	3	5	3	4

Figure 4 Study area. Total no. of settlements in 2001=42, Total no. of settlements in 2011=96

7.1 Accessibility in the Region

The airport region tends to create various kinds of links with respect to the areas it serves. With time, these links change also tend to change in terms of capacities, gets upgraded and at times form new links to connect more and more places in the region. Similarly in the case area of Bagdogra airport region, through this study an attempt has been made to ty to figure out the trend of change in connectivity in terms of change in accessibility in the region. This change has been identified with respect to time as well as distance form the airport, and assessing the most accessible and connected urban settlements in the region. The question addressed here was, whether there is any change in the accessibility indices in the airport region and whether the airport has any role to play in the scenario. For the study, all the census and statutory towns have been taken as nodes, national highways, state highways and major district roads have been taken as the links in the

region. The topological maps are extracted for the years 2001 and 2011 to see the change in these years, as in 2002 the airport was upgraded into an international airport and hence the impacts.

In order to see the change in accessibility during the year 2001 to 2011, centrality and shimbel index has been applied with respect to the distance from the airport. For computing the centrality measures in the region, the tools applied are spatial design network analyst tool in QGIS, further the network graph matrix has been generated for the network by planarizing the network into segments and finally the result has been shown in terms of heat maps.

7.2 Calculation of Centrality

7.2.1 Centrality Measures

Centrality measurements including degree, betweenness, and closeness could quantify how central or important each node or link is inside a network, so as to find out the emerging important nodes and links in the region. These indices are free from the effect of network size road capacities so that cross-network comparison is possible.

“Shimbel Index (or Shimbel distance, nodal accessibility, nodality). “A measure of accessibility representing the sum of the length of all shortest paths connecting all other nodes in the graph. The inverse measure is also called closeness centrality or distance centrality".

$$A_i = \sum_{j=1}^{N} d_{ij}$$

“Betweenness centrality measures the extent to which a particular node lies between other nodes in a network. A node tends to be more powerful if it is on the shortest paths connecting many node-pairs, as it may be in a position to broker or mediate connections between these pairs. The betweenness of a node i is defined as the ratio of all shortest paths passing through it and reflects its transitivity”. Thus,

$$C_B(i) = \sum_{k \neq i \neq j \in N} \sigma_{kj}(i)/\sigma_{kj}$$

where σkj is the sum of all shortest paths between nodes vk and vj, and σkj(i) is the number of shortest paths that pass through vi. Nodes that occur on many shortest paths between other nodes have higher betweenness than those that do not.

“Closeness centrality:

Closeness centrality measures the extent to which a node is close to all other nodes along the shortest path and reflects its accessibility in a given network.” The closeness of node i is written as:

$$C_C(i) = \frac{n-1}{\sum_{v_j \in V, i \neq j} d_{ij}}$$

“In other words, a node’s closeness is the inverse of the average shortest distance from that node i to all other nodes in a given network. The larger the i value, the more convenient it is to reach other nodes”.(Wang et al., 2011)

7.3 Discussion

The measure of betweenness centrality in Figure 5 illustrates a node's importance by the percentage of pathways that connect it to other nodes. The concept is that a node that plays a larger role in connecting more other nodes is more significant.Hence it can be seen in the Figure 5 that during the year 2001 to 2011, the betweenness centrality has been outrightly emerging near the airport and along another city of Jalpaiguri which is directly linked to Siliguri through highway 27.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

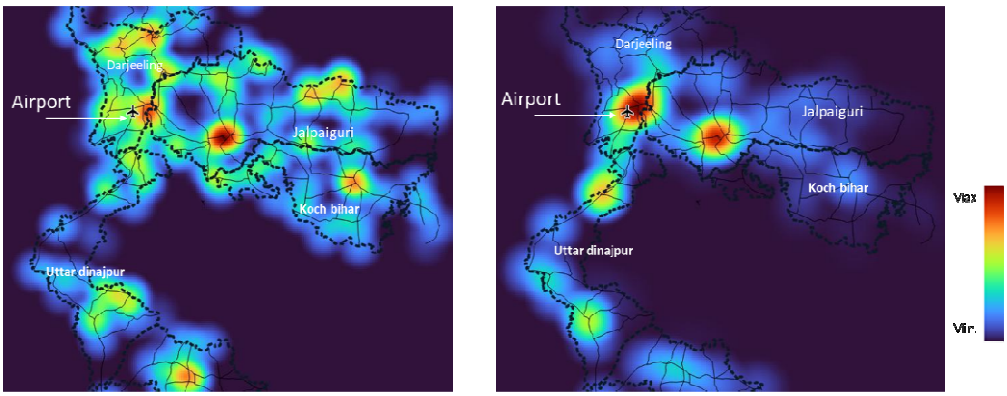


Figure 5 Betweenness centrality 2001 and 2011 (calculated by author)

Further in order to see the emerging nodes with more edges have greater importance, measure of degree centrality in the region has been computed. Degree centrality measures the importance of a node by the number of edges (degree) the node has. The region had a lot no. of important nodes spread out in the region but as it can be seen in 2011, comparatively the emerged nodes are lying in the vicinity of the airport as in the Figure 6.

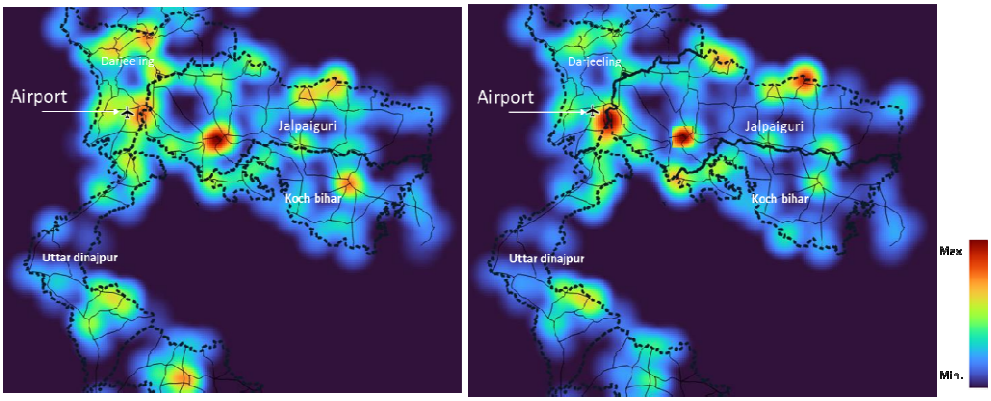


Figure 6 Degree Centrality 2001 and 2011 (calculated by author)

Further, in order to measure accessibility on the basis of shortest paths, another measure of shimbel index has been computed that is shimbel index. Shimbel index is the measure of accessibility representing the sum of the length of all shortest paths connecting all other nodes in the graph. The inverse measure of Shimbel index is also called closeness centrality or distance centrality. It is calculated as the reciprocal of the sum of geodesic distances to all other nodes. The idea of calculating this measure is that the closer a node is to other nodes, the important the node is. The measure is based on the topological distance between the nodes, for which if the value is high then it has lesser accessibility. As it can be seen in the figure 7 the light green patches show the reduction in values in the region specially in the nearby areas to the airport showing increase in accessibility in the region.

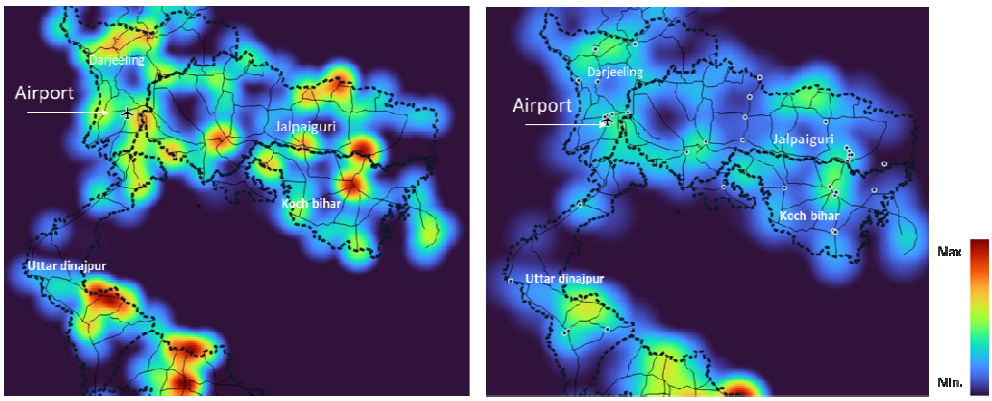


Figure 7 Shimbel Index 2001 and 2011 (calculated by author)

The centrality measures computed for the airport region shows the change in the accessibility in the region during 2001 to 2011, it is important to look into the change in settlement pattern in the region to see the emerging nodes based on the demographic changes. In the delineated area, using the QGIS software, all the census and statutory towns have been mapped to identify the change, along the radius of 50km,100km and 150km. The buffer zones have been mapped, using the buffer tool in QGIS. Further, for the same distances, isochrones have also been mapped, using the network analyst tools for getting the exact geographical distance that can be covered via roads. As in the figure 8 given below, it can be inferred that Emergence of urban settlements in the airport region can also be seen being concentrated more in the vicinity of the airport within a distance of 50 to 100km. Also in the region, there has been a prominent change in class size of the towns. It can be seen that settlements have been upgraded which are concentrated in the proximity of the airport.

Figure 8 Settlement Pattern- 2001 and 2011, computed by author

Based on Change in Class size of the Settlement (2001 to 2011)		
Distance Buffer(km)	Rural to Urban	Change in Class size
50	Out of 54 settlements, 28	23
100	16	8
150	6	3
200	4	2

Figure 9 Settlement class size

Visualizing the two different aspects, it can be inferred that, as per the change in hierarchy of settlements in terms of urbanization with respect to the links spread in the region, the impact is concentrated more in the radius of 50 to 120km of radius from airport.

8 CONCLUSION

Airport Connectivity and Accessibility not only enhance connectivity to other regions but also helps in improvising the intraregional linkages. Airports in a region are envisioned for providing better connectedness at domestic as well as international levels, besides this they are also associated with an emergence of new nodes, edges and links around the airport.

This study has applied the Graph Theory to examine the overall landside structure of road network around the airport in the region and the centrality of the network. This paper has examined the landside network of 36 airport regions, which consequently shows that the tier-I airports dominate the ranking in terms of better connectivity in the region. Further to specifically explore the impact of airport on connectivity in the region, North East region having the lowest ranking has been considered. Major findings in the study are, it could be inferred that in a period of time, the accessibility has increased more in the vicinity of the airport, as compared to other parts of the delineated region. The airport is playing a major role in developing the network and giving rise to emergence of various nodes in the region. The findings confirm previous links between the airport landside network and underlying geographical settlement patterns.Therefore, with upcoming airports, it is a necessity to consider the regional linkages of the airport as they are directly linked to emerging cities and towns and thereby links among them. Airports cannot be planned as isolated silos; they also require a comprehensive planning to avail the profound potentials of airport as a transport infrastructure. Further the study should also be done to analyze the impact on development of the region, as it has been inferred from this study that, in the airport region there lies an emergence of various urban settlements as well as many towns and cities tend to upgrade due to better connectivity and accessibility as an implication of airports.

9 REFERENCES

Amal Jose, S. R., 2019. Influence of 'UDAN' Scheme on Network and Regional Connectivity of Indian Airports. Urban India, p. 16.
Anon., 2019. efrcs, s.l.: iota.
Anon., 2022. Wikipedia. [Online]
Available at: https://en.wikipedia.org/wiki/UDAN
[Accessed 23 march 2022].
Anon., n.d. wikipedia. [Online]
Available at: https://en.wikipedia.org/wiki/Bagdogra_Airport
[Accessed 22 march 2022].
Arlinghaus, S. W. A. a. F. H., 2001. Graph Theory and Geography: An Interactive View. John Wiley & Sons..

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Hansen, W. G., 2007. How Accessibility Shapes Land Use. Journal of the American Institute of Planners, pp. 73-76 .
IBEF, 2021. Indian Aviation Industry. [Online]
Available at: https://www.ibef.org/industry/indian-aviation.aspx
[Accessed FEBRUARY 2022].
Rodrigue, J.-P., 2020. The Geography of Transport Systems. Routledge.
Sreelekha.M.G., K. A. M., 2016. Interaction between Road Network Connectivity and Spatial Pattern. Elsevier Ltd., Issue 24, p. 132.
Burghouwt, G., & Redondi, R. (2013). Connectivity in air transport networks an assessment of models and applications. Journal of Transport Economics and Policy, 47(1), 35–53.
Chen, S., Claramunt, C., & Ray, C. (2014). A spatio-temporal modelling approach for the study of the connectivity and accessibility of the Guangzhou metropolitan network. Journal of Transport Geography, 36, 12–23. https://doi.org/10.1016/j.jtrangeo.2014.02.006
Correia, M. D. F., & De Abreu E Silva, J. (2015). A review of airport concepts and their applicability to the new Lisbon airport process. Revista Portuguesa de Estudos Regionais, 38(1), 47–58.
De Jong, B., Suan-Sanchez, P., & Dross, M. (2008). Towards a relational planning approach? Case studies in the airport regions of Amsterdam, Barcelona and Munich. … Schools of Planning (…, October 2016, 1–25. http://www.raumentwicklung-tum.de/upload/Publikation/pdf/177_2_1212658210.pdf
Gaonkar, P. D. (2013). Analysis of airport ground accessibility in India by explicating the case of CSI Airport , Mumbai. International Journal of Scientific and Research Publications, 3(7), 1–7.
Hambarde, A. (2018). Connecting Indian Airports by Train : An Exploration Title : Connecting Indian Airports by Train : An Exploration Author : Anubandh Hambarde a *. July, 0–28. https://doi.org/10.13140/RG.2.2.10073.62566
Industry High-level Group. (2019). Aviation Benefits Report. 76.
Jagoda EgelandInternational Transport Forum. (2018). Defining, Measuring and Improving Air Connectivity. Corporate Partnership Board Report, 68.
Jose, A., & Ram, S. (2018). Benchmarking for Accessibility and Connectivity of Indian Airports. International Journal of Students' Research in Technology & Management, 6(1), 18–29. https://doi.org/10.18510/ijsrtm.2018.614
Partner, K. (2004). FICCI KPMG Report on High Potential Airport. 40(4), 8–10.
Perera, D., & Development, W. (2019). A Novel Approach For Planning An Aerocity (Aerotropolis) In Negombo-Katunayake Peri-Urban Region. August.
Plan, S. (2010). Strategic plan.
Wang, J., Mo, H., Wang, F., & Jin, F. (2011). Exploring the network structure and nodal centrality of China ' s air transport network : A complex network approach. 19, 712–721. https://doi.org/10.1016/j.jtrangeo.2010.08.012

🏆 *reviewed paper*

Exploring the Role of Digitalisation and Technology Uptake in the Construction Industry: Lessons from Johannesburg, South Africa

Phuthumile Gina, Trynos Gumbo, Nischolan Pillay

(Phuthumile Gina, University of Johannesburg, Johannesburg, South Africa, vumigina@gmail.com)
(Prof. Trynos Gumbo, University of Johannesburg, Johannesburg, South Africa, tgumbo@uj.ac.za)
(Nischolan Pillay, Durban University of Technology, Durban, South Africa, nischolanp@dut.ac.za)

1 ABSTRACT

Businesses within the retailing, banking, and manufacturing sectors have quickly realised and adjusted to digitisation and information technology because they can ensure efficiency and have competitive advantages. The construction industry is yet to fully enjoy the benefits that the above mentioned industries have enjoyed because the adoption of the technology is currently in the early stages with a major focus on the utilization of software. It is imperative that we achieve global sustainability by using every resource at our disposal in an efficient manner which also preserves the environment. South Africa is experiencing challenges with resource wastage, pollution, rising unemployment, housing backlogs, project delays, and financial shortages to name a few. Can digitalisation help remedy these challenges? This research endeavours to investigate the role of Construction 4.0 in South Africa's construction industry. The research objectives specifically focus on highlighting the stages and ways of applying Construction 4.0 technologies in South Africa; assessing the advantages and disadvantages of using Construction 4.0 technologies in South Africa and lastly, proposing a viable scheme for the utilisation of Construction 4.0 technologies in ways that ensure the sustainable development of South Africa. The work utilised a case study research design and is qualitative in nature. Both primary and secondary sources were used during data collection. Sixteen interviewees were chosen by homogeneous sampling and snowball sampling. The interview transcripts were analysed by categorical aggregation and content analysis. Findings reveal that digital technologies are mostly used during the design or engineering, construction, and pre-design phases but they are seldom used during operation and maintenance. It was revealed that some of the advantages of using Construction 4.0 technologies include productivity improvement, flexibility enhancements, business safety, and better customer services. The disadvantages of using Construction 4.0 technologies include implementation cost, technology acceptance, and high knowledge requirements. The benefits of Construction 4.0 exceed its challenges. Construction 4.0 is a worthy endeavour when humans are open minded, well trained to use the technology and the technology is not expected to replace them. It was however revealed that South Africa has not yet fully digitalised its construction industry and as a result, has not fully experienced the rewards of construction digitalisation. In conclusion, the researchers recommend the full adoption of Construction 4.0 and an extra effort from academics and construction specialists to create awareness so as to improve the country's sustainable development.

Keywords: Construction 4.0, Industry 4.0, Digitisation, Digitalisation, Sustainability, Sustainable development

2 INTRODUCTION

The construction industry was late to the tea party where the beneficial nature of information technology was discussed. Industries such as retailing, banking, and manufacturing were quick to see that digitisation and information technology can ensure efficiency and competitive advantages (Ikuabe et al., 2020, March). The construction industry is yet to completely enjoy the benefits that the above mentioned industries have enjoyed because Information and Communications Technology (ICT) is currently in the early stages with a major focus on the utilization of software (Osunsanmi et al., 2018). The fight to achieve global sustainable development is a great fight and one worth winning (Osburg and Lohrmann, 2017). Over the years, many countries, South Africa included, have joined the sustainability bandwagon so as to ensure that the earth's resources are being used in a manner that benefits both the current and future generations. South Africa has experienced challenges with resource wastage, pollution, rising unemployment, housing backlogs, project delays, and financial shortages to name a few (Ikuabe et al., 2020, March and Osunsanmi et al., 2018). There are multiple remedies to the above mentioned issues but the question is, is digitalisation one of them? This research endeavor seeks to find out whether or not the advantages of Construction 4.0 technologies outweigh its disadvantages. This manuscript starts by presenting the introduction and conceptual framework which

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

illustrate that South Africa's construction sector is in need of a technology boost so as to create a better future for the country. The paper goes on to briefly discuss how the study was conducted in the research methodology, presents the findings, and concludes by summarizing the findings and recommending a future course of action.

3 CONCEPTUAL FRAMEWORK

One of the least digitalised industries known to mankind is that of construction. However, over the last decade there has been an increase in the need for waste reduction and an improvement of performance and productivity in the construction sector, resulting in a call for fresh innovative technologies. Both globally and locally, the construction process is being transformed by the latest digital technologies (Finsrud and Kristing, 2021). South Africa is gearing towards digitalization as it is vital for the success of large construction projects such as those that can be found in its biggest city, Johannesburg. Construction projects in Johannesburg are experiencing an increase in the use of Information Technology (IT) throughout some stages of the construction process to save time, resources and maximise productivity (Osunsanmi et al., 2018). It is important to mention that there is a difference between digitisation and digitalisation, and that without digitisation we cannot have digitalisation and digital transformation. The process of converting analogue items such as pictures, documents or sounds into digital files is what we call digitisation (Aji et al., 2021). Digitalisation is what follows digitisation. Digitalisation is the process of using digitised files, social resources and digital technologies to make fundamental changes to the operatoins of a business or a projectto ensure their success (Finsrud and Kristing, 2021). The ultimate stage of digital utilization is digital transformation. Digital transformation means going beyond digitalisation, it is the process of using digital technologies to modify an organisation's model to elevate the organisation and society (Aji et al., 2021). The phrase "Construction 4.0" was largely inspired by the 4th Industrial Revolution (Industry 4.0), it has achieved great success in the manufacturing sector and necessitates the amalgamation of the virtual and physical world by utilising the Internet of Things, virtualisation and simulation (Osunsanmi et al., 2018).

Construction 4.0 has two primary focuses, first, the transition from physical to digital, second, the transition from digital to physical. The aforementioned transitions assist with coordinating, designing and executing built environment infrastructures in a more efficient and effective manner. Construction 4.0 intends to fashion a digital construction site that utilises different methods to follow the progression of the life cycle of the project (Taher, 2021). One can view digital construction as a consolidated approach to state-of-the-art technologies which aim to make building safer and increase productivity. The construction industry has employed a variety of technological innovations such as 3D-printing, Document management, Virtual Reality (VR), Drones, Augmented Reality (AR), Computer Aided Design and Drafting (CADD) systems, Building Information Modeling (BIM), Artificial Intelligence (AI), and Collaboration platforms. Some of these technologies are not fully developed yet and they are quite expensive which is one of the reasons why they are not commonly used throughout most countries, including South Africa (Finsrud and Kristing, 2021). South African construction companies should utilise some of the above mentioned Construction 4.0 technologies so that they can accomplish digital transformation (Osunsanmi et al., 2018).

4 METHODOLOGY

This research endeavour seeks to explore the role of digitalisation and technology uptake in South Africa's construction industry. The inquiry followed the interpretivist paradigm which believes that reality is constructed socially and relies heavily on the various views and opinions that people have (Ngozwana, 2018). This study is an instrumental case study which means that Johannesburg played a supporting role to the phenomenon that is being studied (Crowe et al., 2011 and Lune and Berg, 2017). The research is qualitative in nature and was guided by qualitative methods. Some of the qualitative inquiries took place at various construction sites around Johannesburg while others took place telephonically and via email. The researchers sought out and relied heavily on the words of the interviewees in order to make inferences. Homogeneous sampling was used to select eight construction workers that were interviewed to gather data about their lived experiences. Homogeneous sampling ensured that the people who were interviewed would be the best people to assist with answering the research questions (Shaheen and Pradhan 2019). The eight construction industry specialists who were interviewed were found through Snowball sampling. The primary data collection tool was semi-structured interviews. They are flexible interviews that should yield a lot of

deep and rich information (Alshenqeeti, 2014). Journals, memos, company documents and other forms of documentation were used as secondary data sources. The data was analysed by using categorical aggregation and content analysis, both of which reduced, categorised, and clarified the data so as to yield answers to the research questions. Various methods such as member checking, peer debriefing and reflexive journaling were utilised to ensure that the research findings are valid and reliable. Lastly, the researchers ensured, to the best of their ability, that ethical procedures were adhered to at all times to ensure the success of the inquiry.

5 FINDINGS

The following findings are based on interviews with construction industry specialists and employees, as well as extensive literary works on the topic at hand. This section begins with a discussion about the stages and ways in which some of the construction industry's latest technological innovations are being used in South Africa. The advantages and disadvantages of the technology are explained followed by a proposal of how to implement and use these technologies in a sustainable manner.

5.1 The stages and ways of applying Construction 4.0 technologies in South Africa

Infrastructure development projects typically have four phases, namely, the Construction phase, Pre-design phase, Operation and maintenance, and Design/Engineering phase. Below we will briefly discuss how and when various Construction 4.0 technologies can be used after sampling some direct quotes from industry specialists and employees:

"To be honest, I think for FIRD we mostly focused on real time data"

"We use drones for photos on site to track construction progress or at the start of a project to document the site typography etc."

"We use BIM in all of our day to day activities and projects because it makes running the company much easier and keeps everyone happy"

"During designing, the land surveyors do contour surveys that we feed into our design programs, AutoCAD and Revit, where we can then design buildings and plan road layouts according to the contours and slopes because the programs allow for 3D rendering. You can then see what each stand will look like on site with the environment taken into account."

5.1.1 Drones

Drones are unmanned aerial vehicles that make it easier to access big, hard to reach, high-rise or complex areas. These devices are used to gather images, map information, and aerial photography data which is utilised for security control, monitoring the progress of construction sites (Figure 1), providing visual materials to employees and customers, building inspections and land surveying (Zaychenko et al., 2018 and Taher, 2021). Drones are mostly used during the construction phase (Ikuabe et al., 2020, March).

Fig. 1: Aerial Drone picture of Fleurhof Integrated Residential Settlement (FIRD) construction site (source: Calgro M3, 2015)

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

5.1.2 Building Information Modeling

Building Information Modeling is a digital illustration of the physical and functional attributes of a site in two dissimilar features. Firstly, BIM can be used as a tool that assists with reducing information gaps by constructing and utilising a digital model. Secondly, BIM can be used to stockpile the model's data for the duration of its life cycle. This model is a combination of various processes, policies and technologies that assist with the management of project data and designs on a digital format throughout its life cycle (Ikuabe et al., 2020, March). Currently, BIM is thought to be a great contributor to the digitisation of the construction sector (Forcael et al., 2020). BIM has altered the way facility management, design and construction are handled (Zak and Macadam, 2017, September). Osunsanmi et al. (2018) stated that in order to fully enjoy the advantages of BIM, its use should be integrated with other innovations such as cloud computing which enable an easy flow of data inside the industry, as it has been predicted that it will transport data quickly to construction professionals by utilising cloud data storage.

5.1.3 Internet of Things

The Internet of Things is an instrument that supports the connection of various devices to the internet by utilising sensors and embedded software to converse, exchange and collect information (Forcael et al., 2020). Hindering construction companies from adopting IoT is the lack of data about its applicability in construction practices, as well as companies not having a vision for how IoT can be beneficial to the construction industry. In theory, the Internet of Things can be used in all phases of a construction project (Ikuabe et al., 2020, March).

5.1.4 Augmented Reality

AR is a publishing program and data platform that permits users to converse with people from various areas in real time, passively see material that has been viewed, and remain engaged and communicate with material that has been published (Taher, 2021). This innovation involves the method of integrating virtual components with real world objects with the goal of the user not being able to determine a change in the tangible world (Finsrud and Kristing, 2021). AR can be applied during repair and maintenance within the construction industry. The utilisation of a combination of AR and aerial 3D reconstruction can assist with better observation of a construction site (Ikuabe et al., 2020, March).

5.1.5 Virtual Reality

Virtual Reality is further up than Augmented Reality on the virtual spectrum. VR constructs an immersive virtual experience for the person that is wearing headsets that have 360° visions, this allows the user to interact with totally different environs (Taher, 2021). Virtual Reality can aid the decision-making and design processes through visualisation (Finsrud and Kristing, 2021). Within the construction industry, utilising VR training makes it easy to pinpoint dangerous areas, optimises procedures, and minimises the hazards people may come across (Forcael et al., 2020).

5.1.6 Robotics and Automation

Robotics and Automation are a simultaneous amalgamation of software, electrical, and mechanical engineering. The construction industry has forklifting robots, welding robots, bricklaying robots, drones, 3D printing robots, and demolition robots to name a few. The above mentioned robots can be used from project conception to project completion (Ikuabe et al., 2020, March).

5.1.7 3D Printing

Additive manufacturing which is also referred to as 3D printing is a procedure where a CAD model is used to manufacture a solid 3D structure (Ikuabe et al., 2020, March). Recently, such innovations have caught the attention of the Construction 4.0 sector, specifically with cement, illustrating the potential to replace employees with automated manufacturing, allowing efficient time management in addition to scalable and personalised construction manufacturing. The end product is largely influenced by printing duration between layers, speed, material behaviour, and printing quality (Forcael et al., 2020). 3D printing can be utilised during the construction, operation and maintenance, and design/engineering phases (Ikuabe et al., 2020, March).

5.1.8 Big data

The amalgamation of a variety of data, volume, and velocity is referred to as Big data. Variety alludes to the complex and diverse characteristics of sources and data categories. Volume represents the magnitude of the information that is gathered from networks, advanced technologies, and human interactions. Velocity exemplifies the rapid speed at which information is gathered when compared to traditional systems (Ikuabe et al., 2020, March). Big data could be converted into insights that are usable by utilising predictive analytics to assist businesses with actualising their objectives (Taher, 2021). Big data is mostly utilised in town planning and management, massive quantities of information are utilised to ascertain for example, the effect that social variables have on urban growth, and it can also be utilised to strengthen the standard of living of the residents of smart cities (Forcael et al., 2020).

5.1.9 Artificial Intelligence

Artificial Intelligence is a conceptualisation which refers to a computer that imitates human cognitive functions. It can also be used within the construction sector to differentiate various features of a construction site by using adaptive vision systems, they can also voice and recognise patterns to monitor the headway that employees have made (Forcael et al., 2020). An analysis of how it can predict multiple anomalies that are associated with services, construction and building architecture is being conducted (Taher, 2021). Artificial Intelligence is mostly used during the construction phase (Ikuabe et al., 2020, March).

5.1.10 Sensors

Sensors collect temperature, location, humidity and movement information (Sawhney et al., 2020). Throughout the operation and maintenance stage of construction projects, professionals can place sensors in strategic places within their construction sites so as to ease predictive maintenance, monitor deterioration and update their database (Ikuabe et al., 2020, March).

Advantages	**Explanation**	**References**
Productivity improvement	Construction 4.0 innovations facilitate the improvement of business productivity. Businesses should investigate how their employees utilise their time and execute a mechanism that improves the proficiency of systems. A software that schedules tasks can assist a business with fulfilling its obligations.	(Taher, 2021) (Osunsanmi et al., 2018)
Flexibility enhancements	During the past two decades, numerous technological advances have aided the improvement of communication amongst colleagues as they permit them to work remotely. These innovations have enhanced companies' capability to reply to customer/consumer enquiries faster and more efficiently.	(Taher, 2021) (Hořínková, 2021)
Business safety	Businesses should protect their data by utilising digital technologies and implementing methods that only key personnel would be able to navigate internally. Hackers will find it much harder to gain access to sensitive company data if encrypted passwords are used. As innovative technologies continue to be developed and launched, the transformation of companies will take place and they will enjoy the benefits.	(Taher, 2021) (Finsrud and Kristing, 2021)
Better customer services	Consumers are the bread and butter of all businesses, however, taking advantage of technological innovations will yield a bigger pay day. In order to boost profits and stand out from the rest, businesses should develop and provide around the clock customer care via social media, online chat support, and interactive sites.	(Taher, 2021) (Hořínková, 2021)
Lower cost of production	Implementation of Construction 4.0 technologies can reduce a project's total construction costs by 10-25%. Low requirements for construction site equipment and space, and rapid construction speed results in lower potential costs. The high speed of construction reduces the number of hours that employees work which in turn reduces the amount of money that is spent on their wages and accommodation.	(Hořínková, 2021) (Suliman Eissa Mohammed and Jamal Salem Alharthi, 2022)
Better time management	A cut of the project's duration is largely owed to moving a majority of the work to the inside of the plant, where productivity is not affected by weather conditions. Other positive contributors include work repeatability, digitisation and production automation. Various activities can be performed at the same time because of line production. For example the production of roofs, ceilings and walls is now possible at the same time.	(Hořínková, 2021) (Finsrud and Kristing, 2021)
Less negative impacts on the environment	Construction 4.0 produces less waste than traditional systems. The rapid assembly speed reduces the amount of time that surrounding areas have to tolerate the noise and air pollution that comes from the construction site.	(Hořínková, 2021) (Osunsanmi et al., 2018).
Potential provider of new opportunities	Digitalisation uses innovative digital technologies to better capitalise on current opportunities.	(Finsrud and Kristing, 2021)
Enhanced worker safety	The construction sector is responsible for over 20% of deadly accidents. Construction 4.0 technologies are safer because they reduce the amount of physical and outdoor labour that is needed, both of which are extremely dangerous.	(Osunsanmi et al., 2018). (Hořínková, 2021)

Table 1: Advantages of using Construction 4.0 technologies

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

5.2 The advantages and disadvantages of using Construction 4.0 technologies in South Africa

There are various benefits and shortcomings of the utilisation of Construction 4.0 technologies, both of which are discussed below while considering the South African context.

Disadvantage	Explanation	References
Implementation cost	The deployment of Construction 4.0 technologies can be expensive when looking at ownership and operation. One should not forget that some of these technologies are still in the early development stages which means that they are still to evolve. It is also important to keep in mind that the costs of technical equipment training will accumulate. Time and resources will be spent during this training as it may require hiring a consultant to train the current employees.	(Hořínková, 2021) (Suliman Eissa Mohammed and Jamal Salem Alharthi, 2022)
Technology acceptance	There is concern about workers becoming redundant. Worried workers will hesitate to implement and utilise Construction 4.0 technologies. The adoption of emerging technologies could be affected by the above mentioned growing concern. Populism is one of the outcomes of this public concern and has resulted in a restriction of the employees' capability to respond to technological innovations.	(Taher, 2021) (Finsrud and Kristing, 2021)
High requirements	A qualified employee will be needed to use the new technologies so as to facilitate the transition and progression of Construction 4.0. Introducing Construction 4.0 technologies requires recruiting and preparing workers, in addition to acquiring integration expertise.	(Taher, 2021)
Lack of knowledge	Manufacturing and operations can be affected by the adoption of Construction 4.0 technologies. Complications with productivity, management structure, and work culture can be caused by the above. While there are plenty qualified workers within the sector that are open to implementing the emerging technologies, others may not share the same sentiments because they lack the expertise or desire to learn new techniques. Some construction companies may hesitate to incorporate these new innovations into their operations because of the above mentioned challenges.	(Taher, 2021) (Finsrud and Kristing, 2021)
Poor Long-Term Planning	The introduction of Construction 4.0 technology does not ensure the progressive improvement of a business, especially if it is not monitored closely. When designing a project, a risk analyses should be done and the long-term results should be considered. It is advisable to delegate a team that will monitor the project from conception until the end of the rollout period.	(Taher, 2021) (Hořínková, 2021)
Insufficient Support	If employees are not given a platform where they can voice their questions, opinions or concerns it could affect the business negatively. Employees should be prioritised and given timely assistance when they require it so that they do not hesitate to try to adopt and understand the new technology.	(Taher, 2021)

Table 2: Disadvantages of using Construction 4.0 technologies

5.3 A proposal of a viable scheme for the utilisation of Construction 4.0 technologies in a way that will ensure the sustainable development of South Africa

For the sake of the advancement of the conversion to Construction 4.0, South African construction companies should develop a strategic plan that details every step and decision to ensure transparency and comprehension by all. This plan should assist companies with determining their specific Construction 4.0 aims and developing methods for how to accomplish them. We propose that said plan should consist of five crucial strategies, namely, Strategic Management, IT Development, Smart Manufacturing, Smart Supply Chain Management, and Human Resource Management.

5.3.1 Strategic Management

Strategic management of a Construction 4.0 endevour is key for its success. It is important to select a team that will direct the introduction of Construction 4.0 and digital transition of the company, in addition to the merging of conventional technology with emerging technologies and systems. The team should formulate a transition plan, outline its steps, and describe the attributes of all the transformation stages. Lastly, the team should ensure that everyone understands the technical requirements, priorities, and internal and external performance drivers for every step of Construction 4.0 deployment plan (Taher, 2021).

5.3.2 IT development

The significance of ICT technology in assisting with the transition to Construction 4.0 is illustrated by innovations such as BIM, IoT and Cyber-Physical Systems (CPS) (Sawhney et al., 2020). Companies should start by conducting an exhaustive investigation of their IT infrastructure, which includes qualified personnel, IoT devices, applications, and hardware. What follows is an assessment of the level of IT development and determination of a business to adopt suitable IT strength for Construction 4.0 execution. The IT group has to determine which stages of the market require ICT intervention. If the current IT system is unsatisfactory then they will have to implement Construction 4.0 principles that are related to ICT. Lastly, the group should

ensure that the ICTs that have been adopted can integrate and align perfectly with the previous elements, in addition to ensuring that the entire mechanism is completely compatible (Taher, 2021).

5.3.3 Smart Manufacturing

The characteristics of Smart Manufacturing are connectivity, convergence, and transparency (smart construction site). Smart construction sites are making a change from a traditional manufacturing domain to one which is entirely interconnected, complex, and scalable, while depending on information gathering sources from various manufacturing processes (Sawhney et al., 2020). The application of Radio-Frequency Identification (RFID) and IoT devices is required in order to create smart communication in the manufacturing processes, as well as tactical mixing of personnel, procedures, equipment, databases, and materials to construct a smart construction site. Combining data mining processes with smart Enterprise Resource Planning (ERP) will assist with the invention of a digital mirror image that supplies the network's lifecycle with project details and some of its components for the entire production structure (Taher, 2021).

5.3.4 Smart Supply Chain Management

Supply chain relations have been largely affected by the Construction 4.0 transition as a result of the improvement of data creation tools and the immense digitalisation of operations. Partners should align and integrate their procedure's digital twins in a way that will enable the construction of a smart digital supply chain. This application focuses mostly on Information and Communications Technology organisation in the supply chain which should result in real time data and accessing of data. Utilising blockchain innovations will assist the supply chain with maintaining confidentiality and consistency of data. This is an area of concern within the transition as it safeguards various stakeholders' intellectual assets (Suliman Eissa Mohammed and Jamal Salem Alharthi, 2022). Full integration of manufacturing and managerial skills, materials, finances, operations, and data flow would facilitate the creation of a smart value chain which performs a necessary function in digital transformation. Smart production and Smart value chain convergence permits the cumulation of real time data from multiple operations processes, partners, and customers which results in an increase in supply chain value (Taher, 2021).

5.3.5 Human Resource Management

The final step of the plan to implement Construction 4.0 is the creation of a human resource plan. One of the most important things to consider when planning a successful digital transformation is hiring proficient employees. Construction 4.0 can create a mutual connection among the virtual and real worlds by utilising ICT innovations such as cybersecurity, BIM, cloud networking, modelling systems, IoT, RFID, and CPS. Only employees that are trained in a related field and have exceptional technical expertise can make such a shared connection happen (Osunsanmi et al., 2018). In order to meet Construction 4.0 transition criteria, businesses should carry out a thorough assessment of their workers' technological skills and identify their current competence gap. Current employees possess a big advantage with a state-of-the-art supply chain, the best thing to do is train and prepare them to execute the principles and innovations that are proposed by Construction 4.0. Developers should aspire to hire multi-skilled employees that are keen to learn about the latest ideas and techniques (Taher, 2021).

6 CONCLUSIONS AND RECOMMENDATIONS

Remiss of the value of the construction industry to South Africa, developments inside the industry are characterised by conventional methods and small-scale implementation of ICT that yields the construction of substandard infrastructures, thus, affecting the general conduct of the construction industry. The paper acknowledges that Construction 4.0 will be guided by a call for the creation of a smart construction site, in adddition to adopting simulation softwares and virtualisation for construction processes. This endevour has come to the conclusion that digitalisation cannot be taken advantage of fully in South Africa's construction industry without key transformations and adaptations of procurement arrangements, business models and improving the construction industry. The above mentioned advances are imperative to realise the sustainable development of South Africa through the implementation of Construction 4.0. The researchers determined that the advantages of Construction 4.0 can, in theory, remedy some of the challenges that are faced by the construction sector in South Africa, as they far outweigh the disadvantages. Nevertheless, research within this area is still limited and multiple problems with implementation remain. Specifically, there is a lack of

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

case studies that are centred around or related to the topic at hand. This inquiry recommends the endorsement of Construction 4.0 by construction stakeholders to enhance the general performance of South Africa's construction sector and create awareness about the endevour. In addition, an investment should be made in research which focuses on the implementation of innovative ideas and technologies that can be utilised by the South African construction industry. Lastly, a proactive thinking approach should be adopted by construction sector professionals when tackling their projects.

7 REFERENCES

Aji, N.A., Abana, A. and Moses, J.M., 2021. CHAPTER TWENTY TWO THE PROS AND CONS OF DIGITALISATION AND ITS INTERPLAY IN PUBLIC COMPLAINTS IN NIGERIA: A FOCUS ON PUBLIC COMPLAINTS COMMISSION (PCC) AND SERVICE COMPACT FOR ALL NIGERIANS. Communication and Metacommunication: A Discourse on Media and Society, p.377.

Alshenqeeti, H., 2014. Interviewing as a data collection method: A critical review. English linguistics research, 3(1), pp.39-45.

Calgro M3., 2015. Available: https://www.calgrom3.com/index.php/fleurhof [Accessed: 20 July 2022]

Crowe, S., Cresswell, K., Robertson, A., Huby, G., Avery, A. and Sheikh, A., 2011. The case study approach. BMC medical research methodology, 11(1), pp.1-9.

Finsrud, J. and Kristing, E.M., 2021. Digitalization of processes in the construction production phase: A case study from the Norwegian construction industry Navn (Master's thesis, Handelshøyskolen BI).

Forcael, E., Ferrari, I., Opazo-Vega, A. and Pulido-Arcas, J.A., 2020. Construction 4.0: A literature review. Sustainability, 12(22), p.9755.

Hořínková, D., 2021. November. Advantages and Disadvantages of Modular Construction, including Environmental Impacts. In IOP Conference Series: Materials Science and Engineering (Vol. 1203, No. 3, p. 032002). IOP Publishing.

Ikuabe, M., Aghimien, D., Aigbavboa, C. and Oke, A., 2020, March. Exploring the adoption of digital technology at the different phases of construction projects in South Africa. In International Conference on Industrial Engineering and Operations Management, Dubai, UAE (pp. 10-12). Southfield: IEOM Society International.

Lune, H. and Berg, B.L., 2017. Qualitative research methods for the social sciences. Pearson.

Ngozwana, N., 2018. Ethical Dilemmas in Qualitative Research Methodology: Researcher's Reflections. International Journal of Educational Methodology, 4(1), pp.19-28.

Osburg, T. and Lohrmann, C., 2017. Sustainability in a digital world. New York: Springer International.

Osunsanmi, T.O., Aigbavboa, C. and Oke, A., 2018. Construction 4.0: the future of the construction industry in South Africa. International Journal of Civil and Environmental Engineering, 12(3), pp.206-212.

Sawhney, A., Riley, M., Irizarry, J. and Riley, M., 2020. Construction 4.0. Edited by A. Sawhney, Michael Riley, and J. Irizarry. Routledge. doi, 10, p.9780429398100.

Shaheen, M. and Pradhan, S., 2019. Sampling in qualitative research. In Qualitative techniques for workplace data analysis (pp. 25-51). IGI Global.

Suliman Eissa Mohammed, H. and Jamal Salem Alharthi, W., 2022. Blockchain Technology and the Future of Construction Industry in the Arab region: Applications, Challenges, and Future Opportunities. Engineering Research Journal, 173, pp.411-441.

Taher, G., 2021. Industrial Revolution 4.0 in the Construction Industry: Challenges and Opportunities. Management Studies and Economic Systems, 6(3/4), pp.109-127.

Zak, J. and Macadam, H., 2017, September. Utilization of building information modeling in infrastructure's design and construction. In IOP Conference Series: Materials Science and Engineering (Vol. 236, No. 1, p. 012108). IOP Publishing.

Zaychenko, I., Smirnova, A. and Borremans, A., 2018. Digital transformation: the case of the application of drones in construction. In MATEC web of conferences (Vol. 193, p. 05066). EDP Sciences.

🏆 *reviewed paper*

Exploring the Susceptibility of Gentrification in Taipei City, Taiwan

Tzu-Ling Chen

(Assistant Professor Tzu-Ling Chen, University of Taipei, No.101, Sec. 2, Zhongcheng Rd., Shilin Dist., Taipei City, Taiwan, skylight@mail2000.com.tw)

1 ABSTRACT

Gentrification is a dynamic process due to historically disinvested neighbourhoods experience susceptible class displacement in spatially concentrated areas. The attraction of the physical environment might encourage change of social class in local areas, and such replacement might push the original residents and others who might also suceptible outward to the marginal area or even further areas. The susceptible class includes elder, poorly educated, lower income, and people of colour, while the middle- and upper-class residents who are relatively younger, highly educated, and higher income may be able to stay. Taipei city is the captial and a municipality located in northern Taiwan. The population of Taipei city is around 2.5 million in 2022, and is part of Taipei–Keelung metropolitan area which is the 40th most-populous urban area in the world. The investment in transit and urban renewal projects have stimulated gentrification in Taipei city in the past, present and will do so in the future. Therefore, this study attempts to explore the susceptibility of gentrification for different neighbourhoods at two approaches in Taipei city. The first level is to identify various stages (including early, mid- current, late) of gentrification based upon small sets of indicators based upon real estate value and demographic changes. During the first phase, the temporal and spatial patterns of gentrifictaion will be analysed. The second phase will then apply principle component analysis (PCA) to explore social-economic indicators related to gentrification in various stages of genetrification. The outcome of the principle component analysis can help monitor changing conditions among various stages of gentrification and come up with an appropriate public response to the negative impacts of gentrification.

Keywords: Metropolitan Planning, Taipei city, Principle component analysis, Susceptibility, Gentrification

2 INTRODUCTION

The term gentrification first used in 1964 is indicating that the working class has been successively displaced by the middle class (Glass, 1964). Since then, there are interesting studies attempting to respond to key issues of gentrification in the past fifty years, such as the definition (Hofmeister, 1993; Smith and Williams, 1986), the types, the driving forces, and the impacts (Zuk et al., 2015; Engels, 1994; Bourne, 1993). The classic type of gentrification is proposed by Ruth Glass (1964), and many other types have been identified including new-build gentrification, 'studentification', and rural gentrification (Davidson and Lees, 2010; Lees et al., 2008; Davidson and Lees, 2005; Phillips, 2004). No matter the type, it is quite common to find gentrification in places which have been undergoing the depreciation or deterioration of the built environment and anticipating potential profit return from such land (Smith, 1979). Due to the attraction of the physical environment it might encourage the change of social class in local areas. Such replacement might push the original residents and others who might also be susceptible outward to the marginal area or even further areas of the city. As a result, upgrading the built environment will directly increase land rent and further lead to other indirect impacts, such as the increment of real estate price, the replacement of social classes, the change of industrial activities, and the change of individuals' living behaviours and others (Elliott-Cooper et al., 2020; Ghaffari et al., 2018; Zuk et al., 2018; Ding et al., 2016; Freeman et al., 2016).

Residential displacement is a well-known impact resulting from gentrification, including moving out by choice or through eviction (voluntary or involuntary). Although, the empirical findings of the displacement caused by gentrification is inconclusive and no consistent evidence shows which susceptible households are more likely to move. Some studies find evidence showing the shift of economic status, racial composition, population composition in gentrifying neighbourhoods (McKinnish et al., 2010; Crowder and South, 2005). Conversely, some studies find only few variations between gentrifying and nongentrifying neighbourhoods (Ellen and O'Regan, 2011; Freeman, 2005). Still, there is a filtering process in gentrified areas due to the physical renovation of deteriorated housing and built environment (Lees et al., 2008). A combination of 'push' and 'pull' factors compose the key agents in the filtering process of in-movers and out-movers. In-movers are people often described as those with higher income, higher education attainment levels (Hamnett, 1991), while out-movers are susceptible groups such as the elderly, low-income earners, renters, those with low educational attainment levels, and/or persons and households of colour (Ding et al., 2016).

Gentrification is a dynamic process due to historically disinvested neighbourhoods experience with susceptible class displacement in spatially concentrated areas (Smith, 1998). Both qualitative and quantitative methods are applied to unfold gentrification over time and analyse the phenomenon of gentrification (Brown-Saracino, 2010; Davidson and Lees, 2005). A number of efforts incorporate available data including income, race, educational attainment, housing values, rent, and others to categorise the pattern and/or status of gentrification. Chapple (2009) applies a geographic information system to mapping susceptibility to gentrification based on the indicators of affordable housing programmes. Owens (2012) utilised cluster analysis to explore transitions among urban neighbourhood changes. Bates (2013) applied indicators to separate various stages of gentrification and then to measure the risk of gentrification. Ding et al. (2016) compared residential mobility among various kinds of gentrification categories based on intensity.

To sum up, gentrification has changed the living environment, the character, the population composition of urban neighbourhoods in cities worldwide. Taipei City, the capital city in Taiwan, has been undergoing significant public and private investments, the steep rise of housing price has further changed both in demographic and economic status of residents. The status and the features of displacement caused by gentrification is Taipei City is relatively little researched. The purpose of this study is to understand susceptibility of gentrification better and to come up with appropriate practices to address gentrification for Taipei City. The approach to exploring the socio-economic features of susceptible areas to gentrification has two phases. At the beginning, a relatively small set of indicators including the housing market conditions and demographic change are applied to identify various stages of gentrification in the study area, and the results will be represented as potential targets for emerging at-risk neighbourhoods. The study then applies principle component analysis (PCA) to explore key components among various stages of gentrification. The results of PCA could help to understand the socio-economic features of a particular area towards appropriate strategies to solve the disproportionately impact on present or susceptible residents.

3 RESEARCH DESIGN

3.1 Research Model

Based on past definitions of gentrification, the definition applied in the study is the change of housing market and demographic change. There are two parst of analysis in the study, including the stage of gentrification and the susceptibility of gentrification. In the first phase, a relatively small set of indicators including the housing market conditions and the demographic changes are applied. In the second phase, principle component analysis is used to explore the susceptibility of gentrification.

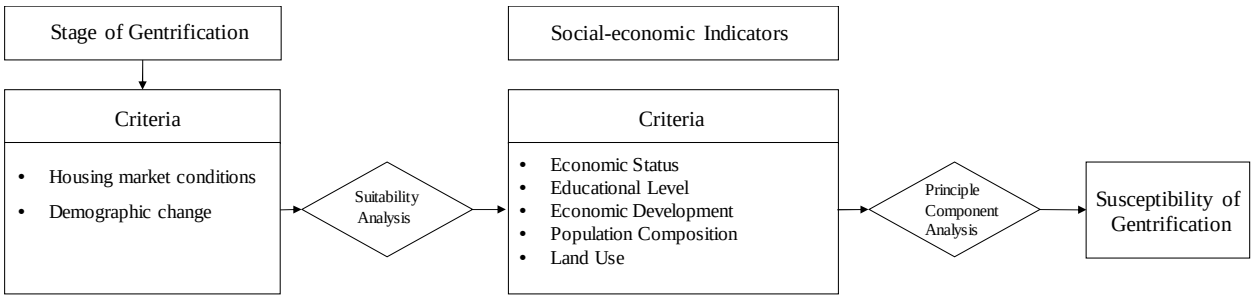


Fig. 1:Conceptual model.

3.2 Study area – Taipei City

Taipei city is the capital and a special municipality located in northern Taiwan. The population of Taipei city is around 2.5 million in 2022, and is part of Taipei–Keelung metropolitan area which together are the 40th most-populous urban area in the world. The study examines the stages and the key component of gentrification in Taipei City from 2012-2019. Like many cities worldwide, gentrification has accelerated its pace in Taipei City. Taipei City has several characteristics which contribute to the rapid gentrification over decades. With the vivid downtown and several major public investments (e.g., Taipei MRT system), Taipei City has a strong and stable economic development and attractiveness for the working class. In addition, large amounts of public investments are attributed to up-grading utilities and facilities in Taipei city which has further stimulated public and private urban renewal projects. As a whole, the investment in transit and urban renewal projects has stimulated gentrification in Taipei city in the past, present and will do so in the

future. Therefore, this study attempts to explore the susceptibility of gentrification for different neighbourhoods in Taipei city, Taiwan.

3.3 Indicators for gentrification susceptibility

The operational definition applied in this study is the change of the housing market, vulnerability to displacement, and demographic change. When gentrification occurs it might create a disconnection between potential value and current value. Once the areas become desirable they would further appeal to developers and/or higher-income households, and there will be a steep rise in housing market. Therefore, both household income and university degree are applied as the indicators of vulnerability to displacement. The categorisation of low, moderate, or high is based on how an individual "Li" compares to the citywide average.

There are three main categories to capture the stage of gentrification: early, mid and later. In the early stage three types are distinguished in 2019 which are at-risk or have early signs of gentrification. Type 1 is close to high-value and high-appreciation, but housing values and appreciation rates remain low or moderate, there is no sign of demographic change. and for both appreciation rates in household income and university degrees stay low. Type 2 is experiencing a high-appreciation rate but housing values remain low or moderate and there is no sign of demographic change. In type 3 housing values remain low or moderate, but it has experienced high-appreciation rate and ia close to high-value and high-appreciation. The mid stage indicates that units are undergoing significant impacts from gentrification. Although mid units remain low and housing values moderate, they are experiencing high-appreciation rates in the housing market and significant change in demographic and there is moderate and high appreciation rate in household income and university degree. Two types of units are regarded as later category. In 2012 housing value in type 1 was low and moderate but then became high-value in 2019. In addition, it is experiencing moderate and high appreciation in household income and university degree. Housing value in type 2 was low and moderate in 2012 but became high in 2019, and both household income and university degree are moderate and high in 2019.

Public and private investments would displace local existing businesses and change the neighbourhood features (de Oliver, 2016), and further shift social networks and culture context (Betancur, 2011). In addition, the improvement of the neighbourhood results in rising home values and rents, and such an increment might force residents to move out (Anguelovski, 2016; Fullilove, 2004). Although there is little agreement on the negative impacts on gentrification, the improvement of a neighborhood might accompany racial displacement (Pattillo, 2007), income shift (Ellen and O'Regan, 2011), or socioeconomic upgrading (Ding et al., 2016). Existing residents who are often older, poorly educated, with low-income, and/or person of coloured households are displaceds by those who are relative young, highly educated, middle- and upper-class, and/or person of white households (Marcuse, 1985). A number of efforts applied indicators to identify gentrification neighbourhoods or risk of gentrification tracts. In this study, the four main sources referred to are Rigolon & Németh (2019), Chapple et al., (2017), Bates (2013), and Freeman (2005).

Freeman (2005) applied national sample and census tracts to measure residential mobility and displacement among gentrifying and nongentrifying neighbourhoods but with potential. Five indicators were used including housing prices, educational attainment level, poverty rate, colour of household, and household income. Bates (2013) categorised gentrifying neighbourhoods based on housing market condition, vulnerability to gentrification and demographic change, and used dozens of indicators (including demographic change, median home value, educational attainment level, communities of colour, median household income) to explore socio-economic features among various stages of gentrification. Chapple et al. (2017) defined four criteria, and if any tracts which meet three out of four will be considered as gentrifying neighbourhoods. The four criteria includes high percentages of low-income households, people without a college degree, renters, and people of colour. Multiple indicators such as housing price, white residents, median rents, college-educated people, and income are applied to analyse gentrified neighbourhood features. Rigolon & Németh (2019) gathered total population amount, people with bachelor's degree, coloured people, household income, rent, home value, and housing units.

In total, based on past literature review and data limitation in Taiwan, the period is 2012-2019, because of the disclosure of information on actual price registration of real estate transactions has been implemented in 2012. The indicators applied to measure gentrification susceptibility include economic status, educational level, population composition, and land use.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Indicators		Description	Source
Economic Status	Housing Value	Median value of owner-occupied housing units	Dept. of Land Administration, M. O. I
	% People of low income [a]	Percentage of low income people	Dept. of Social Welfare, Taipei City Government
Educational Level	% Bachelor Degree or Higher	Percentage of people aged 15 or older with at least a bachelor's degree	Dept. of Household Registration, M. O. I
Population Composition	% 15-64 year-old people	Percentage of 15-64 year-old people	Dept. of Household Registration, M. O. I
	% over 65 year-old people	Percentage of people over 65 year-old	
Land Use	% Residential Use	Ratio between total amount of residential use and the area of 2nd statistic area	National Land Surveying and Mapping Center, M. O. I
	% Industrial Use	Ratio between total amount of industrial use and the area of 2nd statistic area	
	% Commercial Use	Ratio between total amount of commercial use and the area of 2nd statistic area	
	% Public Facilities [b]	Ratio between total amount of public facilities use and the area of 2nd statistic area	

Table 1: Indicators for exploring gentrification susceptibility

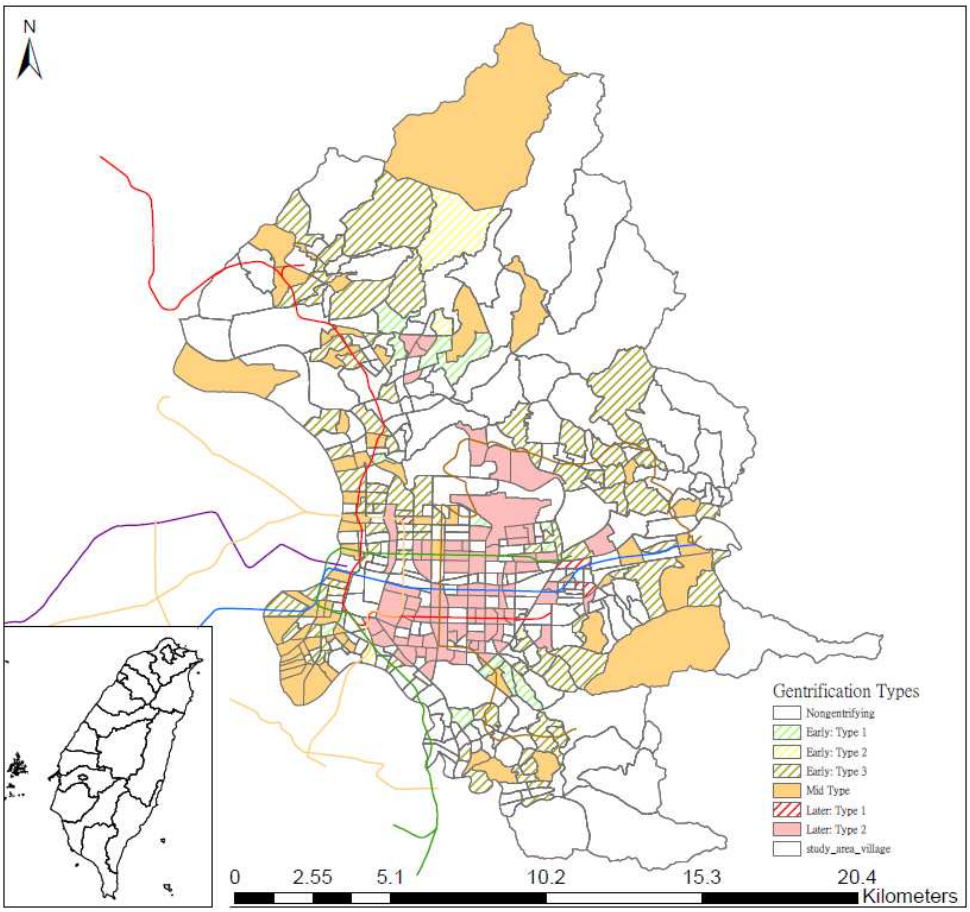


Fig. 2: Gentrification Types.

4 RESULTS

4.1 Gentrification types

The gentrification typology is applied to Taipei based upon the spatial unit of "li", and the map highlights the early, mid, and late stages of gentrification in housing market condition and demographic change. 102 li

belong to the early stage and are located in the outer areas of Taipei. 79 li belong to ther late stage, and are located in the inner city. 58 li belong to the mid stage, and are located in between thr early stage and late stage areas.

4.2 Susceptibility features

The nine attributes describing the physical environment were presented in Table 2 to Table 4. These are housing value, % people of low income, % bachelor degree or higher, % 15-64 year-old people, % over 65 year-old people, % residential use, % industrial use, % commercial use, and % public facilities.

For the early stage, PCA extracted three components that explained 63.2% of the variance and 0.608 of the KMO value (Table 2). The attributes % bachelor degree or higher, % 15-64 year-old people, % over 65 year-old people, % residential use, and % commercial use show a high positive correlation within Early_PC1 and explained 28.9% of the variance. For purposes of descriptive clarity, this combination of attributes that make up Early_PC1 was labelled “strong working population”. The second principal component, Early_PC2, explained 21.7% of the variance with the attributed % industrial use and % commercial use; this combination of attributes was labelled “economic growth”. The attributes % people of low income and % over 65 year-old people are highly positive within Early_PC3 and explained 12.6% of the variance; the combination of the attributes was renamed as “vulnerable population”.

	Component		
	Early_PC1	Early_PC2	Early_PC3
Housing value	0.348	-0.337	-0.562
% People of low income	-0.357	0.372	0.583
% Bachelor Degree or Higher	0.714	-0.562	-0.050
% 15-64 year-old people	0.689	-0.370	0.343
% over 65 year-old people	0.554	-0.204	0.537
% Residential Use	0.712	0.440	0.005
% Industrial Use	0.276	0.671	-0.248
% Commercial Use	0.615	0.649	-0.014
% Public Facilities	0.315	0.383	-0.066
Eigenvalue	23599	1.957	1.131
Proportion (%)	28.883	21.742	12.565
Cumulative (%)	28.883	50.625	63.190
KMO	0.608		
Bartlett test	Test value: 569.763, degrees of freedom: 36		

Table 2: Component matrix of early stage.

For the mid stage, PCA extracted three components that explained 63.2% of the variance and 0.556 of the KMO value (Table 3). The first principal component Mid_PC1 shows high positive correlations with % bachelor degree or higher, % 15-64 year-old people, and % over 65 year-old people, explaining 28.8% of the variance; this combination of attributes was referred to as “strong working population”. The attributes % residential use, % industrial use, and % commercial use show high positive correlation in Mid-PC2 and explained 19.5% of the variance; Mid_PC2 was renamed “economic growth”. Mid_PC3 (working class and low income) explained 14.8% of the variance with the attributes % people of low income and % industrial use. Mid_PC3 was renamed “vulnerable population”.

	Component		
	Mid_PC1	Mid_PC2	Mid_PC3
Housing value	0.323	0.494	-0.552
% People of low income	0.169	0.061	0.821
% Bachelor Degree or Higher	0.869	-0.088	-0.235
% 15-64 year-old people	0.938	0.042	0.111
% over 65 year-old people	0.843	0.079	0.112
% Residential Use	0.180	0.744	-0.090
% Industrial Use	-0.084	0.463	0.524
% Commercial Use	-0.081	0.754	0.025
% Public Facilities b	-0.027	0.448	0.128
Eigenvalue	2.595	1.758	1.331
Proportion (%)	28.833	19.532	14.785
Cumulative (%)	28.833	48.365	63.150
KMO	0.556		
Bartlett test	Test value: 595.465, degrees of freedom: 36		

Table 3: Component matrix of mid stage.

For the late stage, PCA extracted three components that explained 64.5% of the variance and 0.578 of the KMO value (Table 4). Late_PC1 (strong working population) explained 32% of the variance with the

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

attributes % bachelor degree or higher, % 15-64 year-old people, % over 65 year-old people, % residential use, and % commercial use. The second principal component Late_PC2 (economic growth) explains 18.1% of the variance with the attributes % people of low income, % industrial use, % commercial use, and % public facilities. Late_PC3 (better living environment) explained 14.3% of the variance with the attributes housing value and % public facilities.

	Component		
	Late_PC1	Late_PC2	Late_PC3
Housing value	0.279	-0.307	0.534
% People of low income	0.170	0.476	-0.650
% Bachelor Degree or Higher	0.873	-0.332	0.098
% 15-64 year-old people	0.909	-0.017	-0.226
% over 65 year-old people	0.805	-0.288	-0.181
% Residential Use	0.646	0.368	0.195
% Industrial Use	0.140	0.584	-0.081
% Commercial Use	0.532	0.466	0.255
% Public Facilities	-0.042	0.587	0.523
Eigenvalue	2.877	1.633	1.291
Proportion (%)	31.969	18.144	14.347
Cumulative (%)	31.969	50.113	64.460
KMO	0.578		
Bartlett test	Test value: 932.164, degrees of freedom: 36		

Table 4: Component matrix of late stage.

5 DISCUSSION

The results show that vulnerable population, especially the combination of % people of low income and % over 65 year-old people and the combination of % people with low income and % industrial use, exist in both early and mid stage. Although % people of low income also exist in the late stage, but with % industrial use, % commercial use, and % public facilities, indicate that the strong demographic shift might change the amount of vulnerable population. In addition, the combination of housing value and % public facilities representing an improved living environment have increased housing value in the late stage. Economic growth exists in all stages indicating that strong economic activities might attract more highly educated population in such areas. To sum up, there are similarities and divergences among the three stages. Areas where are undergoing gentrification, it seems to have siginifciant features on labour force and economic development. In all three stages, “strong working population” and “economic growth” are the signifcant compositions. As for the divergence, there is vulnerable population before mid stage while it become less significant in the late stage of gentrification. For the positive effect, gentrification indeed revitalize neighborhoods and local businesses. However, numerous consequences include increase in rental leases, higher real estate prices, changes in industrial activities and commercial services, displacement of the already vulnerable residents to either a nearby marginal area or a location further out, and a cascade of disruptions in the lives of the displaced (Elliott-Cooper et al., 2020; Ghaffari et al., 2018; Zuk et al., 2018; Ding et al., 2016; Freeman et al., 2016).

In order to cope with the displacement of vulnerable residents, there have been many strategies studied previously. These include affordable housing production strategies, preservation strategies, teneant protections and suppoprt, and asset building and local economic development (Chapple et al., 2017). There are multiple ways such as impact fees from the private housing market (Kim, 2011) and housing trust funds (Calavita and Grimes, 1992) are fiscal ways to create affordable housing. Taxing and land use controls are possible ways such as property tax exemptions for particular owners and integrate inclusionary housing requirements into zoning regulations to incentivize affordable housing development (Hickey 2014). Lastly, cities can invest and build up city-owned affordable housing on public land (Hickey and Sturtevant, 2015b). Due to the fiscal limitation, the supply of affordable housing might not catch up the displacement of vulnerable residents. Therefore, rent control would be a fisible approach in the short-term. The rent control allows vulnerable residents to stay at the existing neighborhood for relative stable and secure of tenure (Ellen and O’Flaherty, 2013). However, some studies found out rent control might reduce the the quality and quantity of rental units for relative low return on rents (Freeman and Braconi, 2004; Keating et al. 1998). Tenant protections and support limits landlords of having ‘just cause’ to do the further eviction on tenants (Winstead, 2006). Last but not least, it is important to support local economic development to vulnerable

residents. This way, the accumulation of fortune might increase the capacity of affording housing and living standard in gentrifed areas (Lester, 2009; Page-Adams and Sherraden, 1997).

6 CONCLUSION

The driving forces of gentrification might include public-sector investment in transit, upgrading of utilities and facilities, urban renewal and others, and such investments are positive in revitalising neighbourhoods and local businesses. However, the upgrading built enviornmnet will directly increase land rent and further lead to other indiret impacts such as the replacement of social classes, the increment of real estate price, the change of industrial activities, and the change of individuals' living behaviours and so on. This study attempts to explore the susceptibility of gentrification for different neighbourhoods through two phases of analysis in Taipei city, Taiwan. The first phase is to identify various stages (including early, mid, and late) of gentrification ny means of small sets of indicatos based on real estate value changes and demographic changes. During the first phase, the temporal and spatial patterns of gentrifictaion are analysed. The second phase applies principle component analysis (PCA) to explore social-economic indicators related to gentrification in various stages of genetrification. Overall, the outcome of the principal component analysis can help monitor changing conditions among various stages of gentrification and come up with appropriate public response to the negative impacts of gentrification.

7 REFERENCES

Anguelovski, I. (2016). From toxic sites to parks as (green) LULUs? New challenges of inequity, privilege, gentrification, and exclusion for urban environmental justice. Journal of Planning Literature, 31(1), 23–36.

Bates, L. K. (2013). Gentrification and displacement study: implementing an equitable inclusive development strategy in the context of gentrification. Urban Studies and Planning Faculty Publications and Presentations.

Betancur, J. J. (2011). Gentrification and community fabric in Chicago. Urban Studies, 48(2), 383-406.

Bonvalet, C., & Ogg, J. (2007). Ageing in inner cities the residential dilemmas of the baby boomer generation. International Journal of Ageing and Later Life, 2(2), 61-90.

Bourne, L. S. (1993). The demise of gentrification? A commentary and prospective view. Urban Geography, 14(1), 95-107.

Calavita, N., Grimes, K. (1992). The Establishment of the San Diego Housing Trust Fund: Lessons for Theory and Practice. Journal of Planning Education and Research, 11(3), 170-184.

Chapple, K., Loukaitou-Sideris, A., Waddell, P., Chatman, D., Zuk, M., & Ong, P. (2017). Developing a new methodology for analyzing potential displacement. Sacramento, CA: California Air Resources Board.

Crowder, K., & South, S. J. (2005). Race, Class, and Changing Patterns of Migration between Poor and Nonpoor Neighborhoods. American Journal of Sociology, 110(6), 1715-1763.

Davidson, M., and Lees, L. (2010). New-build gentrification: its histories, trajectories, and critical geographies. Population, Space, and Place, 16(5), 395-411.

Davidson, M., and Lees, L. (2005). New-build 'gentrification' and London's riverside renaissance. Environment and Planning A, 37(7), 1165-1190.

de Oliver, M. (2016). Gentrification as the appropriation of therapeutic 'diversity': A model and case study of the multicultural amenity of contemporary urban renewal. Urban Studies, 53(6), 1299-1316.

Ding, L., Hwang, J., & Divringi, E. (2016). Gentrification and residential mobility in Philadelphia. Regional science and urban economics, 61, 38-51.

Ellen, I. G., & O'Flaherty, B. (2013). Chapter 4. How New York and Los Angeles Housing Policies Are Different--and Maybe Why." In New York and Los Angeles: The Uncertain Future. New York: Oxford University Press.

Ellen, I. G., & O'Regan, K. M. (2011). How Low Income Neighborhoods Change: Entry, Exit, and Enhancement. Regional Science and Urban Economics, 41(2), 89-97.

Elliott-Cooper, A., Hubbard, P., & Lees, L. (2020). Moving beyond Marcuse: Gentrification, displacement and the violence of un-homing. Progress in Human Geography, 44(3), 492-509.

Engels, B. (1994). Capital flows, redlining and gentrification: the pattern of mortgage lending and social change in Glebe, Sydney, 1960-1984. International Journal of Urban and Regional Research, 18, 628-653.

Ezema, I. C., Opoko, P. A., & Oluwatayo, A. A. (2016). Urban regeneration through state-led, new-build gentrification in Lagos inner city, Nigeria. International Journal of Applied Environmental Sciences, 11(1), 135-146.

Freeman, L., Cassola, A., & Cai, T. (2016). Displacement and gentrification in England and Wales: A quasi-experimental approach. Urban Studies, 53(13), 2797-2814.

Freeman, L. (2005). Displacement or succession? Residential mobility in gentrifying neighborhoods. Urban Affairs Review, 40 (4), 463–91.

Freeman, L., & Braconi, F. (2004). Gentrification and Displacement New York City in the 1990s. Journal of the American Planning Association, 70(1), 39-52.

Fullilove, M. T. (2004). Root shock: How tearing up city neighborhoods hurts America, and what we can do about it. New York, NY: Ballantine Books.

Ghaffari, L., Klein, J. L., & Angulo Baudin, W. (2018). Toward a socially acceptable gentrification: A review of strategies and practices against displacement. Geography Compass, 12(2), e12355.

Glass, R. (1964). London: Aspects of Change. MacGibbon & Kee, London.

Hackworth J (2000) "The Third Wave." PhD dissertation, Department of Geography, Rutgers University.

Hamnett, C. (1991). The Blind Men and the Elephant: The Expla The Blind Men and the Elephant: The Explanation of Gentrification. Transactions of the Institute of British Geographers, New Series 16(2), 173–89.
Hayes, M. (2020). The coloniality of UNESCO's heritage urban landscapes: Heritage process and transnational gentrification in Cuenca, Ecuador. Urban Studies, 0042098019888441.
Hickey, R. and Sturtevant, L. (2015). Public Land & Affordable Housing in the Washington DC Region: Best Practices and Recommendations. http://washington.uli.org/wpcontent/uploads/sites/56/2015/02/ULI_PublicLandReport_Final020215.pdf.
Hickey, R. (2014). Inclusionary Upzoning: Tying Growth to Affordability. http://www.nhc.org/Inclusionary-Upzoning.pdf.
Hochstenbach, C. (2017). State-led gentrification and the changing geography of market-oriented housing policies. Housing, Theory and Society, 34(4), 399-419.
Hochstenbach, C., & Van Gent, W. P. (2015). An anatomy of gentrification processes: Variegating causes of neighbourhood change. Environment and Planning A: Economy and Space, 47(7), 1480-1501.
Hofmeister, B. (1993). Stadtgeographie, 6.neubearbeitete Auflage. Braunschweig: Westermann..
Keating, W. D., Teitz, M. B., & Skaburskis, A. (1998). Rent Control: Regulation and the Rental Housing Market. New Brunswick, N.J: CUPR/Transaction.
Kim, E. (2011). Mitigating Displacement Due to Gentrification: Tools for Portland, Oregon. Tufts University. http://www.oregonmetro.gov/sites/default/files/Mitigating_displacement_pdx_tools_Eunice_
Kim_2011.pdf.
Lees, L. (2008). Gentrification and social mixing: Towards an inclusive urban renaissance? Urban Studies, 45(12), 2449–2470.
Lees, L., Slater, T., & Wyly, E. K. (2008). Gentrification. New York: Routledge/Taylor & Francis Group.
Lester, T. W. (2009). Towards a Living Wage in the New Economy: The Politics and Economics of Building Labor Market Institutions at the Urban Scale." Ph.D., United States -- California: University of California, Berkeley. http://search.proquest.com/dissertations/docview/503636701/abstract/A5AD46F923A24F9EPQ/1.
Marcuse, P. (1985). Gentrification, abandonment, and displacement: Connections, causes, and policy responses in New York City. Washington University Journal of Urban and Contemporary Law, 28, 195–240.
McKinnish, T., Walsh, R., & White, T. K. (2010). Who Gentrifies Low-income Neighborhoods? Journal of Urban Economics, 67(2), 180–93.
Mehdipanah, R., Marra, G., Melis, G., & Gelormino, E. (2018). Urban renewal, gentrification and health equity: a realist perspective. The European Journal of Public Health, 28(2), 243-248.
Meskell, L. (2019). Heritage, gentrification, participation: Remaking urban landscapes in the name of culture and historic preservation. International Journal of Heritage Studies, 25(9), 996-998.
Owens, A. (2012). Neighborhoods on the rise: a typology of neighborhoods experiencing socioeconomic ascent. City Community, 11(4), 345-369.
Page-Adams, D., & Sherraden, M. (1997). Asset Building as a Community Revitalization Strategy. Social Work, 42(5), 423-434.
Phillips, M. (2004). Other geographies of gentrification. Progress in Human Geography, 28(1), 5-30.
Richardson, J., Mitchell, B., & Franco, J. (2019). Shifting neighborhoods: gentrification and cultural displacement in American cities. National Community Reinvestment Coalition.
Rigolon, A., and Németh, J. (2019). Toward a socioecological model of gentrification: how people, place, and policy shape neighborhood change. Journal of Urban Affairs, 41(7), 887-909.
Smith, N. (1979). Toward a theory of gentrification a back to the city movement by capital, not people. Journal of the American Planning Association, 45(4), 538-548.
Smith, N., and Williams, P. (1986). Gentrification of the City. New South Wales: Allen & Unwin.
Smith, N. (1998). Gentrification. In W. van Vliet (Ed.), The encyclopedia of housing (pp. 198–199). London, England: Taylor & Francis.
Smith, N. (2002). New globalism, new urbanism: gentrification as global urban strategy. Antipode, 34(3), 427-450.
Winstead, B. (2006). The Politics of Tenant Protections in Richmond, Califoria. Center for Community Innovation. http://communityinnovation.berkeley.edu/publications/Winstead- Politics-Tenant-Protections.pdf.
Zuk, M., Bierbaum, A. H., Chapple, K., Gorska, K., & Loukaitou-Sideris, A. (2018). Gentrification, displacement, and the role of public investment. Journal of Planning Literature, 33(1), 31-44.
Zuk, M., Bierbaum, A.H., Chapple, K., Gorska, K., Loukaitou-Sideris, A., Ong, P. & Thomas, T. (2015). Gentrification, displacement and the role of public investment: a literature review. In Federal Reserve Bank of San Francisco (Vol. 79).

🏆 *reviewed paper*

Factor Analysis for Land Value Index in Urban Areas Using Agent Analysis Indicator

Akira Ota, Junya Kobayashi, Toshiyuki Kaneda

(Doctor of Engineering Akira Ota, Tokyo City University, Tokyo, Japan, otaa@tcu.ac.jp)
(Master of Engineering Junya Kobayashi, Shimizu Corporation, Tokyo, Japan, junya_kobayashi@shimz.co.jp)
(Doctor of Engineering Toshiyuki Kaneda, Nagoya Institute of Technology, Nagoya, Japan, kaneda@nitech.ac.jp)

1 ABSTRACT

The factors affecting a land value index such as land assessments are important for the development and growth of urban areas. Ota and Kaneda (2018) conducted a comparative analysis of a land value index in the central Nagoya area of Japan and reported that the factor structure could be explained by three factors: distance from the nearest station as an accessibility factor; the concentration of neighborhood commercial and business uses as a facility volume factor; and the integration value of the entire area as an indicator of the street network centrality of the vis graph analysis of space syntax theory, or "VGA", as a space configuration factor.

In an urban area, a busy street's land value index is considered to be higher. The integration value of the VGA indicator, which represents the street network centrality as a space configuration, has been used as a busy street factor. However, high street network centrality is not always needed for a busy street. Therefore, it is a possible that simulating actual pedestrians from the space configuration is a stronger factor for a busy street than a high street network centrality. Simulating actual pedestrians from the space configuration can be conducted using agent analysis, or "AA."

In this paper, we examine a multiple regression model for the factors and a land value index of the Kanayama area of Nagoya City using a VGA indicator and then replacing the VGA indicator with the AA indicator as a new factor. By comparing the two models, we explore the potential for using the AA indicator as a land value index factor.

In conclusion, the global integration value of the VGA indicator was selected as a factor for a busy street with a multiple correlation coefficient of 0.750, a coefficient of determination of 0.562, and an Akaike information criterion (AIC) of 352.093 with a standard partial regression coefficient of 0.362 in the conventional factor structure. On the other hand, when the number of AA footprints (station occurrences) of the AA indicator was selected as a factor for a busy street, it had a multiple correlation coefficient of 0.830, a coefficient of determination of 0.689, and an AIC of 294.477 with a standard partial regression coefficient of 0.618 in the new factor structure. Thus, we discovered that replacing the VGA indicator with the AA indicator could significantly improve the land value factor structure model.

Keywords: space syntax, space configuration, land value, visibility graph analysis, agent analysis

2 INTRODUCTION

In considering urban development, it is important to understand the factors that contribute to the formation of land value. In the past, multiple regression models have been used to analyze these factors, namely, transportation accessibility (i.e., distance from the nearest station), facility volume (i.e., land use), and space configuration (i.e., accessibility to automobile traffic and street width) (Okubo, 1983). Subsequently, the UCL group explored space syntax (SS) theory and proposed visibility graph analysis (VGA), which quantifies the characteristics of a street network by introducing a fine grid and thus calculates indicators such as street network centrality, visible area, and land value. The factorial analysis of these indicators is described below. In this paper, these indicators are collectively referred to as VGA indicators. Ota and Kaneda (2020) examined the factors of land value indices before 1935 and after 1965, using as factor variable candidates the distance from the nearest Nagoya streetcar stop as accessibility, the concentration of neighborhood commercial business uses as the facility volume, and the VGA as the urban area form. The VGA indicator was adopted using statistical tests in two periods and its validity as a land value factor was confirmed. The analysis was conducted using a model of three groups of factors: space configuration, facility volume (land use), and transportation accessibility.

In an urban area, a land value index is considered to be higher for a busy street, and the integration value of a VGA indicator, which represents the street network centrality as a space configuration, has been used as a factor of a busy street. However, a high street network centrality is not always needed for a busy street.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Therefore, it is possible that simulating pedestrians in the space configuration is a stronger factor for a busy street than a high street network centrality. Simulating actual pedestrians from the space configuration can be done using agent analysis (AA).

The analysis using SS theory is not only VGA, but also AA using exosomatic visual architecture (EVA), which is a vision-driven agent simulation on a fine grid. Penn et al. (2001) applied AA to the spatial distribution of the number of pedestrians in a department store and reported a correlation coefficient (single correlation) of 0.75 between the number of pedestrians calculated by the AA indicator and the cross-sectional traffic volume of a grocery store. When considering the number of pedestrians as bustle, a busy street can quite possibly be a factor of the land value index. Using the AA indicator as an alternative to the VGA indicators as a factor of a land value index is promising, but no factor analysis of a land value index using the AA indicator has yet been conducted.

Therefore, in this paper, we use a multiple regression model for a land value index in the Kanayama district of Nagoya City, Japan using a VGA indicator and then construct a multiple regression model using the AA indicator instead. Comparing the two models and exploring the potential of the AA indicator as a factor for a land value index is the contribution that this study provides to the literature.

3 THEORETICAL BACKGROUND

In existing reports on the factor analysis of land value indices using VGA indicators, Min et al. (2007) conducted a single regression analysis of public land values using street network centrality as a VGA indicator and reported a single correlation coefficient of 0.750. Wang et al. (2010) conducted a multiple regression analysis of public land values with street network centrality as the VGA indicator and the floor-area ratio as a second factor and reported a multiple correlation coefficient of 0.692 for the model. Ota and Kaneda (2020) analyzed the factors forming a land value index pre-1935 and post-1965, using the global integration value (GIV) and the street network centrality as the VGA indicator. The multiple regression model for 1935 had a multiple correlation coefficient of 0.808, while the multiple regression model for 1965 had a multiple correlation of 0.807. The VGA indicator was adopted using statistical tests in the two periods, confirming its validity as a factor for determining land value.

In addition to Penn et al., Kaneda et al. (2020) compared the VGA and AA indicators for a factor analysis of the number of using an encounter survey and reported that the AA indicator model was superior to the VGA indicator model. In Japan, Zhang et al. (2019) conducted a correlation analysis between AA indicators and store rents and reported a single correlation of 0.491, confirming a low level of correlation.

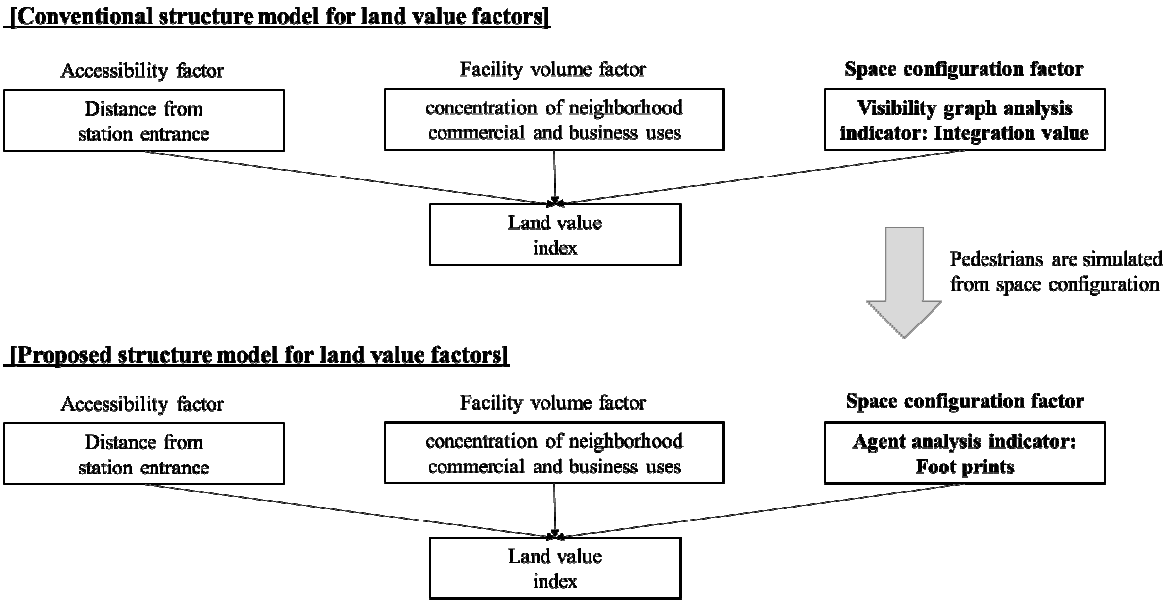


Fig. 1: Land value factor structure models

In a report using mobile phone location data as an alternative indicator for the number of pedestrians, Kaneda et al. (2022) conducted a comparative study using a model that replaced the number of pedestrians from the encounter survey with mobile phone location data and found no significant difference.

For a land value factor structure model, the distance from the nearest station is an accessibility factor, the concentration of neighborhood commercial and business uses is a facility volume factor, and the integration value of the entire area is an indicator of the street network centrality as a space configuration factor. However, the AA indicator, which actually simulates pedestrians from the space configuration is a stronger factor for a busy street than a high street network centrality. Therefore, a novelty of this study is that it creates a land value factor structure model that substitutes the AA indicator for the VGA indicator as a conventional factor, as shown in Fig. 1.

4 KANAYAMA DISTRICT OF NAGOYA CITY AND LAND VALUE INDEX AS AN OBJECTIVE VARIABLE

4.1 Overview of Kanayama District of Nagoya City

The scope of the Kanayama district in Nagoya City, Aichi Prefecture, which is the subject of this study, is based on the "Kanayama Station District Community Development Concept" (2017). Its scope and the distribution of its facilities are shown in Fig. 2. Kanayama Station, located in the Kanayama district, served approximately 440,000 passengers daily in 2016, with five train lines serving the area, making it the second-largest terminal station in Aichi Prefecture after Nagoya Station. The Kanayama area is characterized by public and cultural facilities such as the Kanayama Minami Building, Asnal Kanayama, and the Civic Hall.

To understand the regional characteristics of the target area, we calculated the total floor area according to use in the Kanayama district using geographic information system data from the "2011 Building Use Survey." For buildings with a total floor area of 10,000 square meters (m2) or more, the use of each floor was checked using the "2016 ZENRIN Residential Maps," and the figures were corrected. Residential uses totaled 234,301 m2 (36% of the total), office/school uses totaled 210,402 m2 (32%), commercial uses totaled 130,816 m2 (20%), accommodation uses totaled 39,189 m2 (6%), and cultural facilities totaled 39,157 m2 (6%). Residential use and office/school use each accounted for more than 30%, followed by commercial use. Therefore, the area is a mixed residential/commercial area.

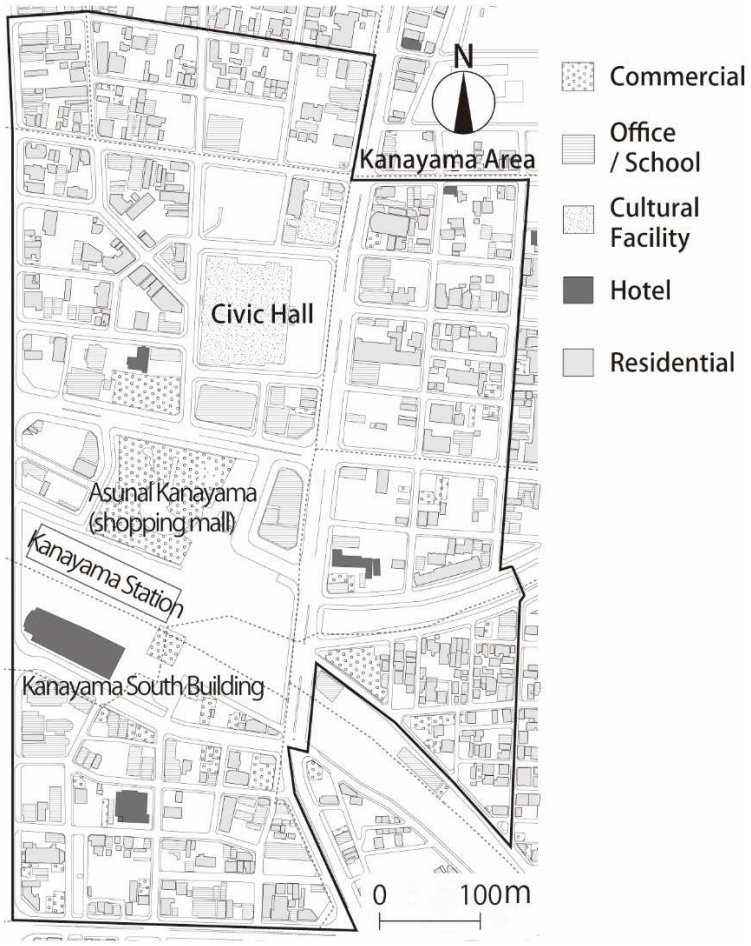


Fig. 2: Spatial distribution in the Kanayama district

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

4.2 Land Value Index as an Objective Variable

The land value index used roadside land value, which is the value per square meter (m) of standard land (i.e., 1,000 yen) facing a roadside used to evaluate land in areas in which roadside land values have been established. Roadside land values are the basis for calculating the taxable value of land for inheritance taxes and gift taxes and are considered the official land value indices published by Japan's National Tax Agency. In this study, roadside land values for 2016 were used.

A total of 178 streets in the target district were included in the study, but nine streets for which the land value index (i.e., road value) could not be obtained were excluded, resulting in a sample size of 169 streets.

5 FACTOR ANALYSIS OF THE LAND VALUE INDEX USING VISIBILITY GRAPH ANALYSIS INDICATORS

5.1 Methods of Factor Analysis Used in this Study

In this study, multiple regression analysis was conducted using data for 169 streets to factor the land value index from candidate variables belonging to three candidate factor groups: space configuration, facility volume (land use), and transportation accessibility. The first candidate factor (group), accessibility, is (X1) the distance from station entrances and exits. This is the shortest distance from a station entrance, of which there are eight in total, to the midpoint of the street in question. Four variables—(X2) the commercial floor-area ratio, (X3) office and school floor-area ratio, (X4) the hotel floor-area ratio, and (X5) the cultural facility floor-area ratio—are used to determine the quantity of facilities for the second candidate factor group.

5.2 Visibility Graph Analysis Indicators as Candidate Factor Variables

While the factor groups for accessibility and the quantity of facilities are straightforward indicators of the OD of the walking trip, i.e., the point of departure or arrival, the third candidate factor group, the space configuration factor group, is an indicator brought about by the form of space configuration. Here two VGA indicators, (X6) visible area and (X7) the GIV, which are urban morphology indicators, are provided as VGA indicators. The walking space to be analyzed includes not only the sidewalks and city blocks excluding the building site, but also the crosswalks between the roadways and passageways inside of stations in the building site. In this case, the roadways, the interiors of other buildings, and railroads are considered to be nonwalkable spaces. The visible area is calculated as the total number of all points visible from a given point. The integration value indicates the strength of spatial connectivity; if the value is high at a point, the point has less depth from its surroundings and is more central in space. This creation method follows Ota et al. (2021). In both cases, Depthmap X software was used and a 1-meter square grid was set up for the measurements.

Correlation coefficient / VIF	(Y) Land value index (JPY'000 /sqm)	(X1) Distance from station entrance (m)	(X2) Floor area ratio Commercial	(X3) Floor area ratio Office / School	(X4) Floor area ratio Hotel	(X5) Floor area ratio Cultural facility	(X6) Visible area	(X7) Global integration value	(X8)Density of AA footprints' flow (station generated)	(X9) Mobile phone location data (weekday)	(X10) Mobile phone location data (weekend)
(Y)Land value index (JPY'000 /sqm)		1.670	1.099	1.169	1.017	1.000	1.038	1.325	2.564	1.937	1.960
(X1)Distance from station entrance (m)	-0.634		1.286	1.122	1.023	1.001	1.000	1.044	1.504	1.441	1.428
(X2)Floor area ratio : Commercial	0.300	-0.472		1.034	1.095	1.003	1.005	1.000	1.171	1.160	1.171
(X3)Floor area ratio : Office / School	0.380	-0.329	-0.181		1.002	1.002	1.000	1.059	1.064	1.022	1.014
(X4)Floor area ratio : Hotel	0.130	-0.149	0.294	-0.048		1.024	1.007	1.002	1.001	1.016	1.011
(X5)Floor area ratio : Cultural facility	0.013	-0.036	-0.051	-0.042	0.154		1.128	1.020	1.006	1.002	1.002
(X6)Visible area	0.190	-0.017	-0.071	-0.006	0.085	0.337		1.237	1.018	1.003	1.005
(X7)Global integration value	0.495	-0.205	0.015	0.236	0.048	0.140	0.438		1.153	1.079	1.088
(X8)Density of AA footprints' flow (station generated)	0.781	-0.579	0.382	0.246	0.027	-0.080	0.132	0.364		1.846	1.985
(X9)Mobile phone location data (weekday)	0.696	-0.553	0.371	0.146	0.125	0.047	0.051	0.270	0.677		35.559
(X10)Mobile phone location data (weekend)	0.700	-0.548	0.382	0.119	0.102	0.045	0.069	0.284	0.705	0.986	

Table 1: Correlation coefficient and variance inflation factors between the land value index and candidate factor variables

We also added (X8) the density of AA footprint flow (station-generated), (X9) mobile phone location data for weekdays, and (X10) mobile phone location data for weekends as candidate factor variables.

5.3 Correlation Analysis for the Land Value Index and Candidate Factor Variables

Table 1 shows the correlation matrix (lower left half) and variance inflation factors (VIFs) (upper right half) for all of the variables used in this analysis.

Examining the correlations between the land value index and the candidate factor variables, the correlations with the land value index were high for (X8) density of AA footprint flow (station-generated) (0.781), and (X10) mobile phone location data for weekends (0.700), while the correlations with (X9) mobile phone location data for weekdays (0.696) and (X1) distance from station entrances and exits (−0.634), resulting in a slightly higher correlation with (X1).

The VIFs between each candidate factor variable were all less than 2, except for (X9) mobile phone location data for weekdays and (X10) mobile phone location data for weekends (35.559). Other than not using these candidate factor variables simultaneously, the prohibition for avoiding multicollinearity was not applied.

5.4 Examination of Selected Multiple Regression Models

Multiple regression analysis was conducted using seven candidate factor variables ranging from (X1) distance from station entrances and exits to (X7) the GIV. For multiple regression analysis, a model was selected that minimized the AIC using the stepwise variable increasing/decreasing method.

A four-variable model was ultimately selected (see Table 2). The multiple correlation coefficient was 0.750 (coefficient of determination of 0.562), and the AIC was 2,363.726. The variables adopted in the model are shown below, organized by accessibility, facility volume (land use), and space configuration, as follows: (X1) distance from station entrances and exits (standard partial regression coefficient: −0.452, first rank) as accessibility, (X3) office/school floor-area ratio (standard partial regression coefficient: 0.166, third rank) as facility volume, (X2) commercial floor-area ratio (standard partial regression coefficient: 0.111, fourth rank), and (X7) the GIV (standard partial regression coefficient: 0.362, second rank) as space configuration.

Multiple correlation coefficient : 0.750
Coefficient of determination : 0.562 AIC : 2,363.726

	Standard partial regression coefficient	Partial regression coefficient	t value	p value
Constant	—	105.319	0.847	—
(X1)Distance from station entrance	-0.452	-1.582	-6.721	0.000
(X7)Global integration value	0.362	205.688	6.732	0.000
(X3)Floor area ratio Office / School	0.166	0.407	2.736	0.007
(X2)Floor area ratio Commercial	0.111	0.539	1.735	0.085

Table 2: Results of factor analysis (multiple regression model selection) for the land value index using VGA indicators

6 FACTOR ANALYSIS OF THE LAND VALUE INDEX USING THE AGENT ANALYSIS INDICATOR

6.1 Overview of Agent Analysis and the Calculation Results

The pedestrian agent in the EVA has a 170-degree field of view centered on the direction of travel, and the area ratio of the segmented field of view is used to select the direction of travel. In this case, the pedestrian agent does not have an OD pair and acts only based on the obstacles in his or her field of view. For the agent onset condition, we used a selective onset in which the agent onset point and the agent onset ratio are determined in advance. In this study, the station is used as the point of the selection generated, so it is referred to as "station-generated." This simulation was conducted under the following conditions for the movement of agents and the generation of agents at the stations.

- Number of agents: 2,000.
- Agent movement distance: A uniform distribution between 0 and 1,500 m (average of 750 m).

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

- Points at which agent stations are generated: Eight entrances and exits at Kanayama Station.
- Ratio of agent stations: Results of a cross-sectional traffic survey (the amount of outflow from the station to the Kanayama area).

Each pedestrian agent is assumed to leave a footprint once per second in the walking space, and the indicator is the number of footprints per meter of street length in each street space after the simulation is completed. The units are (number/m) by definition. It can be seen that the larger the walkable space area and the closer to the station, the denser the walking trajectory. The reasons for this may be due to the behavioral characteristics of the agents and the influence of the agent's point of origin (see Fig. 3).

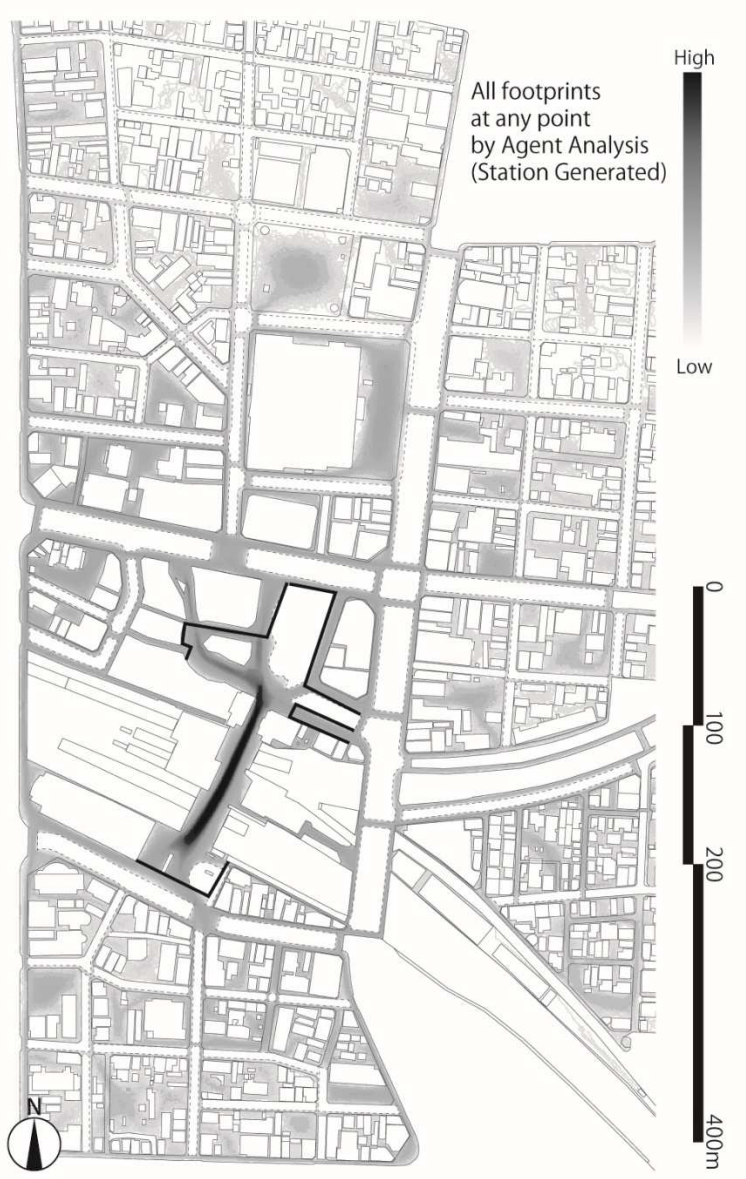


Fig. 3: Spatial distribution of the number of footprints (agent analysis, station-generated)

6.2 The Correlation Between the Land Value Index and the Agent Analysis Indicator

The correlation coefficient between the number of (X8) density of AA footprint flow (station-generated, per meter of street length) as an AA indicator and the land value index was 0.781, as shown in Table 1, confirming a high correlation between the two.

6.3 Factor Analysis Using the Agent Analysis (Station-Generated) Indicator

The same analysis was conducted for the land value index, replacing (X6) visible area and (X7) the GIV as the VGA indicator in the candidate factor variables with (X8) density of AA footprint flow (station-generated) in Table 3.

Multiple correlation coefficient : 0.830
Coefficient of determination : 0.689 AIC : 2,306.111

	Standard partial regression coefficient	Partial regression coefficient	t value	p value
Constant	—	446.506	7.772	—
(X8)Density of AA footprints' flow (station generated)	0.618	143.513	11.500	0.000
(X1)Distance from station entrance	-0.208	-0.729	-3.723	0.000
(X3)Floor area ratio Office / School	0.164	0.402	3.524	0.001
(X4)Floor area ratio Hotel	0.090	0.830	2.037	0.043

Table 3: Results of factor analysis (multiple regression model selection) for the land value index using the agent analysis (station-generated) indicator

As a result, a four-variable model was selected. The multiple correlation coefficient was 0.830 (coefficient of determination of 0.689), and the AIC was 2,306.111. Compared to the model in Section 3, the multiple correlation coefficient and the AIC both improved. As accessibility, (X1) distance from station entrances and exits (standard partial regression coefficient: −0.208, second rank), as facility volume (land use), (X3) office/school floor-area ratio (same: 0.164, 3rd rank), (X4) hotel facility floor-area ratio (same: 0.090, fourth rank), and (X8) density of AA footprint flow (station-generated) (same: 0.618, first rank) as space configuration, were adopted.

The variables were adopted from the accessibility, facility volume (land use), and space configuration groups without any missing variables and have the same structure as the model in Section 3. The strength of the AA (station-generated) indicator is greater than that of the VGA indicator based on the magnitude of the standard partial regression coefficient, which supports the validity of the AA (station-generated) indicator as a factor. It also exceeds the intensity of the accessibility indicator, which is the physical distance from the station ticket gate.

7 FACTOR ANALYSIS USING MOBILE PHONE LOCATION DATA

In this subsection, we conduct factor analysis by replacing the AA (station-generated) indicator, an explanatory variable, with mobile phone location data and compare the results against the analytical framework used in the previous section. The mobile phone location data is the main pedestrian flow data indicator obtained from the KDDI Location Analyzer (KLA) site, which is an extended estimation process based on the global positioning system location data obtained from the smartphone users of the Japanese mobile phone service company, KDDI, and official population statistics. The average values for weekdays and weekends were used for each day (5:00 a.m. that day until 29:00 a.m. the next day) from March 22, 2019 to March 21, 2020.

In the analysis using KLA mobile phone location data, a three-variable model for both weekdays and weekends (hereafter, the KLA model), the factors (X1) distance from station entrances and exits, (X3) office/school floor-area ratio, (X9) mobile phone location data for weekdays, or (X10) mobile phone location data for weekends were adopted. Table 4 and 5 show the results. A comparison of the VGA model and the AA model is shown in Table 6.

Multiple correlation coefficient : 0.783
Coefficient of determination : 0.613 AIC : 2,340.653

	Standard partial regression coefficient	Partial regression coefficient	t value	p value
Constant	—	492.787	7.622	—
(X9)Mobile phone location data (weekday)	0.508	0.001	8.741	0.000
(X1)Distance from station entrance	-0.282	-0.987	-4.628	0.000
(X3)Floor area ratio Office / School	0.213	0.523	4.152	0.000

Table 4: Results of factor analysis (multiple regression model selection) for the land value index using the mobile phone location data (weekday)

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Multiple correlation coefficient : 0.791
Coefficient of determination : 0.625 AIC : 2,335.345

	Standard partial regression coefficient	Partial regression coefficient	t value	p value
Constant	–	493.367	7.863	–
(X10)Mobile phone location data (weekend)	0.524	0.001	9.171	0.000
(X1)Distance from station entrance	-0.271	-0.950	-4.519	0.000
(X3)Floor area ratio Office / School	0.228	0.560	4.506	0.000

Table 5: Results of factor analysis (multiple regression model selection) for the land value index using the mobile phone location data (weekend)

	VGA model	AA model	KLA model (weekday)	KLA model (weekend)
Number of factor variables	4	4	3	3
Multiple correlation coefficient	0.750	0.830	0.783	0.791
Coefficient of determination	0.562	0.689	0.613	0.625
AIC	2,363.726	2,306.111	2,340.653	2,335.345

Table 6: Comparison of the visibilitty graph analysis model, the agent analysis model, and the KLA model

The AA model has the best multiple correlation coefficient (coefficient of determination) and AIC, followed by the KLA model for weekends, the KLA model for weekdays, and the VGA model. This supports the validity of the AA indicator as a factor for determining land value.

The high correlation coefficient of mobile phone location data with the number of AA footprints (station-generated) suggests the possibility of a model with a structure similar to that of Fig. 4, for example. Therefore, further study of the model structure should be conducted.

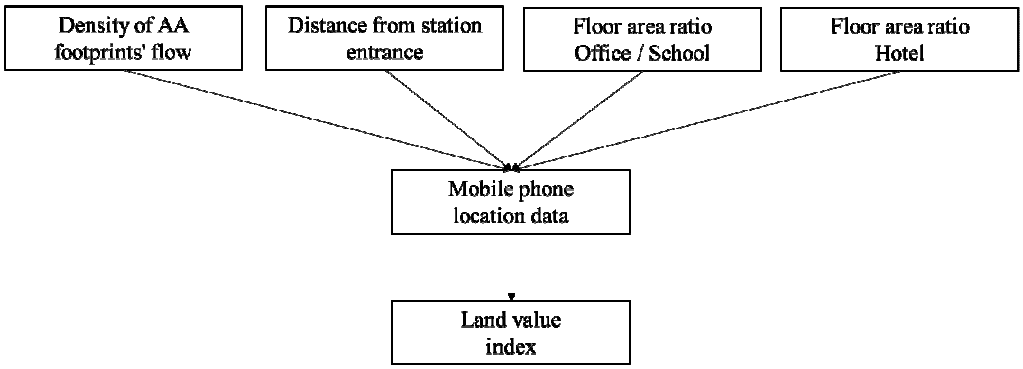


Fig. 4: Further consideration of the structure for a land value index as an example

8 CONCLUSION

In this paper, to explain the land value index in the Kanayama district of Nagoya City in Japan, we selected a multiple regression model with a VGA indicator and then compared it to a multiple regression model with an AA indicator instead. We also created a model using mobile phone location data instead of the AA indicator and compared the results.

In conclusion, the GIV of the VGA indicator is selected as a factor for a busy street with a multiple correlation coefficient of 0.750 (coefficient of determination of 0.562) and an AIC of 352.093 with a standard partial regression coefficient of 0.362 in the conventional factor structure with the VGA indicator. On the other hand, the number of AA footprints (station occurrence) of the AA indicator is selected as a factor for a busy street instead of the VGA indicator with a multiple correlation coefficient of 0.830 (coefficient of determination of 0.689) and an AIC of 294.477 with a standard partial regression coefficient of 0.618 in the new factor structure with the AA indicator. Thus, we discovered that replacing the VGA indicator with the AA indicator could significantly improve the land value factor structure model.

In addition, the model with the AA indicator was found to be superior than the model using mobile phone location data in terms of the multiple correlation coefficient, the coefficient of determination, and the AIC.

9 REFERENCES

Kaneda T., Ota A. and Kobayashi J. Study on Factor Analyses of Pedestrians' Spatial Distribution in Kanayama District, Nagoya - By applying Agent Analysis in Space Syntax studies -. In: Journal of Architecture and Planning (Transactions of AIJ), Vol. 85, No. 767, pp.121-129, 2020 (in Japanese)

Kaneda T., Ota A., Zhang Y. and Kobayashi J. Analyses of Factors for Busy Streets with Space Configuration Indicators. In: Proceedings of 13th International Space Syntax Symposium, 189, 2022

Min K., Moon J., Kim Y. The Effect of Spatial Configuration on Land Use and Land Value in Seoul. In: Proceedings of 7th International Space Syntax Symposium, 63, 2009

Okubo M.: Land Value and City Planning. Gakugei Shuppan-sha, 1983 (In Japanese)

Wang W., Using Land Value Map as an Alternative Approach to Analyze Urban Form: A preliminary Study. In: 17th Conference International Seminar on Urban Form, 2010

Ota A. and Kaneda T. A Comparative Study of Factors of Land Value Index by Space Syntax Measures in Nagoya CBD Between 1935 and 1965: Case Study on Nagoya Downtown Area During Pre- and Post-war Period. In: Downtown Dynamics: As Agent-Based Urban System, Toshiyuki Kaneda (eds.), pp.85-102 (Springer, 2020), 2020

Ota A., Takahashi H. and Kaneda T. Factor Analysis of the Rent Using Space Syntax Measures - Comparative Analysis by Building Use around the Shibuya Station -. In: Frontiers of Real Estate Science in Japan, Yasushi Asami, Yoshiro Higano, Hideo Fukui (eds.) , pp.237-257, (Springer, 2021), 2021

Penn, A. and Turner, A.: Space Syntax Based Agent Simulation, 1st International Conference on Pedestrian and Evacuation Dynamics, 2001

Town development planning division, City maintenance department, Housing and urban bureau, City of Nagoya: Kanayama ekisyuhen machizukuri kousou (Town development design around Kanayama station), 2017 (in Japanese)

Zhang Z., Ota A., Suge A., Kaneda T. and Takahashi H. Rental value analysis with an agent based simulation -A case study of Shimokitazawa-. In: 11th JSAI Special Interest Group on Business Informatics, 2019 (In Japanese)

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

🏆 *reviewed paper*

Gamification in der Regionalplanung: ein Ansatz zur Aktivierung formeller Planungsstrategien

Marvin Stiewing, Tobias Weber, Lena Fastner, Martin Berchtold

(MSc. Marvin Stiewing, Lehrstuhl Regionalentwicklung und Raumordnung, TU Kaiserslautern, Pfaffenbergstraße 95, 67663 Kaiserslautern, marvin.stiewing@ru.uni-kl.de)
(MSc. Tobias Weber, Lehrstuhl Regionalentwicklung und Raumordnung, TU Kaiserslautern, Pfaffenbergstraße 95, 67663 Kaiserslautern, tobias.weber@ru.uni-kl.de)
(BSc. Lena Fastner, TU Kaiserslautern, Pfaffenbergstraße 95, 67663 Kaiserslautern, fastner@rhrk.uni-kl.de)
(Jun.-Prof. Dr. Martin Berchtold, Digitalisierung, Visualisierung und Monitoring in der Raumplanung, TU Kaiserslautern, Pfaffenbergstraße 95, 67663 Kaiserslautern, martin.berchtold@ru.uni-kl.de)

1 ABSTRACT

„Fortschritt! Deiner Gemeinde gelingt die Ansiedlung eines führenden Unternehmens als Cash Cow. Spiele diese Karte, um eine beliebige weitere Karte abzulegen.“ Während formale Festlegungen und deren zugrundeliegenden Abwägungsprozesse, wie in der Planung üblich, abstrakt und für Laien wie politische Entscheidungsträgerinnen schwer verständlich sind, können spielbasierte Medien Sachverhalte kurz und dennoch prägnant darstellen. Dies gilt sowohl für die Funktionsweise der Raumplanung auf verschiedenen Ebenen und insbesondere die formelle Regionalplanung an sich, als auch für die tatsächlichen Folgen kommunaler Untätigkeit oder des Konterkarierens regionaler Festlegungen, wie in diesem Beitrag dargelegt.

Während Gamification in der Planung bereits seit Jahren diskutiert wird, sieht die Planungsrealität (noch) anders aus.[1] In diesem Beitrag werden die Probleme formeller Regionalplanung generell und am Beispiel der Region Stuttgart dargestellt. Bekannt als starke Wirtschaftsregion in Baden-Württemberg mit Global Playern wie Daimler, Porsche und Bosch, sieht sich auch die Region Stuttgart mit Herausforderungen für deren zukünftige Entwicklung konfrontiert, die sich im Großen und Ganzen als Wachstumsschmerzen zusammenfassen lassen. Es stehen sich Akteure der Regionalentwicklung, Bürgerinnen und politische Entscheidungsträger aus verschiedenen Kommunen in vielfältigen Konstellationen mit ihren Positionen und Motivationen gegenüber. Aufgrund der administrativen Kleinteiligkeit und des verbreiteten Konkurrenzdenkens wird die regionale Entwicklung durch inter-kommunale Spannungen, Stagnation durch saturierte „Wohlfühl“-Gemeinden sowie schlicht unsolidarisches öffentliches Handeln behindert. In diesem Zusammenhang sind auch verstärkte Phänome wie NIMBY („not in my backyard”) oder BANANA („built absolutly nothing anywhere near anbody”) zu nennen. Darüber hinaus stößt der formelle Regionalplan als räumliches Gesamtkonzept, das die funktionalen Zusammenhänge der Region integriert berücksichtigen und zwischen konkurrierenden Nutzungen vermitteln soll, häufig auf Unverständnis, Widerwillen oder gar Gegenwind – mit entsprechend negativen Folgen für die Akzeptanz und Wertschätzung der Inhalte. Auch wenn der Stuttgarter Regionalplan als starke Bremse fungiert und den Rahmen des Instruments durch restriktive Regelungen ausschöpft, stößt er dennoch an seine Grenzen, da er nicht in der Lage ist, die relevanten Akteure zu aktivieren und zum Handeln zu bewegen, um die wirtschaftliche Spitzenposition und Lebensqualität der Region zu halten. Es fehlt daher unter anderem an unterstützenden, persuasiven Instrumenten, um dessen Konzepte in politischen Entscheidungsprozessen überzeugend zu vermitteln.

In diesem Beitrag wird ein spielbasierter Ansatz für die oben skizzierte Problematik mit den Schwerpunkten Mediation, Konsultation und Integration in politische Entscheidungsprozesse, welcher im Rahmen eines Studienprojekts im Masterstudiengang „Stadt- und Regionalentwicklung“ an der Technischen Universität Kaiserslautern entwickelt wurde, vorgestellt. Das Kartenspiel richtet sich an Bürgerinnen sowie politische Entscheidungsträger der Kommunen an der Schnittstelle zur Regionalplanung und bietet eine Möglichkeit, regional relevante, aber schwer greifbare Sachverhalte wie politische Handlungsoptionen, planerische Grundsätze sowie gutes und schlechtes regionales Handeln verständlich darzustellen und für eine breite Zielgruppe herunterzubrechen. Dabei schlüpfen politische Entscheidungsträger in die Rolle von Gemeinden, um deren zukünftige Entwicklung zu bestimmen, wobei ihnen auf 60 illustrierten Karten die Folgen verschiedener (Nicht-) Handlungen und Trends aufgezeigt werden. Die sachlich bis humorvoll gestalteten Motive umfassen sowohl Erfolge und Rückschritte als auch einfache Stopp-, Sammel- und Aktionskarten. Ebenso wird aufgezeigt, in welchen Praxisfeldern das entwickelte Kartenspiel eingesetzt werden kann.

Keywords: Gamification, Regionalplanung, informeller Ansatz, Politische Entscheidungsträger, Kartenspiel

[1] vgl. SCHOLLES, Frank (2005): S. 326-333.

2 RAUMORDNUNG IN DEUTSCHLAND UND IN DER REGION STUTTGART

2.1 Das System der formellen Raumplanung in Deutschland

Das politisch-administrative System der Bundesrepublik Deutschland ist im Kern durch die Staatsprinzipien der Demokratie, der Rechts- und Sozialstaatlichkeit sowie des Föderalismus geprägt. Kennzeichnend für das System der Raumordnung in Deutschland ist daher die föderalistische Staatsordnung mit den Ebenen des Bundes, der 16 Länder und der Kommunen in 294 Landkreisen, rund 10.700 kreisangehörigen Gemeinden und 107 kreisfreien Städten. Berücksichtigt man dann noch, dass sich letztere auf 22 Landkreise und 111 Planungsregionen verteilen, lässt sich die Raumordnung in Deutschland als entsprechend dezentral und differenziert bezeichnen.[2] Die Kompetenz- und Aufgabenverteilung entspricht dabei einem System von drei rechtlich, organisatorisch und inhaltlich differenzierten Planungsebenen, die zugleich durch vielschichtige Mitteilungs-, Beteiligungs-, Abstimmungs- und Erfüllungspflichten sowie das für alle Ebenen geltende Gegenstromprinzip miteinander verknüpft sind und durch gegenseitige Rückkopplung und Anpassung gekennzeichnet sind. In mehreren Runden – teils verpflichtend, teils informell – werden weiterhin Träger öffentlicher Belange (z.B. Kommunen, Verbände, Behörden, Öffentlichkeit) und Fachplanungen (z.B. Verkehr, Natur und Landschaft, Energieversorgung) beteiligt.[3]

Während die Aufgabe der Bundesraumordnung vor allem in der Entwicklung von Leitbildern und Handlungsstrategien für die räumliche Entwicklung besteht, entwickelt die Landesplanung auf der Grundlage raumbedeutsamer Fachplanungen landesweite Raumordnungspläne, welche Grundsätze und verbindliche Ziele festlegen. Das umfassende, überörtliche und sektorenübergreifende Landesinstrument setzt die Planungsgrundsätze des Bundes sowie die Ziele und Grundsätze der Landesentwicklung um, einschließlich der Festlegungen zur angestrebten Siedlungs- und Freiraumstruktur, zur Sicherung von Standorten und Trassen der Infrastruktur und des Zentrale-Orte-Systems. Bund und Länder sind über die Ministerkonferenz für Raumordnung miteinander vernetzt.[4]

Die Regionalplanung, wie in diesem Beitrag thematisiert, hat die Landesentwicklungspläne für die einzelnen Teilräume der Länder durch regionale Raumordnungspläne als raumordnerisches Gesamtkonzept einer Region zu konkretisieren. Regionalpläne koordinieren dabei überörtliche Belange der Landnutzung über die Gemeindegrenzen hinweg[5]. Mehr noch, als mittelfristige Konzepte sollen sie die angestrebte Entwicklung einer Region für einen Zeitraum von zehn bis fünfzehn Jahren darstellen. Aufgrund ihrer Sandwichposition vermittelt die Regionalplanung nicht nur zwischen staatlicher und kommunaler Raumplanung sowie Fachplanungen[6], sie vertritt die allgemeinen Interessen einer Region gegenüber den Partikularinteressen der Kommunen[7]. Auf kommunaler Ebene erfolgt dann die Konkretisierung durch die Stadt- und Bauleitplanung als wesentliche Voraussetzung für die Realisierung von Projekten. Die Praxis der Regionalplanung variiert von Bundesland zu Bundesland, bedingt durch unterschiedlich ausgestaltete Planungsregionen, verschiedene Organisationsformen, eigene Landesplanungsgesetze oder die Regelmäßigkeit der Planerstellung und -fortschreibung.[8]

2.2 Regionalplanung in der Region Stuttgart

In der Region Stuttgart ist die zuständige Regionalplanungsbehörde der Verband Region Stuttgart (VRS) als eine von zwölf Regionalplanungsträgern in Baden-Württemberg. Seit 1994 vertritt dieser die Region auf politischer Ebene. Die Mitglieder der Regionalversammlung, des Parlaments, werden alle fünf Jahre von den Bürgerinnen bei den Regionalwahlen gewählt. An der Spitze stehen der ehrenamtliche Verbandsvorsitzende und der hauptamtliche Regionaldirektor. Mit dem Ziel, die Vielfalt, die Lebensqualität, die Mobilität und die wirtschaftliche Leistungsfähigkeit der Region zu sichern, arbeitet der VRS an einer zukunftsorientierten und nachhaltigen Entwicklung der Region. Als Pflichtaufgaben ist der VRS daher für die Regionalplanung mit Landschaftsrahmenplanung, Konzeption und Planung des Landschaftsparks Region Stuttgart, die regionale

[2] vgl. HENCKEL, Dietrich/PAHL-WEBER, Elke (2008): S. 13-39.
[3] vgl. TUROWSKI, Gerd (2005): S.895-898.
[4] vgl. HENCKEL, Dietrich/PAHL-WEBER, Elke (2008): S. 69-73.
[5] vgl. ebenda S. 73.
[6] vgl. PRIEBS, Axel (2018): S. 2051-2052.
[7] vgl. HENCKEL, Dietrich/PAHL-WEBER, Elke (2008): S. 73.
[8] vgl. PRIEBS, Axel (2018): S. 2051-2052.

Verkehrsplanung, den öffentlichen Personennahverkehr, das regionale Verkehrsmanagement, die regionale Wirtschaftsförderung, die Abfallentsorgung (teilweise) und das regionale Tourismusmarketing zuständig.

Der Regionalplan der Region Stuttgart besteht aus drei Teilen (Textteil, Raumnutzungs- und Strukturkarte), die im Jahr 2009 von der Regionalversammlung als Satzung beschlossen wurden. Langfristig soll die Region als prosperierender Wirtschafts- und attraktiver Lebensraum gesichert, indem die Infrastruktur zukunftsfähig erhalten, die Siedlungsentwicklung auf den öffentlichen Verkehr ausgerichtet und Flächen im Einklang mit den ökologischen und ökonomischen Bedingungen bereitstellt werden. Inhaltlich fokussiert der Plan dazu Ziele und Grundsätze, regionale Siedlungsstruktur, regionale Freiraumstruktur und regionale Infrastruktur.[9]

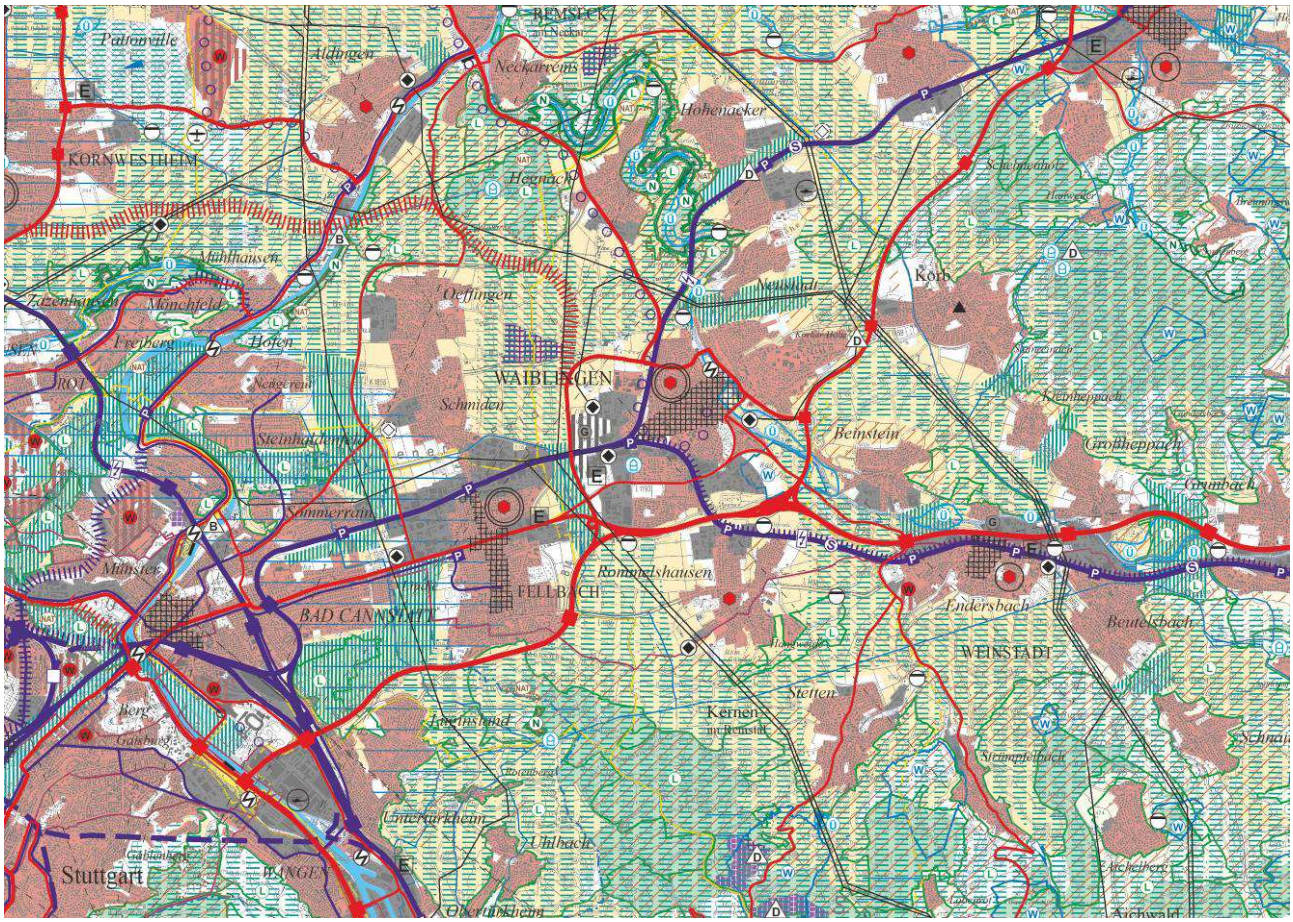


Abb. 1: Raumnutzungskarte des aktuellen Regionalplans Stuttgart (Auszug).[10]

2.3 Herausforderungen der Regionalplanung und der Region Stuttgart

Allgemeine Probleme der formellen Regionalplanung ergeben sich aus dem Regionalplan als umfassendes, aber auf Grund von Entwicklungs- und Abstimmungszeiten unflexibles Instrument. Wie skizziert, basiert die Regionalplanung auf gesetzlichen Anforderungen mit einem unterschiedlichen Grad an Abstimmung und integriertem Ansatz auf lokaler und überlokaler Ebene. Die Umsetzung der von Stadt- und Regionalplanung „gewünschten“ Siedlungsentwicklung variiert dabei auf kommunaler Ebene und ist abhängig von den kommunalen Selbstverwaltungen.[11] Während die Überzeugung der kommunalen Ebene für die Umsetzung regionalplanerischer Strategien daher wesentlich ist, besteht innerhalb der Regionalplanung eine große Heterogenität von Darstellungen und Plansymbolen, wobei selbst innerhalb desselben Bundeslandes Unterschiede auftreten.[12] Regionalplanerische Festlegungen sind daher nicht nur für Laien wie Bürgerinnen und politische Entscheidungsträger unverständlich[13], sondern generell ungeeignet für ein Verständnis des

[9] vgl. VRS (2009a): S. 9-14.
[10] VRS (2009b).
[11] vgl. STIEWING, Marvin/MANGELS, Kirsten/GROTHEER, Swantje (2020): S. 1-2.
[12] vgl. KISTENMACHER, Hans/DOMHARDT, Hans-Jörg/ALBERT, S./JACOBY, Christian et al. (2001): S. 79.
[13] vgl. TAINZ, Peter (1992): S. 369.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Sinnhaftigkeit der Planungsvorgaben[14]. Dies kann dazu führen, dass Ziele der Raumordnung nicht nur schwer wahrgenommen werden können, sondern auch die Umsetzung der Planinhalte behindert wird.[15]

Während die Ziele der Raumordnung zu einem restriktiven Charakter des Regionalplans führen, stellen die Grundsätze der Raumordnung zwar eine Absichtserklärung dar, entfalten aber keine Bindungswirkung auf der lokalen Ebene. Am Beispiel der Siedlungsentwicklung zeigen sich so die fehlende Inanspruchnahme von regionalplanerisch vorbereiteten und gesicherten Flächen sowie ein fehlendes Bewusstsein für den Mangel und eine unzureichende Übernahme von Verantwortung für die Schaffung von Wohnraum als Hemmnisse. Dabei ist der Einfluss der Raumordnung begrenzt – Gemeinden können nicht zur Ausweisung von Flächen gezwungen, sondern lediglich daran gehindert werden, Flächen an suboptimalen Standorten auszuweisen.[16] Die formellen Instrumente der Regionalplanung erweisen sich daher als wirksam, wenn es darum geht, die Wachstumsbestrebungen einzelner Gemeinden auf ein überörtlich akzeptables Maß zu begrenzen. Allerdings fehlt es ihnen an weiteren Durchsetzungsmechanismen, um regionale Vorgaben zur Umsetzung zu bringen.[17] Die Ausgestaltung und das Standing von Regionalplänen mit Unverständnis, Zweifeln, Widerwillen und gar Gegenwind einzelner Kommunen führen dazu, dass viele der integrierten Inhalte nicht ausreichend aktiviert werden oder Lenkungs- und Steuerungsfunktionen regionalplanerischer Festlegungen ohne Wirkung bleiben.

Mit Blick auf die Region Stuttgart ergeben sich, bedingt durch örtliche Gegeben- und Besonderheiten, weitere Herausforderungen. Zum einen zeigt sich eine hohe administrative Kleinteiligkeit mit oft nur unzureichender Kooperation innerhalb der Stadtregion. Vielmehr ist dagegen ein interkommunales Konkurrenzdenken um Wohn-, Gewerbe- und Erholungsflächen weit verbreitet. In diesem Zusammenhang ist auch ein verstärktes „NIMBY“- oder „BANANA“-Phänomen unter den Bürgern und damit indirekt auch den politischen Entscheidungsträgerinnen zu nennen. Regionale Handlungsbedarfe werden zwar mitunter erkannt, aber nicht unbedingt von den Bürgern und stellvertretend für sie handelnden Entscheidungsträgern mitgetragen. Entscheidungen sind daher in gewissem Maße von lokalpolitischen Erwägungen und dem Wohlwollen der Wählerschaft abhängig. Erschwerend kommt hinzu, dass die enge Fokussierung auf den eigenen Einflussbereich der Kommunen dazu führt, dass deren Rolle bei der Lösung des Wohnungsmangels oft nicht problemadäquat wahrgenommen wird.[18] Die strategische Entwicklung der Stadtregion als Ganzes wird so durch interkommunalen Wettbewerb, Stagnation „gesättigter“ Wohlfühlgemeinden und schlicht unsolidarisches Handeln einzelner Kommunen behindert.

Regionale Ansätze sind gerade im Hinblick auf die in der Region bestehenden Probleme notwendig, die sich aus der Funktion als Arbeitsmarkt-, Mobilitäts- und Dienstleistungsregion um das Zentrum Stuttgart ergeben. Zu nennen sind hier die zunehmende Verkehrsbelastung durch Pendler mit Nebeneffekten wie Smog oder Staus, die Wohnungsnot mit einem angespannten Wohnungsmarkt (insbesondere in städtischen Lagen) und die Notwendigkeit von Freiraum- und Klimaschutz in einem topographisch eingeschränkten, weitgehend verdichteten Siedlungsraum. Weitere Aspekte sind eine eingeschränkte wirtschaftliche Entwicklung durch fehlende Erweiterungsflächen für Gewerbe, Industrie und Umstrukturierungen sowie die Abwanderung von Fachkräften durch Wohnungsmangel und fehlende „Restflächen“ für kreative Milieus und Start-Ups. Darüber hinaus bietet die Konzentration auf die klassische Automobilindustrie ein Risiko im wirtschaftlichen Strukturwandel mit Blick auf Trends wie Nachhaltigkeit und Mobilitätswandel. Auch wenn der Regionalplan als starkes Hemmnis für Fehlentwicklungen wirkt und mit restriktiven Regelungen den rechtlichen Rahmen des Instruments ausschöpft, stößt er an seine Grenzen, da es ihm an der Fähigkeit fehlt, Inhalte zu aktivieren und durchzusetzen, um die wirtschaftliche Spitzenposition der Region zu halten. Auch der Einfluss des VRS als Institution und „Anwalt“ regionaler Interessen sowie dessen Bekanntheit bei den Bürgern sind begrenzt.

3 METHODIK UND ANSATZ

3.1 Projektdesign und Gamification als Strategie

Neben den restriktiven Vorgaben hat die Regionalplanung auch einen gesetzlichen Entwicklungsauftrag, um Formate der Information, Kooperation und Bewusstseinsbildung zu nutzen, um zu einem regionalen Konsens

[14] vgl. KEGEL, Ulrich (2006): S. 90-100.
[15] vgl. MÜLLER, Bernhard (1999): S. 244-245.
[16] vgl. STIEWING, Marvin/MANGELS, Kirsten/GROTHEER, Swantje (2020): S. 1-2.
[17] vgl. HEMBERGER, Christoph/KIWITT, Thomas (2018): S. 33-35.
[18] vgl. STIEWING, Marvin/MANGELS, Kirsten/GROTHEER, Swantje (2020): S. 3.

über künftige Entwicklungen zu führen. Die Stärkung der interkommunalen und regionalen Zusammenarbeit durch den Aufbau von Vertrauen ist dabei ein wesentlicher Aspekt und kann die klassischen Instrumente der Regionalplanung ergänzen. Notwendigkeit und Wirksamkeit solcher persuasiven Instrumente zur Beratung, Überzeugung und Konfliktmoderation werden in der Fachwelt daher bereits seit Jahren diskutiert.[19]

In diesem Beitrag wird daher ein am Beispiel der Region Stuttgart entwickeltes Kartenspiel als Ansatz zur Bewältigung der skizzierten Probleme. Die zuvor genannten Herausforderungen wurden im Rahmen eines datenbasierten Quick-Scans der Region Stuttgart, einer Kurzexkursion und Expertengesprächen vor Ort mit Vertretern des VRS identifiziert. Im Arbeitsprozess wurden dann je vier Handlungsfelder, Zukunftsszenarien und Potenzialkarten sowie ein Raumbild (siehe Abb. 2) und eine Wetterkarte zur Verdeutlichung räumlicher Dynamiken für die Region und ihre Teilräume erarbeitet. Um ein regionales Handeln der Kommunen zu etablieren, müssen die Probleme und Herausforderungen in der gesamten Region zunächst bekannt sein und Handlungsoptionen aufgezeigt und verstanden werden. Kommunalpolitikerinnen, Verwaltungen und Bürger sind daher aufgefordert, regional zu denken und entsprechend zu agieren.

Der Bedarf eines leicht verständlichen Mediums, um die gewonnenen Erkenntnisse über die Region und ihre Funktionsweise sowie die Inhalte des Regionalplans zu reduzieren, führte zur Konzeption des vorgestellten Spiels. Der methodische Ansatz basiert auf der Idee bildhafter, spielerischer Elemente anstelle klassischer Instrumente der Regionalplanung. Die Kommunikation unterschiedlicher kommunaler Perspektiven sowie die Erkenntnis, dass regionale Probleme nicht von einzelnen Kommunen allein gelöst werden können, soll so gefördert werden und die Entwicklung eines regionalen Bewusstseins und gegenseitigen Verständnisses dazu beitragen, kommunales Kirchturmdenken und interkommunale Konkurrenzen abzubauen. Auch wenn der Ansatz vor dem Hintergrund der Regionalplanung in Deutschland und den Herausforderungen der Region Stuttgart konzipiert wurde, kann er in Bezug auf die Thematik auch allgemein zur Anwendung kommen.

Abb. 2: Heterogenität an Strukturen, Mustern und Zusammenhänge im Raumbild der Region Stuttgart.

3.2 Regionales Kartenspiel als informeller Ansatz

Das entwickelte Spiel ist als niedrigschwelliges Medium dazu geeignet, planerische Prinzipien und die ihnen zugrundeliegenden Zusammenhänge sowie (politische) Optionen für gutes und schlechtes regionales Handeln für eine breite Zielgruppe herunterzubrechen. Es stellt damit ein Instrument dar, um regionale Grundsätze und Möglichkeiten in Bezug auf thematische Schwerpunkte zu verdeutlichen. Beim Spielen

[19] vgl. STIEWING, Marvin/MANGELS, Kirsten/GROTHEER, Swantje (2020): S. 3.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

schlüpfen Bürger und politische Entscheidungsträgerinnen in die Rolle von Gemeinden, um deren zukünftige Entwicklung zu lenken, indem ihnen auf 60 verschiedenen Bildkarten die verursachten Folgen verschiedener (Nicht-) Handlungen und raumwirksamer Trends aufgezeigt werden. Auf spielerische Art und Weise werden Prinzipien der oben skizzierten Aktivierungsstrategien verdeutlicht und Gemeinden zum Handeln motiviert, während unsolidarisches Handeln und Verstöße gegen regional abgestimmte Strategien sanktioniert werden. Die sachlich bis humorvoll gestalteten Spielkarten beinhalten sowohl (regionale) Erfolgs- und Rückschritt- als auch Verhinderungs-, Handels- und Aktionskarten, die verschiedene lokal-regionale Mechanismen und Umsetzungsbeispiele zu den vier Handlungsfeldern darstellen. Das Spielkonzept sieht vor, dass pro Spielerin sieben Karten verteilt und reihum abgeworfen werden, bis ein Spieler keine Karten mehr auf der Hand hat, um die Runde zu gewinnen. Die 60 Spielkarten des Spiels mit dem Titel „total regional“ sind unterteilt in

- 24 Sammelkarten in 4 Kategorien, die den zentralen Handlungsfeldern entsprechen,
- 3 Joker zur Komplettierung einer beliebigen Sammelkarte,
- 4 reguläre und 4 regionale Fortschrittskarten,
- 4 reguläre und 4 regionale Rückschrittskarten,
- 16 Aktionskarten von unterschiedlicher Bedeutung sowie
- 4 Auf-gar-keinen-Fall-Karten.

3.2.1 Fortschritt und Rückschritt – gutes und schlechtes regionales Handeln

Sowohl reguläre und regionale Fortschritts- als auch die entsprechenden Rückschrittskarten stehen für positive und negative Entwicklungen, die entweder einen Spieler als einzelne Gemeinde (regulär) oder alle Spielerinnen als gesamte Region (regional) betreffen (Siehe Abb. 3). Die Prinzipien veranschaulichen die Auswirkungen bestimmter Entwicklungen, die durch das Handeln der einzelnen Gemeinden beeinflusst werden, und schärfen das Bewusstsein für unterschiedliche Konsequenzen raumwirksamer Entscheidungen.

Wird eine reguläre Fortschrittskarte ausgespielt, wird die Spielerin am Zug (die eine einzelne Gemeinde in der Region repräsentiert) dadurch belohnt, dass sie zusätzlich eine beliebige andere Karte abwerfen darf und so dem Sieg im Spiel näherkommt. Beispiele sind die Ansiedlung eines wirtschaftsstarken Unternehmens als steuerliche „Cash Cow“ sowie die Auszeichnung mit einem Preis für hervorragende Freiraumgestaltung.

Wird dagegen eine reguläre Rückschrittskarte ausgespielt, kann der Spieler am Zug eine Spielerin seiner Wahl (die eine konkurrierende Gemeinde in der Region vertritt) durch Überreichen der Rückschrittskarte behindern. Die Karte muss dann im nächsten Zug der Spielerin abgeworfen werden und es muss eine Karte vom Stapel gezogen werden, Zudem darf keine weitere Aktion mehr durchgeführt werden. Beispiele sind die Auszeichnung für den schlechtesten öffentlichen Personennahverkehr der Region oder die Abwanderung gut ausgebildeter Fachkräfte auf Grund des Mangels an bezahlbarem Wohnraum.

Abb. 3: Beispielhaftes Set mit je einer Fortschritts- und Rückschrittkarte.

Regionale Fortschrittskarten haben dagegen einen stärkeren regionalen Bezug und belohnen nicht nur die einzelnen spielenden Gemeinden, sondern alle Spielerinnen und damit die Region als Ganzes. Von einem beliebigen Spieler ausgespielt, dürfen alle Spieler eine Karte ihrer Wahl ohne Auswirkung des Kartentyps abwerfen. Beispiele sind eine Region der kurzen Wege oder die Region Stuttgart als Pilotregion für innovative Verkehrssysteme und nachhaltige Mobilität.

Regionale Rückschrittskarten haben wiederum einen stärkeren regionalen Bezug und sanktionieren nicht nur die einzelnen spielenden Gemeinden, sondern alle Spieler und damit die Region als Ganzes. Gespielt von einer beliebigen Spielerin, müssen alle Spieler eine Karte vom Stapel ziehen. Beispiele sind ein regionaler Verkehrskollaps mit Stau, Smog und Feinstaubbelastung oder das Verpassen wirtschaftlicher Anpassungen im Strukturwandel durch die prägende Fokussierung auf die Automobilbranche.

3.2.2 Sammelkarten – gute Praxis in den Bereichen Wohnen, Wirtschaft, Mobilität und Freiraum

Unter Berücksichtigung aktueller Trends wie Mobilitätswandel, Notwendigkeit eines wirtschaftlichen Wandels, Wohnungsnot, demografischer Wandel und Klimawandel können die Themen Wohnen, Wirtschaft, Mobilität und Freiraum als zentrale Handlungsfelder benannt werden. Auf jeweils sechs Sammelkarten werden „Good Practices“ auf kommunaler Ebene dargestellt, um regionale Strategien und Problemlösungen maßstabsgerecht abzubilden (siehe Abb. 4). Sammelkarten dürfen generell nur paarweise als Kombination zweier Karten einer selben Kategorie abgelegt werden. Alternativ können im Sinne eines querschnittsorientierten Ansatzes auch vier Sammelkarten aus je einer Kategorie zum Ablegen gespielt werden. Inhaltlich veranschaulichen die Karten unter anderem

- die Ausweisung von neuem Bauland, die Nachverdichtung im Wohnungsbestand oder die Förderung des sozialen Wohnungsbaus,
- die Entwicklung interkommunaler Gewerbegebiete, die Beteiligung an Forschungsclustern oder die Förderung innovativer Existenzgründungen,
- den Ausbau von Fahrrad-, öffentlichen und alternativen Verkehrsinfrastrukturen, die Verbesserung des Modal Splits oder die Förderung des Prinzips der kurzen Wege sowie
- die qualitative und quantitative Gestaltung von Freiräumen, Maßnahmen zur Klimaanpassung oder die Entsiegelung versiegelter Flächen.

Abb. 4: Beispielhaftes Set mit je einer der 24 Sammelkarten

3.2.3 Aktionskarten – unterhaltsame Elemente mit wissenschaftlichem Hintergrund

Zur Veranschaulichung lokal und regional bedeutsamer Prinzipien und Trends als institutioneller Rahmen sowie zur Auflockerung des Spielablaufs wird das Set durch 16 Aktionskarten in neun Kategorien ergänzt, die eine zusätzliche Sensibilisierung für regionale Zusammenhänge und die Verknüpfung von Region und Gemeinde vermitteln.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Als Prinzipien und Mechanismen wirken unter anderem Gemeindepartnerschaften, Förderprogramme und ein Ressourcentausch, um positive Aspekte interkommunaler Zusammenarbeit und regional verträglicher Strategien zu betonen. Kommunales Kirchturmdenken, Zwangsfusion von Gemeinden, Kommunalaufsicht, Abstimmung der Regionalversammlung und gemeinsame Gebietsreform verdeutlichen dagegen interkommunale Konkurrenzen und Sanktionen durch staatliche Institutionen. Beispiele für deren Konsequenzen im Spiel sind das gemeinsame Ablegen oder das Ziehen von Karten, das Aussetzen für eine Runde oder die Neuverteilung aller Spielkarten im Spiel.

Abb. 5: Beispielhaftes Set mit 4 der 16 Aktionskarten.

3.2.4 Auf gar keinen Fall! – NIMBY als Kernpunkt der Raumplanung

In Anlehnung an die Planungsrealität unterliegen (fast) alle skizzierten Spielaktionen der Veto-Option der Öffentlichkeit, indem eine der vier Auf-gar-keinen-Fall-Karten ausgespielt wird. Da auch in der Realität die Meinungen der Bürgerinnen, Politiker und Parteien in den verschiedenen Gemeinden auseinandergehen, kann die Auf-gar-keinen-Fall-Karte selbst durch eine andere Auf-gar-keinen-Fall-Karte eines beliebigen Mitspielers aufgehoben werden. Als einzige Ausnahme sind sowohl reguläre als auch regionale Rückschritts- und Fortschrittskarten vom Veto ausgeschlossen, da sie jeweils eine große Bedeutung für die Region als Ganzes haben und in der Realität unvermeidlich sind.

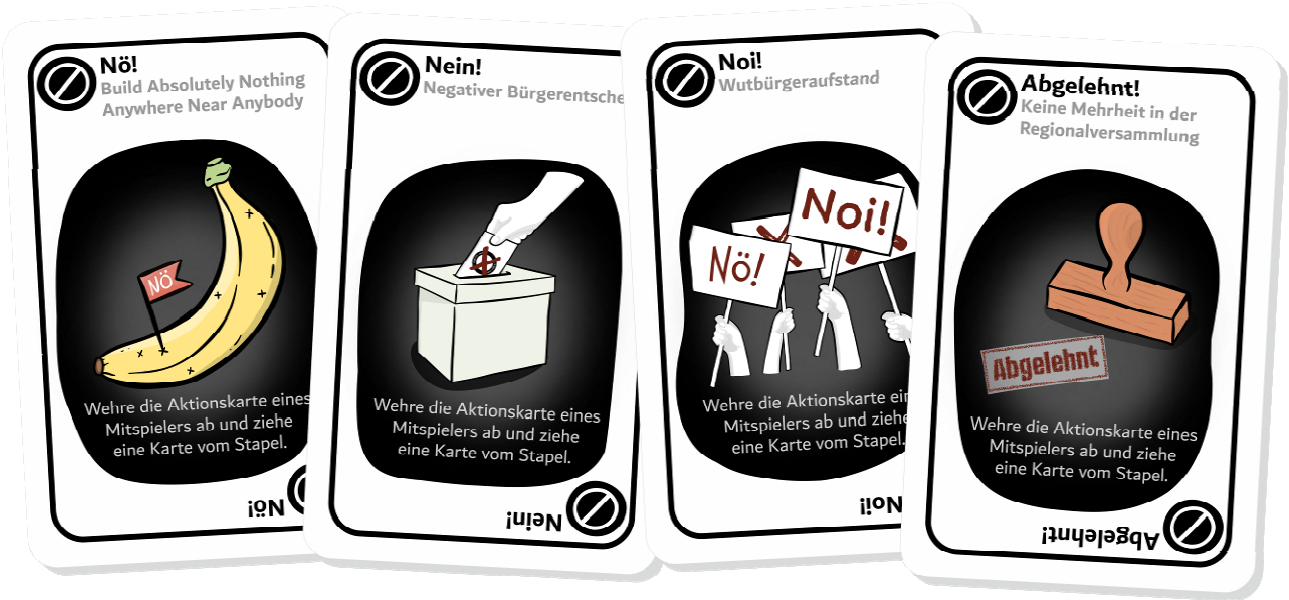


Abb. 6: Set der 4 Stoppkarten

Inhaltlich sind die Auf-gar-keinen-Fall-Karten an bestehende Verhinderungsmechanismen wie das NIMBY- oder BANANA-Phänomen unter Bürgern, Volksabstimmungen, Demonstrationen sowie fehlende politische Unterstützung innerhalb der Regionalversammlung geknüpft. Indem sie im Spiel die Aufmerksamkeit auf diesen entscheidenden Aspekt der Planung lenken, sind die Auf-gar-keinen-Fall-Karten also geeignet, einen entsprechenden Erkenntnisgewinn bei den Akteuren zu erzielen und zum Überdenken eigener Denk- und Verhaltensweisen anzuregen.

4 FAZIT UND AUSBLICK

Raumordnung und im Besonderen Regionalplanung in Deutschland erweist sich als sehr formal, dezentral und nach Regionen und Kommunen differenziert. Der Verband Region Stuttgart als einer der gut vernetzten, innovativen Regionalverbände ist dabei angesichts der gesetzlichen Möglichkeiten der Regionalplanung als starker politischer Akteur in der Region zu nennen. Gleichwohl gibt es im Hinblick auf die bestehenden bzw. sich aktuell ergebenden Fragestellungen und Herausforderungen zunehmend Bereiche, in denen die formelle Regionalplanung mangels Umsetzungskompetenzen nicht zielführend agieren kann. Daraus ergibt sich zwangsläufig ein Bedarf an informellen Begleitinstrumenten mit aktivierendem Charakter, die sich sowohl an Bürgerinnen als auch an kommunalpolitische Entscheidungsträger unterschiedlicher Ausrichtung und Motivation in der Region richten.

Wie dargestellt, bietet ein spielbasierter Ansatz ein vielversprechendes, niedrigschwelliges Medium im informellen Bereich, insbesondere für Nicht-Fachleute oder solche Akteure, die der Regionalplanung skeptisch gegenüberstehen. Durch die vereinfachte, spielerische Auseinandersetzung mit regionalen Themen können die Akteure einen Erfahrungs-, Verständnis- und Vertrauenszuwachs in Bezug auf politisches Handeln und formale Regelungen in der Planung gewinnen. Außerdem werden sie zur Zusammenarbeit und zum gemeinsamen Handeln angeregt. Das Ausprobieren, Kennenlernen und Erleben von themenspezifischen Handlungsoptionen und regionalen Steuerungsprinzipien soll zum einen Spaß an der Auseinandersetzung mit regionalen Themen vermitteln und zum anderen bei den Spielern zumindest unbewusst einen Lerneffekt auslösen.

Wesentliche Zielgruppen lassen sich anhand von drei zentralen Anwendungsfeldern identifizieren. Zum einen kann das Spiel als Kommunikationsmedium dienen, das über die Zusammenführung der Kommunen hinaus einen weiteren Austausch zwischen der regionalen und kommunalen Ebene ermöglichen soll. Als relevante Stakeholder sind hier neben den lokalen Raumordnungsbehörden die bereits erwähnten politischen Entscheidungsträger in den Kommunen, wie Landräte, ehren- und hauptamtliche Bürgermeisterinnen sowie häufig auch Nicht-Fachleute zu nennen. Zweitens können spielbasierte Medien im Bereich der planerischen und politischen Bildung eingesetzt werden, und zwar sowohl bei Studierenden und praktizierenden Fachleuten der Planung als auch bei kommunalen Entscheidungsträgern im Rahmen von Ratsklausuren oder Workshops. Langfristig ist der Ansatz zudem im Rahmen von Partizipationsprozessen unterschiedlicher Art denkbar, etwa als Baustein der Erarbeitung von regionalen Raumordnungsplänen oder bei der Beteiligung von Bürgerinnen und lokalen Initiativen.

5 DANKSAGUNG

Wir bedanken uns bei Antonia Dürig vom Fachgebiet dvmP der Technischen Universität Kaiserslautern für die kollegiale Zusammenarbeit sowie bei Thomas Kiwitt und Dr. Christoph Hemberger vom Verband Region Stuttgart für den fachlichen Austausch und die finanzielle Unterstützung im Rahmen des Projekts.

Im Rahmen dieses Beitrags wurden zur besseren Lesbarkeit bewusst abwechselnd weibliche und männliche Formen oder beide Formen zusammen verwendet. An einigen Stellen wird das generische Maskulinum als geschlechtsneutrale Schreibweise benutzt. Selbstverständlich sind damit ausdrücklich auch alle Menschen angesprochen, die sich nicht dem binären Geschlechtssystem zugehörig fühlen.

6 LITERATURVERZEICHNIS

FASTNER, Lena/HENZEL, Maximilian/RETTKOWSKI, Dominik/STIEWING, Marvin/WEBER, Tobias: Eine Region auf der Suche nach dem Gaspedal. Raumbilder für die Region Stuttgart. Kaiserslautern, 2021.

HEMBERGER, Christoph/KIWITT, Thomas: Gute Bremsen, aber kein Gaspedal! Zur Koordinationswirkung der Regionalplanung. In: Akademie für Raumforschung und Landesplanung (ARL) (Hrsg.): Nachrichten der ARL, 01/2018, S. 33-55. Hannover, 2018.

HENCKEL, Dietrich/PAHL-WEBER, Elke: The Planning System and Planning Terms in Germany. A Glossary. Hannover, 2018.

KEGEL, Ulrich (2006): Neue Planungsprozesse für die Regionalplanung. In: SELLE, Klaus (Hrsg.): Praxis der Stadt- und Regionalentwicklung. Analysen. Erfahrungen. Folgerungen. (Planung neu denken, 2.), S. 90-100. Dortmund, 2006.

KISTENMACHER, Hans/DOMHARDT, Hans-Jörg/ALBERT, S./JACOBY, Christian et al.: Schlanker und effektiver Regionalplan. Praxisuntersuchung und Expertise zur Harmonisierung von Festlegungen in regionalen Raumordnungsplänen auf Grundlage des Raumordnungsgesetzes. Endbericht (Forschungen Bundesamt für Bauwesen und Raumordnung, 101). Bonn, 2001.

MÜLLER, Bernhard: 4.2 Regionalpläne. In: AKADEMIE FÜR RAUMFORSCHUNG UND LANDESPLANUNG (ARL) (Hrsg.): Grundriss der Landes- und Regionalplanung, S. 229-249. Hannover, 1999.

PRIEBS, Axel: Regionalplanung. In: Akademie Für Raumforschung Und Landesplanung (ARL) (Hrsg.): Handwörterbuch der Stadt- und Raumentwicklung. Ausgabe 2018, S. 2047-2062. Hannover, 2018.

SCHOLLES, Frank: Planspiel. In: FÜRST, Dietrich/SCHOLLES, Frank (Hrsg.): Handbuch Theorien + Methoden der Raum- und Umweltplanung, S. 326-333. Dortmund, 2005.

STIEWING, Marvin/MANGELS, Kirsten/GROTHEER, Swantje: Wohnungsnot und Siedlungsentwicklung in wachsenden Metropolregionen. Planspiel für politische Entscheidungsträgerinnen und Entscheidungsträger. In: SCHRENK, Manfred et al. (Hrsg.): REAL CORP 2020 „Shaping urban change – Livable City Regions for the 21rst century“, conference proceedings 15-18 September 2020, S. 1019-1029. Wien, 2020.

TAINZ, Peter: Kartographische Zeichen und ihre Beziehung zur Wirklichkeit. In: BROGIATO, Hans Peter/CLOSS, Hans Martin (Hrsg.): Geographie und ihre Didaktik. Festschrift für Walter Sperling. Teil 2: Beiträge zur Geschichte, Methodik und Didaktik von Geographie und Kartographie (Materialien zur Didaktik der Geographie, 16), S. 363-372. Trier, 1992.

TUROWSKI, Gerd: Raumplanung. In: Akademie für Raumforschung und Landesplanung (ARL) (Hrsg.): Handwörterbuch der Raumordnung, S. 895-898. Hannover, 2005.

VERBAND REGION STUTTGART (VRS): Regionalplan Stuttgart. Stuttgart, 2009a.

VERBAND REGION STUTTGART (VRS): Regionalplan Stuttgart. Raumnutzungskarte. Stuttgart, 2009b.

🏆 *reviewed paper*

Geographic Proximity between Older Adults and Adult Children in Flanders (Belgium)

Wesley Gruijthuijsen, Chidi Nweke, Dominique Vanneste

(MSc. Wesley Gruijthuijsen, KU Leuven, Division of Geography and Tourism, Celestijnenlaan 200E, 3001 Heverlee, Belgium, Wesley.gruijthuijsen@kuleuven.be)
(MSc. Chidi Nweke, KU Leuven, Division of Geography & Tourism, Celestijnenlaan 200E, 3001 Heverlee, Belgium, chidi.nweke@kuleuven.be)
(Prof. Dr. Dominique Vanneste, KU Leuven, Division of Geography and Tourism, Celestijnenlaan 200E, 3001 Heverlee, Belgium, Dominique.vanneste@kuleuven.be)

1 ABSTRACT

Most European countries do not only prioritise policies focused on ageing-in-place, but also re-emphasise the role of informal caregiving which, in reality, is mostly provided by children. Thereby it is often overlooked that organising informal care at home gives rise to complicated and multilayered negotiations between people and their home environments. Distance can be seen as one of the decisive factors regarding informal caregiving. At least, international literature suggests that distance between older parents and adult children (still) matters in receiving and providing informal care, which was further highlighted during the pandemic in which some countries forbid non-essential travel outside the neighbourhood (incl. informal caregiving and support). Altogether, not much is known about the geographic proximity between older adults and adult children. We aim to contribute to the discussion regarding the impact of geographic proximity to provide or receive informal care in the context of a policy of ageing-in-place and the socialisation of care. To realise this, we calculate distances between parents (65+, living in Flanders) and adult children (across Belgium) based on the national population register of Belgium, using a cohort study for the period between 2002 and 2017. We researched ways in which physical distances differ across several dimensions, such as the number of children, age, gender and civil status. Although we found that older adults and adult children in Flanders in general live close by, there are signs pointing to an increase in geographical distance over time, potentially challenging the possibility to age-in-place and to negotiate informal care, while a differentiation of the pattern can be recognised according to dimensions mentioned above.

Keywords: geographic proximity, informal care, distance, Ageing-in-place, residential movements

2 INTRODUCTION

The spatial dimension is often neglected in research focusing on ageing, especially when it comes to the role of the neighbourhood and the home, the availability of informal care (from family and neighbours) and the importance of distance between care givers and care receivers, insight into residential movements, and all of this with regard to the wishes and needs of the older population when it comes to ageing-in-place. For that reason we set-up an interdisciplinary research project (started in 2019) trying to disentangle the concept of ageing-in-place from the perspective of geography, architecture and social sciences (gender studies). From the perspective of geography we focus on age-friendly cities and neighbourhoods (with an emphasis on the quality of public spaces and facilities, especially important for older residents) and the importance of geographical distance between older adults and children. The issue of geographic proximity, and how this influences informal caregiving, is one of the main research concerns of this analysis, trying to generate answers from quantitative and qualitative approaches (mixed-method). This paper explores the quantitative results, focusing on physical–geographical distances between older adults and their (adult) children and how they shifted over time (2002- 2017). Therefore it offers insights into geographic proximity between older adults and their children, but also into the importance of factors such as age, marital status and urbanisation. We focus on the situation of older adults (65+) in 2002 and 80+ in 2017, to see if there are large changes within that specific cohort. For doing so, we were provided by Statbel (the National Statistical Agency of Belgium) with the (anonymous) individual records of all 65+ in 2002 (in Flanders) and data on their children as far as they live in Belgium (in total n= 2.344.145) and the situation of this cohort 15 years later (2017). It is important to stress that this research is not based on a sample but takes the full population into account. This is in contrast with most research into geographical distances which is either based on the Survey of Health, Ageing and Retirement in Europe (e.g. Hank, 2007; Bonsang, 2009; Isengard, 2013; Brandt et al., 2019) or national panels (e.g. Michielin & Mulder, 2007; Van Diepen and Mulder, 2009). More on the complex methodology, taking into account the high volume of data, can be found in the methodology section. Before that a short literature review on ageing-in-place, socialisation of care and the role of distance

is provided, mainly to clarify some concepts. The result section is largely supported by figures. All of these figures are based on extended computer analysis after cleaning the database and offer a brief overview of geographical proximity between parents and children.

3 AGEING-IN-PLACE AND THE SOCIALISATION OF CARE

Ageing in place is the wish of most older people (e.g. Wiles et al., 2012; Costa-Font et al., 2009). Smetcoren et al. (2014) stress for example -based on the Belgian Ageing Studies- that the majority of older people in Flanders (northern, Dutch speaking region of Belgium) have a positive attitude towards independent living in their own dwelling (ageing in place). In contrast to this, less than 5 percent of the older people hold a positive attitude to either moving to a residential care setting (elderly home) or to live with their children. It's therefore not surprising that the majority of older people do not want to move out of their home or home environment. Myncke & Vandekerckhove (2007) show – based on research in Belgium - that more than 70 percent of the older people who are confronted with mobility or physical constraints are still not willing to move to another dwelling. Of course, when the home and the neighbourhood are adjusted and offer a supportive environment to get old, ageing in place can indeed be ideal. However, only 1 out of 2 older people is willing to move when the home is not longer adjusted to their needs (Flemish senior council, 2018), while other international research shows that the willingness for home modifications or adjustments to age-in-place are rather low (e.g. Peek et al., 2016) or blocked by reluctant landlords. This certainly results in challenges when ageing in for example urban or deep rural environments characterised by many old buildings (De Decker & Volckaert, 2020).

Further, the neighbourhood plays a decisive role as well. Even when the home is adjusted, an unsupportive neighbourhood, both in terms of age-friendly public space and the availability of amenities and (in)formal care, will often not lead to what Golant (2015) describes as residential normalcy. The opposite can be true as well, as older people often express a strong attachment to (intangible) neighbourhood features (Van Hees et al., 2017), which can be a reason not to move and stay in the current dwelling, even if the latter shows important shortcomings. In fact when neighbourhoods experience major shifts such as gentrification which can compromise the way of living and affect supporting networks, ageing in place is the preferred option (Versey, 2018). Golant (2015) stresses that reaching residential normalcy is often a (personal) balancing act whereby some positive aspects can offset other negative aspects, which are perceived differently by each person. There is currently a lack of insight in factors contributing to age-friendly environments (e.g. Scharlach, 2017) and the living environment and immediate neighbourhood (meso) are often factors forgotten in research about ageing, in which most attention goes to macro-economic (e.g. health-care expenses, pensions etc.) or micro-economic factors (income, pension etc.) (Greenfield et al., 2019). The trade-off between these factors and e.g. distance to informal care givers is very unclear as well.

Ageing-in-place is not only the wish of the majority of the older population, it is also facilitated and stimulated by most governments in Europe. Moreover, the policy regarding ageing-in-place is often combined with a larger emphasis on informal care giving, the so-called socialisation of care, emphasising that care is a shared responsibility between the family, the community and the government (e.g. Dermaut et al., 2019), often a consequence of austerity measures or to safeguard the long-term financial sustainability of the healthcare system. However, this can lead to what Agotnes et al. (2018) describe as a 'limitless and extensive concept' of voluntarism that blurs the boundaries of informal care. Zigante (2018) stresses that especially in countries with a well-developed formal (home) care sector (e.g. Scandinavia & the Netherlands, Belgium) this means a shift towards the re-familiarisation of care. Dobner et al. (2014) stress by comparing experiences of older adults in Amsterdam (long tradition of state provision of care) and Portland (tradition of individual responsibility and community culture), that a renewed focus on informal care and cutbacks in formal care provisions are not automatically compensated by community initiatives in places with a long tradition of state provision of care. In other words, it is not sure if enough informal (family) care can be safeguarded in the long run. Even if formal care supply is partly substituted by (intensive) informal care (e.g. UK; Zigante et al., 2020) the supply of informal family care to parents cannot follow the demand. For the UK, Pickard (2013) estimates a shortage in informal caregivers of 160,000 by 2032.

From the literature it becomes clear that there is a strong correlation between providing informal care to parents and distance (e.g. Hank, 2007). It is often assumed that geographical distances between family members, and parents and children in particular, are becoming larger as a consequence of 'mobile societies'

(Urry, 2000). Societal tendencies as globalisation and increased mobility also challenge concepts of 'home' and 'away' (ibid.) and challenge the concept of ageing-in-place (Buffel et al., 2018). Furthermore we also have to consider the local structure of settlements which can influence the age-friendliness of environments and possibilities regarding ageing-in-place. Belgium for example has the second highest level of urban sprawl in Europe (EEA, 2016), which brings challenges to (public) service provisions such as home care and goes together with substantial extra costs (Wauters et al., 2021). This might affect also the possibilities of ageing-in-place (with home care), simply because this situation might not be financially sustainable in the future.

4 GEOGRAPHICAL DISTANCE BETWEEN PARENTS AND CHILDREN AND INFORMAL CAREGIVING

Sometimes, we are not aware that most care in Europe is informal care. Eurocarers (2021) estimates that 80% of all long-term care is provided by informal care givers (ranging from family members to friends and neighbours). As mentioned before, there are signals that increased pressure and emphasis on informal care due to cutbacks in professional care can potentially lead to a shortage of caregivers (e.g. Van Broese Groenou & De Boer, 2016). Spouses are often seen as the most important source of informal care and support, often followed by adult children (e.g. Pinquart et al, 2011; Van der Pers et al., 2015). Based on numbers in Belgium, it can be stressed that 80 percent of informal care takes place within the household (e.g. provided by spouses) or family (provided by an adult child(ren) taking care of a parent), while only 20 percent of the informal caregivers provide care to a neighbour or friend (Van Deurzen, 2016). This figures show the emphasis on care as a shared responsibility, and seems to add importance to the proximity of family members or more specifically, adult children. Research during the pandemic showed that involvement of neighbours and the neighbourhood in informal caregiving (ranging from doing groceries to a chat on a regular basis, as well as providing personal care) was indeed very limited, partly because of the lack of (existing) neighbourhood networks, but also due to being reluctant to accept care from neighbours for what was seen mainly as family responsibility (D'Herde – Gruijthuijsen et al., 2021). Moreover, Volckaert et al. (2020) stress that most older people cannot count on much help from both neighbours and family.

Except for the availability of informal care, it is important to take the wishes of the older people themselves into account. Timmer & Kanne (2019) stress for example that a large share of people between 55 and 75 (in the Netherlands) indicate that they mainly hold the government as the responsible actor for caregiving and do not want to burden their children. Tanube (2020) finds that in Japan, while the age group 66- 90 sees care mainly as an individual responsibility, the age group between 35 -65 sees it mainly as a governmental responsibility. This shift can be related to distance, e.g. due to children moving farther away and therefore, adapting wishes to reality. But more detailed research reveals that, even when one does not necessarily prefer care from children, they are seen as a latent resource in times of crisis, which can provide a feeling of (higher) security and safety if they live close-by (Van der Pers et al., 2015). Certainly when the network of older people shrinks it becomes more focused on the family (Schwartz & Litwin, 2018). Of course, the importance of distance to provide support differs according to the type of help and support needed and offered. Bengtson (1991) distinguishes 6 dimensions of solidarity (associational, affectual, consensual, functional, normative and structural), of which Hogerbrugge & Komter (2012) found that contact (associational solidarity), affection (affectual solidarity) and help (functional solidarity) are mutually reinforced and impacted by the geographical distance between parents and children. However, also within these dimensions differences can be noticed, such as face-to-face contact which is influenced by distance, while contact in general (phone, digital) is not affected (ibid.). The same might be true in terms of care and support (functional solidarity). Financial and emotional support are less dependent on distance, while functional support such as personal care mostly requires proximity. To summarise and based on the literature, it can be concluded that distance matters and influences contact and support exchange (Hank, 2007; Bordone, 2009; Mulder & Van der Meer, 2009).

As has been stated before, the insight in geographical distance between parents and children is limited, especially when it comes to changes over time. Furthermore, large international differences are found (e.g. Hank, 2007), which implies that the (care) context, spatial scale and settlement structures matter. Hank (2007) stresses that 85% of parents (50+) have a child co-residing or within 25 kilometer in the 10 European countries that were considered. Although the differences between countries do not look that large at first

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

sight, ranging from 75-76 percent in Sweden and France towards 92 and 93 percent in Spain and Italy, with regard to co-residence they are rather large. While in Denmark and Sweden 16-17 percent of parents aged 50+ lives with a child, in Italy this is 63 percent, and in Spain and Greece around 55 percent (Hank, 2007). To a large extent these numbers of co-residency have to do with different dynamics of children moving out, rather than care needs, as illustrated by the decline in co-residence by age, although in Southern European countries a reverse relationship between co-residence and age has been found in older age categories (Hank, 2007). Chan & Ermisch (2014) found based on a household panel in the UK that around 4 percent of the children (31-54) co-reside with their parents (55+), while more than a third live within 15 minutes from their parent(s). Around a quarter live more than 2 hours from a parent or live abroad. With regard to the older adults (55+) around 70 percent live within 30 minutes of a child (including 20 percent of older adults who co-reside with a child). While comparison is not easy due to different measurement units, Warnes (1986) shows, that around 30 years earlier the mean distance between retired parents and children was 57 kilometers (excluding co-residence), based on a survey in the UK (1983). More specifically, he found that depending on the social class, between 12 and 37 percent of the children of retired parents lived within 2 kilometers and between 33 and 67 percent within 10 kilometers. Based on a survey in the Netherlands, Dykstra & Knipscheer (1995) found that 85 percent of older adults (55+) lived within 30 minutes from at least 1 child. Mulder & Kalmijn (2006) found that the average distance between parents and children is 29 kilometers. Even in a large country like the United States, which is often described as a highly mobile society in which long-distance movements are more common, Choi et al. (2018) stress that 75 percent of adults having at least one child or parent alive, live within 30 miles of their nearest kin. Chui & Miller (2015) stress that on average an adult lives 18 miles from his or her mother, but point at the same time to regional differences. We will discuss these numbers and insights further based on other researchers and articles when discussing the results.

5 DATA AND METHODOLOGY

We make use of the data from the national register (2002-2017) based on a cohort of all people older than 65 in 2002 and their children. These years were chosen for practical reasons and compatibility with other datasets. At the year of application (2019/2020) the dataset of 2017 was the most recent, while the year 2002 allows us to connect the received data with the population census to get more insight into neighbourhood, home and personal characteristics. Two additional measurement moments were chosen (2007, 2011) but they are beyond the scope of this paper, in which we focus on 2002 and 2017. The goal is to get insight into geographical distances between parents and children, and later on as well into residential movements over the years. Although we have access to data about the complete Belgian population of 65 years and over and their children, for practical and computational reasons who chose to limit ourselves to those older people (65+) that live in Flanders (Dutch speaking region of Belgium) in 2002. Both care and spatial planning are to a large extent regional responsibilities, which justifies as well that we focus largely on Flanders. The starting point is all older adults (65+) in Flanders, including their children (if any) regardless of there residential location (Flanders, Walloon or Brussels) (n= 2.344.145). This evolves to a sample size of all older adults (80+) and their children in 2017 (n=1.028.129).

Our data consists of different clusters, which can be linked via the anonymised personal identification number, which means it are microdata on the level of the individual. The first cluster consists of personal characteristics from the population register for each year, more precisely, the anonymised personal identification number, the anonymised personal identification number of the partner (only if married), the civil status, sex, age (date of birth), place of birth, country of birth, nationality (current), first registered nationality and the year of arrival in Belgium. The second cluster consists of variables that are related to household characteristics and variables related to descendancy, such as the (anonymised) personal identification numbers from the parents (if alive), household identification number, the reference person of the household (registered head of household), position in the household, household type, size of the household and the relation between the members of the household. The third cluster consists of geolocational variables, such as coded addresses, the statistical sector (lowest administrative level), the municipality, and the geographical XY-coordinates of the address. Other data clusters which are less relevant for this paper are related to neighbourhood, home and personal characteristics based on the population census.

We used R-studio to explore and clean the raw data, merge the different data sets and create new variables. Analysis was done with both SPSS and ArcGIS for the visualisation of the patterns. We made use of the coordinates to calculate the Euclidean distance between parents and children and vice versa. For each child we indicated the distance to parent 1 and parent 2 (if any), as well as the average distance to their parents. Since the ID of the first and second parent can be switched for each child of the parents (depending on how it was registered by the municipal official of the civil registry), and across the different year, we also created a variable indicating the distance to a mother or father. Calculating the distance for parents to children is more complicated due to the fact that every parent can have multiple children (also from different relationships). Therefore, we created three variables, namely, the distance to the child that lives closest by, the distance to the child that lives furthest away, and the average distance to their children. Since the civil status is the current civil status (e.g. if parents are divorced and re-married it indicates married), we created for each child a variable to indicate if the parents live together (based on the XY-coordinates). Co-residence can in our dataset be calculated in different ways, based on the household ID, address ID and the XY-coordinates. These show high levels of similarity (+- 90%). For each child we created a variable indicating if he/she has a distance of 0 towards at least 1 parent, and if the child lives in the same household (as parent 1 and/or parent 2) and if the child has the same address as the parent(s). Coordinates of the address are normally attributed to the centroid of the plot, which means that several addresses in the same building will have the same coordinates. A distance of 0 between parents and children therefore means that they co-reside or live in the same building, but is in this study described as co-residence.

6 RESULTS

Emphasis on informal care can lead to a potential shortage of informal caregivers. The ratio that is often used in this context, is the "family care ratio", which shows the amount of people older than 80 compared to the population aged 50 – 59 who generally provide most care. Figure 1 displays the situation in Flanders per municipality in 2017. On average the ratio amounts 39.8 per municipality, which means that for 100 people aged 50-59, there are 40 persons aged 80 or above. However, regional differences can be detected, with higher numbers at the seaside and western parts of Flanders and lower numbers in the eastern part of Flanders. This is in line with general patterns regarding the ageing of the population (e.g. Gruijthuijsen & Vanneste, 2018).

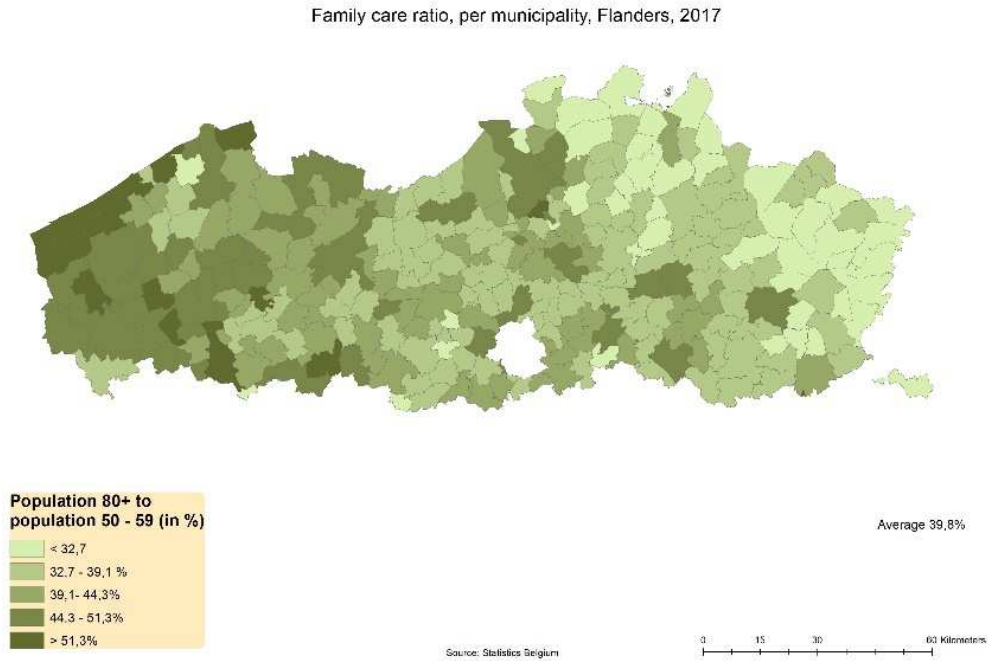


Figure 1: Family care ratio (created by authors)

Using this ratio might be useful on a national or regional scale, but less on a local scale, especially considering that it is mainly children (after the partner if any) who are responsible for informal care provision. These maps imply that the informal caregivers and older adults live close to each other, while in

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

reality this is unknown, which makes it important to look into the distance between parent and children and vice versa.

6.1 Distance between parents and children

Table 1 provides an overview of the geographical distance between parents and children in 2002 (65+) and 2001 (80+). All parents live in Flanders, while the children can live anywhere in Belgium. The maximum distance we found is 277.50 kilometers, which approximates the longest theoretical distance possible (280km). The average distance from a parent to a child in 2002 is 11.33 kilometer when we also take into account parents who co-reside when there is at least 1 child, or 12.71 kilometer without taking into account parents who co-reside with an adult child. By calculating the average distances we followed Van Diepen en Mulder (2009), by first calculating the average distance between the older adult and all children and then taking the average, which means the numbers are actually the 'average average distance', although we speak about the 'average distance' from now on. The same line of thinking applies to the nearest and furthest child.

	Including co-residence in km (median) (standard deviation) (n=757207) **2002 65+**	Excluding co-residence in km (median) (standard deviation) (n=615090) **2002 65+**	Including co-residence in km (median) (standard deviation) (n=302533) **2017 80+**	Excluding co-residence in km (median) (standard deviation) (n=267518) **2017 80+**
Average distance to child(ren)	11,33 km (4,48 km) (SD: 19,34)	12,71km (5,29km) (SD:20,7)	13,16km (5,75km) (SD: 20,36)	14,22km (6,44km) (SD: 21,19)
Nearest distance to child(ren)	6,11km (0,99 km) (SD: 16,68)	7,52km (1,71 km) (SD: 18,22)	6,77km (1,43km) (SD: 17,08)	7,80km (2,03km) (SD: 18,11)
Furthest distance to child(ren)	18,57km (7,02km) (SD: 28,93)	19,7km (7,82km) (SD: 29,58)	21,81km (8,91km) (SD: 31,57)	22,81km (9,65km)(SD: 32,02)

Table 1: Distance between parents and children in Flanders in 2002 and 2017 (Based on data provided by Statbel, own calculations)

When we exclude parents who live together with at least one adult child, we found that 50 percent of the older adults live within 1.71 kilometer from a child in 2002. The average distance to the nearest child (7.52km) is much lower compared to what Bonsang (2009) found based on the SHARE-survey. He found that the distance from adults (65+) to the nearest child was 21.7 on average, which is lower than in neighbouring countries suvh as the Netherlands (25.8km), France (71.3km) and Germany (51.0 km). Van Diepen en Mulder (2009) found an average distance to a child of 28.9km and an average smallest distance to a child of 16.1 kilometer in the Netherlands based on a national kinship panel. When we look into co-residence, it is found that 18.4% of older parents (n=142117) have a distance of 0 to at least 1 child. Although one would probably expect that distance decreases in older age, due to the higher care needs of the older adult, but as there is also the possibility to provide care for grandchildren, we find that distance increases with the age of the parents. For all older adults aged 80+ in 2017, we find that the nearest child lives on average around 7.8 km away, compared to 6.8 km for all older adults aged 65+ in 2002. Also within 2002 we find that the distance to the nearest child increases with age. While people in the age category 65-74 have their nearest child living on average 7.5 km away, for those in the age category 85+ this increases towards 8.1km. Van Diepen & Mulder (2009) found the same in the Netherlands with regard to the average distance to a child, while the smallest distance to a child shows a small decrease (while it remains stable in our data). Of course the chance for having experienced a move becomes bigger when one is older. With regard to gender we see some differences between male (fathers) and female (mothers). Mothers live on average closer to their children than fathers, although the differences are small, which is in line with findings from other researchers (e.g. Hank, 2007). With regard to the civil status, we see that especially parents who are divorced or have never been married live further away from their children, which is consistent over the 2 years. That might be surprising, since it is shown by Dykstra (1993, in Van der Pers et al., 2015) that adult children are a more important source of emotional support for divorced and widowed parents.

Figure 2 and 3 visualise the percentage of parents that live within a certain distance from their children in 2002 and 2017 respectively. Slightly more than 25 percent of all parents in 2002 live within 100 metres from their children, while this drops towards 14 percent of all parents in 2017. As can be seen in Figure 2, in 2002

a relatively high percentage of parents co-reside with their children. This has probably to do with children who did not move out of the parental home yet, rather than with a care motive. It is therefore not surprising that 61 percent of all parents having a distance 0 to at least one child are between 65 and 74, while only 9 percent of them are older than 85. Furthermore, 78 percent of the parents live within 5 kilometers from at least one child in 2002. This can be considered as an important threshold, as Knijn & Liefbroer (2006) indicate that a distance of more than 5 kilometers has a large impact on instrumental support between parents and children. In 2017 this percentage is slightly lower with almost 75 percent. Van der Pers & Mulder (2013) found that in the Netherlands (in 2010), almost 55 percent of all parent (55+)-child (25+) dyads aged 65 and older live within 5 kilometers of each other. Hank (2007) indicates that 85 percent of the parents in Europe (based on SHARE) live within 25 kilometers from the nearest child. In our data this percentage in 2002 is 94.2 percent which is higher than in any of the countries included in her study (Italy: 93,9). Based on the Swedish national register, Malmberg & Petterson (2007) found that 85 percent of parents (65+) live within 50 kilometers to the nearest child, which compares to 97.2 percent in our data. Of course these differences can be partly explained by the size of the countries, something that has to be explored further.

Average distance to children	2002 (65+)	2017 (80+)
Gender		
Male	13,19km (n=268815)	14,98km (n=102857)
Female	12,32km (n=346275)	13,75km (n=159816)
Civil status		
Married	12,64km (n=406137)	14,59km (n=118635)
Not married	18,76km (n=787)	19,21km (n=275)
Widow/widower	11,96km (n=187122)	13,40km (n=133875)
Divorced	20,21km (n=21044)	20,86km (n=9888)

Table 2: distance between parents and children, gender, civil status, 2002, 2017 (Based on data provided by Statbel, own calcualations)

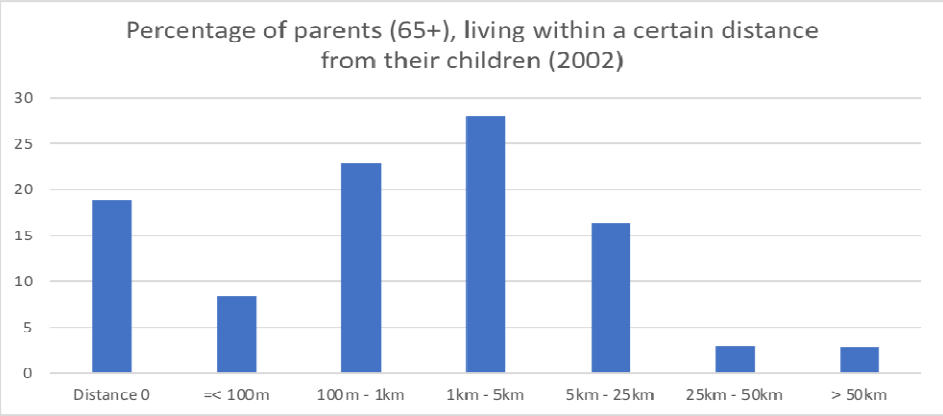


Fig. 2: Distance between parents (n=757207) and children in 2002 (own calculations based on Statbel)

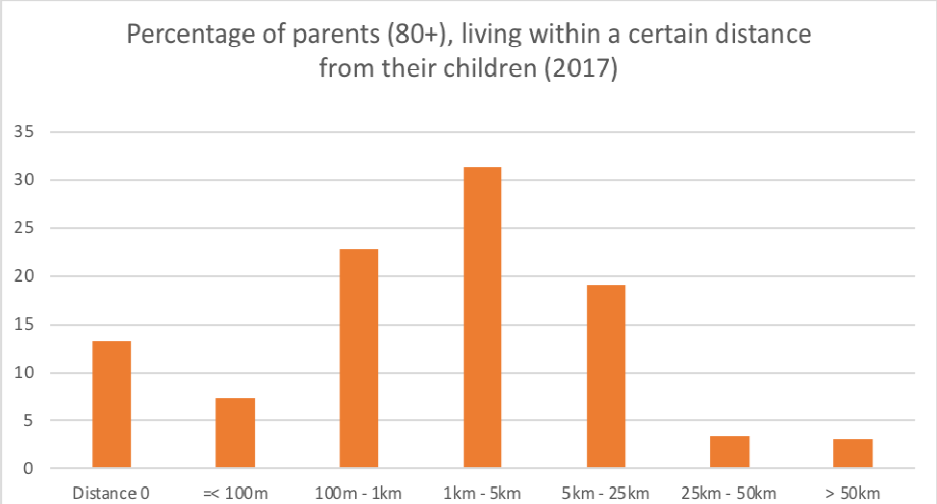


Fig. 3: Distance between parents (n=302533) and children in 2017 (own calculations based on Statbel)

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

7 CONCLUSION

We started this article with the observation that not much is known about the geographical distance between older adults and their children. This is somewhat surprising, given the renewed focus on informal care that comes together with a policy focused on ageing-in-place and the socialisation of care, whereby adult children are playing a larger role in caregiving towards their parents. We obtained data from the national population register to calculate these distances in a cohort of older adults of 65 and older starting from 2002. This article gave a brief and first overview of some main characteristics when it comes to geographical distances between parents and children. The main finding shows that the average (average) distance from parents (65+) in 2002 towards their children is 12.7 km, while we find a larger distance of 14.2 km in 2017. Although we found that older adults and adult children in Flanders live in general close by, there are signs pointing to an increase in geographical distance over time, potentially challenging the possibility to age-in-place and to negotiate informal care. This is especially true when the neighbourhood cannot be considered age-friendly, in terms of public space and the availability of facilities, but as well regarding the informal care potential. Further analysis is necessary in which also the level of urbanisation, regional differences and neighbourhood charachteristiscs are taken into account when looking for patterns of distance. This should also be seen from the perspective of policies of sustainable land use planning, trying to prevent further sprawl, focusing on concentration of facilities in villages and cities, and promoting densification of land-use. Considering that a considerable proportion of the older population lives in rural areas, and together with population shrinkage in some regions, this might probably require a policy that stimulates moving to better equipped neighbourhoods, which is advocated by some experts (Segers et al., 2020), but demands a drastic change in the current health policy. Besides, we need to go beyond merely distance and look into residential movement patterns and how these can be related to either the availability of public transport, amenities and/or distance to children. Although proximity, contact and support are positively related in which a large distance results in less contact (e.g. Hank, 2017; Bordone, 2009; Mulder & Van der Meer, 2009) we hypothesise that mere proximity or a close geographical distance will not automatically lead to care and support. Therefore, we need to look further into emotional distance as well as in residential motivations and future care wishes of older people in the qualitative part of this research which will complement the results presented here.

8 REFERENCES

Ågotnes, Gudmund, Jill-Marit Moholt, and Bodil H. Blix: "From Volunteer Work to Informal Care by Stealth: A 'New Voluntarism' in Social Democratic Health and Welfare Services for Older Adults." In: Ageing & Society, pp. 1–17. https://doi.org/10.1017/S0144686X21001598, 2021

Alders, Peter, and Frederik T. Schut. "Trends in Ageing and Ageing-in-Place and the Future Market for Institutional Care: Scenarios and Policy Implications." Health Economics, Policy and Law 14, no. 1, pp. 82–100. https://doi.org/10.1017/S1744133118000129, 2019

Alders, Peter, Dorly J. H. Deeg, and Frederik T. Schut. "Who Will Become My Co-Residents? The Role of Attractiveness of Institutional Care in the Changing Demand for Long-Term Care Institutions." Archives of Gerontology and Geriatrics 81, pp. 91–97. https://doi.org/10.1016/j.archger.2018.11.014, 2019

Bakx, Pieter, Bram Wouterse, Eddy van Doorslaer, and Albert Wong: "Better off at Home? Effects of Nursing Home Eligibility on Costs, Hospitalizations and Survival." In: Journal of Health Economics 73: 102354. https://doi.org/10.1016/j.jhealeco.2020.102354, 2020

Bengtson, Vern L., and Robert E. L. Roberts. "Intergenerational Solidarity in Aging Families: An Example of Formal Theory Construction." Journal of Marriage and Family 53, no. 4, pp. 856–70. https://doi.org/10.2307/352993, 1991

Bonsang, Eric. "Does Informal Care from Children to Their Elderly Parents Substitute for Formal Care in Europe?" Journal of Health Economics 28, no. 1, pp.143-54. https://doi.org/10.1016/j.jhealeco.2008.09.002, 2009

Bordone, Valeria. "Contact and Proximity of Older People to Their Adult Children: A Comparison between Italy and Sweden." Population, Space and Place 15, no. 4, pp. 359–80. https://doi.org/10.1002/psp.559, 2009

Brandt, M., K. Haberkern, and M. Szydlik. "Intergenerational Help and Care in Europe." European Sociological Review 25, no. 5, pp. 585–601. https://doi.org/10.1093/esr/jcn076, 2009

Broese van Groenou, Marjolein I., and Alice De Boer. "Providing Informal Care in a Changing Society." European Journal of Ageing 13: 271–79. https://doi.org/10.1007/s10433-016-0370-7, 2016

Buffel, T., Handler, S. & Phillipson, C. (eds.): Age-friendly cities and communities. A global perspective. Policy Press: Bristol, 2018

Bui, Q., Miller, C.C.: The Typical American Lives only 18 miles from mom. The Upshot – The New York Times, 2015

Chan, Tak Wing, and John Ermisch. "Family Geography and Family Demography in the UK: Cross-Sectional Perspective", 2014

Choi, H., Schoeni, F., Wiemers, E.E., Hotz, V.J. & Seltzer, J.A. Spatial Distance Between Parents and Adult Children in the United States. In: Journal of Marriage and Family. Pp. 822-840, 2020

Costa-Font, J., Elvira, D. and Mascarilla-Miró, O: "`Ageing in Place'? Exploring Elderly People's Housing Preferences in Spain." Urban Studies 46, no. 2: 295–316. https://doi.org/10.1177/0042098008099356, 2009

De Decker, Pascal and Emma Volckaert: Oud, arm en huurder. Gompel & Svacina: Oud-Turnhout, 2020

Dermaut, Vanessa, Tineke Schiettecat, Stijn Vandevelde, and Griet Roets. "Citizenship, Disability Rights and the Changing Relationship between Formal and Informal Caregivers: It Takes Three to Tango." Disability & Society 35, no. 2, pp. 280–302. https://doi.org/10.1080/09687599.2019.1634521, 2020

D'herde, Jakob, Wesley Gruijthuijsen, Dominique Vanneste, Veerle Draulans, and Hilde Heynen. "'I Could Not Manage This Long-Term, Absolutely Not.' Aging in Place, Informal Care, COVID-19, and the Neighborhood in Flanders (Belgium)." International Journal of Environmental Research and Public Health 18, no. 12: 6482. https://doi.org/10.3390/ijerph18126482, 2021

Dobner, Susanne, Sako Musterd, and Joos Droogleever Fortuijn. "'Ageing in Place': Experiences of Older Adults in Amsterdam and Portland." GeoJournal 81, no. 2, pp. 197–209. https://doi.org/10.1007/s10708-014-9613-3, 2016

Duyvendak, J.W. Thuis. In Het Drama Van Een Sentimentele Samenleving; AUP: Amsterdam, The Netherlands, 2017

Dykstra, Pearl, and C.P.M. Knipscheer. "The Availability and Intergenerational Structure of Family Relationships," 1995.

EEA. Urban Sprawl in Europe; Joint EEA-FOEN Report; European Environment Agency: Copenhagen, Denmark; Swiss Federal Office for the Environment: Bern, Switzerland, 2016

Eurocareres: Position Paper, The gender dimension of informal care. Eurocarers, Etterbeek, Belgium, 2021

Flemish senior council: Woonsurvey 2018. [Online] https://www.vlaamse-ouderenraad.be/pers/woonsurvey-2018-slechts-1-op-2-ouderen-bereid-om-te-verhuizen, accessed 05/08/22, 2018

Gruijthuijsen, Wesley and Vanneste, Dominique: Geographies of Ageing in Flanders (Belgium). SHAPING URBAN CHANGE – Livable City Regions for the 21st Century. Proceedings of REAL CORP 2020, 25th International Conference on Urban Development, Regional Planning and Information Society. pp. 377-390. ISSN 2521-3938 , 2020

Golant, S.M.: Aging in the right place. Health Profession Press: Baltimore, 2015

Greenfield, E. A., Black, K., Buffel, T., & Yeh, J.: Community Gerontology: A Framework for Research, Policy, and Practice on Communities and Aging. In: The Gerontologist, vol. 59, issue 5, pp. 803 -810, 2019

Hank, Karsten. "Proximity and Contacts Between Older Parents and Their Children: A European Comparison." Journal of Marriage and Family 69, no. 1, pp. 157–73. https://doi.org/10.1111/j.1741-3737.2006.00351.x, 2007

Hillcoat-Nallétamby, Sarah, and Jim Ogg: "Moving beyond 'Ageing in Place': Older People's Dislikes about Their Home and Neighbourhood Environments as a Motive for Wishing to Move." In: Ageing & Society 34, no. 10, pp. 1771–96. https://doi.org/10.1017/S0144686X13000482, 20134

Hogerbrugge, Martijn J. A., and Aafke E. Komter. "Solidarity and Ambivalence: Comparing Two Perspectives on Intergenerational Relations Using Longitudinal Panel Data." The Journals of Gerontology: Series B 67B, no. 3, pp. 372–83. https://doi.org/10.1093/geronb/gbr157, 2012

Isengard, Bettina. "'The Apple Doesn't Live Far from the Tree': Living Distances between Parents and Their Adult Children in Europe." Comparative Population Studies : CPoS ; the Peer-Reviewed Open-Access Journal of the Federal Institute for Population Research, - Wiesbaden : Federal Inst. for Population Research, ISSN 1869-8980, ZDB-ID 25766181. - Vol. 38.2013, 2, p. 237-263, 38, no. 2, 2013

Knijn, T.C.M. & Liefbroer, A.C: More than kind: instrumental support in families. In: Dykstra, P.A., Kalmijn, M., Knijn, T.C.M., Komter, A.E., Liefbroer, A.C. & Mulder, C.H. (eds.) (2006) Family solidarity in the Netherlands. Amsterdam: Dutch University Press. 89-106, 2006

Malmberg, Gunnar, and Anna Pettersson. "Distance to Old Parents: Analyses of Swedish Register Data." Demographic Research 17: 679–704. https://doi.org/10.4054/DemRes.2007.17.23, 2007

Michielin, Francesca, and Clara Mulder. "(12-A)Geographical Distances between Adult Children and Their Parents in the Netherlands." Demographic Research 17, pp. 655–78. https://doi.org/10.4054/DemRes.2007.17.22, 2007

Mulder, Clara H., and Marieke J. van der Meer. "Geographical Distances and Support from Family Members." Population, Space and Place 15, no. 4, pp. 381–99. https://doi.org/10.1002/psp.557, 2009

Mulder, C.H. & Kalmijn, M. Geographical distances between family members. In: Dykstra, P.A., Kalmijn, M., Knijn, T.C.M., Komter, A.E., Liefbroer, A.C. & Mulder, C.H. (eds.) Family solidarity in the Netherlands. Amsterdam: Dutch University Press. 43 – 58, 2006

Myncke, and Vandekerckhove. "Toekomstige Ruimtebehoefte Voor Ouderen in Vlaanderen,. Departement RWO, Vlaanderen. Brussel, 2007.

Parekh, Rupal, Arati Maleku, Noelle Fields, Gail Adorno, Donna Schuman, and Brandi Felderhoff: "Pathways to Age-Friendly Communities in Diverse Urban Neighborhoods: Do Social Capital and Social Cohesion Matter?" In: Journal of Gerontological Social Work 61, no. 5, pp 492–512. https://doi.org/10.1080/01634372.2018.1454564, 2018

Pickard, Linda. "A Growing Care Gap? The Supply of Unpaid Care for Older People by Their Adult Children in England to 2032." Ageing & Society 35, no. 1, pp.: 96–123. https://doi.org/10.1017/S0144686X13000512, 2015

Peek, Sebastiaan T. M., Katrien G. Luijkx, Maurice D. Rijnaard, Marianne E. Nieboer, Claire S. van der Voort, Sil Aarts, Joost van Hoof, Hubertus J. M. Vrijhoef, and Eveline J. M. Wouters: "Older Adults' Reasons for Using Technology While Aging in Place."In: Gerontology 62, no. 2, pp. 226–37. https://doi.org/10.1159/000430949, 2016

Scharlach, Andrew E.: "Aging in Context: Individual and Environmental Pathways to Aging-Friendly Communities—The 2015 Matthew A. Pollack Award Lecture." In: The Gerontologist 57, no. 4, pp. 606–18. https://doi.org/10.1093/geront/gnx017, 2017

Schwartz, Ella, and Howard Litwin. "Social Network Changes among Older Europeans: The Role of Gender." European Journal of Ageing 15, no. 4, pp. 359–67. https://doi.org/10.1007/s10433-017-0454-z, 2018

Segers, T., Devisch, O., Herssens, J., Vanrie, J.: Conceptualizing demographic shrinkage in a growing region- creating opportunities for spatial practice. In: Landscape and Urban Planning, issue 195, 2020: 103711

Smetcoren, A., Dury, S., Donder, L., De Witte, N. , Sofie Van Regenmortel, Martin Kardol, and Dominique Verté.: "Denken over Later? Attitudes van Ouderen Ten Opzichte van Verschillende Woonvormen in Vlaanderen." Ruimte En Maatschappij, Vlaams-Nederlands Tijdschrift Voor Ruimtelijke Vraagstukken 6, pp 14–38, 2014

Tanabe, Megumi (2020) Child care in an aging society: Assessing people's attitudes towards the socialization of care in Japan. Master's thesis, Texas A&M University, 2020

Urry, John. "Mobile Sociology1." The British Journal of Sociology 51, no. 1, pp.: 185–203. https://doi.org/10.1111/j.1468-4446.2000.00185.x, 2000

Van der Pers, Marieke, Clara H. Mulder, and Nardi Steverink. “Geographic Proximity of Adult Children and the Well-Being of Older Persons.” Research on Aging 37, no. 5, pp. 524–51. https://doi.org/10.1177/0164027514545482, 2015

Vandeurzen, J.: Nabije zorg in een warm Vlaanderen. Vlaams Mantelzorgplan 2016 – 2020. Brussel: Vlaamse Regering – Vlaams minister van Welzijn, Volksgezondheid en Gezin, 2016

Van Hees, Susan, Klasien Horstman, Maria Jansen, and Dirk Ruwaard: “Meanings of ‘Lifecycle Robust Neighbourhoods’: Constructing versus Attaching to Places.” In: Ageing & Society 38, no. 6: 1148–73. https://doi.org/10.1017/S0144686X16001483, 2017

Vasara, Paula. “Not Ageing in Place: Negotiating Meanings of Residency in Age-Related Housing.” Journal of Aging Studies 35, pp. 55–64. https://doi.org/10.1016/j.jaging.2015.07.004, 2015

Volckaert, Emma, Elise Schillebeeckx, and Pascal De Decker. “Beyond Nostalgia: Older People’s Perspectives on Informal Care in Rural Flanders.” Journal of Rural Studies. https://doi.org/10.1016/j.jrurstud.2020.07.006, 2020

Versey, H. Shellae: “A Tale of Two Harlems: Gentrification, Social Capital, and Implications for Aging in Place.” In: Social Science & Medicine 214, pp. 1–11. https://doi.org/10.1016/j.socscimed.2018.07.024, 2018

Warnes, A M. “The Residential Mobility Histories of Parents and Children, and Relationships to Present Proximity and Social Integration.” Environment and Planning A: Economy and Space 18, no. 12, pp. 1581–94. https://doi.org/10.1068/a181581, 1986

Wauters E., Kobe Boussauw, Lien Poelmans, Thérèse Steenberghen, Marijke Vermander, Koos Fransen, Kelly Wittemans, Liliane Janssen, Carolien Beckx, Steven Broekx, Hans Tindemans: Monetarisering urban sprawl Vlaanderen. Studie uitgevoerd in opdracht van Departement Omgeving, Brussel, 2021

Wiles, J.L., Leibing, A., Guberman, N., Reeve J. and Allen, R.E.S: “The Meaning of ‘Aging in Place’ to Older People.” In: The Gerontologist 52, no. 3: 357–66. https://doi.org/10.1093/geront/gnr098, 2012

Zigante, Valentina, Jose-Luis Fernandez, and Fernanda Mazzotta. “Changes in the Balance between Formal and Informal Care Supply in England between 2001 and 2011: Evidence from Census Data.” Health Economics, Policy and Law 16, pp. 232–49. https://doi.org/10.1017/S1744133120000146, 2020

🏆 *reviewed paper*

Gesundheitsförderung in der Regionalentwicklung zur Schaffung gesunder Lebensverhältnisse

Tobias Weber, Kirsten Mangels, Swantje Grotheer

(MSc. Tobias Weber, Lehrstuhl Regionalentwicklung und Raumordnung, TU Kaiserslautern, Pfaffenbergstraße 95, 67663 Kaiserslautern, tobias.weber@ru.uni-kl.de)
(Dr.-Ing. Kirsten Mangels, Lehrstuhl Regionalentwicklung und Raumordnung, TU Kaiserslautern, Pfaffenbergstraße 95, 67663 Kaiserslautern, kirsten.mangels@ru.uni-kl.de)
(Dr.-Ing. Swantje Grotheer, Lehrstuhl Regionalentwicklung und Raumordnung, TU Kaiserslautern, Pfaffenbergstraße 95, 67663 Kaiserslautern, swantje.grotheer@ru.uni-kl.de)

1 ABSTRACT

Dem Lebens-, Wohn- und Arbeitsumfeld, der bebauten und unbebauten Umwelt und den Verhältnissen, in denen Menschen leben, wird seit jeher ein großer Einfluss auf Gesundheit, Wohlbefinden und Lebensqualität zugeschrieben. Das Thema „Gesundheit“ rückt dabei nicht zuletzt aufgrund der im Jahr 2019 durch die Infektionskrankheit COVID-19 ausgelösten weltweiten Pandemie und deren noch nicht absehbaren (Langzeit-) Folgen in den Fokus gesellschaftlicher und wissenschaftlicher Diskussionen. Gesundheit wird dabei im Sinne der Daseinsvorsorge zunehmend als Aufgabe der Raumplanung verstanden.[1]

Räumliche Planung und Öffentliche Gesundheit stehen durch den, in der Antike erstmals aufkommenden und als Reaktion auf die Zeit der Industrialisierung professionalisierten, Gesundheitsschutz in einem engen Verhältnis. Die Untersuchung von Modellen der Einflussfaktoren der Gesundheit lassen weiterhin eine Identifikation von räumlichen Determinanten der Gesundheit mit Einflussmöglichkeit der räumlichen Planung zu. Das daraufhin entstandene Konzept der Gesundheitsförderung bricht das rein biomedizinische Grundverständnis der Gesundheit auf und öffnet es für eine Vielzahl an Einflussfaktoren als zentrale Gesundheitsdeterminanten in Verbindung mit Lebensweisen und Lebensumwelten der Menschen. Im Fokus der Gesundheitsförderung steht demnach der Prozess, allen Menschen ein höheres Maß an Selbstbestimmung über ihre Gesundheit zu ermöglichen und somit eine präventive Stärkung der Gesundheit im Sinne unterstützender Strukturen für das menschliche Wohlbefinden zu erreichen. Gesundheit ist dabei mehr als Gesundheitsversorgung und die langfristige Sicherung medizinischer Versorgungsstrukturen. Gesundheit im Sinne der räumlichen Planung zielt auf die Schaffung gesunder Lebensverhältnisse, speziell in den Fokusthemen der Regionalplanung: Siedlungsstruktur, Freiraumstruktur und Infrastruktur.[2]

Durch globale Trends, Wandel- und Transformationsprozesse in den vergangenen Jahrzehnten verändern sich Raumstrukturen sowie die bebaute und unbebaute Umwelt. Deren negative Beeinflussung als „räumliche Determinanten” der Gesundheit erfährt dabei eine zunehmende Erhöhung, das heißt, die negativen Auswirkungen der Umwelt auf die Gesundheit des Menschen steigen an. Eine Analyse bisheriger Anknüpfungspunkte der Gesundheitsförderung in Regionalplanung und -entwicklung in den fünf Planungsregionen in Rheinland-Pfalz zeigt, dass das Thema Gesundheitsförderung als solches weder in formellen noch in informellen Plänen und Konzepten genannt wird.

Dieser Beitrag thematisiert mit dem entwickelten „Leitfaden Gesunde Region” einen Lösungsansatz zur Steuerung der räumlichen Determinanten der Gesundheit auf regionaler Ebene, um negative Auswirkungen auf die Gesundheit zu minimieren. Die Etablierung von Aspekten der Gesundheitsförderung in formeller Regionalplanung und informeller Regionalentwicklung kann zur Schaffung gesundheitsförderlicher, das heißt, sich positiv auf die Gesundheit der Menschen auswirkender, Raumstrukturen beitragen. Eine gesunde Region ermöglicht nach dem salutogenetischen Gesundheitsverständnis folglich eine höhere Gesundheit der in der Region lebenden Einwohnerinnen und Einwohner. Der Erhalt menschlicher Gesundheit ist ein Thema von höchster Relevanz, zu dem die Regionalentwicklung durch fokussierte Gesundheitsförderung einen wichtigen Beitrag leisten kann.

Keywords: Gesundheitsförderung, Regionalplanung, Regionalentwicklung, Gesunde Region, Humanökologie

[1] vgl. BAUMGART et al., 2018, S. 5-19
[2] vgl. BAUMGART et al., 2018, S. 5-19

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

2 RAUMPLANUNG UND GESUNDHEIT – ÜBER WELCHE EINFLUSSMÖGLICHKEITEN VERFÜGT DIE RÄUMLICHE PLANUNG?

Mit Hilfe verschiedener Modelle versuchen Gesundheitsforscherinnen und Gesundheitsforscher die Verbindungen zwischen räumlicher Planung und Gesundheit bzw. den Einfluss von Planung auf Gesundheit aufzuzeigen. Basis bildet dabei häufig die Definition von Gesundheit der WHO aus dem Jahr 1946, die Gesundheit als „state of complete physical, mental and social well-being and not merely the absence of disease or infirmity" beschreibt. Dieses Verständnis bricht das rein biomedizinische Grundverständnis auf und öffnet es insbesondere für das Verständnis einer Vielzahl von Einflussfaktoren auf die Entstehung von Gesundheit und Krankheit. Als zentrale Gesundheitsdeterminanten werden so psychsiche, physische und soziale Faktoren in Verbindung mit den Lebensweisen und Lebensumwelten der Menschen identifiziert. Wichtiger Grundstein des mehrdimensionalen Gesundheitsverständnisses ist dabei das von Henrik Blum entwickelte Modell „Force Field and Well-Being Paradigms of Health", das Gesundheit als „Konglomerat aus zahlreichen, sich wechselseitig beeinflussenden Größen und simultan wirkenden Kräften" bezeichnet.[3] Neben der Heredität und der verfügbaren medizinischen Versorgung verfügen auch der individuelle Lebensstil sowie die (Lebens-)Umwelt eines Menschen über Einfluss auf die Gesundheit.[4] Im Hinblick auf die Beeinflussung durch die Umwelt, besitzt die räumliche Planung demnach durch ihre Steuerungswirkung auf die bebaute und unbebaute Umwelt direkte Einflussmöglichkeiten. Zahlreiche Weiterentwicklungen dieses Modells im Laufe der Jahre verdeutlichen die Verbindungen zwischen Raumplanung und Gesundheit. Die Komplexität der möglichen Wechselwirkungen zwischen der dabei relevanten bebauten und unbebauten Lebensumwelt wird insbesondere durch das im Jahr 2006 auf Grundlage des sog. „Regenbogenmodells" entwickelte „Humanökologische Modell der Gesundheitsdeteminanten im Siedlungsraum" (siehe Abb. 1) von Hugh Barton und Marcus Grant (im Original: Determinants of Health and Well-Being in our Neighbourhood) – oder auch in Kurzform als HealthMap bezeichnet – verdeutlicht.[5] Neben individuellen, personenbezogenen Faktoren stellt es die Einflussnahme der physischen, sozialen und ökonomischen Umwelt dar.

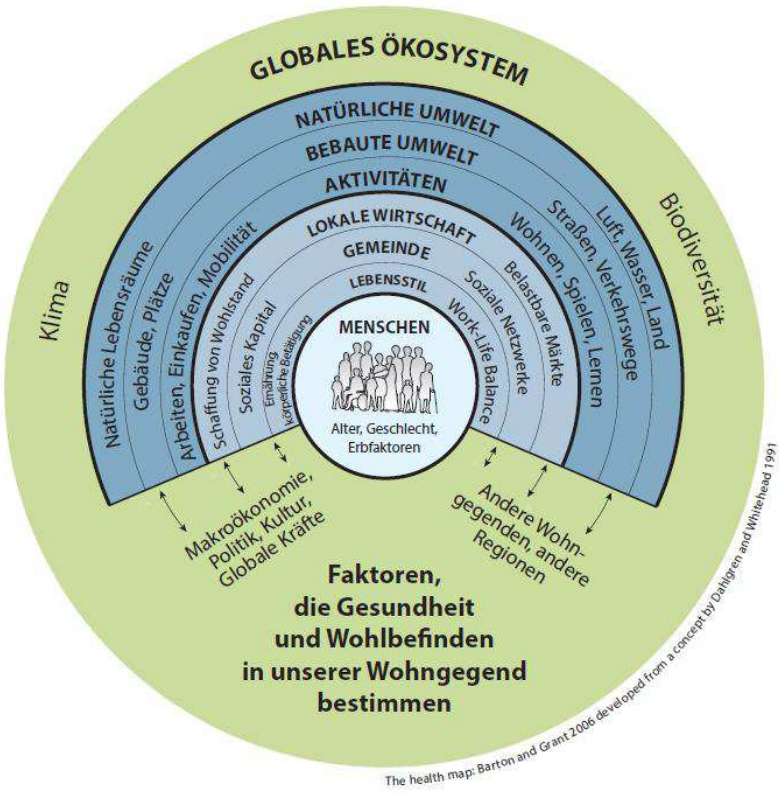


Abb. 1: Humanökologisches Modell der Gesundheitsdeterminanten im Siedlungsraum[6]

[3] HORNBERG et al, 2018, S. 47
[4] vgl. HORNBERG et al., 2018, S. 47
[5] vgl. BARTON / GRANT, 2006
[6] CLASSEN, 2020, S. 7

Als gesundheitliche Determinanten mit Steuerungsmöglichkeiten werden demnach gesundheitsbestimmende Aktivitäten sowie die bebaute und unbebaute Umwelt identifiziert. Zu den Aktivitäten zählen im Grunde sämtliche Bereiche der Daseinsvorsorge: Wohnen, Arbeiten, Bildung, Mobilität sowie Versorgung und Erholung. Deren Ausgestaltung, Zuordnung zueinander sowie die individuelle Wahrnehmung übt in unterschiedlichem Maß Einfluss auf die Gesundheit eines Einzelnen aus. Jegliche Aktivitäten wiederum sind durch die bebaute Umwelt beeinflusst: Gebäude, Plätze, Straßen und andere Verkehrswege stellen die Grundlage zur unterschiedlichen Wahrnehmung der Aktitivtäten dar und werden durch die Raumplanung gesteuert. Die Variablen der unbebauten Umwelt, wie natürliche Lebensräume, Luft, Wasser und Land, stehen in engen Wechselwirkungen zur bebauten Umwelt sowie den menschlichen Aktivitäten und nehmen einen hohen Stellenwert im Einflussgefüge der gesundheitlichen Faktoren ein. Ebenso werden sie teils maßgeblich durch die Raumplanung – mit den Zielen diese zu schützen und zu entwickeln – gesteuert.

Die Health Map verdeutlicht das große Spannungsfeld der Einflussfaktoren und deren gegenseitige Wechselwirkungen auf die Gesundheit. Dabei offenbart das Modell auch die komplexen Verbindungen und Abhängigkeiten zwischen Gesundheit und räumlicher Planung: Gerade die Faktoren in den äußeren Sphären (u.a. bebaute und natürliche Umwelt) befinden sich nicht im Zugriff des Gesundheitssektors, sondern liegen in den Zuständigkeitsbereichen der unterschiedlichen Planungsträger. Dies verdeutlicht die Notwendigkeit einer „gesundheitsförderlichen Planung im Rahmen anderer raumbezogener Planungen (zum Beispiel Stadt-, Umwelt-, Verkehrs- oder Sozialplanung)“[7]. Raumplanung hat damit wesentliche Auswirkungen auf die Lebensumwelten der Menschen und kann durch die Zuordnung, das räumliche Nutzungsmuster der unterschiedlichen Aktivitäten auch die Lebensweisen der Menschen mittelbar beeinflussen.

3 GESUNDHEITSFÖRDERUNG – STAND DER DISKUSSION IN DER RAUMPLANUNG

3.1 Das Konzept der Gesundheitsförderung

Im Zentrum der Verbindungen und Zusammenhänge von räumlicher Planung und öffentlicher Gesundheit hat sich die sog. Gesundheitsförderung herausgebildet – nach dem Verständnis der WHO ein Konzept, das an der Analyse und Stärkung von Gesundheitsressourcen sowie Gesundheitspotenzialen der Menschen ansetzt. Bereits 1997 definierte die WHO den Begriff wie folgt: „Gesundheitsförderung ist ein Prozess, der Menschen befähigen soll, mehr Kontrolle über ihre Gesundheit zu Erlangen und sie zu verbessern. Durch Investitionen und Maßnahmen kann Gesundheitsförderung einen entscheidenden Einfluss auf die Determinanten für Gesundheit ausüben.”[8] Prägend dafür ist die salutogenetische Perspektive mit der Leitfrage, wie und wo Gesundheit hergestellt wird.[9] Gesundheitsförderung stellt dabei – in Verbindung mit Prävention – eine gesamtgesellschaftliche und über die Gesundheitspolitik hinausreichende integrierte Querschnittsaufgabe dar, die verschiedene Politikbereiche tangiert und in die Zuständigkeitsbereiche von Kommunen, Ländern und des Bundes fällt.[10]

Als wichtigste Umsetzung der Gesundheitsförderung hat sich in der Praxis der sog. Setting-Ansatz etabliert. Der Ansatz richtet die Gesundheitsförderung auf diejenigen Lebensbereiche, Systeme und Organisationen aus, in denen Menschen einen großen Teil ihrer Lebenszeit verbringen und die mit ihrem sozialen Gefüge sowie ihrer Organisationsstruktur und -kultur die Gesundheit der Einzelnen beeinflussen.[11] Die Bundeszentrale für gesundheitliche Aufklärung definiert das Setting als dauerhaften „Sozialzusammenhang, in dem Menschen sich in ihrem Alltag aufhalten und der Einfluss auf ihre Gesundheit hat”[12] oder kurz gesagt: ein konzeptioneller Rahmen für die nachhaltige Gestaltung gesunder Lebenswelten.[13] Anerkannt sind u.a. die Settings Schule, Arbeitsplatz, Kindertagesstätte, Krankenhaus sowie die Kommune.[14]

Die Kommune ist dabei ein Setting von besonderer Bedeutung, weil sie zum einen von hoher gesundheitlicher Relevanz für die Bevölkerung ist und zum anderen weil sie – im Gegensatz zu den weiteren

[7] CLASSEN, 2020, S. 7
[8] WHO, 1997, S. 2
[9] vgl. BZgA, 2018
[10] BMG, 2009, S. 6
[11] vgl. BZgA, 2018
[12] BZgA, 2015
[13] KGC, 2014, S. 2
[14] WHO, o.J.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Settings – einen räumlichen Rahmen spannt und die anderen Settings sozusagen umgreift. Die Kommune wird daher auch als „Dach" der Settings des Lernens, Arbeitens, Freizeitgestaltung etc. gesehen. Im Setting Kommune erfolgen die Planung, Steuerung und Veränderung der bebauten und unbebauten Umwelt durch Planerinnen und Planer, die mittelbar und unmittelbar Einfluss auf die Gesundheit ausüben. Gerade im Rahmen baulicher Maßnahmen können durch die gezielte Planung „Lebens(um)welten geschaffen und verstetigt werden […], die nachhaltig einen positiven Betrag zum Erhalt von Gesundheit und Wohlbefinden in den unterschiedlichen Bevölkerungsgruppen leisten."[15] Demnach finden sich in der Gestaltung der alltäglichen Umwelt Anknüpfungspunkte für die räumliche Planung zur Mitgestaltung und Steuerung der Gesundheitsförderung im Setting Kommune.[16] Zudem kommt der Kommune aufgrund ihres verfassungsmäßigen Selbstverwaltungsrechts – „alle Angelegenheiten der örtlichen Gemeinde im Rahmen der Gesetze in eigener Verantwortung zu regeln"[17] – und dem damit einhergehenden kommunalen Auftrag zur Sicherung einer nachhaltigen Daseinsvorsorge eine steuernde Funktion für die kommunale Gesundheitsförderung zu.[18] Sie kann durch die Bereitstellung von Infrastrukturen und Angeboten der Daseinsvorsorge maßgeblich Einfluss auf die Rahmenbedingungen, in denen Menschen in der Kommune leben, nehmen. Der räumlichen Planung eröffnen sich durch den Setting-Ansatz Wirkungsmöglichkeiten zur Gesundheitsförderung auf allen Ebenen der Lebenswelten, „insbesondere auf der Regional-, Kommunal-, Nachbarschafts- und Quartiersebene."[19]

3.2 Bestehende planerische Ansätze der Gesundheitsförderung in der Praxis

Es existieren bereits verschiedene Ansätze, die sich der aus der Gestaltung der bebauten und unbebauten Umwelt ergebenden Aufgabe der räumlichen Planung zur Schaffung gesundheitsförderlicher Raumstrukturen, widmen. Die nachfolgend aufgeführten Beispiele stellen keinesfalls einen abschließenden Katalog dar, sondern dienen mehr einer exemplarischen Darstellung bisheriger Anknüpfungspunkte.

Mit dem Ziel, die Gesundheit der Bevölkerung langfristig zu verbessern, fördert das Bayerische Staatsministerium für Gesundheit und Pflege derzeit 60 **Gesundheitsregionen plus** in Bayern.[20] Mit der Schaffung regionaler Netzwerke, die räumlich aus mindestens einem Landkreis bestehen, soll auf die unterschiedlichen medizinischen und pflegerischen Versorgungsstrukturen sowie die regionsspezifischen demografischen Herausforderungen reagiert werden. In Anpassung an die regionalen Bedarfe sollen Gesundheitsförderung, Gesundheitsversorgung und Pflege unter Einbezug der relevanten Akteure verbessert werden. In den regionalen Netzwerken sind Akteure aus dem gesundheitlichen Feld sowie aus Verwaltungen, Verkehr, Umwelt und weiteren Bereichen mit Bezug zur räumlichen Planung als Träger der Gesundheitsförderung integriert.[21]

Mit einer koordinierten Zusammenarbeit in den Bereichen Umwelt, Bauen, Verkehr, Soziales, Bildung und Wirtschaft soll die **Gesunde Planung** in Nordrhein-Westfalen zu umweltgerechten und gesundheitsförderlichen Lebensbedingungen führen. Wesentliche Akteure wie auch Adressaten sind Entscheidungsträgerinnen und Entscheidungsträger der räumlichen Planung der Stadtentwicklung, der Regionalplanung und Regionalpolitik. Zur Stärkung des umweltbezogenen Gesundheitsschutzes wurde der Masterplan Umwelt und Gesundheit NRW verabschiedet. Eines der sieben fokussierten Handlungsfelder zielt auf die Integration von Umwelt und Gesundheit in räumlicher Planung als wesentliche Stellschraube für die Verbesserung der Umwelt- und Gesundheitsverhältnisse. Aus diesem Handlungsfeld ist u.a. der Leitfaden Gesunde Stadt, eine Handreichung zur Gesundheitsförderung für Kommunen, hervorgegangen.[22]

Ein weiterer Ansatz ist die **Gesundheitsplanung** in Baden-Württemberg, die insbesondere das Aufzeigen von Problemfeldern in der Gesundheitsförderung und Prävention, der gesundheitlichen und pflegerischen Versorgung sowie die Definition von Schnittstellen einschließlich des Koordinierungs- und Vernetzungsbedarfs zwischen den verschiedenen Handlungsträgerinnen, Handlungsträgern und

[15] HORNBERG et al., 2018, S. 37
[16] vgl. KÖCKLER, 2018, S. 10
[17] Art. 28 Abs. 2 GG
[18] GKV-SPITZENVERBAND, 2020, S. 32f.
[19] CLASSEN, 2020, S. 9
[20] vgl. STMGP, o.J.
[21] vgl. STMGP, o.J.
[22] vgl. LZG.NRW, 2016

Planungsbereichen forciert. Gemeinsam mit den kommunalen Gesundheitskonferenzen der Stadt- und Landkreise wurde im Rahmen der Gesundheitsplanung die Landesinitiative „Gesund aufwachsen und leben in Baden-Württemberg“ etabliert. Städte und Gemeinden werden im Sinne einer gesundheitsförderlichen Stadt- und Gemeindeentwicklung dahingehend unterstützt, eine integrierte Gesundheitsstrategie zu entwickeln oder Gesundheit in eine Gesamtstrategie der Kommunalentwicklung zu integrieren.[23]

Die Recherche und Auswertung bestehender Ansätze und im Besonderen der genannten Leitfäden zur Gesundheitsförderung auf kommunaler Ebene werfen die Frage auf, inwiefern sich die bislang auf kommunale Ebene ausgerichteten Ansätze auf die regionale Ebene übertragen lassen. Bieten Regionalplanung und -entwicklung mit zahlreichen räumlichen Aufgaben und Steuerungsmöglichkeiten ebenfalls Anknüpfungspunkte zur Gesundheitsförderung und dementsprechend das Potenzial die Determinanten der Gesundheit zu beeinflussen?

3.3 Ansätze zur Gesundheitsförderung auf regionaler Ebene in Rheinland-Pfalz

Zur Analyse möglicher Anknüpfungspunkte der Gesundheitsförderung auf regionaler Ebene wurde als Untersuchungsraum das Land Rheinland-Pfalz mit seinen fünf Planungsregionen ausgewählt. Dabei wurden u.a. die regionalen Raumordnungspläne und vorhandene Entwicklungskonzepte analysiert sowie qualitative Experteninterviews mit Mitarbeiterinnen und Mitarbeitern der Planungsgemeinschaften und weiteren relevanten Akteuren aus dem planerischen und gesundheitlichen Bereich geführt. Hinsichtlich der Regionalplanung finden sich Anknüpfungsmöglichkeiten in den Bereichen Siedlungs-, Freiraum- und Infrastruktur. Der konkrete Begriff der Gesundheitsförderung findet jedoch in keinem der genannten Dokumente Beachtung und wird bislang von keinem der betroffenen Akteure berücksichtigt.[24]

Im Bereich der Siedlungsstruktur finden sich insbesondere Anknüpfungspunkte zur Gesundheitsförderung über eine nachhaltige und sparsame Flächeninanspruchnahme zum Schutz der unbebauten Umwelt und ihrer positiven Effekte für die Gesundheit sowie in der kompakten Siedlungsentwicklung als Region kurzer Wege, um vor allem MIV-Wege zu reduzieren und die individuelle (körperliche) Bewegung zu fördern. Mit dem Zentrale-Orte-Konzept verfügt die Regionalplanung über ein multifunktionales Instrument zur Gewährleistung der Daseinsvorsorge als Basis gesunder Lebensbedingungen einer Region.

Hinsichtlich der Freiraumstruktur bieten sich Anknüpfungsmöglichkeiten bezüglich des Schutzes der natürlichen und gesunden Lebensgrundlagen der unbebauten Umwelt. Nachhaltigkeit, Umwelt- und Klimaschutz stehen im Einklang mit der Sicherung gesundheitsförderlicher Raumstrukturen. Hierzu verfügt die Regionalplanung mit regionalen Grünzügen und Grünzäsuren über multifunktionale Instrumente. Weitere Einflussmöglichkeiten bestehen im Bereich der (Nah-) Erholung, einem grundlegenden Baustein zur Förderung der Gesundheit.

Im Bereich der Infrastruktur bestehen Verknüpfungspunkte zwischen Regionalplanung und Gesundheitsförderung insbesondere im Ausbau des ÖPNV zur Gewährleistung der Erreichbarkeit von Einrichtungen der Daseinsvorsorge. Vor dem Hintergrund des Schutzes der natürlichen und gesunden Lebensgrundlagen forciert die Regionalplanung zudem die Reduzierung der Verkehrsemissionen und den Ausbau regenerativer Energien.

Im Bereich der Gesundheit findet sich zudem auf Landesebene die Landeszentrale für Gesundheitsförderung in Rheinland-Pfalz e.V. (LZG.RLP), die vor allem im Bereich der Gesundheitsförderung auf kommunaler Ebene aktiv ist. Mit Fokussierung auf das Setting Kommune besteht bereits eine intensive Zusammenarbeit mit Kommunen hinsichtlich Beratung, Strukturbildung und Qualitätsentwicklung, wobei Ansprechpartnerinnen und Ansprechpartner insbesondere in den Bereichen Soziales und Gesundheit, weniger im Bereich der Planung, angesiedelt sind.

4 HANDLUNGSEMPFEHLUNGEN ZUR REGIONALEN GESUNDHEITSFÖRDERUNG

Als Ergebnis der in diesem Beitrag skizzierten Arbeit stehen Handlungsempfehlungen in struktureller wie inhaltlicher Hinsicht zur Gesundheitsförderung bzw. zur Sicherung und Schaffung gesundheitsförderlicher Raumstrukturen und Lebensbedingungen auf regionaler Ebene.

[23] vgl. LGA BW, o.J.
[24] vgl. Ergebnisse aus WEBER, 2021

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

4.1 Zielsetzung

Das Ziel der Implementierung des Konzepts der Gesundheitsförderung auf regionaler Ebene ist es, durch eine gesundheitsförderliche Regionalentwicklung die Gesundheit fördernde Raumstrukturen und Rahmenbedingungen zu schaffen und zu sichern. Hierzu soll die Gesundheitsförderung eine nominale Nennung in Plänen und Strategien der Regionalplanung und -entwicklung erfahren, um dieser einen größeren Stellenwert zuzuschreiben. Zudem sollen Schnittmengen zwischen der Gesundheitsförderung und der räumlichen Planung auf regionaler Ebene sowie den raumordnerischen Leitvorstellungen der nachhaltigen Raumentwicklung und der Gleichwertigkeit der Lebensverhältnisse aufgezeigt werden. Insgesamt ist eine Sensibilisierung der regionalen Planungsträger und weiterer Akteure für das Thema Gesundheitsförderung und deren damit verbundene Möglichkeiten, Einfluss auf die Gesundheit der Menschen nehmen zu können, anzustreben. Wesentliche Bausteine zur Implementierung der regionalen Gesundheitsförderung sind dabei

- die Beachtung des Konzepts der Gesundheitsförderung bei raumwirksamen Planungen und Entscheidungen auf regionaler Ebene,
- die Vernetzung der Akteure der Regionalplanung und des öffentlichen Gesundheitsdienstes,
- die Schaffung, Sicherung und Erhalt gesundheitsförderlicher Raumstrukturen und Lebensgrundlagen,
- die Informationsbereitstellung für relevante Akteure auf regionaler Ebene sowie
- eine Rahmensetzung zur weiteren Gesundheitsförderung auf nachfolgenden Ebenen.

4.2 Relevante Akteure

Gesundheitsförderung – unabhängig des Settings oder der räumlichen Ebene – erfolgt nicht als Selbstlauf, sondern benötigt einer strukturierten Initiierung, Organisation und nachhaltigen Sicherung. Relevante Akteure der regionalen Ebene sind gleichermaßen im Bereich der räumlichen Planung sowie der Gesundheit angesiedelt. In Rheinland-Pfalz sind demnach das Ministerium für Wissenschaft und Gesundheit, speziell das Referat „Gesundheitsförderung und -berichterstattung, Prävention", als oberste Gesundheitsbehörde sowie die Landeszentrale für Gesundheitsförderung und die Koordinierungsstelle Gesundheitliche Chancengleichheit Rheinland-Pfalz in Verantwortung. Weiterhin einzubeziehen sind u.a. das Landesamt für Soziales, Jugend und Versorgung als obere Gesundheitsbehörde, die Gesundheitsämter und die Akteure der Gesundheitsförderung auf kommunaler Ebene. Im Bereich der räumlichen Planung sollten die Landesplanungsbehörden und die fünf Planungsgemeinschaften auf regionaler Ebene tragende Funktionen wahrnehmen. Neben Akteuren der formellen Planung sind Organisationen des Regionalmanagements und -marketings einzubinden. Weiterhin sind u.a. im Rahmen der Planaufstellung beteiligte Träger öffentlicher Belange, die Kreisverwaltungen, die Kommunalpolitik oder beispielsweise LEADER-Regionen als relevante Akteure im Bereich der Gesundheitsförderung einzustufen.

Der Akteurskreis ist dabei je nach Anknüpfungspunkt und Konstellation, um weitere relevante Partnerinnen und Partner zu erweitern. Eine Rolle können dabei beispielsweise auch Akteure aus dem Umwelt- oder Klimaschutz, dem Tourismus, der Handwerks-, Industrie- und Handels- sowie Landwirtschaftskammer oder dem Vereinswesen spielen.

4.3 Handlungsempfehlungen zur Sicherung und Schaffung gesundheitsförderlicher Raumstrukturen und Lebensbedingungen

Die inhaltliche Ausrichtung von Regionalplanung und Regionalentwicklung sollte insgesamt eine Gewährleistung gesunder Lebensbedingungen in der Region durch die Sicherung und Schaffung gesundheitsförderlicher Raumstrukturen forcieren. In Ergänzung der bestehenden Leitvorstellung einer nachhaltigen Raumentwicklung mit gleichwertigen Lebensverhältnissen werden daher Handlungsempfehlungen in nachfolgenden Themenbereichen formuliert, die in wechselseitiger Abhängigkeit und Beeinflussung stehen.

4.3.1 Region der kurzen Wege planen

Die Bestrebungen einer gesunden, regionalen Siedlungsstruktur lassen sich mit den Ideen des Leitbilds „Stadt/Region der kurzen Wege" bzw. „15 Minuten Stadt" zusammenfassen. Übertragene Elemente einer

gesunden regionalen Siedlungsstruktur sind u.a. Kompaktheit, Nutzungsmischung, gute ÖPNV-Erreichbarkeiten sowie attraktive öffentliche (Frei-)Räume, um die zurückzulegende Strecke zwischen zwei Standorten, beispielsweise Wohnort und Arbeitsplatz, einerseits so gering wie möglich zu halten und dadurch Verkehrswege zu reduzieren sowie Zeit einzusparen und andererseits die Nutzung unterschiedlicher Mobilitätsarten zu ermöglichen (Fuß, Rad, ÖPNV oder Pkw). Gleichzeitig vermindert die Entwicklung kompakter, verdichteter Siedlungsräume die Notwendigkeit weiterer Freiflächeninanspruchnahme zu Siedlungs- und Verkehrszwecken. Die Regionalplanung ist demnach durch das Konzept der „kurzen Wege" in der Lage, die natürlichen Lebensgrundlagen eines gesunden Wohnumfelds in mehrfacher Weise positiv zu beeinflussen – u.a. durch Umsetzung folgender Maßnahmen:

- nachhaltige, kompakte Siedlungsentwicklung nach dem Leitbild der Innen- vor Außenentwicklung,
- Orientierung der Siedlungsentwicklung an den Achsen des SPNV,
- Festsetzung abgestufter Mindestdichten für Neu-, Umbau- und Erweiterungsplanungen in Abhängigkeit von Zentralität und Lage sowie
- Nutzungsmischung zur Gewährleistung kurzer Wege zwischen Standorten der Daseinsgrundfunktionen (koordinierende Funktion mit Übertrag an die kommunale Ebene).

4.3.2 Gesunde Wohnraumvielfalt vorsehen

Ein Wohnsitz bzw. eine Wohnung ist elementar für ein gesundes Leben, da die Wohnsituation weite Teile des Lebens, wie etwa das persönliche Wohlbefinden, die physische und psychische Gesundheit, beeinflusst. Weiterhin beeinflusst der Standort der Wohnung als (räumlicher) Mittelpunkt die Möglichkeit der Inanspruchnahme bzw. den Zugang zu allen Bereichen der Daseinsvorsorge. Unumstrittene Aufgabe der Raumordnung ist es daher, potenzielle Wohnbauflächen in ausreichender Quantität und Qualität zu sichern. Dabei bewegt sich die Raumplanung stets im Spannungsfeld zwischen der Sicherung ausreichender Flächen und der Vermeidung zusätzlicher Flächenneuinanspruchnahme für Siedlungs- und Verkehrszwecke. Es ist daher von besonderer Relevanz Flächenverfügbarkeiten, -potenziale und -bedarfe regelmäßig zu ermitteln, um auf Basis derer gezielt zu agieren und zu reagieren. Um den unterschiedlichen Bedürfnissen und Ansprüchen an den individuellen Wohnraum gerecht zu werden ist eine regionale Vielfalt des Wohnraums hinsichtlich Faktoren wie Lage, Art oder Kosten erstrebenswert, was u.a. durch die Umsetzung folgender Maßnahmen erreicht werden kann:

- Sicherung vielfältiger (ggf. durch Festlegungen/Empfehlungen unterschiedlicher Dichtewerte), hinsichtlich Qualität und Lage geeigneter, Flächen in städtischen und ländlichen Räumen unter Berücksichtigung einer nachhaltigen Siedlungsflächenentwicklung,
- Erstellung und Berücksichtigung komplexer Wohnraumbedarfsprognosen und -modellierungen sowie Wohnraum- und Baulandkataster bzw. -monitorings,
- Sicherung eines gesunden Lebensumfelds der Wohnstandorte ohne Beeinträchtigungen durch konkurrierende Nutzungen oder störende (Umwelt-) Einflüsse sowie
- Gewährleistung angemessener Erreichbarkeiten zu Einrichtungen der Daseinsvorsorge, insbesondere der Grundversorgung und Erholungsmöglichkeiten.

4.3.3 Daseinsvorsorge sichern und entwickeln

Es ist staatliche Aufgabe, die für ein menschliches (gesundes) Dasein als notwendig erachteten Güter und Leistungen bereitzustellen. In diesem Handlungsfeld ist es die Aufgabe der Raumordnung, zur Gewährleistung einer angemessenen Grundversorgung in der Region beizutragen: „Die Versorgung mit Dienstleistungen und Infrastrukturen der Daseinsvorsorge, insbesondere die Erreichbarkeit von Einrichtungen und Angeboten der Grundversorgung für alle Bevölkerungsgruppen, ist zur Sicherung von Chancengerechtigkeit in den Teilräumen in angemessener Weise zu gewährleisten; dies gilt auch in dünn besiedelten Regionen."[25] Neben der klassischen Versorgung mit Waren und Dienstleistungen umfasst die Grundversorgung indes auch die Bereitstellung von Angeboten zu Wohnen, Bildung, Erholung und Arbeiten sowie die Gewährleistung der (gleichwertigen) Erreichbarkeit dieser durch entsprechende

[25] §2 Abs.2 Nr. 3 ROG

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Verkehrsinfrastrukturen. Die Daseinsvorsorge vereint insgesamt eine Vielzahl der räumlichen Determinanten der Gesundheit und bedarf daher im Hinblick auf eine gesunde Region bzw. gesundheitsfördernde Raumstrukturen einer nachhaltigen Sicherung und Entwicklung durch die Regionalplanung. Neben den klassischen Instrumenten der Raumordnung, wie beispielsweise der konsequenten Anwendung der Grundzüge des Zentrale-Orte-Konzepts, sind folgende Maßnahmen empfehlenswert:

- Weiterentwicklung des „Ausstattungskatalogs" zentraler Orte durch eine Integration digitaler, mobile und hybrider Versorgungsformen,
- Entwicklung modellhafter (informeller) Konzepte zur Gewährleistung aller Bestandteile der Daseinsvorsorge in allen Teilräumen der Region,
- Erstellung lokaler/regionaler Nahversorgungskonzepte zur interkommunalen Kooperation zwischen Versorgungszentren und Umlandgemeinden,
- Sicherung landwirtschaftlicher Flächen in ausreichender Qualität und Quantität zur Förderung regionaler Produktion sowie
- Aufbau eines Netzwerks für Akteure der Wertschöpfungskette regionaler Produkte.

4.3.4 Naherholung bedenken, sichern und entwickeln

Der Erholung in allen Formen wird als Ausgleich zum Alltags- und Berufsleben ein hoher Stellenwert für die Gesundheit Einzelner zugesagt. Erholung wird dabei zumeist mit (körperlicher) Bewegung an der Luft in Zusammenhang gebracht. Zu deren Förderung kann die Regionalplanung insbesondere zur Erholung geeignete Flächen in angemessener Quantität und Qualität – beispielsweise in Form von Grün- und Freiräumen – sichern und entwickeln. Um die Brandbreite an gesundheitsförderlichen Aktivitäten im Bereich der Naherholung (von kurzen Spaziergängen und stillem Naturerlebnis über Wanderungen und Waldbaden bis hin zu Fahrradtouren und anderer sportlicher Betätigung) abbilden zu können, kommt insbesondere den Akteuren der Regionalentwicklung die Ausgabe der qualitativen Entwicklung und Gestaltung von Erlebnis- und Erholungsräumen zu. Folgende Maßnahmen sind zur positiven Beeinflussung der gesundheitsförderlichen (Nah-) Erholung für die Regionalentwicklung und -planung empfehlenswert:

- Sicherung und Entwicklung von zur Erholung geeigneter Flächen in ausreichender Qualität und Quantität,
- Vernetzung von Grünflächen und Einbindung in überregionale Grünzusammenhänge,
- gezielte Ausweisung von Grünzügen und Grünzäsuren als multifunktionale Instrumente zur Sicherung der Grün- und Erholungsräume,
- qualitativer Ausbau und Vernetzung von Wander- und Fahrradrouten,
- Erstellung lokaler/regionaler Naherholungskonzepte zur Steuerung der qualitativen Entwicklung von Erholungsräumen sowie
- Weiterentwicklung des Regionalpark-Ansatzes zur projektorientierten, qualitativen Entwicklung von Natur- und Erholungsräumen.

4.3.5 Erreichbarkeit für alle sichern und Bewegung fördern

Eine Vielzahl räumlicher Determinanten können ihre positive Wirkung nur dann erzielen, wenn sie für die Menschen erreichbar und zugänglich sind: Arbeitsplätze, Versorgungseinrichtungen, Erholungsmöglichkeiten, Bildungsangebote oder andere Bereiche der Daseinsvorsorge bedürfen einer Vernetzung durch geeignete Verkehrsinfrastrukturen. Als gesunde Verkehrsinfrastrukturen können dabei niederschwellige Angebote für alle sowie gleichwertige Erreichbarkeiten unabhängig des Wohnstandorts angesehen werden. Gerade in ländlichen Räumen, in denen die Pkw-Nutzung häufig alternativlos erscheint, stellt die zukünftige Mobilitätsgewährleistung eine große Herausforderung dar. Der Zugang zu öffentlichen Verkehrsmitteln mit einer entsprechenden Anbindung an zentrale Orte und Einrichtungen versteht sich im Hinblick auf gesundheitsfördernde Raumstrukturen als Grundvoraussetzung, um den umweltbelastenden motorisierten Individualverkehr zu reduzieren und eine Gleichwertigkeit der Anbindung zu gewährleisten. Weiterhin kann eine auf kurze Wege ausgerichtete regionale Raumstruktur einen Beitrag zu Bewegungsförderung und damit zur Gesundheit Einzelner leisten. Handlungsempfehlungen sind daher u.a.

- Vorrang der Entwicklung des öffentlichen Verkehrs vor der des (motorisierten) Individualverkehrs,
- Förderung multimodaler Mobilitätsangebote zur Schaffung einer flächendeckenden, aber flexible und individuell gestaltbaren Erreichbarkeit (z.B. Mobility Hubs, Sharing-Mobility, Park&Ride),
- Berücksichtigung spezieller Bedürfnisse aller Gruppen im Verkehr,
- Ausbau der lokalen/regionalen Fuß- und Radwegeinfrastruktur,
- Schaffung attraktiver Angebote zur Nutzung des öffentlichen Verkehrs (Jobticket) bzw. des Fahrrads (Radwegenetz, Radschnellwege) sowie
- Sensibilisierung der Bevölkerung für das Thema Bewegungsförderung

4.3.6 Herausforderungen in Umwelt- und Klimaschutz sowie erneuerbaren Energien angehen

Die (unbebaute) Umwelt bildet als natürliche Lebensgrundlage des Menschen eine der bedeutendstem räumlichen Determinanten der Gesundheit. Kaum ein anderer Einflussfaktor kann derartige positive wie auch negative Auswirkungen auf die Gesundheit ausüben. Daher ist es von höchster Relevanz, dass die Regionalplanung und -entwicklung dem Umwelt- und Klimaschutz sowie der Förderung erneuerbarer Energien einen großen Stellenwert zuweist – auch zur Schaffung gesundheitsförderlicher Lebensbedingungen.

Eine ausreichende Energieversorgung kann ebenfalls als Grundvoraussetzung der Daseinsvorsorge und eines gesunden Lebens angesehen werden. Dabei nimmt auch die Form der Energiegewinnung Einfluss auf die Gesundheit eines Menschen. Fossile Energieträger sind nicht nur begrenzte natürliche Ressourcen, sondern verursachen bei der Ernergiegewinnung erhebliche negative Auswirkungen auf die Umwelt und die Gesundheit und solltem demnach auf ein Minimum gegenüber der Nutzung regenerativer Energiequellen begrenzt werden.

Für die Regionalplanung und -entwicklung ergeben sich in diesen Bereichen folgende Handlungsempfehlungen, um einen Beitrag zur Gesundheitsförderung zu leisten:

- Reduzierung der Luftverschmutzung und Lärmbelastung u.a. in den Bereichen Verkehr und Industrie,
- Gewährleistung konfliktfreier Nachbarschaften konkurrierender Flächennutzungen (u.a. Wohnen und Industrie; in gemeinsamer Wahrnehmung mit der kommunalen Ebene),
- Minimierung der Flächenneuinanspruchnahme für Siedlungs- und Verkehrszwecke, Minimierung der Flächenversiegelung,
- Sicherung klimatischer Ausgleichsflächen u.a. zur Kaltluftentstehung und -verteilung sowie zur Luftzirkulation,
- Vorrang der Entwicklung erneuerbarer Energien vor fossiler Energien durch Sicherung von Flächen für Standorte regnerativer Energiequellen und notwendiger Verteilungsinfrastruktur,
- Aufstellung regionaler/lokaler Klima- und Umweltschutzkonzepte,
- Etablierung eines Klimamanagements,
- verstärkte Sensibilisierung der Bevölkerung für die Themen Klima- und Umweltschutz sowie den bestehenden Zusammenhang zur Gesundheit (z.B. regionale Klimaaktionstage) sowie
- Sensibilisierung der Bevölkerung hinsichtlich der Mehrwerte regenerativer Energiequellen zur Förderung der Akzeptanz von Anlagen im Landschaftsbild.

5 FAZIT UND AUSBLICK

Gesundheit und Raumplanung – zwei Themenfelder mit zahlreichen Verknüpfungen auf allen räumlichen Ebenen und einer an Bedeutung gewonnenen Verbindung zwischeneinander. Dabei kristallisiert sich besonders die Gesundheitsförderung mit dem Ziel der Stärkung und Erhaltung von Gesundheitsressourcen und Möglichkeiten der Einflussnahme auf die (räumlichen) Determinanten der Gesundheit als Schnittpunkt beider Themenfelder heraus.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Gesundheit selbst ist bereits heute ein sehr bedeutsames Thema und wird durch aktuelle Ereignisse wie die Corona-Pandemie, der Klimawandel oder Extremwetterereignisse auch in Zukunft von großer Relevanz sein. Die Frage, inwiefern im Sinne der salutogenetischen Perspektive Einfluss über die Steuerung der gesundheitlichen Determinanten genommen werden kann, wird in den nächsten Jahren mehr und mehr Einhalt in politische Diskussionen gewinnen. Gerade im Bereich der räumlichen Planung bieten sich dabei zahlreiche Anknüpfungspunkte, um die Gesundheit einzelner durch gesundheitsförderliche Lebensbedingungen und Raumstrukturen positiv zu beeinflussen. Neben der bereits initiierten Gesundheitsförderung auf kommunaler Ebene weist dabei die regionale Ebene spezifische Potenziale auf, um durch Gesundheitsförderung einen Mehrwert für die Gesundheit der Bevölkerung generieren zu können.

Dieser Mehrwert definiert sich vornehmend darüber, negative Auswirkungen der räumlichen Determinanten auf die Gesundheit zu minimieren und gleichermaßen gesundheitsförderliche, das heißt sich positiv auf die Gesundheit auswirkende, Raumstrukturen zu schaffen. Potenziale bieten dabei die Steuerung und Entwicklung der Siedlungs-, Freiraum- und Infrastruktur mit Fokus auf die skizzierten Themen- und Handlungsbereiche:

- Region der kurzen Wege planen,
- gesunde Wohnraumvielfalt vorsehen,
- Daseinsvorsorge sichern und entwickeln,
- Naherholung bedenken, sichern und entwickeln,
- Erreichbarkeit für alle sichern und Bewegung fördern sowie
- Herausforderungen in Umwelt- und Klimaschutz sowie erneuerbaren Energien angehen.

Dabei ist weitergehend zu prüfen, inwiefern Ansätze zur Gesundheitsförderung mit Leitlinien und Handlungsmaximen aktueller Leitvorstellungen, Strategien und Konzepte der Raumplanung übereinstimmen bzw. vereinbar sind. Insbesondere in der Schaffung gleichwertiger Lebensverhältnisse in allen Teilräumen sowie der nachhaltigen Raumentwicklung liegen viele Überschneidungen zu Handlungsansätzen einer regionalen Gesundheitsförderung, weshalb dem Thema Gesundheit allgemein ein höherer Stellenwert in planerischen Abwägungsentscheidungen beizumessen ist.

Die Analyse der Determinanten der Gesundheit verdeutlicht weiterhin die Relevanz von Gesundheitsförderung auf den unterschiedlichen Ebenen der räumlichen Planung: Der Großteil der räumlichen Einflussfaktoren (v.a. bebaute und unbebaute Umwelt) liegt nicht im Zugriff des Gesundheitssektors, sondern im Zuständigkeitsbereich der regionalen und lokalen Planungsträger. Entsprechend kommt der Regionalplanung und -entwicklung eine entscheidende Rolle zur Schaffung gesundheitsförderlicher Lebensbedingungen und damit zur Beeinflussung der Gesundheit zu. Gesundheitsförderung leistet demnach nach dem salutogenetischen Gesundheitsverständnis einen wichtigen Beitrag zur Entwicklung gesundheitsförderlicher Raumstrukturen und gesunder Lebensverhältnisse, die wiederum zu einer höheren Gesundheit der in der Region lebenden Einwohnerinnen und Einwohner führen.

Dem Thema Gesundheit sollte daher in der Regionalplanung und Regionalentwicklung in Zukunft ein größerer Stellenwert beigemessen werden. Es ist zu erwarten, dass dadurch sowohl die Gesundheitsförderung als auch die Regionalplanung in einer Art „Win-win-Situation“ voneinander profitieren: Mit dem Themenfeld Gesundheit kann die Regionalplanung greifbarerer und verständlicher für Bürgerinnen und Bürger werden, da keine abstrakten Regelungsgegenstände in der Zukunft behandelt werden, sondern Entscheidungen getroffen werden, die jede:n Einzelne:n unmittelbar betreffen. Mit einem größeren Verständnis der Regionalplanung besteht die Möglichkeit der Akzeptanz- und letztlich Effizienzsteigerung regionalplanerischer Festlegungen.

6 LITERATURVERZEICHNIS

BARTON, Hugh/GRANT, Marcus: A health map for the local human habitat, In: ROYAL SOCIETY FOR PUBLIC HEALTH (Hrsg.): The Journal of the Royal Society for the Promotion of Health. London, 2006.

BAUMGART, Sabine/KÖCKLER, Heike/RITZINGER, Anne/RÜDIGER, Andrea: Gesundheitsförderung – Ein aktuelles Thema für Raumplanung und Gesundheitswesen. Einführung, In: BAUMGART, Sabine/KÖCKLER, Heike/RITZINGER, Anne/RÜDIGER, Andrea (Hrsg.): Planung für gesundheitsfördernde Städte. Forschungsbericht der ARL 08. Hannover, 2018.

BAYERISCHES STAATSMINISTERIUM FÜR GESUNDHEIT UND PFLEGE (STMGP): GesundheitsregionenPlus, unter: https://www.gesundheitsregionenplus.bayern.de/ (10.07.2022)

BUNDESMINISTERIUM FÜR GESUNDHEIT (BMG): Gesundheitsförderung und Prävention für ältere Menschen im Setting Kommune. Dortmund, 2009.

BUNDESZENTRALE FÜR GESUNDHEITLICHE AUFKLÄRUNG (BZgA): Leitbegriffe – Settingansatz/Lebenswelten, unter: https://leitbegriffe.bzga.de/alphabetisches-verzeichnis/settingansatz-lebensweltansatz/, 2015 (15.07.2022)

BUNDESZENTRALE FÜR GESUNDHEITLICHE AUFKLÄRUNG (BZgA): Leitbegriffe – Grundlagen, unter: https://leitbegriffe.bzga.de/alphabetisches-verzeichnis/gesundheitsfoerderung-1-grundlagen/, 2018 (15.07.2022)

CLASSEN, Thomas: Gesundheitsförderliche Stadtentwicklung – Zwischen Renaissance und Neuerfindung, in: BUNDESINSTITUT FÜR BAU-, STADT- UND RAUMFORSCHUNG (BBSR) IM BUNDESAMT FÜR BAUWESEN UND RAUMORDNUNG (BBR) (Hrsg.): Informationen zur Raumentwicklung: Gesundheit und Krankheit aus räumlicher Perspektive, Heft 1/2020, S. 4-17. Bonn, 2020.

GKV-SPITZENVERBAND: Leitfaden Prävention – Handlungsfelder und Kriterien nach §20 Abs. 2 SGB V. Berlin, 2020.

HORNBERG, Claudia/LIEBIG-GONGLACH, Michaela/PAULI, Andrea (2018): Gesundheitsförderung – Ein Konzept und seine Entwicklung in Deutschland, In: BAUMGART, Sabine/KÖCKLER, Heike/RITZINGER, Anne/RÜDIGER, Andrea (Hrsg.): Planung für gesundheitsfördernde Städte. Forschungsbericht der ARL 08. Hannover, 2018.

KÖCKLER, Heike: Das Präventionsgesetz – Die Krankenkassen als neuer Akteur der Stadtentwicklung, in: INFORMATIONSKREIS FÜR RAUMPLANUNG E.V. (IfR) (Hrsg.): Raumplanung – Stadtentwicklung und Gesundheit, Heft 186, 4/2016. Dortmund, 2016.

KOOPERATIONSVEREINIGUNG GESUNDHEITLICHE CHANCENGLEICHHEIT (KGC): Gesundheitsförderung im Quartier – Factsheet. Berlin, 2014.

WEBER, Tobias: Leitfaden Gesunde Region – Handlungsansätze der Regionalentwicklung zur Gesundheitsförderung in Rheinland-Pfalz. Masterarbeit am Lehrstuhl Regionalentwicklung und Raumordnung der Technischen Universität Kaiserslautern. Kaiserslautern, 2021.

WELTGESUNDHEITSORGANISATION (WHO): Ottawa-Charta zur Gesundheitsförderung. Ottawa, 1986.

WELTGESUNDHEITSORGANISATION (WHO): Die Jakarta Erklärung. Jakarta, 1997.

WELTGESUNDHEITSORGANISATION (WHO): Introduction to Healthy Settings, unter: http://www.who.int/healthy_settings/about/en/ (24.07.2022)

LANDESZENTRUM GESUNDHEIT NORDRHEIN-WESTFALEN (LZG.NRW): Gesunde Planung, unter: https://www.lzg.nrw.de/versorgung/ges_plan/index.html (07.07.2022)

LANDESGESUNDHEITSAMT BADEN-WÜRTTEMBERG (LGA BW): Gesundheitsplanung, unter: https://www.gesundheitsamt-bw.de/lga/de/themen/gesundheitsfoerderung/gesundheitsdialog/seiten/gesundheitsplanung/ (07.07.2022)

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

🏆 *reviewed paper*

GIS-based Identification of Densification Types

Yingwen Deng, Sabine Gadocha, Wolfgang Spitzer, Thomas Prinz

(Yingwen Deng, MSc, Research Studios Austria Forschungsgesellschaft mbH, Studio iSPACE, Schillerstraße 25/Stiege Nord, 5020 Salzburg, Austria, yingwen.deng@researchstudio.at)
(Mag. Sabine Gadocha, Research Studios Austria Forschungsgesellschaft mbH, Studio iSPACE, Schillerstraße 25/Stiege Nord, 5020 Salzburg, Austria, sabine.gadocha@researchstudio.at)
(Mag. Wolfgang Spitzer, Research Studios Austria Forschungsgesellschaft mbH, Studio iSPACE, Schillerstraße 25/Stiege Nord, 5020 Salzburg, Austria, wolfgang.spitzer@researchstudio.at)
(Mag. Dr. Thomas Prinz, Research Studios Austria Forschungsgesellschaft mbH/Universität Salzburg (PLUS) – IDA Lab, Schillerstraße 25/Stiege Nord, 5020 Salzburg/Jakob-Haringer-Straße 6, Techno 6, 5020 Salzburg, Austria, thomas.prinz@researchstudio.at)

1 ABSTRACT

Due to the prevailing settlement pressure and the increasing demand for living space, land consumption is draining the limited land reserves in the alpine region. From 2018 to 2020, an average of 11.5 hectares of land per day were used in Austria[1]. Until 2020, while the population grew by just 10.9 percent, land use in Austria has increased by more than 27 percent since the turn of the millennium[2]. As urban sprawl increases, green spaces decrease and are more and more sealed by asphalt and concrete. To avoid the constant exploitation of open and green spaces, promoting higher land-use efficiency by densification within existing settlement areas is pursued as an alternative, more sustainable path of settlement development. It is therefore essential to provide decision-makers, planners, developers, and architects with a detailed overview of the densification potential within current settlement areas. This paper introduces a GIS-supported methodology to facilitate this task.

In our research within the Alpine Building Centre – Simulation of Settlement Systems (Zentrum Alpines Bauen), we first developed a GIS-analysis model for the automated identification of theoretical densification potentials on building plot level while taking legal building regulations and local specifications for structural density into account. In a further step, we elaborated a building-related typology for the classification of these potentials, by integrating the geometry and cubature information of the existing building stock and building plots. GIS analysis models were then developed in accordance with this typology to identify and quantify these potentials theoretically, and to model their generalized three-dimensional (3D) shapes. The proposed typology characterises current densification potentials in Salzburg state into four types: building replacement, roof stacking, building extensions, and independent building annexes. As a case study, this analysis was implemented on a test municipality in Salzburg state - Henndorf am Wallersee. Experimental outcomes are visualized in an interactive 3D web map that provides an overview of the result. The outcome data provide important information and a planning basis that support local planners and decision-makers in achieving more sustainable, resource-efficient future settlement development.

Keywords: GIS-analysis, densification potential, densification typology, 3D-web map

2 INTRODUCTION

The Alpine region is confronted with major planning challenge: While the availability of land is severely limited by natural landscape conditions, the demand of living space increases and thus results in high settlement pressure. Under this pressure, built-up urban areas expand with inefficient land use and leads to urban sprawl, which is a crucial issue for sustainable development in the future (EEA, 2006). It inevitably causes a loss of agriculture land and open green spaces, and in return a replacement with almost irreversible sealed soil. Such unsustainable use of land has negative impacts on the quality of life and ecosystems, which includes aspects such as agriculture production, biodiversity, climate protection, energy consumption, increased mobility, etc. (EEA, 2019). These negative effects can bring about potentially serious environment, economic, social and health risks. Until 2020, while the population grew by just 10.9 percent, land use in Austria has increased by more than 27 percent since the turn of the millennium (WWF, 2021). Accordingly, Austria has set a national-wide soil protection strategy for more economical land use with a target for

[1] Flächeninanspruchnahme. (2021, June). Umweltbundesamt. https://www.umweltbundesamt.at/umweltthemen/boden/flaecheninanspruchnahme
[2] WWF: Bodenverbrauch fast dreimal so stark gestiegen wie Bevölkerungswachstum. (2021, December). WWF. https://www.wwf.at/wwf-bodenverbrauch-fast-dreimal-so-stark-gestiegen-wie-bevoelkerungswachstum/

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

reducing land use to a net of 2.5 hectare per day by the year 2030 (Bundeskanzleramt Österreich, 2020). However, the average consumption of land in Austria from 2018 to 2020 amounts up to 11.5 hectares per day (Umweltbundesamt, 2021), which significantly exceeds the target.

Such excessive land use is not a unique phenomenon in the Alpine region. It is one of the major environment challenges in Europe (EEA, 2006). To address this problem, 'No Net Land Take' in EU by 2050 is promoted in the 7th EAP (EU Environment Action Programme to 2020) and the EU Roadmap to Resource Efficient Europe (European Commission, 2011). This 'No Net Land Take' goal aims to reduce the effect of urban sprawl by avoiding sealing agricultural land and open spaces. Instead, it stresses the focus to the utilization of land that has already been sealed (Science Communication Unit, 2016). In response, densification (or infill development) is promoted by policymakers and pursued as a solution to urban sprawl (Artmann, Inostroza, & Fan, 2019). Priority is stressed for inward settlement development in the spatial planning handbook for Salzburg state (Amt der Salzburger Landesregierung, 2012). By concentrating development in existing settlement areas, additional dispersed, low density settlement development is prevented. As result, land that may consumed by urban sprawl is spared. Reasonable densification is considered as a crucial element to the path of sustainable development (Marique & Reiter, 2014; McConnell & Wiley, 2012; Pelczynski & Tomkowicz, 2019; Wicki & Kaufmann, 2022).

Several case studies in European countries that provide overviews and recommendations for densification are conducted: Nabielek (2011) summarized the Dutch national urban planning policy concerning densification, and ,through empirical research, provided insights of the intensity and types of locations of densification within the existing urban area in the four largest Dutch cities; Attia (2015) first reviewed the existing building stock in Liège city, Belgium, then he generalized urban densification scenarios of the city along with recommendations and potential challenges; Netsch (2021) gave an overview of 22 densification projects in Salzburg over the past 25 years. With the advance in open data availability, geospatial data have been used to the automatic identification of densification potential in multiple scales: Vuckovic et al. (2017) proposed a computational environment to generate potential densification schemes in 3D based on a spatial dataset in an urban area within the city, Graz, Austria; Abedini and Khalili (2019) used multi-criteria evaluation techniques combined with geographic information system (GIS) to determine the capacity of Urmia, Iran, and identified suitable plots for densification; Eggimann et al. (2021) presented a geospatial simulation framework to evaluate densification potentials at neighbourhood level; Amer, Reiter, and Attia (2018) adopted multiple criteria and boundary conditions to identify densification potential through roof stacking; Schiller et al. (2021) validated the feasibility of automated detection and monitoring of densification potentials via GIS-based procedures.

As it is mentioned in the guidelines for the 'spatial development concept' of Salzburg state, densification potentials are considered as one essential source of building land reserves (Land Salzburg, 2019). It is therefore important to provide a detailed overview of these densification potentials. This paper introduces a generic GIS-supported methodology for the automated identification of theoretical densification potential types on building plot level. Our objective is to assess and quantify the densification potentials that exist in the current settlement areas for each densification type. Using available geospatial data, we model the theoretical generalized 3D shapes of these potentials and provide a realistic view of them in an interactive web map. With this tool, we aim to assist decision-makers, planners, developers, and architects in recognizing and reflecting on the existing densification options. The delivered information can serve as a basis for further investigation for on-site implementation.

3 APPROACH

3.1 Densification types

Urban densification within existing settlement areas can be implemented through building extension in both vertical and horizontal directions (Attia, 2015). In our research, four densification types are further derived based on their characteristics among these two general densification directions. The first type is building replacement - replacing existing low-density buildings with new residential building structures with higher density. The second type is roof stacking. With this densification type, buildings are extended vertically - additional stories are added to the top of existing buildings in order to accommodate more households, thus occupying more land are avoided (Amer, Mustafa, Teller, Attia, & Reiter, 2017). With both the third type,

building extensions, and the fourth type, independent building annexes, the horizontal extent of existing buildings are expanded. For example, building potentials located in the gardens of built-up building plots are utilized for constructing new residential buildings (Marique & Reiter, 2014). The difference between these two types is that, with the type „building extension", an extension is directly attached to existing building, while independent building annexes are additional residential units that share the same building plots with existing buildings but are unconnected to the existing buildings and are usable independently. The building-related typology that we established for the classification and GIS-based identification of densification potentials are based on these four types.

It is worth noting that, besides above-mentioned densification types, gap closure is another type of urban densification that are adapted in the cities (Attenberger, 2014). It is to fill the gaps between existing buildings on neighbouring building plots with new dwellings (Amer et al., 2017). However, this type is excluded from this research, as the filled gaps are across building plot boundaries which are not depictable in our building plot-based analysis.

3.2 Simulation parameters

The future development of settlement area regarding densification is constrained by various spatially relevant conditions that are listed in land development law and building regulations. There are horizontal and vertical limitations of spatial growth when it comes to expanding existing building stocks for additional living spaces (Vuckovic et al., 2017). Spatial relevant parameters are used as constraints in this study for the establishment of the building-related typology for densification potentials and the simulation of possible cubature for densification at each building plot. These parameters include legal building regulations for Salzburg state and local specifications for structural density.

According to the land development law of the Salzburg state (Land Salzburg, 2015), the buildings must be located in the building plot in such a way that their fronts are at least from the boundaries of the building site by a minimum distance of 3/4 of their eave heights, but in any case larger than 4 meters. Therefore, in this research, we use this constraint as a baseline to model the maximum possible height of each simulated cubature.

Moreover, since the municipalities in Salzburg state (except for Salzburg city) usually do not have digital development plans, from which the maximum building density can be automatically read out by GIS analysis models, the concept of local specification for structural density (*Ortsübliche Dichte*) is introduced in this research (Gadocha, Spitzer, Deng, & Prinz, 2021). For each analysis building plot, its structural density is calculated from an intersection with the available spatial dataset of building stock in Salzburg state. The second highest density for each analysis plot is derived from the surrounding eight analysis plots and stored as the local specification for structural density for this building plot. The local specification for structural density includes following parameters: ground space index, floor space ratio, cubic index, number of full floors, and ridge height. Table 1 provides an overview of these parameters and their definitions.

Parameter Name	Definition
Ground space index	The ratio between the building's footprint area and the surface area of the corresponding building plot
Floor space index	The ratio between the permissible aggregate surface area of all the storeys in a building and the surface area of the corresponding building lot
Cubic index	The ratio between the cubic meters of building mass and the surface area of the corresponding building lot
Number of full floors	The number of all floors of a building except basement, roof, and attic floors
Ridge height	Height of a building measured up to the ridge

Table 1: List of parameters used for local specification for structural density.

3.3 Building-related typology for densification potentials

To automatically identify and quantify densification potentials regarding previously introduced densification types with GIS analysis model, a building-related typology (Fig. 1) was established with taking legal building regulations and local specifications for structural density into account. Values of the modelling parameters used in the typology were chosen in consultation with urban planners from spatial planning

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

departments of the city and state as well as stakeholders from a non-profit housing association. However, these values can be adjusted accordingly to fit individual study areas and particular development regulations.

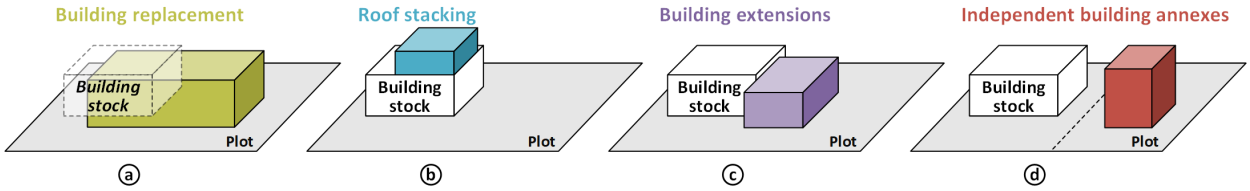


Fig. 1: Illustration of the building-related typology: (a) Type 0: Building replacement, (b) Type 1: Roof stacking, (c) Type 2: Building extensions, (d) Type 3: Independent building annexes

Type 0: Building replacement

For this type, under the consideration of the legal distance requirement (minimum distance equals to 4 meters or 3/4 of the eaves height), possible cubatures are simulated for each analysis building plot. The maximum utilization of each analysis building plot is then selected according to the calculation of gross floor area of each simulated building model. The selection of the maximum utilization is limited by the condition that the simulated cubature doesn't exceed any local specification for structural density.

Type 1: Roof stacking

For this type, the simulation of possible cubature is limited to the extent of the footprint of building stock. Existing buildings with minimum 90m² gross floor area are selected for the simulation. Under the consideration of the legal distance requirement and local specification for structural density, simulated roof stacking model with the largest gross floor area is selected. Simulated roof stacking model is the part of the simulated cubature that is above the ridge height derived from the existing building. The total cubature of existing building and roof stacking model is limited by local specification for structural density. Additionally, the roof stacking model should be wider than 5 meters and with minimum 85 m² gross floor area (approximately 1 housing unit).

Type 2: Building extensions

For this type, the extent of the simulated cubature's footprint is limited to the rest of its located building plot minus the existing building's footprint. Following the legal distance requirement and local specification for structural density, a simulated building extension that is directly connected to the existing building and with the largest possible gross floor area (larger than 85 m², approx. 1 household) is selected. The minimum width of the building extension models is differentiated into potential for the extension of living space (width from 5 to 8 meters) and potential for additional residential units (wider than 8 meters).

Type 3: Independent building annexes

In the simulation of independent building annexes, as in the case of building extensions, the footprint of the simulated cubature is restricted from overlapping with the existing building's footprint. However, the annex model is required to have a minimum distance to the neighbouring existing building. Two variations are modelled in this research. The first variation is to add building annexes without building plot division. In this variation, a minimum distance of 3/4 of the height of the existing building plus 3/4 of the height of the annex model between them is assumed. The second variation is that when a building plot is suitable for subdivision based on its shape and size (larger than 1200 m²), selection criteria of a minimum distance of 15 meters between the existing building and the annex model, as well as a minimum gross floor area of 180 m² of the annex model is assumed.

3.4 Workflow

The methodology (Fig. 2) for deriving densification types starts with the selection of building plots depending on land use zoning. For these plots, different cubatures are simulated depending on distance to the parcel boundaries in the simulation model. For each cubature, its density parameters (i.e., ground space index, floor space ratio, cubic index, number of full floors, ridge height) are calculated. For each plot, the structural density is estimated by the eight nearest neighbouring existing buildings and their plots. Depending on the derived structural density as a constraint, the cubature with the maximum gross floor area is selected.

The difference of this maximum gross floor area and the gross floor area of the building is assumed as the densification potential of type 0 (Building replacement).

In the next step, the plots with a densification potential of type 0 are simulated again for the other types in a similar way but with different parameters and constraints (according to the typology, see section 3.3). For type 1 (Roof stacking) the footprint of the building stock is used, for type 2 (Building extension) and 3 (Independent building annexes) the plot minus the existing building's footprint is used. The selected cubature of type 2 has to be connected to the existing building and for type 3 the selected cubature must be detached from the existing building with a defined minimum distance.

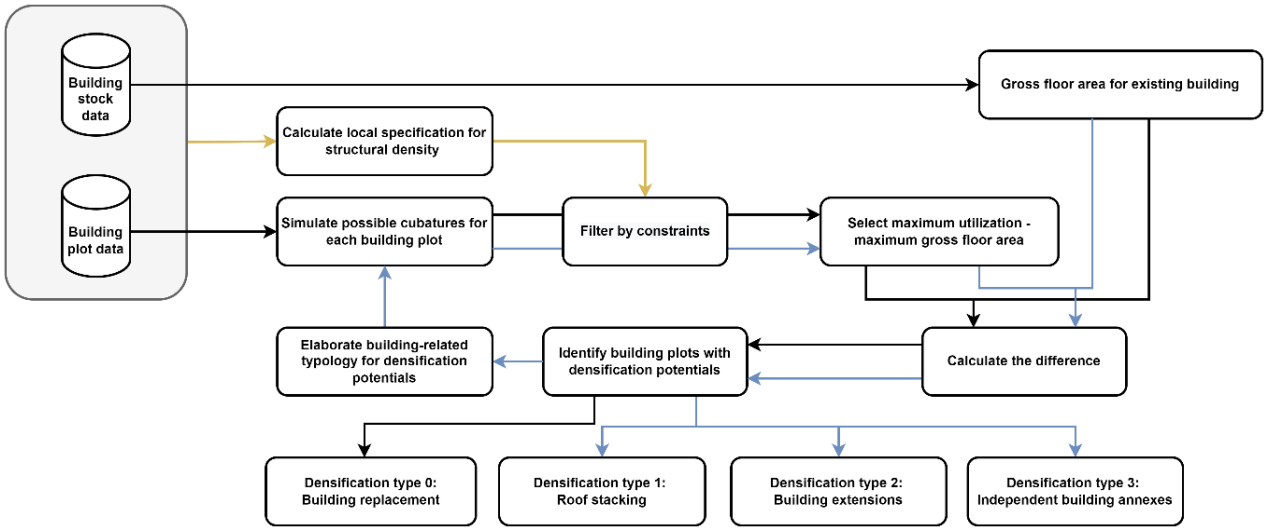


Fig. 2: Workflow of the GIS-based identification of densification types

4 CASE STUDY AND RESULT VISUALIZATION

Henndorf am Wallersee is a municipality located in the north of Salzburg state. It is with an area of 23,51 km² and 4933 inhabitants by 2020 (Salzburg Wiki, 2022). This section focuses on a case study of this municipality. Previously introduced densification type identification workflow was implemented in this test municipality. As outcome, densification potentials in accordance with the building-related densification typology are identified and quantified for each land parcel. An overview of the analysis result is given in this section (see Table 2). Additionally, in this section, we introduce the prototypical user interface and features of the interactive web map that was developed for the visualization of the analysis result in 3D (see Fig. 3).

4.1 Experimental results

In our case study, residential building plots that are built-up with buildings' footprints larger than 12 m² and with construction windows larger than 100 m² or wider than 10 meters are selected for the analysis. There are 3625 building plots in Henndorf, with 40% designated for residential building plots. Among these building plots, almost 51% of them, which takes up more than 78% of the total area, are already built-up with buildings that meet our selection criteria. According to our experimental result (see Table 2), almost half of these analysis building plots are identified with densification potential (or underused). It means that the gross floor area of the existing buildings on these building plots are smaller than the theoretical maximum gross floor area that can be achieved. With the densification type 0 – building replacement, approximately 1144 housing units could be added. Among the other three densification types, most building plots with densification potentials are identified with the possibility to add building extensions (i.e. Densification type 2), corresponding to accommodation of approximately 857 households. More than 95% of these building plots have the potential to add an extension that is wider than 8 meters, which can be used to create new residential units. It is possible for around 25% of the underused building plots to add independent building annexes to the existing buildings. Only less than 3% of the underused building plots are eligible for building independent annexes with land subdivision, which could add approximately 92 housing units. As for the densification type roof stacking, limited by the cubatures of the existing buildings, only around 4% of

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

the underused building plots have such potential. Approximately 18 housing units can be created by this densification type.

Henndorf am Wallersee		Building plots		Potential [Maximum utilization, Local specification for structural density, Densification types]	
		Number	Area	Gross floor area (m²)	Housing units (85m² per Housing Unit)
Building plots		3625	2352.6 ha	-	-
Residential building plots		1468	93.8 ha	-	-
Built-up building plots - Buildings ≥12m² - with construction windows (≥100m² / ≥10m)		745	73.7 ha	-	-
without potential		*388*	*33.9 ha*	*6483*	*0*
Type 0 Building Replacement		**357**	**39.8 ha**	**111131**	**1144**
Type 1 Roof Stacking		**16**	**2.2 ha**	**1993**	**18**
Type 2 Building Extensions	**Living space extension**	**277**	**32.7 ha**	**83805**	**857**
	Additional residential units	**265**	**31.2 ha**	**80731**	**827**
Type 3 Independent Annexes	**Without subdivision**	**91**	**15.1 ha**	**32930**	**344**
	With subdivision	**10**	**3.6 ha**	**8226**	**92**

Table 2: Summary of the identified densification potentials in Henndorf am Wallersee

4.2 Web visualization

In order to make the analysis result easily accessible and explorable for our target groups (i.e. decision-making authorities, planners, developers, and architects), an easy-to-use, straightforward 3D web map is developed to facilitate this task. Figure 3 provides an overview of the application's user interface and its components. The components of the user interface can be divided into following categories: application header, 3D map elements, and core features that allow users to interact with the identified densification potentials regarding each densification type.

The header (Fig. 3 – A) includes the title of the application, followed by a short description of the application's purpose. 3D map elements include a main map view (Fig. 3 – B1), map controls (Fig. 3 – B2), layer list (Fig. 3 – B3), address search panel (Fig. 3 – B4) and pop-up window (Fig. 3 – B5). The map view provides a 3D view of selected study region, with OpenStreetMap and world hill shade layer from ArcGIS Platform as base map. Map controls include zoom control, navigation toggle for panning or rotating the view, home button and compass button for resetting the map extent and orientation to default, full-screen control, and base map gallery widget for switching map view's base map. The layer list at bottom left corner indicates the visualized map layers. Users can control the visibility of individual map layer with the 'eye-shaped' toggle in each layer panel. Map legend is integrated into the layer list. Core features include densification type selection cards (Fig. 3 – C1), summary panel (Fig. 3 – C2), feature table (Fig. 3 – C3), distance and area measurement toggle (Fig. 3 – C4), as well as daylight and shadow simulation widget (Fig. 3 – C5). Each selection card represents one densification type, followed by a brief description of each type. With one densification type selected, generalized 3D geometries of the corresponding type of identified densification potential are visualized in the map view. Densification type roof stacking is selected and shown in Figure 3. The visualization results of the densification type building extensions and independent building annexes are shown in Figure 4. In the summary panel, extra living area (gross floor area) and household capacity that can be theoretically created by the selected type of densification are summarized. With the interactive feature table, users are provided with a tabular view of each visualized geometry's attributes. Multiple interactions are supported by the feature table: Features can be sorted by attributes in ascending or descending order; Users can select feature of interest from the table, highlight and zoom to the selected feature in the map view. By clicking on the filter icon at the right top corner of the summary panel, a filter list is expanded. It allows users to filter and visualize a subset of the identified densification potentials that satisfy the user-defined criteria based on their feature attributes (Building volume, height, number of full floors). Users can set filter thresholds by dragging label thumbs or editing their label values above (Fig. 3 –

C2.1). The filtered results are highlighted in the map view (Fig. 3 – C2.2). Contents of the summary panel and the feature table are updated automatically when a filter is applied to the dataset. Users can remove all filters by clicking on the reset button.

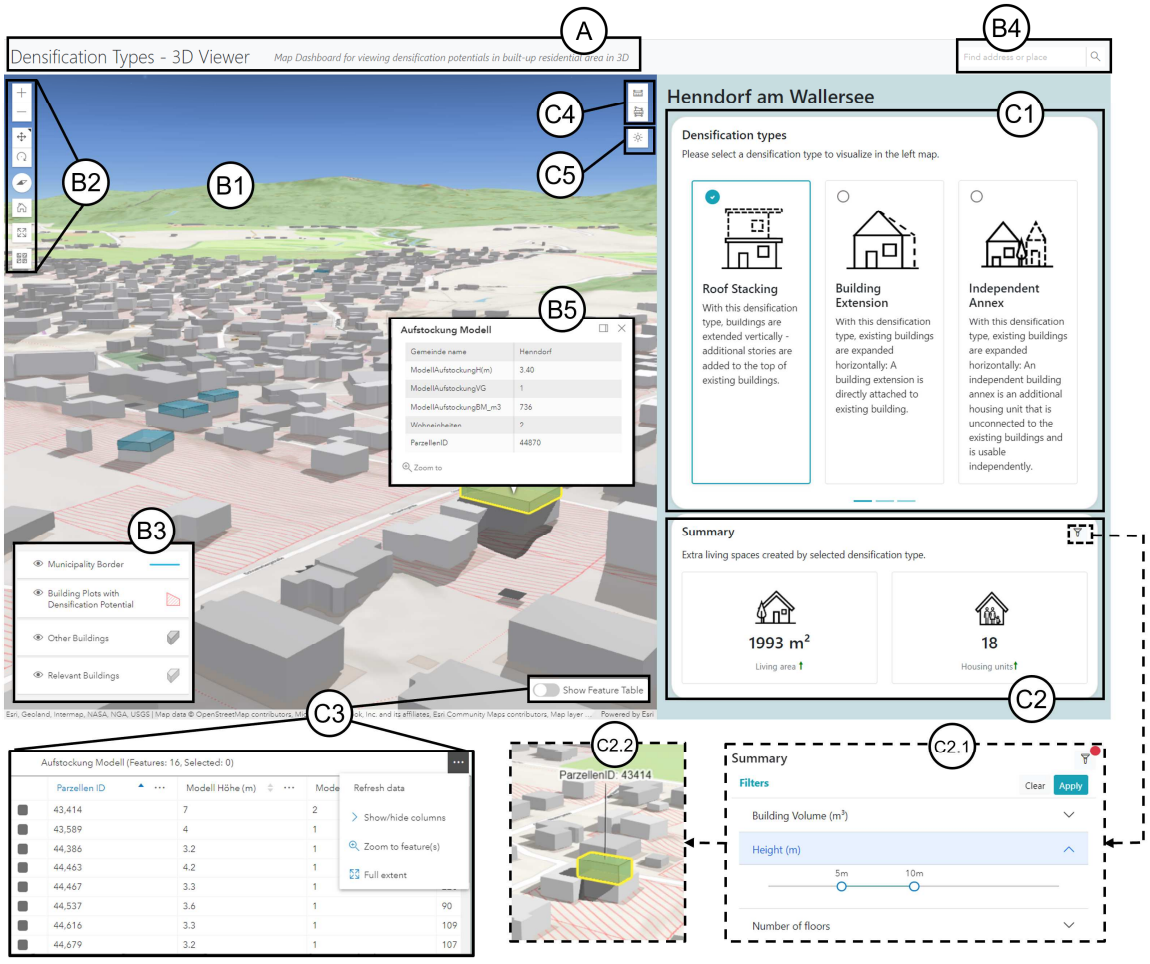


Fig. 3: User Interface: Use case in Henndorf am Wallersee. Densification type 'roof stacking' is selected. (A) header, (B1) map view, (B2) map controls, (B3) layer list, (B4) address search panel, (B5) pop-up window, (C1) densification type selection cards, (C2) summary panel, (C2.1) expanded filter with user-defined height threshold, (C2.2) simulated roof stacking model selected by filter (C3) feature table, (C4) measurement toggle, (C5) daylight and shadow simulation widget.

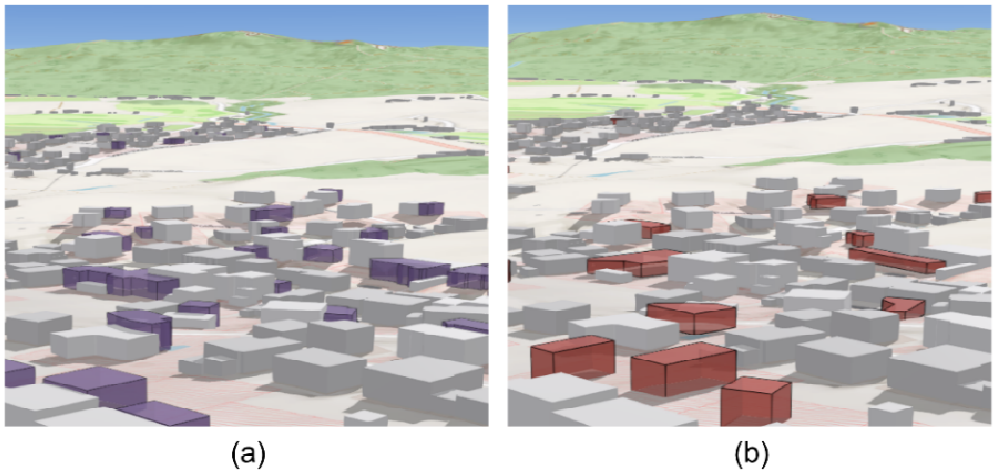


Fig. 4: Visualization of the identified densification potential: (a) building extensions, (b) independent building annexes.

The implementation (Fig. 5) of this interactive web map is mainly on client-side. Data to be visualized in the web map are initially stored in a file geodatabase. These data are then imported via data management tools in ArcGIS Online and published as ArcGIS data service. They are hosted in the cloud as feature layers in a

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

feature service (ArcGIS Developers, 2022b). The user interface (client-side) of the web map is implemented using HTML, CSS, and JavaScript. The design of the user interface is supported by additional libraries including Bootstrap and Bootstrap Icons. The user interactivity of the web map is enhanced by JavaScript and JavaScript library jQuery. To allow client side to access the data from the hosted feature layer, we use ArcGIS API for JavaScript (ArcGIS Developers, 2022a), a web API provided by ArcGIS. It allows us to display, query and filter data in our map application. To visualize the densification potential geometries in 3D, we embedded a local scene in our map view. It allows us to project our data on a plane in a 3D environment. Existing buildings and the identified densification potential geometries are the visualized 3D features in this scene. Their footprints are displayed on the terrain and extruded based on derived height information. These features are placed in the scene based on their located building plots' average absolute heights to the sea-level.

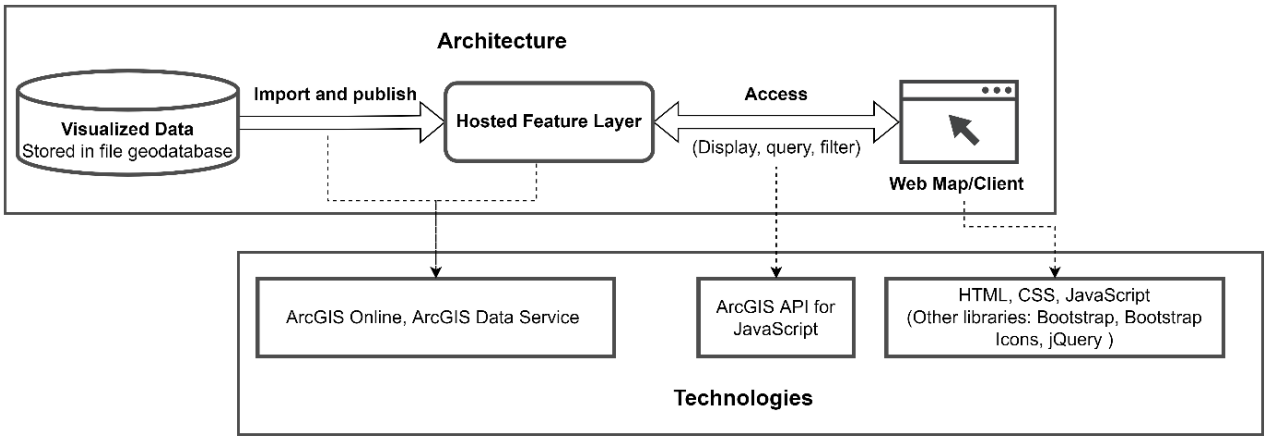


Fig. 5: Implementation of the web map

5 CONCLUSION

This paper introduces a generic GIS-supported methodology for the automated identification of theoretical densification potential types on building plot level. In this paper, we first characterised current densification types in Salzburg state. Then we introduced the spatial relevant parameters used as constraints for the establishment of the building-related typology for densification potentials. These constraints include legal building regulations and local specifications for structural density. Based on these constraints and combined with the characterised densification types, we proposed a building-related typology for densification potentials within existing settlement areas. It includes four types: building replacement, roof stacking, building extensions and independent building annexes. Later, we described the geospatial data-driven workflow used for identifying built-up building plots with densification potentials and modelling theoretical generalized 3D shapes of these potentials per the previous proposed building-related typology. This workflow was then implemented on a test municipality, Henndorf am Wallersee. The result shows that nearly half of the selected analysis building plots are underused and have great potential for densification: with the type „building replacement", over a thousand new housing units could be created; Limited by the size and shape of the existing buildings and building plots, the type „building extensions" can add over 800 housing units, while the type „independent building annexes" can add around 90 housing units and the type „roof stacking" with the creation of only 18 housing units. Furthermore, to visualize the analysis result in a realistic scene, a straight-forward, interactive 3D web map was developed. We introduced the user interface, features and the implementation of this web application in this paper.

It should be noted that this methodology is not meant to substitute building-by-building investigation for the implementation of densification. The analysis results of the creatable housing units and the generalized 3D shapes with different densification types do not represent the real future development. It represents the maximal potentials that are derived from our simulation based on the available geospatial data and parameters assigned to the constraints used in our GIS model (see section 3.2). In reality, the implementation of such densification process is rather complex, which is affected by multiple factors such as availability of the building plots, opinions of the house owners or neighbours, as well as materials and accessibility of the existing buildings, etc. However, the quantified results of this methodology can serve as an information basis

in the planning phase: for example, during the expert consultation provided to building owners in the research project „BONUS" (Schöpflin, Erber, Madlener, & Prinz, 2022).

The focus of this study is to provide a generic methodology that can use spatial dataset to identify densification potentials within existing settlement areas in terms of location, generalized building shapes and creatable housing units per densification types. It aims to make such information accessible for decision-makers, planners, developers, and architects, thus assisting them in recognizing and reflecting on the existing densification options. The delivered spatial information of the identified underused building plots can be used for the creation of the densification potentials inventory in the context of land-use management. It provides relevant data to steer densification process from building plot scale. This methodology can be applied to other municipalities in Salzburg state. It helps decision makers and planners to follow the guideline for the spatial development concept (Land Salzburg, 2019) and to formulate spatial development concepts for individual municipalities in Salzburg state, with the aim of promoting inward settlement development so as to achieve more sustainable, resource-efficient settlement development in the future.

6 REFERENCES

Abedini, A., & Khalili, A. (2019). Determining the capacity infill development in growing metropolitans: A case study of Urmia city.

Amer, M., Mustafa, A., Teller, J., Attia, S., & Reiter, S. (2017). A Methodology to Determine the Potential of Urban Densification through Roof Stacking. Sustainable Cities and Society, 35, 677. doi:10.1016/j.scs.2017.09.021

Amer, M., Reiter, S., & Attia, S. (2018). Urban Densification through Roof Stacking: Case Study. 97.

Amt der Salzburger Landesregierung. (2012). Handbuch Raumordnung Salzburg.

ArcGIS Developers. (2022a). ArcGIS API for JavaScript - Overview. Retrieved from https://developers.arcgis.com/javascript/latest/

ArcGIS Developers. (2022b). Store, mange, and access your data. Retrieved from https://developers.arcgis.com/documentation/mapping-apis-and-services/data-hosting/

Artmann, M., Inostroza, L., & Fan, P. (2019). Urban sprawl, compact urban development and green cities. How much do we know, how much do we agree? Ecological Indicators, 96, 3-9. doi:https://doi.org/10.1016/j.ecolind.2018.10.059

Attenberger, T. (2014). Stadtentwicklung in Köln Lückenschluss in der Innenstadt. Retrieved from https://www.ksta.de/koeln/stadtentwicklung-in-koeln-lueckenschluss-in-der-innenstadt-638998

Attia, S. (2015, 2015-06-18). Overview and recommendation on urban densification potential in Liège, Belgium.

Bundeskanzleramt Österreich. (2020). Aus Verantwortung für Österreich. Regierungsprogramm 2020–2024. Retrieved from https://www.bundeskanzleramt.gv.at/bundeskanzleramt/die-bundesregierung/regierungsdokumente.html

EEA. (2006). Urban sprawl in Europe. The ignored challenge. EEA Report No 10/2006. Retrieved from http://www.eea.europa.eu/publications/eea_report_2006_10

EEA. (2019). Land take in Europe. Retrieved from https://www.eea.europa.eu/data-and-maps/indicators/land-take-3

Eggimann, S., Wagner, M., Ho, Y. N., Züger, M., Schneider, U., & Orehounig, K. (2021). Geospatial simulation of urban neighbourhood densification potentials. Sustainable Cities and Society, 72, 103068. doi:https://doi.org/10.1016/j.scs.2021.103068

European Commission. (2011). Roadmap to a Resource Efficient Europe, (COM/ 2011/0571). . Retrieved from https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52011DC0571&from=EN

Gadocha, S., Spitzer, W., Deng, Y., & Prinz, T. (2021). GIS-Bausteine für eine automatisierte Bewertung und Simulation der Siedlungsinnenentwicklung. Paper presented at the Dresdner Flächennutzungssymposium.

Bebauungsgrundlagengesetz – BGG, (2015).

Land Salzburg. (2019). Leitfaden: Räumliches Entwicklungskonzept. Retrieved from https://www.salzburg.gv.at/bauenwohnen_/Documents/2019_11_06_REK-Leitfaden.pdf

Marique, A.-F., & Reiter, S. (2014). Retrofitting the suburbs: Insulation, density, urban form and location. Environmental Management and Sustainable Development, 3(2), 138.

McConnell, V., & Wiley, K. (2012). Infill Development: Perspectives and Evidence from Economics and Planning. The Oxford Handbook of Urban Economics and Planning. doi:10.1093/oxfordhb/9780195380620.013.0022

Nabielek, K. (2011). Urban Densification in the Netherlands: national spatial policy and empirical research of recent developments. Paper presented at the Global Visions: Risks and Opportunities for the Urban Planet. 5th Conference of International Forum on Urbanism. Singapore, Singapore: International Forum on Urbanism (IFoU). Retrieved September.

Netsch, S. (2021). Densification of the Existing Urban Pattern: the Case Salzburg. Paper presented at the CITIES 20.50–Creating Habitats for the 3rd Millennium: Smart–Sustainable–Climate Neutral. Proceedings of REAL CORP 2021, 26th International Conference on Urban Development, Regional Planning and Information Society.

Pelczynski, J., & Tomkowicz, B. (2019). Densification of cities as a method of sustainable development. Paper presented at the IOP Conference Series: Earth and Environmental Science.

Salzburg Wiki. (2022). Henndorf am Wallersee. Retrieved from https://www.sn.at/wiki/Henndorf_am_Wallersee

Schiller, G., Blum, A., Hecht, R., Oertel, H., Ferber, U., & Meinel, G. (2021). Urban infill development potential in Germany: comparing survey and GIS data. Buildings and Cities, 2(1).

Schöpflin, F., Erber, S., Madlener, D., & Prinz, T. (2022). Densification Of Single And Two-Family Houses Considering Green Space And Mobility. Paper presented at the Central Europe towards Sustainable Building 2022, Prague.

Science Communication Unit. (2016). FUTURE BRIEF: No net land take by 2050? Retrieved from

Umweltbundesamt. (2021). Flächeninanspruchnahme. Retrieved from https://www.umweltbundesamt.at/umweltthemen/boden/flaecheninanspruchnahme

Vuckovic, M., Mahdavi, A., Tauber, C., Kiesel, K., Glawischnig, S., Heiderer, A., . . . Raudaschl, M. (2017). Generation and evaluation of alternative urban densification scenarios. 15th IBPSA.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Wicki, M., & Kaufmann, D. (2022). Accepting and resisting densification: The importance of project-related factors and the contextualizing role of neighbourhoods. Landscape and Urban Planning, 220, 104350. doi:https://doi.org/10.1016/j.landurbplan.2021.104350

WWF. (2021). WWF: Bodenverbrauch fast dreimal so stark gestiegen wie Bevölkerungswachstum. Retrieved from https://www.wwf.at/wwf-bodenverbrauch-fast-dreimal-so-stark-gestiegen-wie-bevoelkerungswachstum/

🏆 *reviewed paper*

Green Facades – How they Matter for Working Environments, Public Spaces and the Livability of a City

Barbara Smetschka, Willi Haas, Rosemarie Stangl

(Dr. Barbara Smetschka, Institute of Social Ecology, BOKU Vienna)
(Dr. Willi Haas, Institute of Social Ecology, BOKU Vienna)
(Prof. Dr. Rosemarie Stangl, Institute of Soil Bioengineering and Landscape Construction, BOKU Vienna)

1 ABSTRACT

Sustainable urban development is the focus of many research initiatives, especially due to increasing urbanization and climate change. Buildings and their renovation are central to the European "Green Deal". In the new Austrian climate and energy program, the topic of buildings comes first with a target renovation rate of 3%. Current climate change adaptation strategies call for an increase in greening of existing buildings and on facades. Public spaces are shaped by the surrounding buildings. The facades and roofs of these buildings can have a high potential to mitigate urban heat island effects. Social change and innovation in working cultures result in reshaping working environments and the need for public space.

Large-scale glass buildings are widely considered architectural highlights, but pose problematic challenges to urban spaces. Glass has a significant impact on the microclimate inside the building and in the immediate outdoor environment: a concentration of radiant energy and high indoor temperatures put a strain on the energy balance and the well-being of the occupants. The retrofit greening of glass facades is a gap in building expertise and there is a lack of standard applications for the retrofit shading and insulation of glass buildings to obtain associated microclimatic benefits.

The project GLASGrün aims to develop, implement, test and monitor modular vertical greening standards for active external shading by deciduous plants on commercial buildings with large glazed facades. Transferable modular-based designs are to be developed. Additionally, sociological surveys on acceptance and perception will be implemented. GLASGrün generates quantitative data on energy, temperature and microclimate balance as well as qualitative data on the perception of the building situation before and after greening interventions and on public awareness. New findings on the acceptance and well-being of employees and customers, on purchasing behavior and market-economic parameters will be available.

GLASGrün is developing guidelines for constructive solutions, submission processes and care and maintenance management plans for the systems under consideration and for the vertical green standards tested, which are scalable and transferable and form an economic basis for future adaptations of further buildings as well as for their maintenance.

A socio-ecological transformation faces the challenge of how integrated solutions can be developed in dialogue with the users and to what extent these produce the desired effects such as greenhouse gas reduction or better indoor climate. On the other hand, the best solutions in the technical sense can also fail due to social barriers: the acceptance of decision-makers, a lack of willingness to cooperate on the part of employees, or a loss of image in the neighborhood, to name just a few examples. Acceptance depends amongst other factors on both the concrete technical implementation and the process of introduction. Thus, acceptance is not a static variable, but is in a relationship with the technical solution options themselves.

Public spaces are key to the discussion on sustainable urban development in their function against urban heat islands. Their diversity of uses and users allows for both a broad discussion and start of discourses and the testing of innovative sustainable measures, in this case greening of facades on buildings perceived in public space. In this paper we will present 2 case studies in Austria with the first results of interviews with employees and users of glass facade buildings and the users of public space.

Keywords: perception, vertical green, sustainable urban development, green infrastructure, urban public space

2 INTRODUCTION AND GLASGRÜN PROJECT

In the face of rapid urbanization and climate change research focuses on sustainable urban development mitigating and adapting the severe risks of heat in cities. The European "Green Deal" states the importance of the built environment and the renovation and sustainble use of buildings. The new Austrian climate and energy program gives a target renovation rate of 3% for buildings. Adapting to the risks of climate change

calls for strategies to increase the greening of existing buildings, including their surroundings as much as their roofs and facades. Vegetation on facades and roofs can play an important role in preventing urban heat islands, especially as public spaces are shaped by the surrounding buildings. Access to urban public spaces with shadow, cooling effects and fresh air for all citizens is getting more important with rising numbers of heat days. New forms of working cultures with more flexibility, sharing and homeoffice regulations need innovative concepts for adapted working environments.

Cities with their densly built areas are characterized by higher temparatures and prone to produce urban heat islands. Lacking the possibility to enlarge horizontal green spaces, greening initiatives need to resort to facades and roofs as vertical and elevated space and their potential for vegetation. The effects of vegetation on microclimate, air quality, noise pollution, biodiversity but also on the building substance and the quality of life of users have been shown (Stangl et al., 2019; Schmauck, 2019; Stadt Wien MA 22, 2019).

The city of Vienna has gained experience with greening facades and a growing network of experts and scientists has contributed to Guidelines for greening facades in Vienna (Statd Wien MA 22, 2019). Some of these best practice projects and the learnings of implementing green facades are presented by the competence centre for greening buildings “GrünstattGrau” (https://gruenstattgrau.at/). Greenpass software has been developed as a smart tool for sustainable urban planning and assessing the effects of greening efforts (https://greenpass.io/).

As glass facades enhance heat even more through reflection and radiation, the project GLASGrün[1] aims to find solutions for livable cities, climate change adaption and innovative paths for sustainable urban development. Large glass buildings are still built widely, but pose some challenges for sustainable urban development. Glass facades have an impact on the microclimate inside the building and in the immediate outdoor surroundings. The concentration of radiant energy and high indoor temperatures put a strain on the well-being of all occupants of a building, mostly on employees concerning the work place environmental standards but also on clients, customers and visitors, who are more or less attracted to enter the building. The retrofit greening of glass facades is a gap and challenging. Currently, standard applications for the retrofit shading and insulation of glass buildings and the associated microclimatic benefits are completely lacking. The project GLASGrün aims to develop, implement, test and monitor vertical greening solutions for green retrofit and external shading by deciduous plants on commercial buildings with large glazed facades. We have the goal to develop economically sound and transferable modular-based standard designs which are socially accepted.

Surveys on acceptance and perception of greening glass facades will give us insight in the factors influencing positive or negative reactions to greening efforts. GLASGrün generates quantitative data on energy, temperature and microclimate balance as well as qualitative data on the perception of the building situation before and after greening interventions and on public awareness. New findings on the acceptance and well-being of employees and customers, on purchasing behavior and market-economic parameters will be available. GLASGrün is developing guidelines for constructive solutions, submission processes and care and maintenance management plans for the systems under consideration and for the vertical greenery tested, which are scalable and transferable and form an economic basis for future adaptations of further buildings as well as for their maintenance.

A socio-ecological transformation faces the challenge of how integrated solutions can be developed in dialogue with the users and to what extent these produce the desired effects such as greenhouse gas reduction or better indoor climate. On the other hand, the best solutions in the technical sense can also fail due to social barriers: the acceptance of decision-makers, a lack of willingness to cooperate between employees and employers, or a loss of image in the neighborhood, to name just a few examples. Acceptance depends on both the concrete technical implementation and the process of introduction. Thus, acceptance is not a static variable, but is in a reciprocal relationship with the technical solution options themselves.

Public spaces are key to the discussion on sustainable urban development in their function against urban heat islands and green open space for all citizens. Their diversity of uses and users allows for both a broad

[1] GLASGrün, project funded by FFG, Stadt der Zukunft, August 2021 – Juli 2024, project lead Institut für Ingenieurbiologie und Landschaftsbau (IBLB) BOKU Vienna; Projektpartner Institute of Social Ecology, BOKU Vienna; MPREIS; rataplan; lichtblauwagner; IBO - Österreichisches Institut für Baubiologie und -ökologie und GRÜNSTATTGRAU. - https://nachhaltigwirtschaften.at/de/sdz/projekte/glas-gruen.php

discussion and start of discourses and the testing of innovative sustainable measures, in this case greening of facades on buildings perceived in public space. In this paper we present 2 case studies in Austria with the first results of interviews with employees and users of glass facade buildings and the users of public space.

3 CASE STUDIES IN VIENNA AND SÖLL

In the GlasGrün project we cooperate between academic researchers and experts on greening buildings on creating new solutions for glass facades. We further cooperate with two companies who operate in buildings with glass facades. They are interested in greening these facades to improve thermal comfort conditions and are willing to test the first solutions developed for their specific buildings as demonstration sites. The transdisciplinary project team develops vertical greenery components as standard modules. These are sought to be aesthetically fully integrated in the architectural and constructural design, whilst highly effective referring to indoor and outdoor microclimate and the energy balance. The GLASGrün concepts and designs will be implemented and monitored in 2 demonstration sites.

3.1 Urban office building: Vienna

In Vienna an "Engineering office for technical building equipment and technical physics" has office space at Kreuzgasse 74 behind a high glass façade. The building is at the edge of an open space frequented by customers of several shops and citizens using public transport at the tramway station with very little green infrastructure. The employees work behind the glass façade. The employer hopes to find a green and climate friendly solution providing protection from heat and views. (Fig. 1)

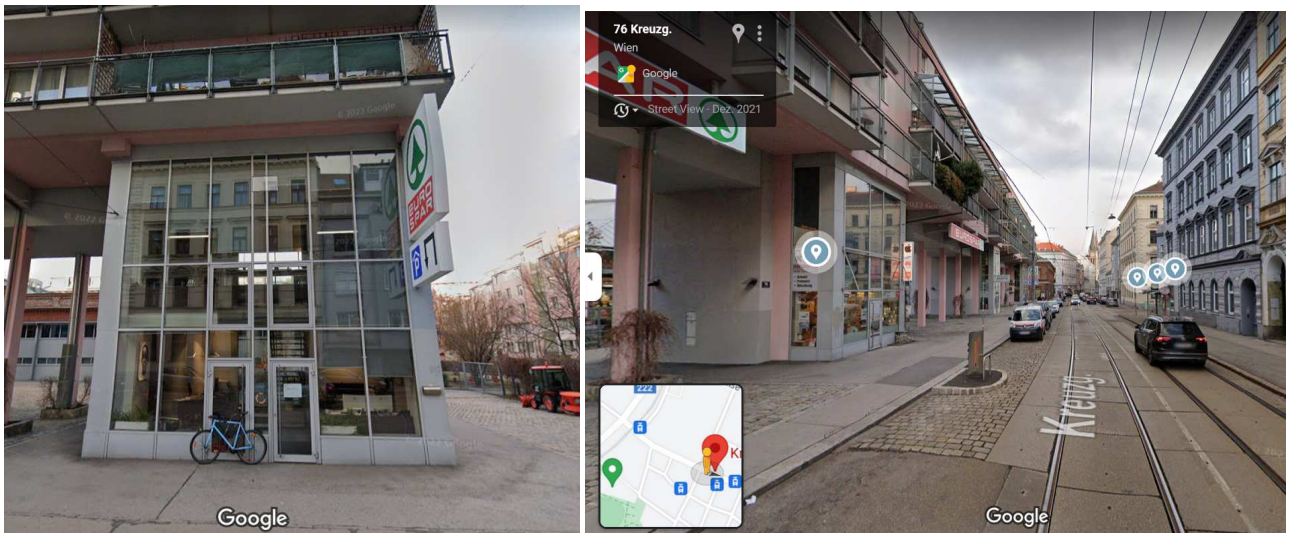


Fig. 1: Google Street View: Kreuzgasse 74, 1180 Wien

Due to juridical and planning issues not yet solved, the greening installation has not been developed yet. The survey on acceptance and perception of passersby and employees of the office were conducted in May 2022.

3.2 Rural supermarket: Söll

On the outskirts of Söll, a village (4,200 inhabitants, 703 m above sea level) in the Tyrolean tourist region "Wilder Kaiser", the company MPreis has a supermarket which is frequented by villagers, tourists and costumers approaching via the highway. The supermarket has a large glass facade allowing for an open inviting view, as this is a generally acknowledged architectural up-to-date concept for commercial buildings. The company tried to lessen problems of high indoor temperatures by shading the glass front with a wall of timber. (Fig. 2)

The physical monitoring of indoor conditions and electricity consumption was implemented in February 2022. Surveys on acceptance and perception of costumers and employees of the supermarket were conducted in May 2022 prior to the first steps of installing new vertical greening systems. The installation of the innovative and effective GLASGrün systems as integrative addition and the intended pre-measurement setups were completed in 06/2022. Follow-up surveys are planned for spring 2023, when plants are successfully growing and in spring 2024, when shadowing effects can be expected.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Fig. 2: Söll MPreis outdoor view; https://www.wilderkaiser.info/de/soell/info/mpreis-supermarkt-soell.html

4 PERCEPTION AND ACCEPTANCE: SURVEYS AMONG USERS AND EMPLOYEES

4.1 Perception of vertical greenery and green facades

Various studies prove the positive effect of green environments on people (Bringslimark et al., 2009; Fjeld et al., 1998; Flagler et al., 2018; Lohr, 2007). Green open spaces and gardens have been shown to have therapeutic effects, as the plant-human interaction exerts regulatory functions to reduce stress, anxiety, anger, blood pressure, muscle tension, and more. Reinwald et al. (2021) point out, that urban green infrastructure and open spaces support in coping with the consequences of crises and climate change referring to human health and well-being. Vertical gardens are increasingly seen as important natural structures that can positively influence people's moods. Urban green has been linked via various pathways with positive effects on mental health (Chen 2021; Dzhanibov 2018; Lee 2019). There is also evidence of the benefits of gardens and plants in workplaces and schools, reducing absenteeism and stress levels and increasing productivity (Fjeld, 2000).

There is little empirical work available on the acceptance of façade greening, but a few surveys are available for Cologne and Genoa (Magliocco & Perini, 2015; Schlößer, 2003), and a master's thesis on the perception of green façades in Vienna has recently been approved at BOKU Vienna (Pichl, 2021). Radić et al. (Radić et al., 2019), for example, highlight the ambivalent perception of citizens, which on the one hand is characterized by positive effects on the environment and well-being and at the same time by uncertainties such as "expensive and problematic" (Magliocco & Perini 2015, p. 906).

Research on the perception of façade greening shows the need for an early involvement of people who might feel and judge positive or negative effects of façade greening. Furthermore, the acceptance of greening measures must primarily be asked of building owners, financiers, planners and architects. Schmauck (2019) points out that communication and public relations work carried out in parallel to the greening implementation contribute to raising awareness and acceptance among the population.

4.2 Pre-greening survey with costumers and employees

Prior to the greening installation students conducted surveys on the 2 sites in the form of online and personal interviews. The same questionnaire was used for employees in Vienna and Söll and for supermarket customers in Söll and for passersby using the public space in Vienna. The questionnaires on the 2 sites differed only in the presentation of the foto of the object without and with potential greening.

The surveys were conducted by 2 teams of students of the Bachelor programme Environment and Bioresources Management at BOKU Vienna. The questionnaire was developed within the project course “Interdisciplinary projects” under guidance of the authors. Students approached passing persons personally and gave them questionnaires to be filled on site or flyers with a QR code for the online survey. The printed questionnaire was formatted in 2 pages, containing 2 fotos and 16 questions on vertical greening, sustainable development and personal preferences and 8 demographic questions. After an opening question followed a mix of open questions, multiple choice questions and a Likertscala to assess a series of statements from

former studies. Lime Survey was used for the online survey, the data from personal interviews were added to Lime Survey by the students. In sum we can draw on a total of 187 filled questionnaires for the case in Vienna and 64 filled questionnaires for Söll by users/costumers. The questionnaire for employees had the same structure with questions modified to the specific role of the persons working on the sites, resulting in data from 5 questionnaires in Vienna and 10 questionnaires in Söll.

4.3 Post-greening survey with costumers and employees

We plan a next round of the survey when the greening installation is in place, plants are growing and visible to a certain extent from inside and outside the building. The questionaire will contain the same questions modified to the new situation, in order to grasp the perception of actual plants and their effects. This will then allow to explore the difference in perception between an imaginated greening and an actual green façade shading. Data and information from technical monitoring will then be available and used for additional questions.

5 FIRST RESULTS AND DISCUSSION

The survey conducted by students provides first impressions on the perception and acceptance of vertical greening by passers-by, costumers and employees and the factors possibly influencing their perceptions. We present and discuss the first results along selected topics asked in the survey, showing data for costumers in Söll and passersby in Vienna and add the summary of responses from employees.

5.1 Advantages and disadvanteges of green facades

The open questions at the beginning situate the respondents in view of the façade as is (with the glass face) and ask their impression. They then are asked to comment on 2 pictures, one of the façade at the moment without greening and one with a potentially green façade. When asked for the most important advantages and disadvantages of greening facades in an open question costumers of the supermarket in Tyrol state 80% positive and 20% negative effects. Respondents name mostly aspects of aesthetics and nature and climate protection and refer to the importance of improving air quality, protecting wildlife habitat and controlling temperature. In Vienna approval of greening the glass façade is lower with 68% positive and 32% negative items. The passers-by provide the same items as in Tyrol but add the improvement of noise pollution on the positive side and molesting insects as negative effect.

To the question “In your opinion, do the advantages or disadvantages of greening the façade prevail?” customers in Söll state 70% advantages, 29% balanced and 1% disadvantages. In Vienna passers-by see 91% advantages, 5% balanced and 4% disadvantages (Fig. 3).

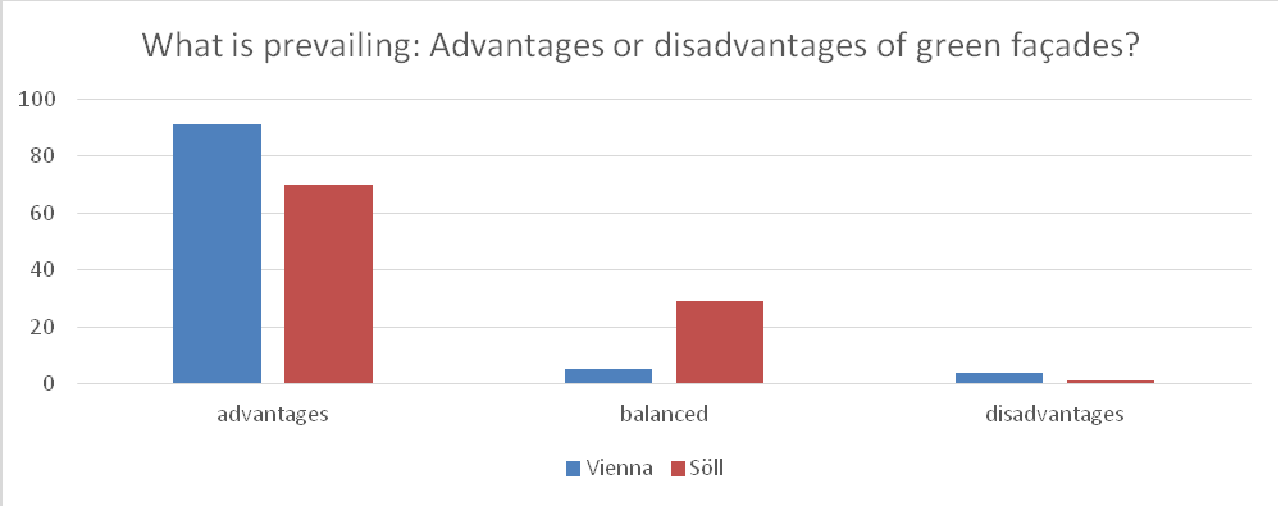


Fig. 3: Advantages or disadvantages of green façades (Seminar paper IP UBRM, 2022)

Small differences can be seen, when controlling for age, with higher approval in older people. No differences come up with educational level and sex. But persons with caring responsibilities for children show slightly more approval.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Overall all groups (customers, passersby and employees) give a high approval of greening facades with higher approval rates as well as more critical aspects named in Vienna.

5.2 Effects on climate and nature protection

Climate and nature protection are further issues with high approval, reflecting either awareness or desirable responses. Nevertheless, as ist is not possible to control for these effects, the data show high agreement with the needs to alleviate climate change effects and the aim to find adaptation measures to achieve foremost control over temperature, air and noise pollution and protection of wildlife habitats. Customers agree to the statement that supermarkets should contribute to climate and nature protection (82,8% agreement).

The question “Does climate change require quick and decisive action?” 78% of respondenst in Söll say “yes,” or “rather yes” and 3% say “no” (Fig. 4) . In Vienna affirmative responses sum up to 96% with only 1% negative response.

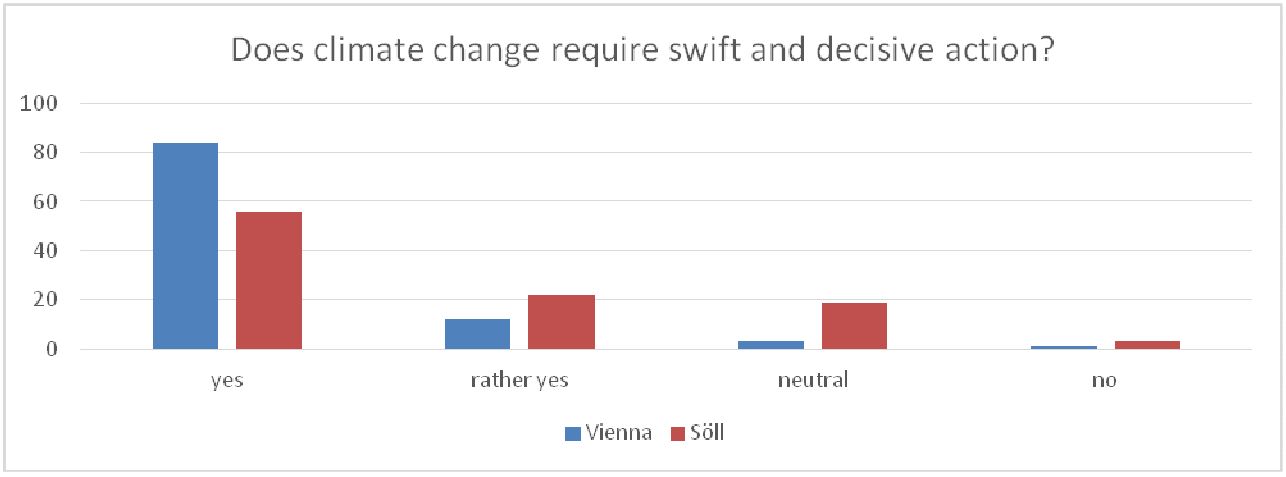


Fig. 4: Action on climate change (Seminar paper IP UBRM, 2022)

Combining the 2 questions we see a clear linkage between the perceived advantages of greening facades and the need for action on climate change (Fig. 5).

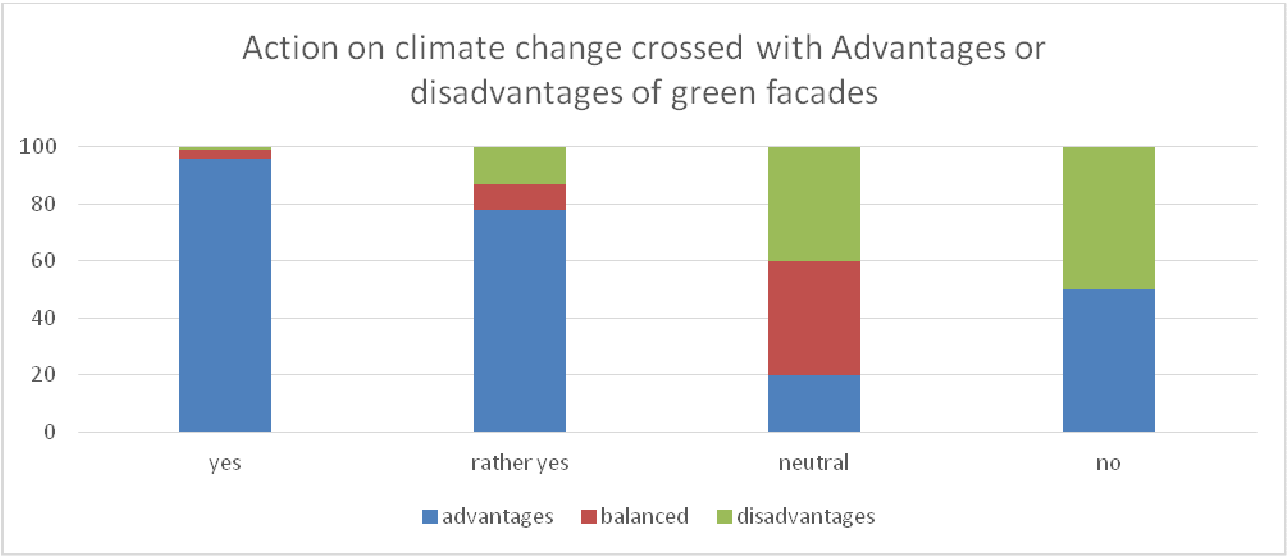


Fig. 5: Action on climate change crossed with Advantages or disadvantages of green facades, survey Vienna (seminar paper team Vienna, 2022)

5.3 Perceived burdens: insects and birds

Annoyance with insects and birds was amongst the disadvantages we asked to be rated. In rural Söll only a very small share of respondents agreed to the statement that this is a big burden, while about half of the respondents rather agreed. Interestingly enough, in Vienna the share of agreeing was significantly higher, but the group stating that this is rather a burden was far smaller (for plaguing insects about a quarter and for annoying birds below 10%). Maybe this hints at a bigger group potentially more strongly opposing greening

intiatives, but with a smaller support base from other people who rather see a problem here in Vienna. In the rural area there might be more differentiated views with a very small group in strong opposition regarding these issues, but more people who may need to be addressed but are more likely to be responsive.

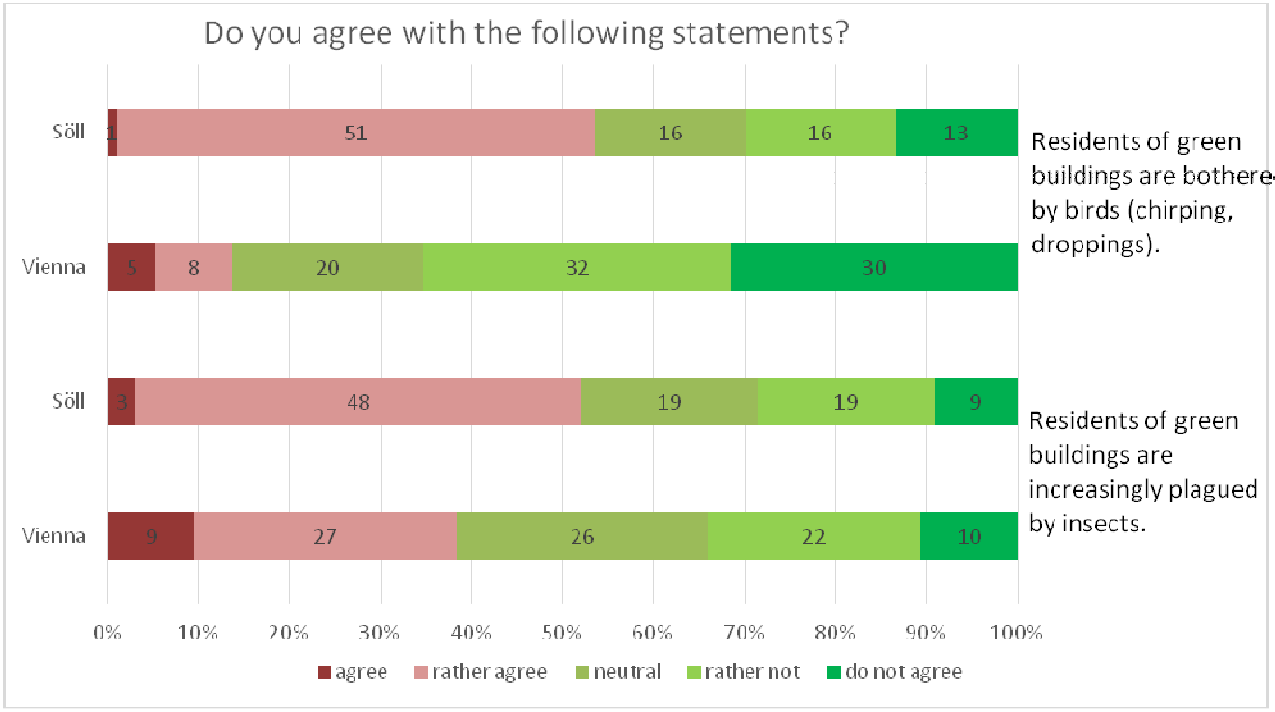


Fig. 6: Agreement to statements on birds or insects (seminar paper team Vienna, 2022)

5.4 Perceived benefit: Aesthetics

Most respondents agree on higher aesthetics of a green façade. A fact which seems rather surprising as glass facades seem to be the architectural choice of the moment. Eventually a change of perception on green infrastructure has already happened or is at least deemed as a desired response. The glass façade was perceived as: cold, dull, grey, dirty and only few characterized it as modern.

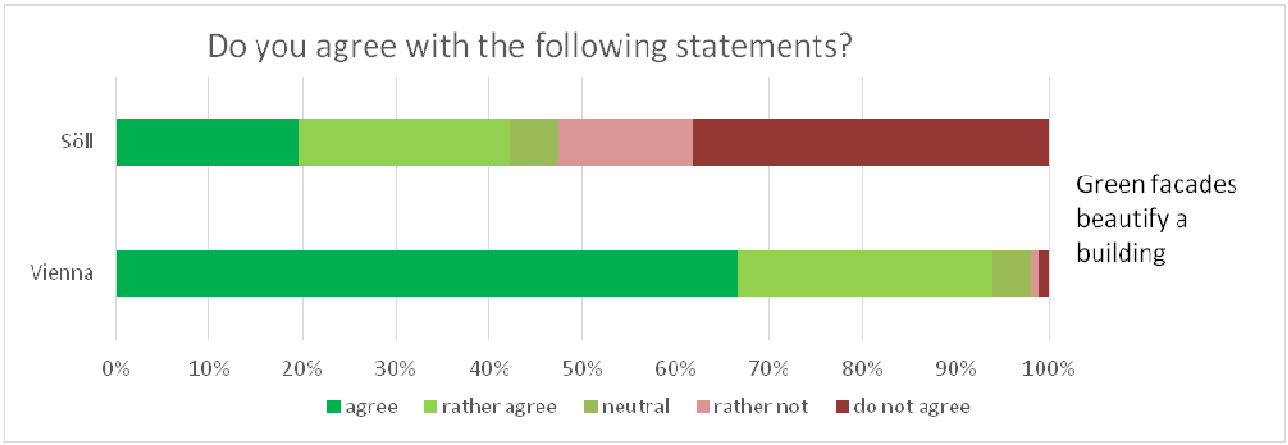


Fig. 7: Agreement to statement on beauty (seminar paper team Vienna, 2022)

Asked if greening beautifies facades, about 40% of customers in Söll agree or rather agree, whereas in Vienna over 90% of the passers-by agree or rather agree. Thus, beautifying facades could be a strong motivator in urban settings (Fig.7).

Employees give similar responses and agree strongly with the statement that greening efforts raise the image of the supermarket (90%).

5.5 Personal preferences

Respondents were asked for their personal preferences for example on greening the buildings they live in or the need for green environments. Surprisingly many have already green infrastructure on their houses in

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Tyrol in addition to gardens. Thus building on traditional forms of greening walls can be a promising way of promoting vertical green. In Vienna respondents have less green surroundings, and therefore most likely more need for it. On the other hand, bad experiences with old facades damaged by ivy are mentioned as bad examples in Vienna.

Employees see many benefits in greening the façade, hoping for shadow, cooler temperatures and less exposure to views. Albeit, they are concerned that green facades may require more work than glass façades and would need information on the amount and nature of work involved in an early phase of planning. The question of maintenance and willingness to participate in it is of upmost importance for a successful implementation of green facades.

6 CONCLUSION

6.1 Working environment

Employees hope for an array of advantages from green facades including lower temparatures in warm seasons, better indoor climate, less visibility and distraction from outside. They do appreciate a green ambiente and see that it could improve the image of their workplace. Yet they have questions regarding maintenance and practical issues. Their insecurity regarding the work eventually involved in greening facades has to be addressed early on.

6.2 Public spaces

Green public urban spaces will gain in importance under conditions of increasing heat days, especially for people who have small living spaces and no outdoor space. Additionally, green and cool space is of high importance for persons caring fro children and these children and young people in need of recreational space. In urban settings the beautification effect of greening is perceived as an important benefit. Access to free, cool, consumption free space within short distance is a must in urban planning under conditions of climate change. Green spaces have the complemnetary advantage of reducing stress levels and increasing human well-being.

6.3 Sustainable development and livability of a city

Reducing the advent of urban heat islands is key to sustainable urban development. Green and blue infrastructures need to be further advanced in order to make the most use of urban vegetation in reducing temperature, retaining excessive water and reducing air and noise pollution. Additionally, greening installations help to keep wildlife habitats in urban areas.

6.4 Summary and outlook

Overall, we see similar results as Jim (2022) in his survey on public opinion on green roofs and green walls (GRGW) in Tokyo, where it is mandatory to install greening in new building.

“Respondents mostly agreed with the contribution of GRGW to thermal comfort, air quality, and cityscape but weakly endorsed other potential benefits. High costs as well as mosquitoes and plant litter nuisances were the most recognized negative issues. Mandatory installation was the least preferred promotion policy. Instead, respondents expected installation on public buildings and provision of installation guidance. Respondents predominantly held a “moderate” view towards both the benefits and negative issues, showing indifferent attitudes towards GRGW. Income level and housing type shaped the overall perceptions, whereas age, sex, and current living environment influenced perceptions of individual aspects. Our findings signified a need for a bottom-up strategy to heighten public awareness for the advanced development of GRGW to complement and prime the top-down mandatory installation policy.” (Jim et al., 2022; p 35)

This moderate views in combination with a lack of information can be corroborated in our surveys for Vienna and Söll. In light of rapid climate change strong efforts to inform on the potentials of greening facades and roofs seem highly necessary.

GLASGrün is developing guidelines for constructive solutions, submission processes and care and maintenance management plans for the systems under consideration and for the vertical green modules tested, which are scalable and transferable and form an economic basis for future adaptations of further buildings as well as for their maintenance.

Greening glass facades will become more necessary in rural and urban areas for a variety of reasons: Stabilising indoor climate with low energy input in summer (mitigation), improving outdoor microclimate (adaptation), biodiversity (co-benefits), to name just a few. Therefore, the question of how to avoid failures and how to implement such projects with high quality and a high level of acceptance is important. Successful implementation requires successful technical implementation, but also good communication. Interactive communication processes can ensure that objections and concerns of the different groups are dealt with seriously and are reflected in the project planning. Such projects with interactive (two-way) communication processes enable broad implementation.

All pathways for socio-ecological transformation face the challenge of how integrated solutions can be developed in dialogue with the users and to what extent these produce the desired effects of green facades such as greenhouse gas reduction, better indoor climate and the necessary green urban spaces open for all citizens. As the best solutions in a technical sense can fail due to social barriers, we need to develop vertical green installations and guidelines for best installation and maintenance together with decision-makers, stakeholders (employees, customers) and the wider public. Information on gains from energy efficiency, on microclimatic effects in- and outdoors and on the costs and time needed for maintenance have to be specified. With best practice examples, adequate information and practical guidelines for each step of implementing greening in existing buildings we can start a public discourse, environmental education and raise awareness for the greening potential in cities. Such guidelines should be designed for being useful to further acceptance of decision-makers, the willingness to cooperate between stakeholders, and the awareness in local neighborhoods and the wider public opinion. In the GlasGrün project they are designed and developed for the retrofitting of glass facades in a socially, ecologically and economically acceptable version.

7 REFERENCES

Stangl, R., Medl, A., Scharf, B., & Pitha, U. (2019). Wirkungen der grünen Stadt: Studie zur Abbildung des aktuellen Wissenstands im Bereich städtischer Begrünungsmaßnahmen. BMVIT (Ed.), Vienna. https://nachhaltigwirtschaften.at/resources/sdz_pdf/schriftenreihe-2019-12-wirkungen-gruene-stadt.pdf.

Bringslimark, T., Hartig, T., & Patil, G. G. (2009). The psychological benefits of indoor plants: A critical review of the experimental literature. Journal of Environmental Psychology, 29(4), 422–433. https://doi.org/10.1016/j.jenvp.2009.05.001

Fjeld, T. (2000). The Effect of Interior Planting on Health and Discomfort among Workers and School Children. HortTechnology, 10(1), 46–52. https://doi.org/10.21273/HORTTECH.10.1.46

Fjeld, T., Veiersted, B., Sandvik, L., Riise, G., & Levy, F. (1998). The Effect of Indoor Foliage Plants on Health and Discomfort Symptoms among Office Workers. Indoor and Built Environment, 7(4), 204–209. https://doi.org/10.1177/1420326X9800700404

Flagler, J., Flagler, J., & Poincelot, R. P. (2018). People-plant relationships: Setting research priorities. http://www.vlebooks.com/vleweb/product/openreader?id=none&isbn=9781351425513

Jim, C. Y., Hui, L. C., & Rupprecht, C. D. D. (2022). Public Perceptions of Green Roofs and Green Walls in Tokyo, Japan: A Call to Heighten Awareness. Environmental Management, 70(1), 35–53. https://doi.org/10.1007/s00267-022-01625-8

Lohr, V. I. (2007). Benefits of Nature: What We Are Learning about Why People Respond to Nature. Journal of PHYSIOLOGICAL ANTHROPOLOGY, 26(2), 83–85. https://doi.org/10.2114/jpa2.26.83

Magliocco, A., & Perini, K. (2015). The perception of green integrated into architecture: Installation of a green facade in Genoa, Italy. AIMS Environmental Science, 2(4), 899. https://doi.org/10.3934/environsci.2015.4.899

Pichl, M. (2021). Wahrnehmungen zum Einfluss von Vertikalbegrünungen im städtischen Raum. Masterarbeit an der Universität für Bodenkultur Wien.

Radić, M., Brković Dodig, M., & Auer, T. (2019). Green Facades and Living Walls—A Review Establishing the Classification of Construction Types and Mapping the Benefits. Sustainability, 11(17), 4579. https://doi.org/10.3390/su11174579

Reinwald, F., Haluza, D., Pitha, U., & Stangl, R. (2021). Urban Green Infrastructure and Green Open Spaces: An Issue of Social Fairness in Times of COVID-19 Crisis. Sustainability, 13, 10606. https://doi.org/10.3390/su131910606

Schlößer, S. (2003). Zur Akzeptanz von Fassadenbegrünung. Meinungsbilder Kölner Bürger—Eine Bevölkerungsbefragung. Dissertation, Universität zu Köln.

Schmauck, S. (2019). Dach- und Fassadenbegrünung - neue Lebensräume im Siedlungsbereich: Fakten, Argumente und Empfehlungen. Bundesamt für Naturschutz. http:// www.bfn.de/skripten.html

Stadt Wien MA 22. (2019). Leitfaden Fassadenbegrünung. MA 22.

Further Sources:

GrünstattGrau - Kompetenzstelle für Bauwerksbegrünung - https://gruenstattgrau.at/

GreenPass - Software is an innovative planning-, evaluation- and certification tool for climate resilient urban planning - https://greenpass.io/

Föger, Simon; Schermer Paul und Lara Thier 2022: Die Akzeptanz und Wahrnehmung der Begrünung von Glasfassaden am Beispiel des MPreis in Söll, Tirol. - Seminar paper IP UBRM on the case Söll.

Bauer, Herbert; Böhm Florian, Kamper, Ines und Paula Pircher 2022: Fassadenbegrünung Wien - Die Wahrnehmung und Akzeptanz der Begrünung einer Glasfassade am Beispiel eines Bürogebäudes in Wien. - Seminar paper IP UBRM on the case Vienna

🏆 *reviewed paper*

Human-biometeorologisch angepasste Routenführungen durch mathematische Optimierung

Lena Albert, Nicolas Fröhlich, Nils Hausbrandt, Sascha Henninger, Tessa Maurer, Stefan Ruzika

(Prof. Dr. Sascha Henninger, TU Kaiserslautern, Fachbereich Raum- und Umweltplanung, Pfaffenbergstraße 95, 67663 Kaiserslautern, Sascha.henninger@ru.uni-kl.de)
(Prof. Dr. Stefan Ruzika, TU Kaiserslautern, Fachbereich Mathematik, Paul-Ehrlich-Straße 14, 67663 Kaiserslautern, ruzika@mathematik.uni-kl.de)
(Dr. Nicolas Fröhlich, TU Kaiserslautern, Fachbereich Mathematik, Paul-Ehrlich-Straße 14, 67663 Kaiserslautern, froehlich@mathematik.uni-kl.de)
(Lena Albert, MSc., TU Kaiserslautern, Fachbereich Raum- und Umweltplanung, Pfaffenbergstraße 95, 67663 Kaiserslautern, lena.albert@ru.uni-kl.de)
(Nils Hausbrandt, MSc., TU Kaiserslautern, Fachbereich Mathematik, Paul-Ehrlich-Straße 14, 67663 Kaiserslautern, nils.hausbrandt@mathematik.uni-kl.de)
(Tessa Maurer, BSc., TU Kaiserslautern, Fachbereich Mathematik, Paul-Ehrlich-Straße 14, 67663 Kaiserslautern, t_maurer@rhrk.uni-kl.de)

1 ABSTRACT

Innerstädtische Freiflächen, aber auch Wälder und Waldfächen, werden zur Erholung, zur Bewegung und dem Aufenthalt im Freien von verschiedenen Bevölkerungs- und Nutzergruppen aufgesucht. Für den Aufenthalt im Freiraum spielen bioklimatische und lufthygienische Faktoren eine wichtige Rolle, die sich für verschiedene Altersgruppen unterscheiden. Tatsächlich können durch die grüne Infrastruktur nicht nur eine Vielzahl von Vorteilen verzeichnet werden, sondern es entstehen durchaus auch gesundheitliche Beeinträchtigungen durch sogenannte biologische Noxe.

Ziel der Forschungskooperation ist es, möglichst lokalklimatisch, lufthygienisch und gesundheitlich optimierte Routen auszuweisen. Eine erste Untersuchung erfolgt am Beispiel von Waldflächen und der Ozonvorläufersubstanz Isopren. Isopren gehört zur Gruppe der biogenen Kohlenwasserstoffe und wird von verschiedenen Baumarten in unterschiedlicher Konzentration emittiert. Diese Emissionsrate hängt von unterschiedlichen Bedingungen ab, wie meteorologische Faktoren (z.B. Strahlungstemperatur und -intensität), aber auch dem Alter der Bäume sowie den Standort- und Bodeneigenschaften. Bei autochthonen Wetterlagen erreichen die Isoprenemissionen ihr Maximum. Nur sind dies auch die Zeitpunkte, an denen Menschen Grünflächen zur Erholung und Abkühlung aufsuchen. Hierzu gehören auch Waldflächen. Dort finden sich unterschiedliche Baumarten, respektive unterschiedliche Emissionspotenziale; allerdings sind dort aber auch viele Wanderrouten zu verzeichnen.

Ziel ist es daher, diejenigen Bereiche, in denen ein erhöhtes Ozonbildungspotenzial vorhanden ist, durch eine angepasste Wegeführung zu meiden. Hierzu werden OpenStreetMap-Daten des betrachteten Wandergebiets in ein mathematisches Knoten-Kanten-Netzwerk transfomiert und jeder Kante deren Länge und deren Isoprenwert basierend auf dem Baumbestand entlang der Kante zugeordnet. In einer ersten Untersuchung wird dabei zwischen drei Isoprenwerten (niedrig, mittel, hoch) unterschieden. Der Isoprenwert eines Weges ergibt sich aus der Summe der Isoprenwerte aller Kanten entlang des Weges.

Das zugrundeliegende Optimierungsproblem beschreibt die Aufgabe, zu einem gegebenen Wanderweg einen alternativen Weg geringeren Isoprenwerts zu ermitteln. Dabei soll der neue Weg den selben Start- und Endknoten wie der gegebene Weg haben und möglichst wenig von diesem abweichen. Das Problem wird mathematisch modelliert und mit Methoden der ganzzahligen Optimierung gelöst. Die beschriebene Technik liefert nachweislich gute Lösungen und ist auf jedes beliebige Wandergebiet durch Austauschen der Datengrundlage übertragbar. Gleichzeitig eröffnet die Problemstellung neue Forschungsrichtungen in der mathematischen Grundlagenforschung zu restringierten Kürzesten-Wege-Problemen. Die vorgestellte Arbeit bildet die Basis zur algorithmischen Berechenbarkeit gesundheitsfreundlicher Wanderwege und motiviert tiefergehende Forschung zukünftig auch tagesaktuelle Werte wie Wind oder Temperatur in die Berechnungen einfließen zu lassen und so tagesaktuelle Empfehlungen auszusprechen.

Das Vorhaben ist in das Verbundprojekt „Ageing Smart – Räume intelligent gestalten“ eingebunden. Das Projekt wird durch die Carl-Zeiss-Stiftung gefördert. Das Gesamtprojekt adressiert die geburtenstarken Jahrgänge 1955 bis 1969, die Babyboomer. Durch deren Eintritt in das Rentenalter sind Kommunen oftmals damit konfrontiert, altersgerechte Wohnstandorte, Versorgungs- sowie Freizeitstrukturen zu schaffen. Ziel des Gesamtprojektes ist es, ein datengestütztes Entscheidungsunterstützungssystem zu entwickeln, das öffentliche Akteure in ihren Planungsprozessen unterstützt.

Keywords: Navigationssystem, Lokalklima, Human-biometeorologie, Mathematische Optimierung , grüne Infrastruktur

2 EINLEITUNG

Besonders in den Sommermonaten gehören (urbane) Grünflächen zu den am häufigsten und intensivsten genutzten Räumen (vgl. Henninger 2013, 74 f.). Soweit vorhanden und erreichbar, gehören hierzu auch Waldflächen. Sie bieten vielfältige Nutzungsmöglichkeiten, sei es zur Erholung oder als Bewegungs- oder Aufenthaltsräume. Die positiven Aspekte, Nutzen und Vorteile der sogenannten grünen Infrastruktur sind häufig thematisiert und allgemein bekannt. Allerdings können auch gesundheitliche Beeinträchtigungen für die Bevölkerung durch das Vorhandensein von Pflanzen und Bäumen durch sogenannte biologische Noxe auftreten (vgl. Dosch et al. 2015, 47).

Ein Beispiel hierfür sind biogene flüchtige organische Kohlenwasserstoffe (BVOC), die zu den Vorläuferstoffen des sekundären Schadstoffes Ozon gehören. Durch das Vorhandensein dieser BVOCS kann die Bildung des troposphärischen (bodennahen) Ozons verstärkt werden und der positiven gesundheitlichen Wirkung der Grün- und Waldflächen entgegen wirken.

Hier setzt das dargestellte Forschungsprojekt an. Mit Hilfe mathematischer Modellierung und Optimierung soll algorithmisch ermittelt werden, wie Bereiche mit potenziell lufthygienischen Beeinträchtigungen bei bestimmten Wetterlagen vermieden und umgangen werden können. Hierfür soll eine Art „human-biometeorologisches“ Navigationssystem entwickelt werden.

2 LITERATUR

In der Literatur existieren unterschiedliche Ansätze, bestehende Waderrouten algorithmisch zu verbessern oder neue Wanderrouten zu generieren. Cziferszky & Winter 2002 haben einen Algorithmus entwickelt, der Wanderrouten berechnet, die möglichst viele Kriterien eines Nutzers erfüllen. Diese Kriterien wurden zur Berechnung neuer Routen gewichtet und die Gewichte aus einer Umfrage ermittelt. Cyganski 2007 hat mit Hilfe eines adaptiven Ameisenalgorithmus nutzerangepasste Wanderrouten generiert. Insbesondere wird die Frage addressiert, wie geeignete Start- und Zielpunkte bestimmt werden können. Im Gegensatz zu dem in dieser Foschung gewähltem Ansatz, berechnen beide Verfahren neue Wege in einem gegebenen Netzwerk und zielen nicht darauf ab, bestehende Wege zu optimieren. Mayr et al. haben basierend auf Dijkstras Algorithmus ein Routenplanungssystem entwickelt, das optimierte Wege, speziell Bergwanderwege, bestimmt. Im Fokus steht die Beachtung der postiven und negativen Höhenmeter entlang eines Weges. Allgemeine Routenplanungsprobleme (z.B. im Verkehr oder der Logistik) sind natürlich ein sehr gut untersuchtes Forschungsgebiet, so dass dieses spezielle Anwendungsproblem auf einer soliden Grundlage aufbauend behandelt werden kann.

3 UNTERSUCHUNGSGEGENSTÄNDE

Um ein solches Navigationssystem entwickeln zu können, wird ein Luftschadstoff sowie ein Untersuchungsgebiet benötigt. Hierfür werden in einem ersten Schritt beispielhaft die Waldgebiete in und um Kaiserslautern, Deutschland, sowie der Ozonvorläuferstoff Isopren, gewählt.

Als sekundärer Schadstoff wird Ozon durch photochemische Reaktionen von Vorläuferstoffen in der Gegenwart von Sonnenstrahlung gebildet. Demnach treten die höchsten Ozonkonzentrationen an Tagen mit hoher Strahlungsintensität und hohen Temperaturen, also im Sommer auf. Da Ozon gleichzeitig ein Reizgas ist, hat das Vorhandensein von hohen Ozonkonzentrationen gesundheitliche Auswirkungen auf die Menschen, die sich besonders an solchen Wetterlagen vermehrt im Freien aufhalten (vgl. Umweltbundesamt 2022, o.S.).

Zu den Ozonvorläuferstoffen gehört die Stoffgruppe der biogenen Kohlenwasserstoffe, die durch verschiedene Arten von Grünpflanzen und Bäume in unterschiedlichen Konzentrationen und Raten ausgestoßen werden. Sie spielen eine wichtige Rolle in der Atmosphärenchemie und beeinflussen die Bildung von verschiedenen sekundären Schadstoffen (vgl. Kesselmeier & Staudt 1999, 25). Neben der oftmals hohen Reaktivität von BVOC spielt auch die hohe Rate ebendieser eine bedeutende Rolle, da sie die Emissionsraten von anthropogenen Kohlenwasserstoffen übersteigen (vgl. Sharkey et al. 2008, 5). Zudem sind sie nur schwer einer Beeinflussung zugänglich.

Unterschiedliche Faktoren beeinflussen die Emissionsrate der biogenen Kohlenwasserstoffe, wie beispielsweise das Pflanzen- und Baumalter, die jeweilige Phänologie, die verfügbaren Nährstoffe. Auch Wasser- und Hitzestress haben einen Einfluss auf die Ausstoßraten. Zusätzlich dazu sind die meteorologischen Bedingungen wie die Lufttemperatur und die Intensität der photosynthetisch aktiven Strahlung (PAR) bedeutende Faktoren (vgl. Wiedinmyer et al. 2004, 128 ff.).

In einem ersten Schritt wird aus der Gruppe der biogenen Kohlenwasserstoffe der Stoff Isopren zur weiteren Betrachtung ausgewählt. Isopren weist eine hohe Reaktivität auf und ist durch die hohe Emission durch Vegetation ein bedeutender Ozonvorläuferstoff (vgl. Wagner & Kuttler 2014, 104). Wie auch bei den weiteren BVOCs ist bei Isopren eine hohe Emission durch Pflanzen an Tagen mit autochthonen Wetterlagen, also an warmen und windarmen Tagen, zu verzeichnen. Das Isopren wird besonders durch Laubbäume emittiert, während Nadelbäume stattdessen häufiger Monoterpene emittieren (vgl. Henninger & Weber 2020, 220). Diese gehören auch zur Gruppe der BVOC, werden an dieser Stelle aber nicht weiter betrachtet.

Durch das Vorhandensein vieler Baumarten bieten sich Waldflächen besonders als Untersuchungsgebiet für die Entwicklung des Navigationssystems an. Dementsprechend erfolgt die weitere Betrachtung zunächst am Beispiel der Waldflächen in und um Kaiserslautern, als Ausläufer der Pfälzerwaldes. Da eine vereinfachte und planungspraxisbezogene Betrachtung anvisiert ist, liegt der Fokus auf den vorhandenen Hauptbaumarten. Diese Informationen sollten den zuständigen Forstämtern bereits digitalisiert vorliegen und können so zur weiteren Untersuchung genutzt werden.

Neben den genannten Aspekten bieten sich Waldflächen zudem an, da sie häufig eine Vielzahl von offiziell ausgewiesenen Wanderwegen beherbergen. In Kaiserslautern sind übersichtliche Routen vorhanden, da im Rahmen eines abgeschlossenen Projektes in Kooperation mit der Stadt Kaiserslautern zahlreiche offizielle, inoffizielle, regionale sowie überregionale Wanderwege untersucht und zusammengefasst wurden. Ebendiese übersichtlichen Routen bilden nun die Grundlage für die human-biometeorologische Optimierung der Routen sowie die Entwicklung des Navigationssystems.

4 VORGEHENSWEISE

Die Grundlage der Untersuchung stellt das Untersuchungsgebiet mit den vorhandenen Baumarten dar. In Kooperation mit den zuständigen Forstämtern werden die vorhandenen Informationen aufgearbeitet und in Form von Geodaten in ein Geographisches Informationssystem (GIS) übernommen. Zur Vereinfachung der Untersuchung und der besseren Übertragbarkeit auf andere deutsche Waldflächen werden die Baumarten gemäß ihrer Gattungen in Cluster zusammengefasst (s. Tab. 1). Die flächenhafte Darstellung dieser Cluster in Form von Polygonen ermöglicht somit eine erste Visualisierung der Verteilung der Hauptbaumarten (Abb. 1).

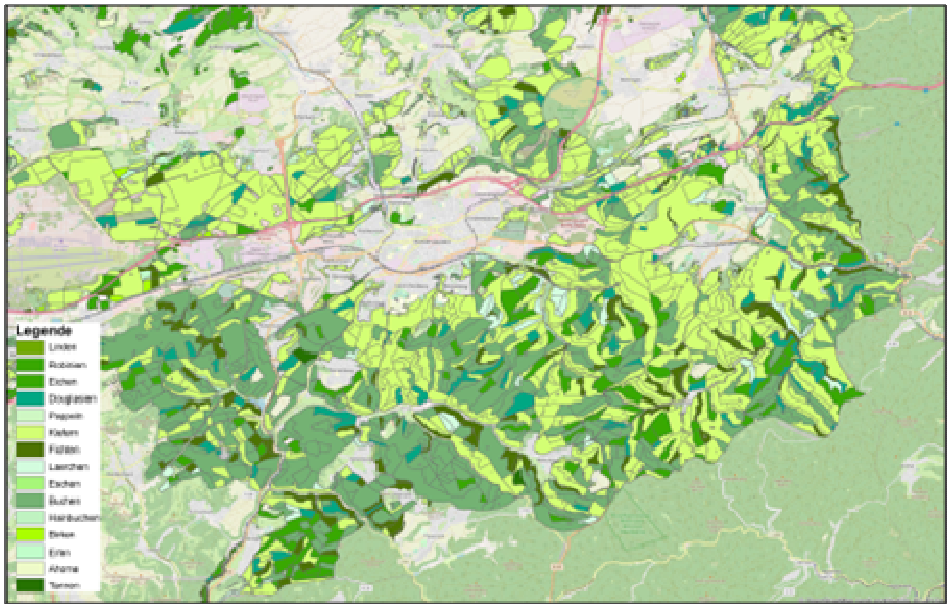


Abb. 1: Darstellung der Baumarten-Cluster am Beispiel der Wälder der Forstämter Kaiserslautern und Otterberg (Quelle: Eigene Darstellung)

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Die Verknüpfung dieser Cluster mit dem Isopren erfolgt durch die Zuordnung von Isopren-Mittelwerten nach Wiedinmyer et al. 2004 sowie Werten aus der weiteren Literatur nach 2004. Diese Mittelwerte beinhalten sämtliche Isoprenemissionswerte von im Untersuchungsgebiet und in Deutschland vorkommenden Baumarten. Durch das Vorgehen im Sinne einer Worst-Case-Betrachtung werden somit alle möglichen potenziellen Emissionen in die Betrachtung eingeschlossen. Aus allen gesammelten Werten wird das arithmetische Mittel gebildet, um einen Durchschnittswert für die jeweilige Baumgattung zu erhalten.

Die so erhaltenen Werte werden in Anlehnung an Calfapietra et al. 2009 in Emissionsklassen eingeteilt. Dies ermöglicht eine bessere Betrachtung und die Darstellung der Klassen und Waldflächen im Sinne eines Ampel-Systems mit den zugehörigen Farben grün, gelb und rot. Zu den drei Emissionsklassen gehören low-emitter-Baumarten mit 0,1 – 3 µg g(dw)-1 h-1 Isopren, medium-emitter-Baumarten mit einer Spanne von 3 – 20 µg g(dw)-1 h-1 sowie high-emitter-Arten mit Emissionsraten > 20 µg g(dw)-1 h-1 (vgl. Calfapietra et al. 2009, 1479).

wiss. Name Gattung	deutscher Name	Isopren-Mittelwert (µg $g(dw)^{-1}$ h^{-1})	Emitter-Klasse nach Calfapietra et al. 2009
Abies	Tanne	27	high
Acer	Ahorn	< 0,1	low
Alnus	Erle	< 0,1	low
Betula	Birke	< 0,1	low
Carpinus	Hainbuche	0,21	low
Fagus	Buche	< 0,1	low
Fraxinus	Esche	< 0,1	low
Larix	Lärche	< 0,1	low
Picea	Fichte	4,24	medium
Pinus	Kiefer	0,28	low
Populus	Pappel	58,32	high
Pseudotsuga	Douglasie	0,7	low
Quercus	Eiche	61,83	high
Robinia	Robinie	32	high
Tilia	Linde	0	low

Tab. 1: Isopren-Mittelwerte nach Wiedinmyer et al. 2004 für vorhandene Baumgattungen und zugehörige Emitter-Klassen (Quelle: Eigene Bearbeitung nach Wiedinmyer et al. 2004, Calfapietra et al. 2009, 1479)

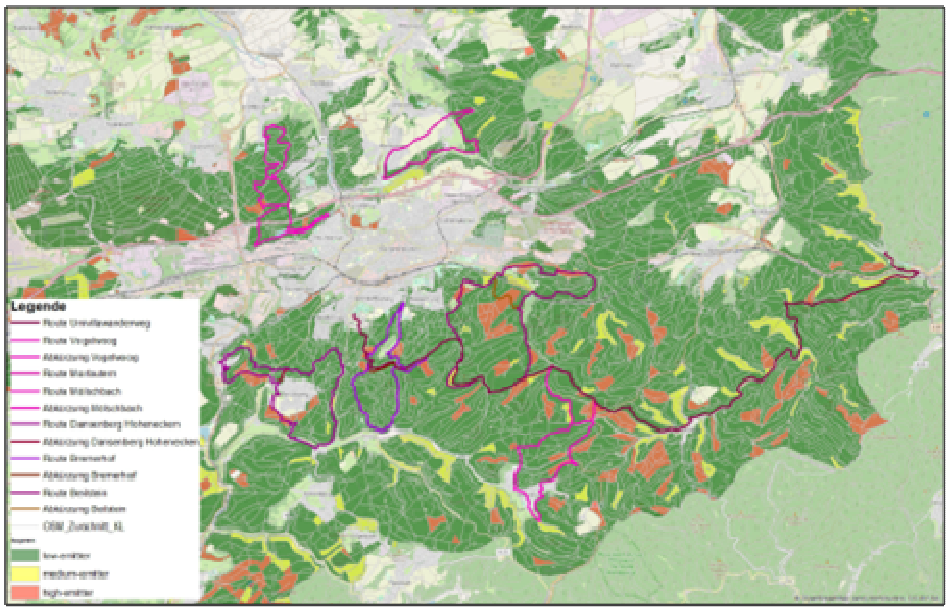


Abb. 2: Überlagerung des Emissionskatasters und der Wanderwege am Beispiel der Wälder der Forstämter Kaiserslautern und Otterberg (Quelle: Eigene Darstellung)

Durch die Visualisierung der Klassen als Ampel-System entsteht ein „Isopren-Baum-Kataster“. Dieses zeigt auf, welche Gebiete welche potenziellen Isopren-Emissionen besitzen und wo dementsprechend das Ozonbildungspotenzial erhöht ist.

Das Kataster wird dann mit den vorhandenen Wanderwegen, bestehend aus offiziellen Wanderwegen, eigens erfassten GPS-Routen sowie OpenData in Form von OpenStreetMap, überlagert. Dieses Vorgehen ermöglicht die Visualisierung der Streckenabschnitte im Wald, an denen während autochthoner Wetterlagen die Isoprenkonzentration und damit verbunden das Ozonbildungspotenzial erhöht ist (Abb. 2).

Auf dieser Basis kann nun die Optimierung der Wanderrouten aus human-biometeorologischer Sicht erfolgen.

5 MODELLIERUNG

Basierend auf Hamacher & Klamroth 2006 werden in diesem Kapitel die wichtigsten graphentheoretischen Definitionen formuliert und beschrieben, wie aus den Rohdaten ein mathematisches Modell entsteht. Für die spätere Optimierung muss das reale Wegenetz in ein mathematsiches Netzwerk transformiert werden. Im Folgenden wird aufgezeigt, wie ein solches mathematisches Netzwerk definiert ist.

Definition 1: Ein mathematisches Netzwerk G = (V, E) ist ein Graph mit nichtleerer Knotenmenge V und Kantenmenge E, wobei jede Kante e ∈E eine nicht-negative Länge l(𝑒) besitzt.

Definition 2: Ein Weg P in G ist eine Folge von Knoten P=(v_1,…,v_i,v_(i+1),…,v_r) mit e_i=[v_i,v_(i+1)]∈E und e_i≠e_(i+1) für alle i=1,…,r-1. Der Knoten v_1 heißt Anfangsknoten des Weges P und der Knoten v_r heißt Endknoten des Weges P.

Definition 3: Neben einer Länge l(𝑒) besitze jede Kante e ∈E einen nicht-negativen Isoprenkoeffizienten k(𝑒)∈R_+. Der Isoprenwert i(𝑒) einer Kante e ∈E ist gegeben durch das Produkt ihrer Länge l(𝑒) und ihres Isoprenkoeffizienten k(𝑒). Der Isoprenwert eines Weges P ist gegeben durch die Summe der Isoprenwerte aller Kanten entlang des Weges.

Die im Projekt genutzten und relevanten OpenStreetMap-Daten weisen sog. nodes (Punkte) und ways (Linienzüge) aus. Jeder node hat eine eindeutige ID sowie geographische Position gespeichert. Ein way besteht aus einer geordneten Liste von mindestens zwei nodes. Wann immer mindestens zwei ways über den selben node verlaufen, handelt sich bei diesem node im realen Wegenetz um eine Kreuzung. Ein solcher node wird daher zu einem Knoten im mathematischen Netzwerk. Zwei Knoten im mathematischen Netzwerk werden durch eine Kante verbunden, wenn ein way (oder eine Komposition von ways) existiert, der beide Knoten aufeinanderfolgend enthält. Die realen Wanderwege werden nun durch die entsprechende Abfolge der Knoten im mathematischen Netzwerk repräsentiert. Jeder Wanderweg wird anschließend mit einem Weg im mathematischen Netzwerk identifiziert: Der Anfangsknoten s bzw. der Endknoten t ist der Knoten im Netzwerk, der am nächsten an den Koordinaten des Startpunktes bzw. Endpunktes des Wanderweges liegt.

Die Länge einer Kante entspricht der Strecke in Metern von ihrem Startknoten zu ihrem Endknoten entlang des räumlichen Verlaufs des ways und damit im Allgemeinen nicht der Luftlinienentfernung zwischen Start- und Endknoten. Weiterhin besitzt jede Kante e ∈ E auch einen Isoprenwert i(𝑒), der angibt, wie hoch der Isoprenausstoß der angrenzenden Bäume entlang der Kante ist. Der Isoprenwert i(𝑒) ergibt sich aus dem Produkt der Länge l(e) und des Isoprenkoeffizienten k(e). Basierend auf der Unterteilung der Wanderkarte in vier verschiedene Farbbereiche der Cluster (Abb. 2), wird dementsprechend zwischen vier Isoprenkoeffizienten unterschieden. Befindet sich eine Kante vollständig in einem grünen (gelben, roten) Gebiet, werden die Isoprenkoeffizienten als den mittleren Ausstoßwert 1,5 (11,5, 40,5) des jeweiligen Gebietes definiert. In weißen Flächen liegt kein Baumbestand vor oder wurde in den Daten des Forstamtes nicht erfasst, sodass Kanten, die vollständig in einer weißen Fläche liegen, einen Isoprenkoeffizienten von 0,7 erhalten. Kanten, die durch verschieden gefärbte Flächen verlaufen, werden an den Übergängen zwischen zwei Flächen geteilt. Den entstandenen neuen Kanten wird der Isoprenkoeffizient der Fläche, in der sie sich befinden, zugeordnet. Weiterhin berechnen wir für jede neue Kante ihre Länge.

Jede Kantenteilung erhöht die Anzahl der Kanten und damit die Laufzeit des Algorithmus auf dem Netzwerk. Daher werden Kanten erst ab einer Länge von 25 m geteilt. Einer kürzeren Kante kann jeder Isoprenkoeffizient, der zu den Flächen gehört, in denen sich die Kante befindet, zugeordnet werden. Abhängig von einem Parameter können optimistischere oder pessimistischere Szenarien modelliert werden. Verläuft beispielsweise eine Kante, deren Länge kleiner als 25 m ist von einem grünen Bereich in einen roten, so kann in einem optimistischeren (pessimistischeren) Szenario die Kante den Isoprenkoeffizienten der Farbe Grün (Rot) bekommen.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

6 PROBLEMSTELLUNG

Die mathematische Modellierung aus Kapitel 5 ergibt folgende Probleminstanz: gegeben ist ein mathematisches Netzwerk G = (V, E) und ein Weg P in G mit Startknoten s und Endknoten t. Jede Kante e ∈E besitze eine Länge l(e) und einen Isoprenwert i(e)= l(e)*k(e). Dabei ist zu beachten, dass s und t nicht notwendigerweise verschieden sein müssen.

Gesucht ist nun ein neuer Weg P‘ mit Startenknoten s und Endknoten t, der einen geringeren Isoprenwert als der Weg P aufweist und sich zudem nur möglichst geringfügig von P unterscheidet. Diese Problemstellung beinhaltet zwei gegensätzliche Ziele, ist also eigentlich ein multikriterielles Optimierungsproblem: zum einen gilt es möglichst viele Abschnitte des gegebenen Weges zu laufen und zum anderen möglichst wenig Isopren aufzunehmen. Die Suche nach möglichst isoprenarmen Wegen führt tendenziell zu einer kürzeren Alternative, da mehr Strecke auch ein höheres Potenzial zur Isoprenaufnahme bietet. Auf der anderen Seite führt die Bedingung, dass möglichst viel Strecke auf dem gegebenen Weg liegen soll, zu längeren Alternativen. Die Problemstellung führt somit im Allgemeinen nicht zu einer eindeutigen Optimallösung.

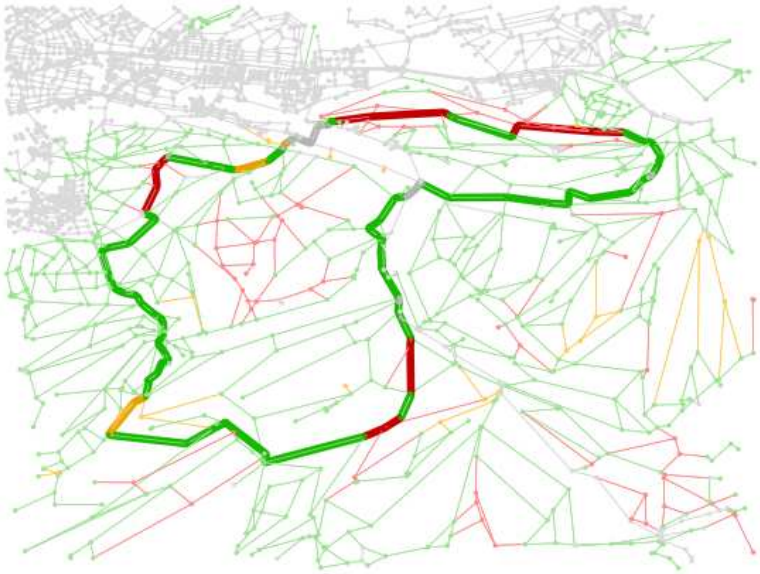


Abb. 3: Die Graphik zeigt den Wanderweg “Route Beilstein“ und den zugehörigen Ausschnitt des mathematischen Netzwerkes rund um den Wanderweg. Jede Kante besitzt die Farbe des Gebietes, in dem sie sich befindet.

7 LÖSUNGSVERFAHREN

Um eine Lösung für die Problemstellung zu finden, besteht grundsätzlich die Möglichkeit, zwei heuristische Verfahren zu verwenden, die mit unterschiedlicher Priorität die beiden Ziele berücksichtigen. Das erste Verfahren beabsichtigt, möglichst viele Abschnitte des gegebenen Weges zu benutzen und dabei möglichst wenig Isopren aufzunehmen. Das zweite Verfahren erlaubt eine höhere Variabilität bei der Auswahl neuer Kanten und liefert Wege, deren Isoprenwert mindestens so klein ist wie der Isoprenwert des Weges, der mit dem ersten Verfahren berechnet wurde. Beide Verfahren beruhen auf Dijkstras Algorithmus und berechnen Wege, die einen geringeren Isoprenausstoß als der gegebene Weg P aufweisen. Hat der Weg P bereits einen minimalen Isoprenwert, ist keine Verbesserung möglich und die gewählten Verfahren geben P als Optimallösung aus. Die Verfahren sind exemplarisch an dem Wanderweg “Route Beilstein“ aus Abbildung 3 durchgeführt. Es ist jedoch zu beachten, dass die Verfahren auf jedes beliebige Wandergebiet und jeden Wanderweg übertragbar sind. Hierzu muss lediglich die Datengrundlage bestehend aus den OpenStreetMap-Daten und dem Emissionskataster des Wandergebietes sowie die GPS-Koordinaten der Wanderwege ausgetauscht werden.

7.1 Verfahren 1

Das erste Verfahren berechnet einen Weg, der alle grünen und weißen Teilstücke des Weges P beibehält, um eine große Übereinstimmung mit P zu sichern. Mit P_1,…, P_k bezeichnen wir die Teilstücke des Weges P, die nur grüne oder weiße Kanten enthalten. Hierbei wird angenommen, dass die Teilstücke in der Reihenfolge vorliegen, in der sie im Weg P abgelaufen werden. Seien P_l=(v_1,…,v_p) und P_(l+1)=(w_1,…,w_q) zwei aufeinanderfolgende Teilstücke grüner oder weißer Kanten von P. Für je zwei

solcher Teilstücke P_l und P_(l+1) wird der isoprenärmste Weg zwischen dem Endknoten v_p von P_l und dem Anfangsknoten w_1 von P_(l+1) berechnet. Hierzu wird der Algorithmus von Dijkstra (Dijkstra 1959) verwendet, um einen kürzesten Weg zwischen v_p und w_1 bezüglich der Isoprenwerte l(e)*k(e) zu berechnen.

Die Berechnung wird beispielhaft für den Wanderweg „Route Beilstein“ aus Abbildung 3 durchgeführt. In Abbildung 4 wird die berechnete Alternative gezeigt. Diese behält Großteile der ursprünglichen Route bei, enthält aber im Gegenzug auch nur eine geringe Isoprenreduktion. In der oberen linken Ecke wurde ein ca. 300 m langer Abschnitt roter Kanten durch grüne Kanten ersetzt. Die Alternative ist ca. 500 m länger als das Original. Abbildung 6 zeigt die Zusammensetzung roter, gelber, grüner und weißer Kanten der Wanderroute vor und nach der Optimierung durch Verfahren 1.

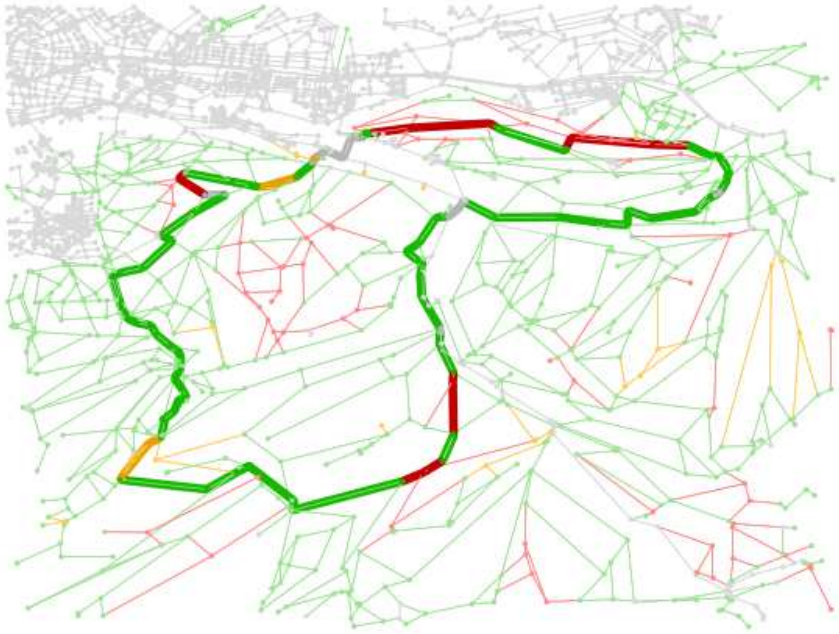


Abb. 4: Die von Verfahren 1 berechnete isoprenärmere Alternative zur Route „Beilstein“.

7.2 Verfahren 2

Das Festsetzen eines gesamten Teilstücks P_l=(v_1,…,v_p) grüner oder weißer Kanten kann einen negativen Einfluss auf den Isoprenwert der berechneten Lösung haben. Führen beispielsweise alle benachbarten Knoten des Endknotens v_p in einen roten Bereich, so kann es besser sein, das Teilstück P_l bereits in einem vorherigen Knoten v_i mit i<p zu verlassen. Verfahren 2 wirkt dieser Einschränkung entgegen und erlaubt eine höhere Variabilität in der Auswahl der Kanten.

Nimmt man wie zuvor an, dass P_1,…, P_k die Teilstücke des Weges P sind, die nur grüne oder weiße Kanten enthalten, und nimmt man zudem an, dass die Teilstücke in der Reihenfolge vorliegen, in der sie im Weg P abgelaufen werden, dann sind P_l=(v_1,…,v_p) und P_(l+1)=(w_1,…,w_q) zwei aufeinanderfolgende Teilstücke grüner oder weißer Kanten von P. Anstatt den isoprenärmsten Weg zwischen v_p und w_1 zu bestimmen, wird anschließend der isoprenärmste Weg zwischen einem Knoten v_i∈P_l und einem Knoten w_j∈P_(l+1) berechnet. So ist sichergestellt, dass jedes Teilstück in der berechneten Lösung zumindest teilweise vorhanden ist.

Betrachtet man aber je zwei Paare P_l und P_(l+1) ohne das darauffolgende Teilstück P_(l+2), kann man einen Knoten in P_(l+1) besuchen, der einen Weg mit vergleichsweise hohem Isoprenwert zwischen P_(l+1) und P_(l+2) impliziert. Um das zu verhindern, werden zwischen je zwei Paaren P_l und P_(l+1) die zehn isoprenärmsten Wege ermittelt. Anschließend kommt es zu einer Verknüpfung dieser Wege mit allen zehn isoprenärmsten Wegen zwischen P_(l+1) und P_(l+2). Diese werden vom Startknoten s zum ersten Teilstück P_1 bis zum letzten Teilstück P_k zusammen- und anschließend zum Endknoten t fortgeführt – und unter allen möglichen Kombinationen die Alternative mit geringstem Isoprenwert ausgewählt.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Nach Konstruktion kann die von Verfahren 1 berechnete Lösung immer auch mit Verfahren 2 berechnet werden. Somit besitzt der von Verfahren 2 berechnete Weg einen Isoprenwert, der mindestens so klein ist, wie der des von Verfahren 1 berechneten Weges.

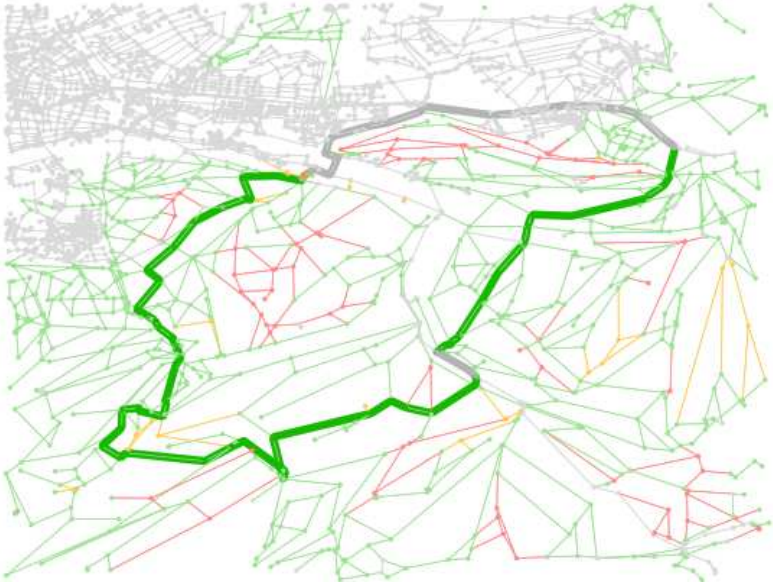


Abb.5: Die mit Verfahren 2 berechnete isoprenärmere Alternative zur Route „Beilstein“.

In Abbildung 5 wird die mit Verfahren 2 berechnete Alternative zur Route „Beilstein“ gezeigt. Diese stellt eine größere Abweichung von der ursprünglichen Route dar, verfügt dafür aber über einen deutlich geringeren Isoprenwert. Mit Ausnahme eines kurzen gelben Abschnittes (ca. 40 m) in der oberen linken Ecke, beinhaltet die Alternative nur grüne und weiße Kanten. Die Alternative stellt also eine erheblich gesundheitsfreundlichere Route als die ursprüngliche dar. Die Alternative ist ca. 500 m kürzer als das Original. Abbildung 6 zeigt die Zusammensetzung roter, gelber, grüner und weißer Kanten der Wanderroute vor und nach der Optimierung durch Verfahren 2.

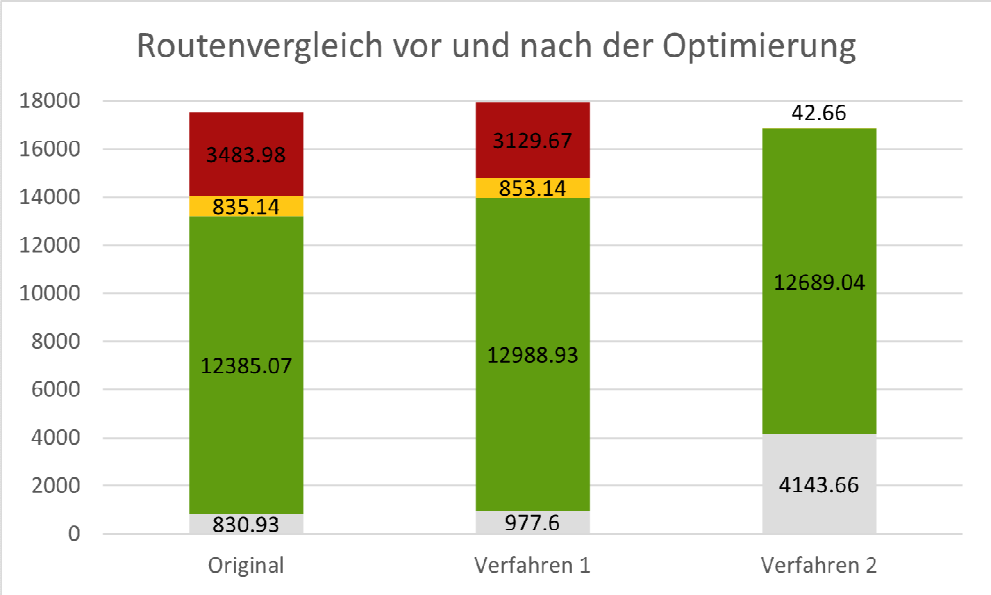


Abb. 6: Die durch Verfahren 2 berechnete Lösung ist etwas kürzer, läuft weniger Strecke auf dem Originalweg, besitzt aber einen erheblichen besseren Isoprenwert.

8 AUSBLICK & HERAUSFORDERUNGEN

Nach erfolgreicher Erprobung des Algorithmus wird die Entwicklung eines Navigationssystems als App angestrebt, die es ermöglicht, potenziell gesundheitsschädigende Routenabschnitte von Wanderwegen bei bestimmten Wetterlagen vermeiden zu können. Ziel hierbei ist es, alternative Streckenabschnitte aufzuzeigen, die sich an der Länge der ursprünglichen Route orientieren und möglichst kurze Umwege

aufzeigen . Ist dies erfolgt und anwendbar, wird es als Ziel gesetzt, die Ergebnisse auf weitere Luftschadstoffe sowie Standorte übertragen zu können. Auch wäre es möglich, in Abhängigkeit der Meteorologie und der Bebauungsdichte/ -struktur, aus stadtklimatologischer Sicht optimale Routen für Fußgänger aufzuzeigen. So soll die Funktionalität sowohl im ruralen, suburbanen und urbanen Raum gegeben sein. Ebenso soll im weiteren Verlauf des Projektes der Einsatz Künstlicher Intelligenz (KI) geprüft werden. Denkbar wäre hierbei die Datengenerierung anhand von Sensoren mit Echtzeit-Daten sowie damit verbunden automatische KI-gestützte Analysen.

In einem weiteren Schritt sollten die neuen vorgeschlagenen Routen bzw. Wegabschnitte auf ihre Begehbarkeit sowie Attraktivität für Besuchende geprüft werden. Diese Notwendigkeit ergibt sich dadurch, dass zur mathematischen Optimierung alle vorhandenen Wege genutzt werden, unabhängig ihres Zustandes. Gegebenenfalls werden hier Handlungsempfehlungen nötig, die eine Aufwertung der gesundheitsfreundlicheren Streckenführungen als Ziel haben.

Die Ergebnisse des vorliegenden Projektes sollen nicht nur Nutzenden im Sinne der Navigationsapp dienen, sondern auch für Planungs- und Entscheidungsträger nutzbar werden. Dies könnte in Form von Handlungs- und Planungsempfehlungen erfolgen. So soll aufgezeigt werden, wie besonders im Bestand mit möglichen Gesundheitsbelastungen durch Pflanzen und Bäume sowie lokaler Überwärmung umgegangen werden kann. Auch für die Neuplanung von Grünflächen und damit verbunden die Neupflanzung sollen mögliche Empfehlungen dargestellt werden.

Anpassungsmaßnahmen und neue Forschungsansätze sind im Hinblick auf den Klimawandel und die Auswirkungen auf lokaler Ebene unbedingt erforderlich, um die positiven Wirkungen der grünen Infrastruktur und vor allem städtische Räume als lebenswerte Orte erhalten zu können. Dieses Forschungsprojekt stellt hierzu einen ersten Ansatz dar.

9 QUELLEN

CALFAPIETRA, C.; FARES, C.; LORETO, F.: Volatile organic compounds from Italian vegetation and their interaction with ozone, In: Environmental Pollution 157 (2009), pp. 1478 – 1486. 2009.

CYGANSKI, R.: Generierung nutzerangepasster Wandertouren mit Hilfe eines adaptierten Ameisenalgorithmus. In: Angewandte Geoinformatik. Beiträge zum 19. AGIT-Symposium Salzburg pp. 127-136. H. Wichmann Verlag. 2007.

CZIFERSZKY, A.; WINTER, S.: Automatisches Generieren von Wanderrouten. In: Strobl, J.; Blaschke, T.; Griesebner, G. (Hrsg.): Angewandte Geographische Informationsverarbeitung XIV, 77 – 86. Heidelberg, Fraunhofer IRB Verlag, Wichmann. 2002.

DIJKSTRA; E. W.: A note on two problems in connexion with graphs. In: Numerische Mathematik, 1, 269–271. 1959

DOSCH, F.; HAURY, S.; SKOWSKI, J.; WAHLER, B.; WILLINGER, S.; ARNDT, T.; MAYER, F.; HOMMES, M.; MÖSCH, S.: Grün in der Stadt – Für eine lebenswerte Zukunft – Grünbuch Stadtgrün. Bundesministerium für Umwelt, Naturschutz, Bau und Reaktorsicherheit (BMUB), Berlin. https://www.bmi.bund.de/SharedDocs/downloads/DE/publikationen/themen/bauen/wohnen/gruenbuch-stadtgruen.pdf;jsessionid=0579552F86E06061833DBE35443E1754.2_cid373?__blob=publicationFile&v=4 (Zugriff 01.07.2022). 2015.

HAMACHER, H. W.; KLAMROTH, K.: Lineare und Netzwerkoptimierung In: Vieweg + Teubner Verlag, Wiesbaden. 2006

HENNINGER, S.: Notwendiger Wandel im Umgang mit innerstädtischen Grünflächen? in: Junkernheinrich, M.; Ziegler, K.: Räume im Wandel. 2013.

HENNINGER, S.; WEBER, S.: Stadtklima. Schöningh Verlag, Paderborn. 2020.

KESSELMEIER, J.; STAUDT, M.: Biogenic Volatile Organic Compounds (VOC): An Overview on Emission, Physiology and Ecology. In: Journal of Atmospheric Chemistry 33: pp. 23-88. 1999.

MAYR, S., KLEINDIENST, H., HELLER, A.: Der Weg ist das Ziel - Online Routenplanung auf Wanderwegen. In: Strobl, J.; Blaschke, T.; Griesebner, G. (Hrsg.): Angewandte Geoinformatik. Beiträge zum 18. AGIT-Symposium Salzburg, pp. 415 – 422. 2006.

MUREKATETE, R., M., SHIRABE, T.: An experimental analysis of least-cost path models onordinal-scaled raster surfaces. International Journal of Geographical Information Science, 35:8, 1545-1569. 2021.

SHARKEY, T; WIBERLEY, A.; DONOHUE, A.: Isoprene Emission from Plants: Why and How. In: Annals of Botany 101: pp. 5-18. 2008.

UMWELTBUNDESAMT: Gesundheitsrisiken durch Ozon, https://www.umweltbundesamt.de/daten/umwelt-gesundheit/gesundheitsrisiken-durch-ozon#gesundheitliche-risiken-von-ozon-und-hoher-lufttemperatur, Zugriff: 08.07.2022. 2022.

WAGNER, P.; KUTTLER, W.: Biogenic and anthropogenic isoprene in the near-surface urban atmosphere – A case study in Essen, Germany. In: Science of the Total Environment 475 (2014), pp. 104-115. 2014.

WIEDINMYER, C.; GUENTHER, A.; HARLEY, P.; HEWITT, N.; GERON, C.; ARTAXO, P.; STEINBRECHER, R.; RASMUSSEN, R.: Global Organic Emissions from Vegetation. In: Granier, C.; Artaxo, P.; Reeves, C. (Edit.): Emissions of Atmospheric Trace Compounds, pp. 115-170, Kluwer Academic Publishers, Dordrecht. 2004.

🏆 *reviewed paper*

Integrated Simulation-based Framework for Parametric Open Space Design with Focus on Sustainable Mobility and Climate Resilience

Theresa Fink, Martin Jung, Thomas Matyus, Thomas Tophof, Nariddh Khean

(Theresa Fink MSc, AIT Austrian Institute of Technology, theresa.fink@ait.ac.at)
(Mag. Martin Jung, AIT Austrian Institute of Technology, martin.jung@ait.ac.at)
(DI Thomas Matyus, AIT Austrian Institute of Technology, thomas.matyus@ait.ac.at)
(Thomas Tophof MSc, AIT Austrian Institute of Technology, thomas.tophof@ait.ac.at)
(Nariddh Khean MSc, AIT Austrian Institute of Technology, nariddh.khean@ait.ac.at)

1 ABSTRACT

Recent advances in the application of computational design show great potential in the holistic assessment of design scenarios. To tackle the challenges of climate change and urbanisation, we need intelligent planning methods to design sustainable urban development and resilient open spaces. Therefore, this paper presents an integrated simulation-based framework for parametric urban design with focus on sustainable mobility and climate resilience. Precisely, aspects from mobility, water management and microclimate are used for the evaluation of open space planning. The result is the framework including interfaces and the exemplary application to real-world scenarios in Aspern at Nelson Mandela Square.

Keywords: Performance-based design, Climate resilience, Sustainable mobility, Parametric design, Open space design

2 INTRODUCTION

2.1 Challenge

The microclimate and mobility patterns of a neighbourhood have a significant impact on the social and economic development within the city, as well as on the quality of life of the residents (Sharmin, Steemers 2020). The structure of public spaces, the built environment and blue-green urban spaces have a decisive influence on whether squares, streets and sidewalks are attractive areas to dwell and rest. Additionally, with the acceleration of the climate crisis, urban heat stress can have serious health repercussions for vulnerable demographic groups, such as the elderly, infants or individuals with pre-existing conditions. Likewise, water retention plays an increasingly crucial role, as urban growth leads to more sealed surfaces, while extreme precipitation is expected to intensify (Tabari 2020). The time for closer collaborations between landscape planners and the scientific community for truly resilient urban designs is now. Design, choice of materials and anticipated user behaviour are crucial factors in determining whether our urban fabric will stand the test of time. Municipalities and local governments are becoming increasingly aware of the importance of these factors in designing urban spaces. Within the city of Vienna, the aspects of microclimatic resilience and sustainability are rooted in municipal strategies (Vienna Municipal Department 2018) and has become institutionalised in the planning of selected urban development areas through the tool of the Quality Advisory Board ("Qualitätsbeirat") of the wohnfonds_wien.

Equally, a change in our mobility behaviour can contribute significantly to curbing greenhouse gas (GHG) emmissions, as passenger vehicles are responsible for approximately 70 percent of motorised transport emissions in industrialised nations (Tran et al 2021). Urban mobility modelling can plays a key role in facilitating the infrastructure required to attract urban dwellers in adapting more sustainable modes of transport (i.e. walking and cycling). In this regard, accessibility and possibilities to meet current and future mobility requirements need to be taken into account efficiently throughout the planning stages of public spaces and mobility hubs. Knowledge of this is not only of interest to municipalities and urban planners, but also to developers and business owners in their respective investments.

2.2 Background

This paper aims to establish the potential of cross-disciplinary framework from microclimate and active mobility simulations as planning support for open spaces. Located in a greenfield development 'Seestadt Aspern' in the Austrian capital city of Vienna, this case study depicts the strengths of a methodology comprised of simulation and parametric planning. The integration of urban analysis and optimisation into the planning process in practice is a major challenge, therefore tools and frameworks are needed to make different aspects of scenarios assessable.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

In order to solve complex simulations for many variants, computational urban modelling was used to support the modelling, simulation and evaluation process (Koenig et. al 2019). In recent years, the use of computational urban modelling in architecture and urban planning has increased enormously (Fink 2018).

3 METHODOLOGY

The methodology is structured in three steps: the first step is the parametric modelling of buildings and vegetation (trees, green spaces, surfaces) within the given context and boundary conditions of the project site. The modelling of the urban design is done using the software environment Rhinoceros 3D and its native parametric plug-in Grasshopper. The second step of the methodology – the analyses - is split into three different topics: 1. Pedestrian Simulation, 2. Microclimate Simulation and 3. Urban Water Consultation. The microclimate simulations were conducted using the Rhinoceros 3D software alongside the Ladybug Tools plug-in to simulate the environmental impact of their designs. The pedestrian models were simulated using Simulate modelling software, developed by AIT. The methodology estimates the water retention potential of the area under investigation utilised the respective runoff coefficients of the anticipated surface materials. In close coordination with the partnering landscape architect, the surfaces and their characteristics were discussed to meet the client's expectations and the local resilience standards. The third step of the methodology concerns the evaluation of the results and translation into design decisions. Therefore, the results are therefore superimposed on the design across themes, further design scenarios are developed and used as a basis for decision-making for open space elements and the properties of surfaces.

3.1 Step 1 – Parametric modelling

The use of parametric modelling allows many variants to be created under semi-automated processes. 2D CAD plans are used as a data basis, which are modelled in 3D within the software environment Rhinoceros 3D and Grasshopper with self-developed scripts. Buildings (height, land-use), vegetation (trees, green areas), benches, bus stops, entrances and public transport lines are created parametrically in three different variants within the framework conditions. The trees are modelled as simplified 3D shapes, differentiating between street trees and square trees in height and crown diameter to correspond to real conditions. Furthermore, the surface conditions of the ground surfaces are modelled differentially on layers to provide information for both stormwater management and the walkability of surfaces for pedestrians.

3.2 Step 2 – Simulations and Analyses

The analyses are further solved via additional plug-ins and other software environments. For this purpose, the data is prepared via interfaces from Grasshopper for the respective simulations and serve as a basis. In the following sub-chapters (Figure 1), the simulations for the individual topics are explained in more detail.

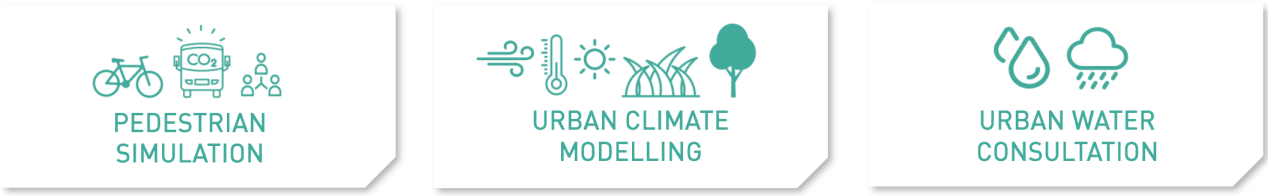


Fig. 1: Topic overview.

3.2.1 Pedestrian Simulation

For the analysis of the pedestrian flows at Nelson Mandela Square an agent-based simulation model (Simulate) was used to simulate the movements of all boarding and alighting public transportation passengers and of all persons crossing the square during five minutes of the morning peak hour. For this purpose, the entire transport infrastructure, including bicycle parking and all planning measures were taken into account. The data preparation for the interface between Rhinoceros 3D and Simulate is done in the parametric plug-in Grasshopper. Spatial elements with their properties (buildings, stops, PoI, (accessible) green spaces, benches, etc.) are modelled in 3D and exported as a .geojson file. A self-developed python parser translates the geometries, functional elements, start and end points into the input format of Simulate. The simulation in Simulate enables the integration of further information (i.e. number of pedestrians, public

transport frequency) as well as the user group-specific definition of speeds and routes. All parametrically generated scenarios are analysed and a holistic overview for the planners and stakeholders generated.

3.2.2 Microclimate Simulation

To perform a microclimatic simulation of the design, the Ladybug tools from the Grasshopper plug-in are used. This allows the simulation of climate comfort based on the solar radition on open spaces to avoid unpleasant conditions for pedestrians. The evaluation and visualisation is also carried out in the Grasshopper software environment, which supports the creation of simulation maps in project-specific legend colours.

3.2.3 Urban Water Consultation

To assess the impact of pluvial events on the open spaces from green spaces and roofs over waterbound surfaces, site concrete and slab surfaces the local mean annual precipitation as well as the local design storm water events are used as a basis. The NaNu3 research project deals with the parametric planning of a sustainable utility roof by combining green roof, photovoltaics and grey water treatment. Based on this project, the local framework conditions and the building parameters are used to evaluate the planning along the indicators. There are synergies between the two projects, both in the subject matter and in the parametric approach of the evaluation.

3.3 Step 3 – Evaluation

The evaluation of the design scenarios is based on the simulation results and carried out in discussions with the thematic experts. Strengths and weaknesses of designs can be better understood, and the fact-based simulation basis can ensure a performance comparison between variants.

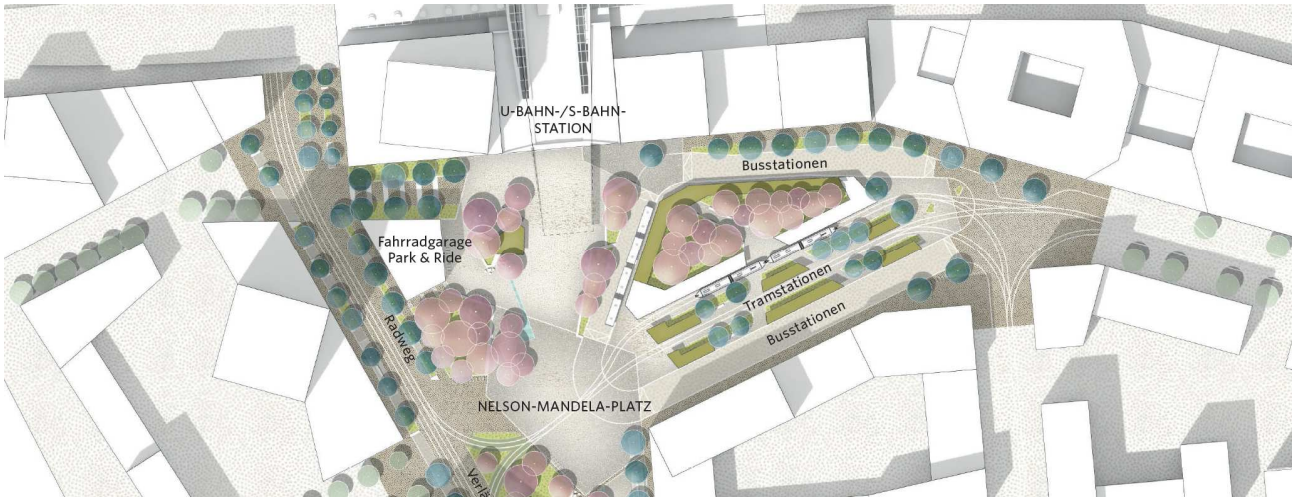


Fig. 2: Top view scenario 03 – Nelson Mandela Square, Aspern (© Lindle+Bukor)

4 CASE STUDY

4.1 Description Aspern Use Case

The presented framework was applied for the assessment of the landscape plan of Nelson Mandela Square in Vienna (see Figure 2). This public square has access to metro, bus and tram stops and is located in the north of a planned high traffic shopping street in the Aspern urban development area. This entails high demands on the multimodal mobility hub and on the quality of the square. The parameters for this use case are based on the objectives from the developers and on the weather boundary conditions of this location. The population, visitor frequencies of the shopping street and capacity of public transport were assumed for the case study based on GFA (gross floor area) of the buildings and reference mobility values from Vienna. The tasks identified were the parametric modelling of the landscape plan, the translation into a simulation model and the assessment based on the issues of microclimatic open space comfort, pedestrian flows and water management. The buildings from a master plan for the development area in the north are generated from the contour lines with height allocation. Space-defining elements such as the canopy in the metro access area and stops were reproduced in detail to achieve accurate results. In interactive workshops, three scenarios differentiated by land-use, density, green areas and trees were developed and evaluated. The development of

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

the scenarios includes the change in building heights and land-use as well as vegetation and green spaces at Nelson Mandela Square (see Table 1). These variations have an impact on pedestrian behaviour (origin, destination, frequency), solar radiation and urban water management. The synergies and impacts of the planning decisions were examined on the basis of the three scenarios.

4.2 Simulaton Set-up

4.2.1 Pedestrian Simulation

Simulations of pedestrian flows in the whole area were used to study the mobility aspects of the layout. For this purpose, an approach was implemented which uses social forces to describe the movements of the pedestrians and their interactions (Helbing et al 2009) with each other and with obstructing infrastructure elements. In general, pedestrians choose the shortest path to get from their starting point to their destination. By positioning attraction points along their path, it is possible to adjust their routes and and generate higher frequency on more attractive routes. Five minutes during the morning peak period were used as basis for estimating the passenger numbers. This resulted in a total of 1.310 persons, including 650 from and to the metro, 200 to and from the trams, 100 to and from the busses and 360 others, who passed through the area without using any form of public transport. Additionally, depending on the scenario, between 105 and 140 pedestrians walked through the area, starting at the building exits. These numbers are determined by the type of use of the buildings (e.g. office or residental building) and their GFA. As a consequence, pedestrian's mobility patterns are strongly linked to the building development of the area.

	Scenario 1	Scenario 2	Scenario 3
Planning KPIs	Total GFA: 187.623m² GFA commercial: 15.763m² GFA office: 41.025m² GFA residential: 130.835m² Residents: 2.617 Employees: 1.476 Density: 2,5 Average number of floors: 6,8	Total GFA: 129.948m² GFA commercial: 8.721m² GFA office: 67.831m² GFA residential: 129.948m² Residents: 2.599 Employees: 1.945 Density: 2,8 Average number of floors: 6,6	Total GFA: 203.896m² GFA commercial: 30.790m² GFA office: 75.062m² GFA residential: 98.044m² Residents: 1.961 Employees: 2.756 Density: 2,7 Average number of floors: 7,1
Pedestrian simulation	The pedestrian simulation reveals two areas of concern. 1) Many paths are crossing the bus lane in front of the bus stops. This prevents the buses from arriving and departing smoothly. 2) pedestrians are crossing the tram tracks right in front of the station. Since they are approaching the waiting vehicles from behind right this may lead to dangerous situations when a tram starts to leave the station.	The layout changes in this scenario do not solve the problems concerning the pedestrian flows described in scenario 1.	The redesign in this scenario significantly defuses the analyzed problem areas. The paths crossing the bus lanes are concentrated in a corridor between two bus stops and less pedestrians are crossing the tram tracks in front of the station. Furthermore, they are now approaching the waiting vehicles from the front which makes it much easier for the drivers to avoid collisions.
Microclimate Simulation	Number of trees: 98 Share of green: 11% % of >5Wh areas: 26,5% % of <2kWh areas: 20,7% Average solar radiation: 3,63 kWh/day Total solar radiation: 42.546kWh	Number of trees: 153 Share of green: 22% % of >5kWh areas: 25,6% % of <2kWh areas: 23,3% Average solar radiation: 3,51 kWh/day Total solar radiation: 41.173kWh	Number of trees: 140 Share of green: 18% % of >5kWh areas: 25,7 % of <2kWh areas: 21,7 Average solar radiation: 3,56 kWh/day Total solar radiation: 41.795kWh
Urban Water Consultation	Amount of water to be discharged (m^3 per area) 73 % of mean annual precipitation or design precipitation	Amount of water to be discharged (m^3 per area) 66 % of mean annual precipitation or of design precipitation	Amount of water to be discharged (m^3 per area) 69 % of mean annual precipitation or design precipitation

Table 1: KPI overview of the 3 scenarios developed.

4.2.2 Microclimate Simulation

Weather data of a meterological reference year for Vienna between 2004 and 2018 from an online data base was used as the basis for the simulations. The analysis period was set on 21st of June, a very hot summer day, and is intended to generate insights into the heat development at the site. The grid size for the simulation was set at 2 metre resolution for the entire area.

4.2.3 Urban Water Consultation

For the analyses the local mean annual precipitation as well as the local design storm water event were accessed via eHYD for the grid point 2791 (mean precipitation 563 mm) and two nearest modelled grid points 2765 'Stadlau' (near the intersection of Hans-Steger-Gasse and Aribogasse) and 2766 'Eastern Seestadt' (near the intersection of Niklas-Eslarn-Straße and Hänischgasse) repectively. Since the planning area is located in the mid-point between the two grid points, the mean value for local design storm of 48.1 mm for 60 minutes with a return period of 50 year was assumed for further calculation.

4.3 Results

4.3.1 Pedestrian Simulation

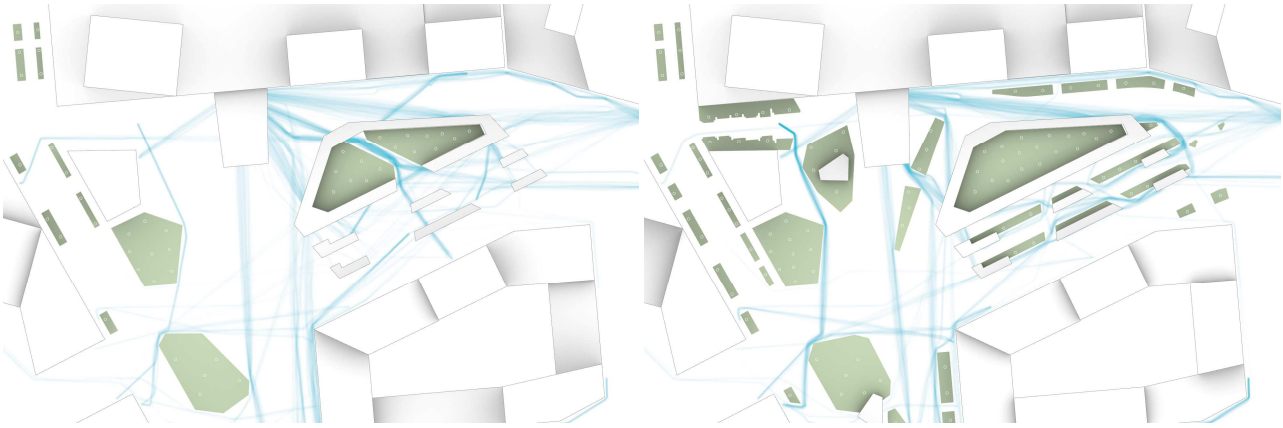


Fig. 3: Pedestrian simulation paths results - scenario 1 left, scenario 2 right

The results of the pedestrian flow simulations (see Figure 3) were visualized by marking the course of the most used paths and indicating the spots of high densities by orange or red colors (see Figure 4). Both the diagonal connections and the crossability, as well as the sufficient dimensions of the walkable areas, ensure smooth movements of the pedestrians (green). Increased person densities are expected only in the area in front of the entrance to the metro station (orange-red).

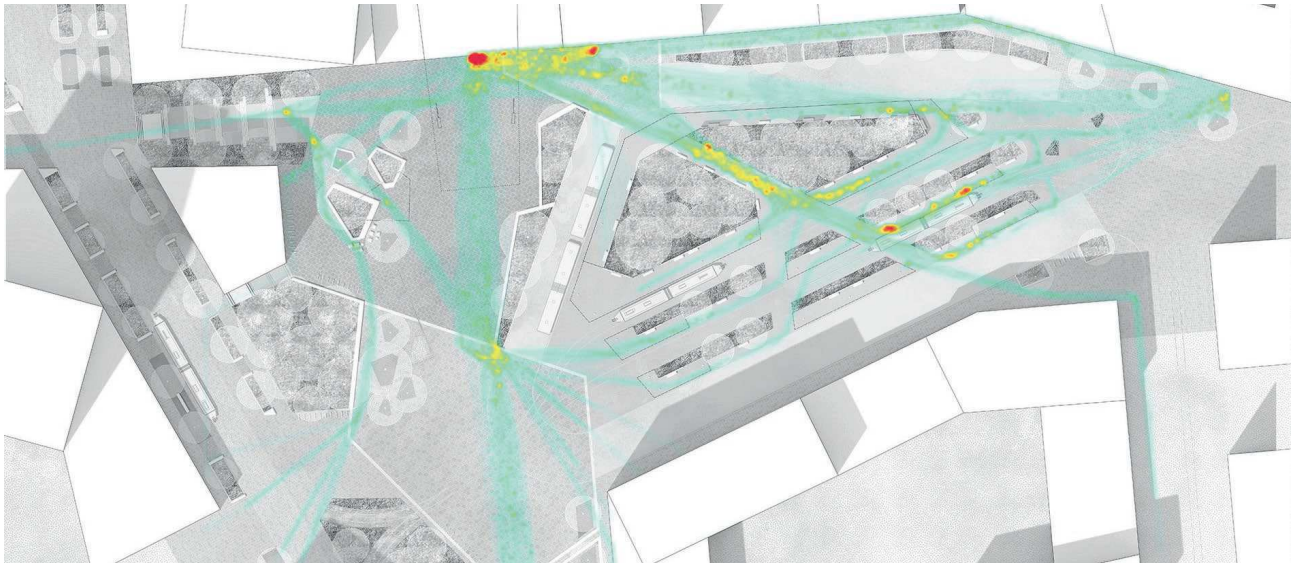


Fig. 4: Pedestrian simulation density results (© AIT, Lindle+Bukor)

4.3.2 Microclimate Simulation

The results on the solar radiation simulation show the effect of shading of vegetation, building configuration and bus stops. The optimised position of the trees reduces the percentage of places with high solar radiation to avoid overheating in summer. The mean radiation temperature - the perceived temperature by human - is strongly influenced by solar radiation. Especially in the waiting areas of the bus stops, the vegetation and canopies have a shading effect, which is characterised by the blue areas (see Figure 5). The red areas receive

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

a high amount of solar radiation, these indicate a strong heat development on hot summer days. In addition to solar radiation, the surface properties of the square and the surrounding buildings also have a significant influence on the microclimate. The results of the three scenarios reflect the different building heights and tree placements. Scenario 2 achieves the best performance with 25.6% of the areas above 5kWh and 153 trees despite having the highest density in the area.

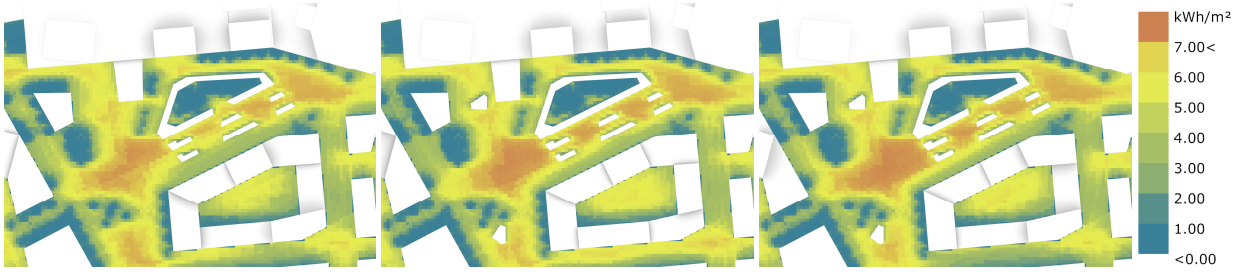


Fig. 5: Solar radiation results – scenario 1 left, scenario 2 middle, scenario 3 right.

4.3.3 Urban Water Consultation

The results in Table 2 show that at most 73% of the precipitation (scenario 1) must be discharged, with the majority originating from the more (heavily) sealed surfaces (97%) – site concrete and slabbed surfaces. Consequently, the integration of infiltration-capable surfaces and targeted planning of green spaces was discussed together with the landscape planners.

	Scenario	m²	Runoff coefficients (Range)	Applied runoff coefficient	Mean annual precipitation (m^3)	Amount of water to be discharged (m^3) Mean annual precipitation	Design precipitation (m^3)	Amount of water to be discharged (in m^3) Design precipitation
Total Area	1	20.325			11.443	8.359	550	402
	2					7.597		365
	3					7.839		377
Green space (flat)	1	2.276	0-0,1	0,10	1.281	128	62	6
	2	4.411			2.483	248	119	12
	3	3.557			2.003	200	96	10
Site concrete, sealed surface	1	9.317	0,9-1	1,00	5.245	5.245	252	252
	2	9.030			5.084	5.084	245	245
	3	8.854			4.985	4.985	240	240
Slabbed surfaces of all squares and sidewalk, Water-bound surface	1	7.844	0,5-0,75 (depending on joint closure)	0,65	4.416	2.871	212	138
	2	5.810			3.271	2.126	157	102
	3	6.888			3.878	2.521	187	121
Green roofs (6-12 cm substrate; e.g. tram/bus stop roofs)	1	888	0,13-0,33	0,23	500	115	24	6
	2	1.074			605	139	29	7
	3	1.026			578	133	28	6

Table 2: Pluvial impact assessment of the planned open spaces and estimated water to be discharged for the man annual precipitation (563 mm) and the local design storm water event (48,1 mm for 60 minutes with a return period of 50 years). Runoff coefficient is based on DIN 1986 [2016], DWA-M 153 (2007), ÖNORM B 2506 (2013).

The result of this framework is a visual respresentation of the simulation output and KPI-based evaluation to support multi-stakeholder discussions and the decision-making process. Based on the integrated analysis using all three components, the planning variants were compared, and individual aspects of the designs optimised (i.e. tree locations). The evolution from the heavily sealed, low-density scenario 1 to the intensively greened scenario 2 was further optimised after evaluating the performance indicators to scenario 3. In addition, the problems of pedestrian flows arising in scenarios 1 and 2 were solved, and good performance was achieved in urban water management and microclimatic considerations, while at the same

time achieving the necessary building density in the area. Furthermore, recommendations for action for the spatial elements of open space planning (benches, bus stops, etc.) can be derived and can be integrated in the further process.

5 CONCLUSION

The application to a real planning task has refined the key performance indicators (KPIs) and optimised them for practical applicability. The evaluation and analysis of the simulations served to optimise the open space planning scenarios. The height of buildings, land-use mix, position of trees and shading elements, the bus stop roofs and the design of seating elements were adjusted based on the analysis results. The bus stop design could also be optimised in the placement of columns and walls based on the results of the pedestrian simulation.

In addition, the methodology developed can be applied to all open space planning, but also to the optimisation of urban squares. With the same structured data basis, the tasks can be solved for different locations, and the framework conditions (weather data) can be used for any locations in Austria to generate findings on the performance of open space scenarios. A potential further development of the methodology can go into the parts of the individual simulations, as well as into the broader scope and integrate further analyses.

Moving forward, the methodology and its associated findings can be utilised by a number of actors and experts in the field of urban planning. For actors in the private sector, visibility, accessibility and duration of stay can have a significant impact on their interaction with customers and pedestrian traffic to individual locations. For example, restaurants and cafés in urban heat islands will have a harder time attracting customers than competitors in comfortable areas. As the use of retail space is considered in early planning stages of developments, our findings embody an important variable in these planning stages.

On a societal level, the data may be used to climate-proof urban spaces that are being exposed to higher average temperatures throughout the warmer seasons. Heat-related health implications are on the rise (Matthews et al 2017), especially for vulnerable groups such as the elderly and infants. To promote safe and sustainable mobility for all in society, the findings and methodology should be taken into consideration in the planning phases for new and redevelopments alike.

6 ACKNOWLEDGEMENT

The Aspern use-case was developed in cooperation with the landscape planners Lindle+Bukor from Vienna.

7 REFERENCES

DEUTSCHES INSTITUT FÜR NORMUNG E.V., 2016. DIN 1986-100:2016-12: Entwässerungsanlagen für Gebäude und Grundstücke - Teil 100: Bestimmungen in Verbindung mit DIN EN 752 und DIN EN 12056. Berlin: Beuth, 00.12.2016

DWA-M 153. Handlungsempfehlungen zum Umgang mit Regenwasser. Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall e.V., Hennef, 2007.

Fink, T.: On urban planning and procedural modeling, TU Graz, Graz, Austria. 2018

Koenig, R., Miao, Y., Aichinger, A., Knecht, K., & Konieva, K.: Integrating urban analysis, generative design, and evolutionary optimization for solving urban design problems. Environment and Planning B: Urban Analytics and City Science, 47(6), 997–1013. 2020

Helbing, D., and Johansson, A. Pedestrian, Crowd and Evacuation Dynamics. Springer New York, New York, NY, 2009.

Matthews, T. K., Wilby, R. L., & Murphy, C. Communicating the deadly consequences of global warming for human heat stress. Proceedings of the National Academy of Sciences, 114(15), 3861-3866. 2017

Sharmin, T., Steemers, K. Effects of microclimate and human parameters on outdoor thermal sensation in the high-density tropical context of Dhaka. Int J Biometeorol 64, 187–203, 2020.

Tabari, H. Climate change impact on flood and extreme precipitation increases with water availability. Sci Rep 10, 13768, 2020.

Tran, M., Brand, C.: Smart urban mobility for mitigating carbon emissions, reducing health impacts and avoiding environmental damage costs. Environ. Res. Lett. 16 114023, 2021

ÖNORM B 2506-1.Ausgabe: 2013-08-01 Regenwasser-Sickeranlagen für Abläufe von Dachflächen und befestigten Flächen Teil 1: Anwendung, hydraulische Bemessung, Bau und Betrieb, Wien, 2013.

Vuckovic, M., Mahdavi, A., Tauber, C., Kiesel, K., Glawischnig, S., Heiderer, A., Pirstinger, I., Majcen, M. and Raudaschl, M.: Generation and evaluation of alternative urban densification scenarios, 15th IBPSA, San Francisco, USA. 2017.

🏆 *reviewed paper*

KLIMUR: Methodik für ein klimaresilientes urbanes Ressourcenmanagement zur Umsetzung einer lokalen Ressourcenkreislaufwirtschaft

Ernst Gebetsroither-Geringer, Roman Löffler, Stefan Geier, Theresa Fink, Maria Wirth, Tamara Vobruba, Daniel Podmirsek, Andreas Gugumuck, Martin Jung

(Dr. Ernst Gebetsroither-Geringer, AIT Austrian Institute of Technology, ernst.gebetsroither@ait.ac.at)
(DI Roman Löffler, Universität für Bodenkultur Wien, roman.loeffler@boku.ac.at)
(DI Stefan Geier, Universität für Bodenkultur Wien, stefan.geier@boku.ac.at)
(Theresa Fink MSc, AIT Austrian Institute of Technology, theresa.fink@ait.ac.at)
(Maria Wirth MSc, alchemia-nova GmbH, maria.wirth@alchemia-nova.net)
(Tamara Vobruba MSc, alchemia-nova GmbH, tamara.vobruba@alchemia-nova.net)
(Dr. Daniel Podmirseg, vertical farm institute, podmirseg@verticalfarminstitute.com)
(Mag. Andreas Gugumuck, Zukunftshof eG, gugumuck@zukunftshof.at)
(Mag. Martin Jung, AIT Austrian Institute of Technology, martin.jung@ait.ac.at)
(Helen Dolinsek BSc, alchemia-nova GmbH, helen.dolinsek@alchemia-nova.net)

1 ABSTRACT

KLIMUR leistet einen Beitrag zur Entwicklung resilienter klimaneutraler Stadtteile mit hoher Ressourcen- und Energieeffizienz, verstärkter Nutzung erneuerbarer Energieträger, sowie hoher Lebensqualität. Weiters wird zur Optimierung und Anpassung der städtischen Infrastruktur und des Dienstleistungsangebots beigetragen. Der hohe Ressourcenverbrauch des derzeitig vorherrschenden linearen Produktions- und Nutzungssystems stellt eine wesentliche Barriere für eine nachhaltige Entwicklung dar.

Für das Fallbeispiel Zukunftshof (ZKH) werden die Möglichkeiten ausgelotet, wie aus einem alten Gutshof ein Vorzeigeprojekt für innovative urbane Landwirtschaft und klimaresiliente Stadtentwicklung werden kann. Der Zukunftshof soll der Startpunkt für ein nachhaltiges Energie- und Ressourcenkreislaufsystem im Wiener Stadtentwicklungsgebiet Rothneusiedl werden.

KLIMUR entwickelt dazu die Methodik und Instrumente, um die Planungs- und Entscheidungsprozesse für die Realisierung lokaler Ressourcenkreislaufwirtschaft (Energie, Lebensmittel, Wasser) und integrierter Stadtteil-Energiekonzepte zu begleiten. Für das Fallbeispiel Zukunftshof werden neben den Energieflüssen (Wärme, Kälte und Strom) auch Ressourcenströme (Biomasse, Nährstoffe und Wasser) ermittelt, analysiert und simuliert.

Die dabei verwendeten multikriteriellen Analysemodelle für die Simulation und Bewertung lassen Einschätzungen hinsichtlich ökologischer und energetischer Indikatoren zu und berücksichtigen wirtschaftliche Rahmenbedingungen der Realisierungsvarianten. Ebenso lassen sich aus der zeitlich und räumlich hoch aufgelösten Simulation auch Empfehlungen hinsichtlich organisatorischer Optimierungen (z.B.: abgestimmte Produktions- und Öffnungszeiten) als auch baulicher und infrastruktureller Anforderungen zur Unterstützung eines umfassenden lokalen Kreislaufwirtschaftssystems, ableiten.

Dabei werden die teils in Konflikt stehenden Ziele dargestellt und in den Planungs- und Abstimmungsprozess mit den Stakeholderinnen und Stakeholdern diskutiert. Daraus werden mögliche Entwicklungsszenarien im Quartiersmaßstab für das Demonstrationsprojekt Zukunftshof sowie für den Stadtteil Rothneusiedl abgeleitet.

Das Paper präsentiert die entwickelte Methodik und Instrumente, um die Planungs- und Entscheidungsprozesse für die Realisierung lokaler Ressourcenkreislaufwirtschaft (Energie, Lebensmittel, Wasser) und integrierter Stadtteil-Energiekonzepte zu begleiten (Stadt Wien, 2019).

Keywords: Klimawandelanpassung, Ressourcenmanagement, Stadtplanung, Kreislaufwirtschaft, Urban Farming

2 EINLEITUNG

Der Klimawandel und die damit verbundenen Folgen stellen eine der größten globalen Herausforderungen unserer Zeit dar (IPCC, 2018). Vor diesem Hintergrund kommt gerade Städten eine besondere Bedeutung zu. Einerseits sind sie für etwa drei Viertel des weltweiten Energieverbrauchs und der damit verbundenen Treibhausgasemissionen verantwortlich (Gouldson et al., 2015) und damit ein wesentlicher Hebel zur Minderung des Klimawandels. Andererseits sind Städte aufgrund ihrer hohen Siedlungsdichte besonders anfällig für Auswirkungen des Klimawandels wie Hitzestress (Chapman et al., 2017) und

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Starkregenereignisse (Arnbjerg et al., 2013) und bedürfen daher umfassender Strategien zur Klimawandelanpassung.

Während in den letzten Jahrzehnten auf dem Gebiet der Steigerung der Energieeffizienz und der Integration erneuerbarer Energiequellen im Hinblick auf die Minderung des Klimawandels große Fortschritte erzielt wurden (Economidou et al., 2020), stecken Aspekte der Anpassung an den Klimawandel in Großstädten noch in den Kinderschuhen (Araos et al., 2016). Ausgehend von einer kombinierten Betrachtung der Aspekte Klimaschutz und Anpassung an den Klimawandel gewinnt der Übergang von einem linearen „take-make-dispose"-Ansatz zu einem Kreislaufmodell oder einer Kreislaufwirtschaft zunehmend an Bedeutung (Prendeville et al., 2018). Auf der Ebene von Produkten und Unternehmen ist dieser Ansatz bereits weitgehend etabliert (Bakker et al., 2014). In größerem Maßstab, z. B. auf der Ebene von Stadtteilen, werden Synergien, die sich aus einer ganzheitlichen Betrachtung der Ressourcenströme (Energie, Wasser, Lebensmittel, Materialien, Abfälle) und dem Einsatz von naturbasierten Lösungen ergeben können, bisher jedoch nicht ausreichend berücksichtigt (Stefanakis et al., 2021). Dadurch bleiben die vorhandenen Potentiale (Seto et al., 2010), insbesondere in städtischen Ballungsräumen, zur Valorisierung von Ressourcen wie Biomasse oder Abwasser durch Schließung von Kreisläufen anstelle einer energieintensiven zentralen Behandlung, weitgehend ungenutzt.

Ein Grund für die zögerliche Umsetzung von Maßnahmen zur Etablierung oder Stärkung der Kreislaufwirtschaft auf Stadtebene ist der Mangel an validierten Leitlinien und erprobten Methoden. In diesem Bereich gibt es grundlegende Forschungslücken, die von der Erhebung des Kreislaufpotentials einer Region bis hin zu etwaigen Managementaspekten reichen (Levoso et al., 2020). Darüber hinaus besteht das Problem, dass es bisher keine Planungs- und Simulationswerkzeuge gibt, die die komplexen Wechselwirkungen der Kreislaufwirtschaft auf Stadt- oder Stadtteilebene abbilden können.

In den letzten Jahren hat die fortschreitende Anwendung von computergestützten Entwurfssystemen in städtebaulichen Entwurfspraktiken eine noch nie dagewesene und ganzheitliche Erkundung eines physischen Raums ermöglicht. Eine neue Art der digitalen Modellierung revolutioniert den Planungsprozess und die Methode, wie städtische Umgebungen entworfen werden können. Entgegen dem konventionellen Zugang, einzelne Entwurfslösungen zu erarbeiten, ist ein parametrisches Modell in der Lage unzählige Entwurfsiterationen zu erzeugen, die jederzeit bedarfsorientiert geändert, untersucht und bewertet werden können. Dadurch können eine hohe Transparenz und Zeitersparnis von Planungsprozessen und nutzerorientierte Ergebnisse in Szenarien entwickelt werden (Fink, 2018; Koenig et al., 2020)

Vor diesem Hintergrund ist es das Ziel des Sondierungsprojektes KLIMUR[1], das in diesem Artikel vorgestellt wird, eine Methode für eine Transformation der derzeit vorherrschenden linearen Produktions- und Nutzungskonzepte in eine Kreislaufwirtschaft mit kombinierten Rollen (z.B. Konsument ist auch Produzent ist auch Verteiler) zu entwickeln (siehe Abbildung 1). Der Zukunftshof als Fallbeispiel und das daran angrenzende neu entstehende Stadtentwicklungsgebiet Rothneusiedl bieten aufgrund der unterschiedlichen Nutzungen und Rollen, sowie der technischen und räumlichen Möglichkeiten, eine ideale Grundlage, um eine Methode für eine umfassende Ressourcenkreislaufwirtschaft mit Hilfe von parametrischen Modellen zu entwerfen und zu testen.

Abb. 1: Übergang vom linearen zum Distributed-Prosumer-Ansatz für Ressourcenmanagement © KLIMUR

[1] https://www.ait.ac.at/themen/drc/projects/klimur getestet am 26.09.2022

3 METHODENENTWICKLUNG

Um ein umfassendes Ressourcenmanagement im Sinne einer Kreislaufwirtschaft für einen ganzen Stadtteil aufzubauen, ist es notwendig die unterschiedlichen Arbeitsmethoden und Tools des interdisziplinären Projektteams in ein gemeinsames Framework zu integrieren.

Ein wichtiger Teil der Methodenentwicklung war es einen Untersuchungsraster für die räumliche Zuordnung der Nutzungen zu den Ebenen und den Schnittstellen sowie Systemgrenzen zu erarbeiten (siehe Abbildung 2). Der Raster ist hierarchisch aufgebaut und umfasst die einzelnen Nutzungen bzw. Produktionseinheiten des Zukunftshofes und im Stadtentwicklungsgebiet Rothneusiedl. Durch die hierarchische Gliederung können die unterschiedlichen Energie- und Ressourcenströme auf den dazugehörigen Ebenen analysiert und optimiert werden. Auf Basis einer zeitlichen Auflösung (je nach Verfügbarkeit) können die Wechselwirkungen zwischen den Nutzungen und Ebenen betrachtet werden. Alle zur Verfügung stehenden Daten wie z.B. detaillierte Lastprofile, Simulationsergebnisse oder statistische Daten werden den Nutzungen zugeordnet und auf die jeweilige verfügbare zeitliche Auflösung normiert. Dadurch können infrastrukturelle Bedarfe wie z.B. Speichergröße, etc. abgeschätzt, aber auch die Basis für Diskussionen zu Produktions- und Nutzungszeiten etabliert werden.

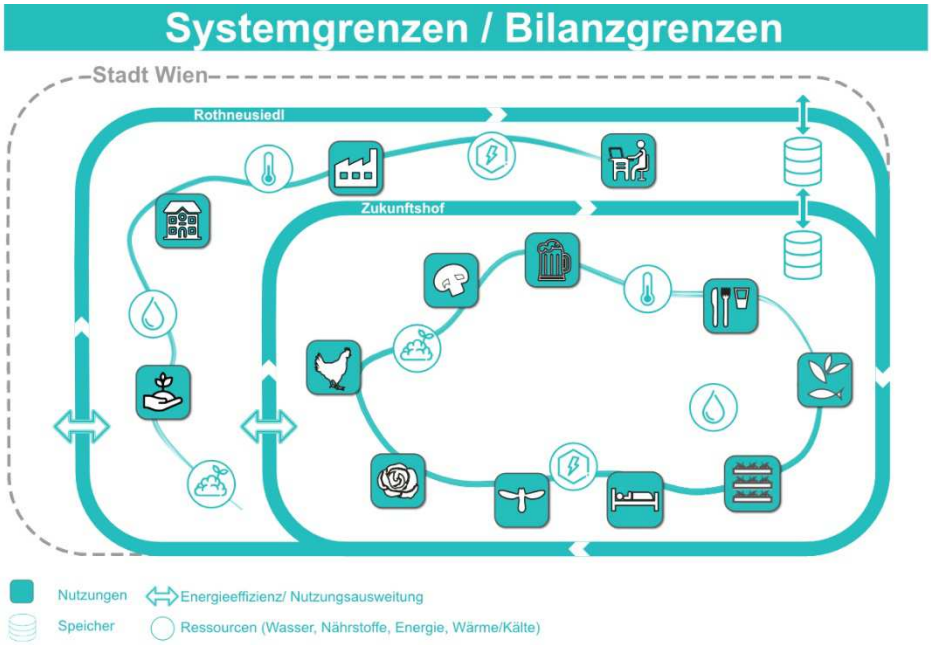


Abb.2: Darstellung der System- und Bilanzgrenzen © KLIMUR

Dieser räumliche und zeitliche Untersuchungsraster dient auch dazu die unterschiedlichen Methoden und Werkzeuge der einzelnen Disziplinen zusammen zu führen. Der Raster bietet auch ein Gerüst, um Änderungen oder Erweiterungen der Nutzungen nachträglich integrieren zu können.

3.1 Methodenüberblick

Die in KLIMUR entwickelte Methode ist im Gedanken der Kreislaufwirtschaft in einem interativen Prozess aufgebaut. Um die Erkenntnisse aus den Simulationen mit den Zielvorgaben zu kombinieren, benötigt es ein kontinuierliches Qualitätsmanagement (Adaptive Management) und ganzheitliche Sicht auf das System von der Planungsphase angefangen, während der Umsetzung und im Betrieb. Die Veränderungen der äußeren Rahmenbedingungen (z.B. demografische Entwicklung, Wirtschaft, Energiepreise) müssen laufend in den Planungs- und Betriebsprozessen reflektiert werden. Die Entwicklung von Zukunftsszenarien soll dabei unterstützen, auf potentielle Wirkungen frühzeitig reagieren und das Quartier resilient zu gestalten. Die Synthese aus den Zielwerten und Rahmenbedingungen ist ein essentieller Schritt um die Entwicklungsszenarien daran zu orientieren. Die Entwicklungsszenarien (für Rothneusiedl und den ZKH) werden in weiterer Folge simuliert und auf deren Impact analysiert, um eine laufende Evaluierung und positive Wechselwirkungen zu gewährleisten. Die Schnittstellen zwischen den Entwicklungsszenarien und der Simulation wurden im Detail ausformuliert, um aussagekräftige Indikatoren für die Optimierung von Ressourcenströmen zu erreichen. Der laufende Diskurs des interdisziplinären Projektteams und die

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Einbindung von Stakeholderinnen und Stakeholdern (z.B. Stadt Wien, Genossenschaft – Produzentinnen und Produzentinnen) bedarf einer koordinierten Abstimmung und klar definierten Prozessen. Um ein transparentes Bild der Analyseergebnisse für alle Beteiligten zu generieren, werden interaktive 3D Modelle sowie Flussdiagramme unter Einsatz der Toolbox des KLIMUR Projektes erstellt (siehe dazu die Prozessbeschreibung in Abbildung 3).

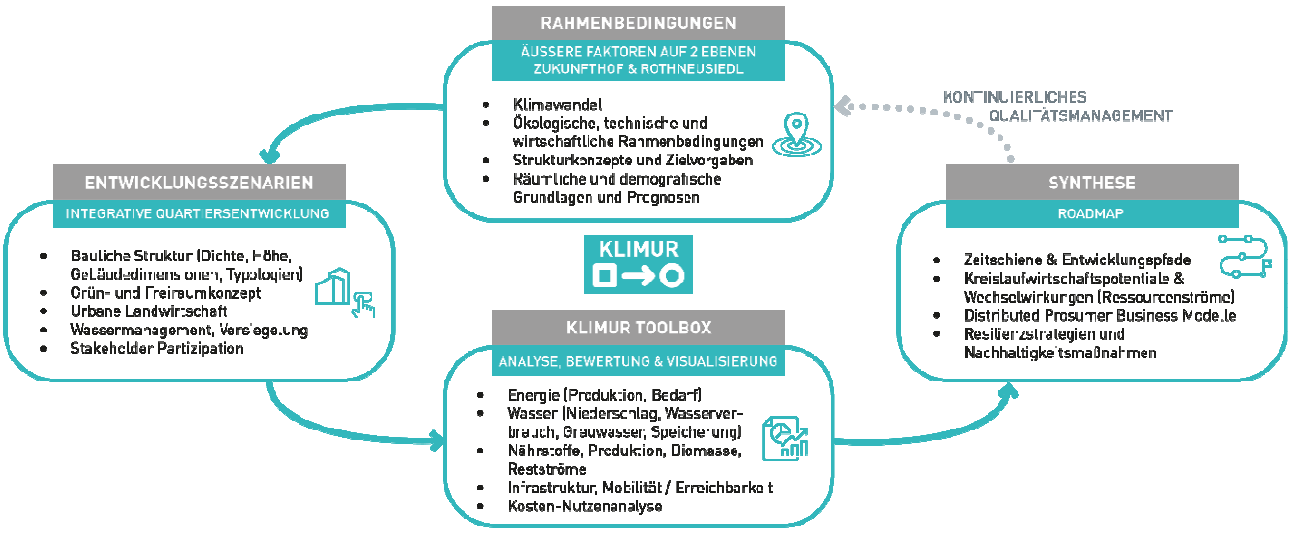


Abb. 3: KLIMUR-Framework-Übersicht (© KLIMUR)

Das Objekt der Untersuchung von KLIMUR bzw. deren Ableitungen auf dessen Skalierungspotential für das Stadtentwicklungsgebiet Rothneusiedl ist der Zukunftshof im Süden von Wien. Die Grundlage für die Entwicklung einer geeigneten Methode ist die Erhebung und Analyse der für das Untersuchungsgebiet relevanten Daten und Rahmenbedingungen.

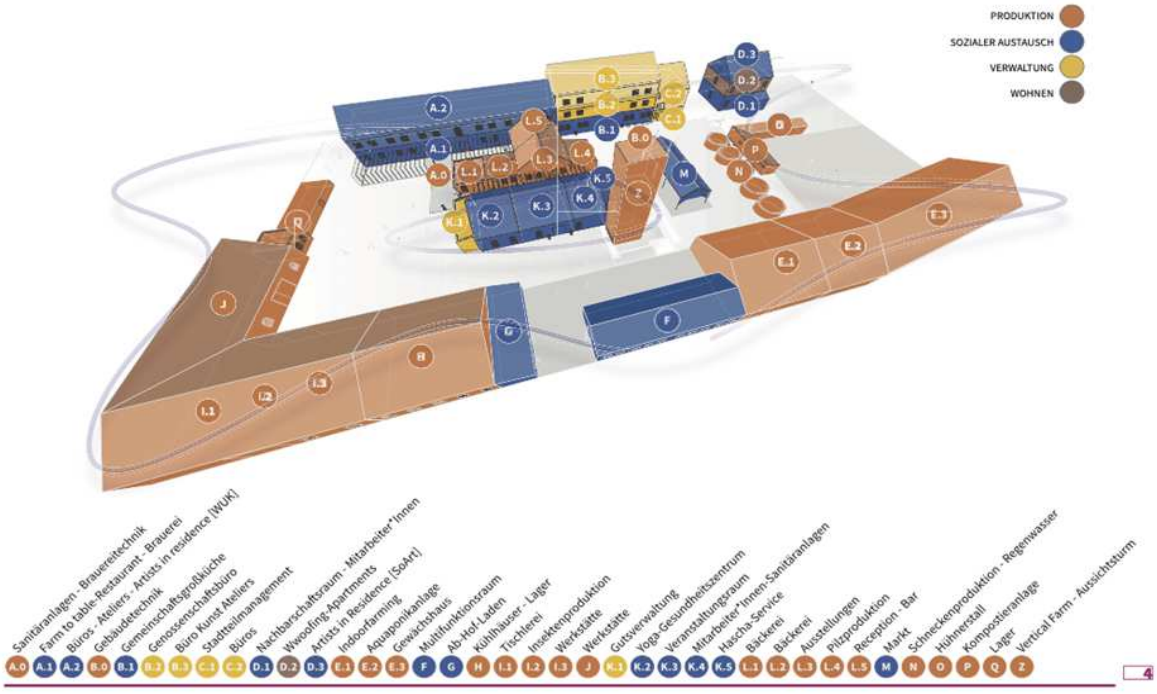


Abb. 4: Nutzungskonzept der Räumlichkeiten des Zukunftshofes (Quelle: Zukunftshof , ©Zukunftshof eG

3.2 Zukunftshof

Der Zukunftshof, welcher im Eigentum des wohnfonds_wien[2] steht, ist ein Projekt zur Neubelebung des ehemaligen Haschahofs, dem letzten Gutshof in Wien. Das Funktions- und Raumprogramm des Zukunftshofs setzt dabei auf die Verdichtung und Vertikalisierung urbaner Lebensmittelproduktion. Ziel ist

[2] https://www.wohnfonds.wien.at/

es, auf 10.000 m² Grundfläche sowie 7.400 m² Bruttogeschoßfläche etablierte und zukunftsweisende Lebensmittelproduktionsweisen zu integrieren, um neben einem genossenschaftlichen shared-facility Prinzip die Wirtschaftlichkeit urbaner Lebensmittelproduktion darzustellen und weiter zu entwickeln, sowie Skalierungspotentiale aus der Praxis für künftige Stadtentwicklungsgebiete ableiten zu können - urban farming als Teil nachaltiger urbaner Lebens- und Wirtschaftsräume (KLIMAFONDS, 2020).

Die Abbildung 4 zeigt die geplante räumliche Verteilung der verschiedenen Funktionen des Zukunftshofs, unterteilt in Produktion, sozialen Austausch, Verwaltung und Wohnen.

3.2.1 Analyse der lokalen Ressourcenströme

Zur Erhebung der Ressourcenströme wurden aufbauend auf dem Nutzungskonzept des Zukunftshofes die wesentlichen Stoffströme, wie Abwasserproduktion, Wasserbedarf, organischer Abfall aus Gastronomie und Landwirtschaft, sowie landwirtschaftliche Produkte und Nährstoffe erfasst. Neben den personenbezogenen Stoffströmen (z.B. Abwasseranfall), welche aus der Nutzung der Gastronomie-, Veranstaltungs- und Büroräumlichkeiten resultieren, sind vor allem die landwirtschaftlichen Produktionsstätten und Lebensmittelverarbeitungsanlagen von besonderem Interesse. Die Wasserströme sind in Abbildung 5 exemplarisch dargestellt. Die identifizierten Stoffsröme (Wasser, Nährstöffe und Biomasse) bilden die Basis für die Erstellung und Optimierung potentieller Enwticklungsszenarien zur Schliessung der Wasser und Nährstoffkreisläufe. So kann z.B. mittels einer Pflanzenkläranlage (constructed wetland in Abbildung 5) Abwasser aufbereitet werden, um es wieder in der Landwirtschaft einsetzen zu können (siehe Abbildung 5 Fluss von constructed wetland zu Urban farming). Dabei werden die Ressourcenströme für jedes Monat getrennt berechnet um den Wasserbedarf und die Abwasserproduktion monatlich bilanzieren zu können.

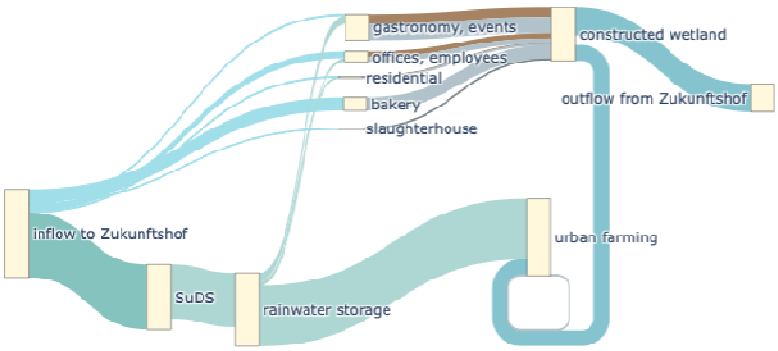


Abb. 5: Wasserstrom am Zukunftshof (© KLIMUR)

3.2.2 Szenarienentwicklung für den Zukunftshof

Um einen Rahmen und eine Zielmatrix für die Auswertungen der Parameter aufbauen zu können, wurden unterschiedliche qualitative Szenarien erarbeitet und ausformuliert. Die drei Szenarien sind so gewählt, dass diese aufeinander aufbauend angewendet und erweitert werden können. Sie bieten so die Grundlage für die Umsetzung unterschiedlich intensiver Produktionsprozesse und Ressourcennutzungen, je nach bestehenden finanziellen Rahmenbedingungen und angepasst and die Umsetzungsphasen des neuen Stadtteils.

Szenario 1: Low-tech Lösungen und Fokus auf Regenwassermanagement

Der Fokus im Szenrio 1 liegt auf kosteneffizienten und einfachen Lösugen, die wenig technischen Umbau bzw. Aufwand erfordern. Es soll das Regenwassermanagement optimiert werden, um einen möglichst hohen Anteil des Brauchwasserbedarfs am Zukunftshof zu decken. Zur Nährstoffrückgewinnung sollen organische Abfälle kompostiert werden, um einen Anteil des Nährstoffbedarfs in der loakalen Landwirtschaft zu decken.

Szenario 2: Bedarfsdeckung für lokale Lebensmittelproduktion am ZKH

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Durch naturbasierte und kreislauffähige Lösungen soll der Wasser- und Nährstoffbedarf gänzlich gedeckt werden. Es werden einfache und kostengünstige Lösungen bevorzugt. Potentielle Überschüsse können in der umliegenden Landwirtschaft zur Bewässerung und Düngung verwendet werden.

Szenario 3: Maximierung der Ressourcenrückgewinnung

Hier soll das volle Potential zur dezentralen Wasser- und Nährstoffrückgewinnung ausgeschöpft werden, indem alle anfallenden organischen Abfälle und das gesamte Abwasser rückgeführt werden. Dabei werden naturbasierte kreislauffähige Lösungen erarbeitet, die den Wasser- und Nährstoffbedarf am Zukunftshof gänzlich decken. Etwaige Überschüsse sollen zur Erweiterung der Anbauflächen bzw. der Bewässerung und Düngung der umliegenden Landwirtschaft verwendet werden.

3.3 Einbettung bzw. Wechselwirkungen in die Region Rothneusiedl

Das Stadtentwicklungsgebiet Rothneusiedl umfasst eine ca. 124 ha große Fläche im Süden des 10. Wiener Gemeindebezirks direkt an der Grenze zu Niederösterreich. Die Grenzen des Gebiets stellen dabei die Rosiwalgasse im Norden, die Himbergerstraße im Osten, die Schnellstraße S1 im Süden und das Güterzentrum Wien Süd im Westen dar (Abbildung 6). Das Areal ist, mit Ausnahme von Teilen des ebenfalls im Stadtentwicklungsgebiets befindlichen Zukunftshofs, derzeit ausschließlich agrarisch genutzt.

Abb. 6: Abgrenzung des Stadtentwicklungsgebietes Rothneusiedl (Quelle: basemap.at, MA 21 A © eigene Darstellung KLIMUR)

Im Zuge eines dialogorientierten Planungsprozesses wurden seit 2019 in einer Reihe von Workshops unter breiter Beteiligung von Bürgerinnen, Bürgern, Stakeholderinnen und Stakeholdern konkrete qualitativ und quantitativ formulierte Ziele für die zukünftige Stadtentwicklung in Rothneusiedl definiert und in der „Charta Rothneusiedl“ (Stadt Wien, 2021a) dokumentiert. Die Charta Rothneusiedl soll den neuen Stadtteil zu einem Modellprojekt für eine auf die Anpassung an den Klimawandel und den Klimaschutz ausgerichtete Stadtentwicklung machen. Zu diesem Zweck formuliert sie in neun verschiedenen Themenfeldern Anforderungen für eine klimafreundliche Entwicklung. Die Zielsetzungen umfassen Siedlungsentwicklung, Mobilität, Grün- und Freiflächen sowie die Versorgung mit Infrastruktur mit besonderem Fokus auf Klimawandelanpassung und Klimaschutz. Aus diesen Rahmenbedingungen wurden für die Methodenentwicklung die wesentlichen quantitativen und qualitativen Vorgaben aus dem Planungsprozess für das Stadtentwicklungskonzept Rothneusiedl (Stadt Wien, 2021b) berücksichtigt.

Quantitative Zielsetzungen:

Die nachfolgend dargelegten städtebaulichen Größenangaben wurden im Strukturkonzept Rothneusiedl als Mindestwerte definiert und beziehen sich auf einen angenommenen Bedarf, der von insgesamt 10.000 Wohneinheiten ausgeht. Demzufolge entfallen von den 124 ha, die das Gebiet des Stadtentwicklungsgebiets

Rothneusiedl aufweist, 60 % auf Nettobauland, 20 % auf Grünflächen, 16 % auf Erschließungsflächen und 4 % auf Sondernutzungen, wie die U-Bahn oder der Zukunftshof.

Qualitative Zielsetzungen:

Die qualitativen Zielsetzungen für das Stadtentwicklungsgebiet beinhalten u.a. die folgenden Schwerpunkte:

Lokale Prägung

Die „Charta Rothneusiedl“ beschreibt als Voraussetzung für die Entwicklung eines zukünftigen Stadtquartiers die Anknüpfung an den für das Stadtgebiet typischen landwirtschaftlichen Nutzungskontext, sowie die Erhaltung von Bezügen zur dominanten Kulturlandschaft.

Grün und Freiraum

Bei der Planung von Rothneusiedl als Modellstadtteil für Klimaschutz und Klimawandelanpassung ist die Freiraumgestaltung von zentraler Bedeutung. Die Zielsetzungen sollen dazu beitragen, dass klimawirksame Grün- und Freiräume den Quartierscharakter bestimmen.

Regenwassermanagement

Als Modellstadtteil für Klimaschutz und Klimawandelanpassung setzt die „Charta Rothneusiedl“ auf ein Konzept zur wassersensiblen und wärmeangepassten Entwicklung, bei dem die Nutzung der Ressource Wasser zur Kühlung eine wesentliche Rolle spielt.

- Entwässerung als quartiersbezogenes Handlungsfeld.
- Entwässerungsstrategie als ganzheitlicher Ansatz nach dem „Schwammstadt-Prinzip“ – rückhalten, speichern, verdunsten, kühlen.

3.3.1 Analyse der Rahmenbedingungen und Szenarien für Rothneusiedl

Um einen Referenzrahmen für die Bewertung unterschiedlicher städtebaulicher Konfigurationen und deren Auswirkungen auf die Voraussetzungen für Kreislaufwirtschaft am Zukunftshof und im Stadtteil Rothneusiedl zu haben, wurde in einem ersten Arbeitsschritt eine Basisvariante erstellt, die auf den quantitativen Zielen für Rothneusiedl basiert. Anschließend wurde die Variante als dreidimensionales Modell mit Rhino3D umgesetzt und anschließend hinsichtlich Nutzenergiebedarf und Solarpotential bewertet. Die Bewertung der energetischen Performance der Gebäude auf Ebene des neuen Stadtentwicklungsgebiets Rothneusiedl erfolgt mittels einer „bottom-up“ Methode, basierend auf der Simulation des Energiebedarfs auf Grundlage der physikalischen Eigenschaften der zu bewertenden Gebäude. Für die Bewertungen hinsichtlich Heiz- und Kühlenergiebedarfs, Beleuchtungsenergiebedarfs, Warmwasserwärmbedarfs sowie Strombedarfs wird EnergyPlus verwendet (Custódio et al., 2022).

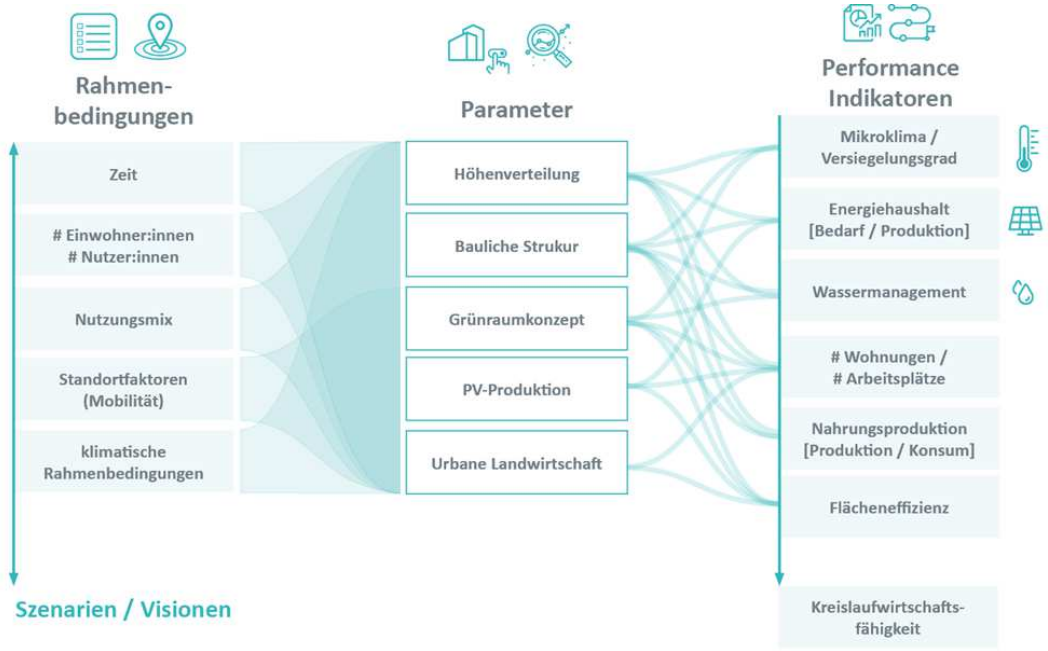


Abb. 7: Workflow für die Analyse der Entwicklungsszenarien © KLIMUR

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Das beispielhaft erzeugte Gebäude- und Flächengerüst dient auch dazu wesentliche städtebauliche Kennwerte wie Versiegelungsgrad, Grün- und Freiflächenanteile und Baumassenverteilung zu berechnen. Des Weiteren können auf dieser Basis Regenwasserabfluss-, Wind- und Mikroklimasimulationen durchgeführt werden (siehe Abbildung 7).

3.4 Sonstige Rahmenbedingungen (wirtschaftlich und raumzeitlich)

Zur Analyse des Kreislaufwirtschaftssystems für den Zukunftshof in Wechselwirkung mit dem Stadtentwicklungsgebiet Rothneusiedl muss eine nachvollziehbare ganzheitliche Planung unter Einbeziehung der Faktoren (Energie, Ökonomie, Biomasse, Wasser) erfolgen. Die Bewertung hinsichtlich ökologischer und energetischer Indikatoren wird basierend auf den wirtschaftlichen Rahmenbedingungen und Auswirkungen für den Zukunftshof durchgeführt. Unter Einsatz multikriterieller Modelle können viele Aspekte gleichzeitig miteinbezogen werden (z.B. Herstellungskosten, Betriebskosten, Erträge). Daher werden für die einzelnen Realisierungsvarianten Annahmen aufgrund aktueller Zahlen getroffen, jedoch besteht die Möglichkeit auf äußere Veränderungen zu reagieren und diese Simulationen rasch anzupassen. Aufbauend auf zeitlich und räumlich hoch aufgelösten Simulationen können Optimierungen hinsichtlich der Planung- und Quartiersentwicklung als auch in weiterer Folge für den Betrieb definiert werden. Somit können die Ressourcenbedarfe mit den Produktionsmöglichkeiten (inkl. Kreislaufpotentialen) abgestimmt werden.

4 SCHLUSSFOLGERUNGEN

Die dargestellte Methodik, entwickelt im Rahmen des KLIMUR Projektes, zur Kreislaufwirtschaft am ZKH in Wechselwirkung mit dem Stadtentwicklungsgebiet Rothneusiedl, stellt eine interdisziplinäre Methode zur Planung, Evaluierung und den Betrieb dar. Um die übergeordneten Ziele einer Stadtentwicklung unter Anbetracht der gegebenen Herausforderungen des Klimawandels erfüllen zu können, muss das Indikatorenset zur Bewertung breit aufgestellt sein. So können Synergien und Zielkonflikte zwischen unterschiedlichen Themen wie z.B. kompakte Siedlungsformen und Regenwassermanagement, PV-Potential und Mikroklima, aufgezeigt, bewertet und als Erkenntnisse in den Planungsprozess eingebracht werden.

Dieses digitale Planungsframework ermöglicht die gezielte Einbindung von Stakeholderinnen und Stakeholdern in Form von partizipativen Prozessen bereits in frühen Projektphasen, damit deren Bedürfnisse und Wünsche einfließen können. Die holistische Bewertung der Szenarien unterstützt Entscheidungsträgerinnen und Entscheidungsträger mit einer faktenbasierten Grundlage in Diskussionen und Entscheidungen.

Die Methodenentwicklung und die Diskussionen mit den Stakeholderinnen und Stakeholdern haben die Herausforderungen für die Umsetzung einer lokalen Kreislaufwirtschaft klar aufgezeigt. Zum einen waren Daten nicht bzw. in sehr unterschiedlicher Qualität und Auflösung vorhanden, wodurch eine Abschätzung der Wechselwirkungen in hoher zeitlicher Auflösung erschwert wurde. Für ein ökologisch und auch ökonomisch nachhaltiges Kreislaufwirtschaftssystem ist eine genaue Betrachtung der Ressourcenströme jedoch von hoher Bedeutung. Ein wichtiges Beispiel sind die Auswirkungen des Klimawandels auf den lokalen Wasserhaushalt, insbesondere von Starkregenereignissen und Dürren.

Auf Basis dieses Zuganges können auch andere Maßnahmen zur „Optimierung“ von Energie- und Ressourcenflüssen wie z.B. Anpassungen von Öffnungs- oder Produktionszeiten, untersucht werden. Jedoch sind solche Maßnahmen nur schwer organisatorisch umsetzbar. Sofern solche Anpassungen möglich sind, bedürfen sie eines erheblichen Abstimmungs- und Koordinationsaufwandes.

Durch eine ganzheitliche Kreislaufwirtschaft angewandt auf ein ganzes Quartier entstehen auch Verschiebungen der Kostenstrukturen. Zum einen zwischen privaten und öffentlichen Kosten z.B. im Bereich der Infrastruktur (Regenwassermanagement), aber auch zwischen Investitionen und Betrieb. Aber auch die Möglichkeit aus Abfällen eine neue Ressource zu machen, wirft neue Fragen für die Wirtschaftlichkeitsbetrachtungen auf. Diese neuen Organisations- und Kostenstrukturen lassen sich nur schwer darstellen und bedürfen noch erheblichen weiteren Forschungs- und Entwicklungsaufwand.

5 LITERATUR

ARAOS, M., Berrang-Ford, L., Ford, J. D., Austin, S. E., Biesbroek, R., & Lesnikowski, A.: Climate change adaptation planning in large cities: A systematic global assessment. Environmental Science & Policy, 66, 375-382, 2016

ARNBJERG-NIELSEN, K., Willems, P., Olsson, J., Beecham, S., Pathirana, A., Bülow Gregersen, I., ... & Nguyen, V. T. V.: Impacts of climate change on rainfall extremes and urban drainage systems: a review. Water science and technology, 68(1), 16-28, 2013.

BAKKER, C., Wang, F., Huisman, J., & Den Hollander, M.: Products that go round: exploring product life extension through design. Journal of Cleaner Production, 69, 10-16, 2014

CHAPMAN S., Watson, J. E., Salazar, A., Thatcher, M., & McAlpine, C. A.: The impact of urbanization and climate change on urban temperatures: a systematic review. Landscape Ecology, 32(10), 1921-1935, 2017

CUSTÓDIO I., De Castro Quevedo T., Melo A., Rüther, R.: A holistic approach for assessing architectural integration quality of solar photovoltaic rooftops and shading devices. Solar Energy. 237. 432-446. 10.1016/j.solener.2022.02.019. 2022

ECONOMIDOU, M., Todeschi, V., Bertoldi, P., D'Agostino, D., Zangheri, P., & Castellazzi, L.: Review of 50 years of EU energy efficiency policies for buildings. Energy and Buildings, 225, 110322, 2020

FINK, T.: On urban planning and procedural modeling, TU Graz, Graz, 2018.

GOULDSON, A., Colenbrander, S., Sudmant, A., McAnulla, F., Kerr, N., Sakai, P., ... & Kuylenstierna, J.:Exploring the economic mencase for climate action in cities. Global Environmental Change, 35, 93-105, 2015

IPCC: Intergoverntal Panel on Climate Change, United Nations Environment Programme, World Meteorological Organization, 1,5 °C Globale Erwärmung Zusammenfassung für politische Entscheidungsträger 2018.

KLIMAFONDS 2020: Strategiedokument Smart Cities Initiative Periode 2020-2024.

https://www.klimafonds.gv.at/wp-content/uploads/sites/16/200623_Strategiedokument_Smart_Cities_2020_BF_v1.0_final.pdf, getestet am 16.8.2022

KOENIG, R., Bielik, M., Dennemark, M., Fink, T., Schneider, S., Siegmund, N.: Levels of Automation in Urban Design Through Artificial Intelligence 46, 21. 2020.

LEVOSO, A. S., Gasol, C. M., Martínez-Blanco, J., Durany, X. G., Lehmann, M., & Gaya, R. F.: Methodological framework for the implementation of circular economy in urban systems. Journal of Cleaner Production, 248, 119227, 2020

PRENDEVILLE, S., Cherim, E., & Bocken, N.: Circular cities: Mapping six cities in transition. Environmental innovation and societal transitions, 26, 171-194, 2018

SETO, K. C., Sánchez-Rodríguez, R., & Fragkias, M.: The new geography of contemporary urbanization and the environment. Annual review of environment and resources, 35(1), 167-194, 2010

STADT WIEN 2019: Fachkonzept Energieraumplanung. Unter Mitarbeit von Bernd VOGL, Stefan GEIER und Andrea KINSPERGER. Wien: Magistratsabteilung 20 - Energieplanung (Werkstattbericht). Online verfügbar unter V:AT-OBV;B:AT-UBTUW application/pdf http://media.obvsg.at/AC15452878-2001 TUW Volltext.

STADT WIEN 2021a: Strukturkonzept Rothneusiedl. Modellstadtteil für Klimaschutz und Klimaanpassung.-61.STEK, download: https://www.wien.gv.at/stadtentwicklung/projekte/pdf/stek-rothneusiedl-2021.pdf , getestet am 16.08.2022

STADT WIEN 2021b, MA21 A Stadtteilplanung und Flächennutzung Innen-Südwest: Strukturkonzept Rothneusiedl, Wien, 2021

STEFANAKIS, A. I., Calheiros, C. S., & Nikolaou, I.: Nature-based solutions as a tool in the new circular economic model for climate change adaptation. Circular Economy and Sustainability, 1(1), 303-318, 2021

VUCKOVIC, M., Loibl, W., Tötzer, T. and Stollnberger, R.: Potential of Urban Densification to Mitigate the Effects of Heat Island in Vienna, Austria, Environments, 6, 82. Vienna, 2019.

🏆 *reviewed paper*

Leichtbau im urbanen System: Potenzialanalyse für die Entwicklung performativer Planungsansätze bei innovativen Bauvorhaben

Edith Schwimmer, Steffen Braun

(MSc. Edith Schwimmer, Universität Stuttgart - Institut für Arbeitswissenschaft und Technologiemanagement IAT, edith.schwimmer@iat.uni-stuttgart.de)
(Dipl.-Ing. Steffen Braun, Fraunhofer-Institut für Arbeitswirtschaft und Organisation IAO, Nobelstr. 12, 70569 Stuttgart, steffen.braun@iao.fraunhofer.de)

1 ABSTRACT

Heutzutage werden kommunale Herausforderungen, beispielsweise Klimaadaption und Digitalisierung, oftmals nicht von innerstädtischen Neu- und Umbauprojekten berücksichtigt, obwohl diese einen positiven Beitrag zur lebenswerten Stadt leisten könnten. Kommunen stehen vor der Problematik, dass sie entsprechende Leistungskriterien, welche diese Herausforderungen adressieren würden, bisher nicht oder in sehr geringem Umfang in ihren Ausschreibungsprozessen integrieren. Hinzu kommt, dass das aktuelle deutsche Baurecht innovativen Vorhaben, welche neue Eigenschaften wie zum Beispiel Konzeptleichtbau oder Funktionsintegration berücksichtigen könnten, oftmals Hemmnisse in der Realisierung aufzeigt. Zur Adressierung dieser Hürden wird im Paper ein performativer Planungsansatz für die effektive Integration von Leichtbau und Funktionsintegration im urbanen System abgeleitet (SCHWIMMER, 2019).

Anhand des Anwendungsfalls »Flexibles Bauen« erfolgt eine Analyse hinsichtlich baurechtlicher Hürden. Ziel ist es aufzuzeigen, welche Möglichkeiten bereits heute in der Praxis bestehen mehr Raum für Innovation bei Bauvorhaben zu ermöglichen (BMWi, 2019). Zudem wird ein Ausblick gegeben, welche Einflussfaktoren zukünftig stärker berücksichtigt werden müssen. Im Rahmen der wissenschaftlichen Arbeit wurden zusätzlich strategische Handlungsempfehlungen für die verschiedenen Stakeholder entwickelt, um innovative Vorhaben durch performative Kriterien, Vorgaben und Anreize zu flankieren.

Im Rahmen der Analyse werden folgende Fragestellungen beantwortet: Welche regulatorischen Rahmenbedingungen bestehen im Planungs- und Bauprozess für den gennanten Anwendungsfall? Wo liegen Barrieren im Baurecht, die innovative Bauprojekte nach Leichtbauprinzipien verhindern? Wie könnte ein innovationsförderlicher SOLL-Prozess zur Überwindung der Barrieren aussehen? Die Arbeit stellt damit ein konzeptionelles Rahmenwerk dar und formuliert konkrete Handlungsempfehlungen zu performativen Ansätzen in der experimentellen und zukunftsfähigen Stadtgestaltung.

Keywords: Funktionsintegration, Leichtbau, Baurecht, innovative Bauvorhaben, Multifunktions-Hubs

2 EINFÜHRUNG

Bereits in der vorangegangenen Studie »Leichtbau im urbanen System« (SCHWIMMER, 2019) wurde deutlich, dass ein performativer Planungsansatz für die effektive Nutzung von Leichtbau und der Funktionsintegration notwendig ist. Aktuell bestehen insbesondere hinsichtlich Funktionsintegration und innovativer Leichtbauvorhaben noch zahlreiche rechtliche Einschränkungen, welche innovationshemmend wirken. Als potenzielle Innovationsfelder zur Überwindung der derzeitigen Barrieren wurden folgende Anwendungsfälle identifiziert:

- Fall 1: »flexibles Bauen«, beispielsweise temporäre multifunktionale Hubs (Mobilität, Logistik, Wohnen, Services),
- Fall 2: »adaptives Bauen« im Bestand, beispielsweise Gebäudeaufstockungen, Erweiterungen oder „Upgrading“ und
- Fall 3: »aktivierendes Bauen«, z.B. Aktivierung bisher nicht vorhandener Flächen durch Überdeckelungen, „Fill-ins“ in Baulücken etc.

Für die Literaturanalyse wurde der Prozess von der Ausschreibung bis zur Umsetzungsplanung betrachtet, da diese aufeinander aufbauenden Phasen voneinander abhängig sind und sich gegenseitig beeinflussen können. Dazu wird der Anwendungsfall »flexibles Bauen«, welcher Multifunktionshubs miteinschließt, nachfolgend näher betrachtet und analysiert.

Der aktuelle IST-Prozess innovativer Bauvorhaben besteht im Wesentlichen aus fünf übergeordneten Prozessschritten: der instrumentellen-informellen Vorplanung, der Flächenplanung, der Bau- und

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Objektplanung, der Bauwerkserstellung und der Betriebsphase mit eventuellen Umbaumaßnahmen im Lebenszyklus. Eine schematische Darstellung kann der Abbildung entnommen werden.

Abbildung: Zusammenhängende Prozessschritte von kommunaler Bedarfsbeschreibung bis Betrieb [eigene Darstellung]

Im Rahmen der Studie wird eine Analyse der aktuellen Rahmenbedingungen durchgeführt, internationale Best-Practices identifiziert und Handlungsempfehlungen für die unterschiedlichen Akteure formuliert. Zur Untersuchung werden auch Fallbeispiele herangezogen. In diesen wird deutlich, dass deren Ausschreibungsprozesse erste innovative Ansätze aufzeigen. Diese Ansätze werden aber oftmals nicht im Prozess weitergeführt, da sie teilweise aufgrund rechtlicher Rahmenbedingungen eingeschränkt werden. Zudem wurde ein performativer (=leistungsorientierter) Kriterienkatalog auf Basis der Studie »Leichtbau im urbanen System« entwickelt und um weitere Prozesskriterien ergänzt, welche in der vorliegenden Arbeit eingeführt werden.

3 METHODIK

Für die Analyse des aktuellen Prozesses erfolgte zunächst eine umfassende Literaturrecherche, insbesondere hinsichtlich bindender Gesetzestexte. Hierfür wurden das Baugesetzbuch (BauGB), die Honorarordnung für Architekten und Ingenieure (HOAI), die Baunutzungsordnung (BauNVO) und die Landesbauordnung Baden-Württemberg (LBO BW) untersucht und in einem IST-Prozess zusammengefasst. Hierbei sei erwähnt, dass in städtischen Vorhaben noch eine Vielzahl weiterer Verordnungen, Richtlinien und Gesetze zu beachten sind. Die genannten Regularien wurden hinsichtlich des Anwendungsfalls »flexibles Bauen« betrachtet und analysiert.Auf Basis einer ersten Literaturrecherche wurden vertiefende Interviews mit Experten und Expertinnen, Vertretern und Vertreterinnen aus der kommunalen Stadtplanung, Organisationen der Nachhaltigkeitszertifizierung und des zuständigen Landesministeriums geführt. Hierbei wurde vor allem auf identifizierte Hemmnisse im Prozess eingegangen und Optimierungsmöglichkeiten diskutiert.

Aufbauend auf den Ergebnissen der Experteninterviews wurden internationale Fallbeispiele für innovative Umsetzungen und performative Regulierung (vgl. „performance-based building & zoning codes“) identifiziert. Hier wurde eine kurze Übersicht der Beispiele zusammengestellt. Letztlich wurde mit Hilfe der Erkenntnisse aus den Literaturanalysen, Fallbeispielen und Interviews ein möglicher theoretischer Ansatz für einen neuen Soll-Prozess abgeleitet, welcher in der Praxis getestet werden kann, sowie Handlungsempfehlungen für die einzelnen Akteure formuliert.

4 REGULATORISCHE RAHMENBEDINGUNGEN UND STEUERUNGSINSTRUMENTE

4.1 Analyse aktueller Rahmenbedingungen anhand formeller Steuerungsinstrumente

Um die Prozesse in Deutschland bzw. in Baden-Württemberg zu verstehen, erfolgt zunächst eine kurze Einordnung formeller Steuerungsinstrumente in Form von relevanten Gesetzestexten und Verordnungen sowie ihrer inhaltlichen Schwerpunkte. Zudem werden exemplarisch einzelne Hemmnisse der ausgewählten Ebenen analysiert. Auf Bundesebene ist das öffentliche Baurecht bereits im Bürgerlichen Gesetzbuch (BGB) verankert. Zusätzlich gibt es das Baugesetzbuch (BauGB), das beschäftigt sich mit der Flächenplanung und der baulichen Nutzung im Rahmen des Allgemeinen Städtebaurechts sowie dem Besonderen Städtebaurecht, welches Themen wie städtebauliche Entwicklungsmaßnahmen behandelt. Die Baunutzungsverordnung (BauNVO) legt die Definition von Art und Maß der baulichen Nutzung fest (FARWICK, 2014). Wie eine öffentliche Aus-schreibung und Vergabe für die anfallenden Bauleistungen ablaufen muss, wird in der Vertrags- und Vergabeordnung für Bauleistungen (VOB) geregelt. Die VOB ist in drei Teile untergliedert. Teil A (VOB/A) regelt die Bestimmungen für die Vergabe von Bauaufträgen, wie beispielsweise den Schwellenwert für EU-weite Ausschreibungen. Die Vertragsbedingungen für die Ausführung von Bauleistungen stehen in Teil B (VOB/B) und die allgemeinen technischen Vertragsbedingungen in Teil C (VOB/C) (WERNER, 2018). Die Vergütung für Architekten und Ingenieure wird bundesweit in der Honorarordnung für Architekten und Ingenieure (HOAI) festgesetzt, diese war bis zum Juli 2019 bindend

und gilt nun als Orientierungshilfe. Auf Landesebene ist die Landesbauordnung Baden-Württemberg (LBO BW) und das Landesplanungsgesetz Baden-Württemberg (LplG BW) vorgeschrieben. Die LBO legt unter anderem die Definition von baulichen Anlagen sowie verschiedenen Gebäudeklassen fest und regelt die Abstandsflächen.

4.1.1 Baugesetzbuch (BauGB)

Durch die hohe Redundanz im hier betrachteten „Kapitel 1 Allgemeines Städtebaurecht“ des Baugesetzbuches, insbesondere des ersten Teils Bauleitplanung, ist eine Verschlankung dessen und des daraus entstehenden Planungs- und Genehmigungsprozesses anzustreben.

Für die Festlegung von nachhaltigen und innovativen Ansatzpunkten bietet BauGB §11 Städtebauliche Verträge in Verbindung mit dem Bebauungsplan eine gute Grundlage für innovative Planungen. Hierdurch werden bestimmte Vereinbarungen mit einem privaten Vertragspartner festgelegt, die diesen zur Einhaltung bestimmter städtebaulicher Rahmenbedingungen zwingen. Wichtig ist hierbei, dass die Forderungen innerhalb der Verträge immer im direkten Zusammenhang mit der Planung stehen müssen. Beispielsweise kann der Nachweis eines Mobilitätskonzeptes für ein Areal gefordert sein. Dies sollte bestimmte innovative Ansätze fordern, welche zukunftsorientiert gedacht sind, um nicht nur den heutigen, sondern vor allem den zukünftigen Bedarf bedienen zu können (BAU GB, 2019).

Ein Grundsatz des Baugesetzbuches ist es nicht auf der grünen Wiese zu bauen, daher ist §34 des BauGB ein wichtiger Paragraf, welcher die Bebauung innerhalb im Zusammenhang bebauter Ortsteile regelt. Hierunter fallen beispielsweise Dachaufbauten auf Wohngebäuden, ein Beispiel des »adaptives Bauens«, welche jedoch in Ermangelung allgemeingültiger Regelungen stets Einzelfallentscheidungen sind.

4.1.2 Honorarordnung für Architekten und Ingenieure (HOAI)

Bei der Betrachtung der Bauleitplanung ergibt sich wie im BauGB eine Redundanz der Prozessschritte für den Flächennutzungsplan und den Bebauungsplan, welche aber zeitlich nacheinander angeordnet sind. Der Flächennutzungsplan und der Bebauungsplan sind sowohl im BauGB, als auch in der HOAI als Teil der Bauleitplanung verankert. Bei der Analyse der HOAI wird deutlich, dass auch hier viele sehr ähnliche Arbeitsschritte mehrfach geleistet werden. Als Beispiel sind nachfolgend die Leistungsphasen des Flächennutzungsplans und des Bebauungsplans aufgezeigt:

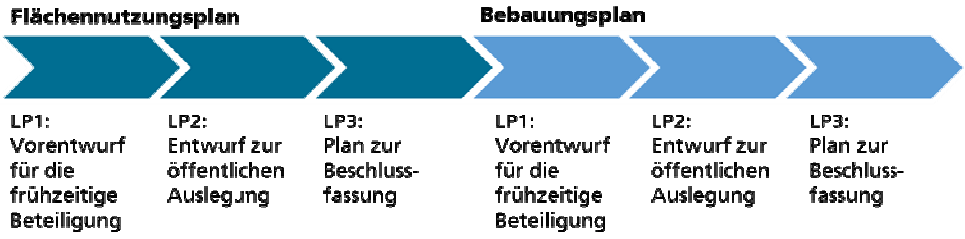


Abbildung: Detaillierte Betrachtung der Leistungsphasen für Flächennutzungs- und Bebauungsplanung [eigene Darstellung nach HOAI]

Die HOAI an sich stellt keine Barriere bei Erstellung innovativer Baukonzepte dar, da sie nicht bindend ist. Allerdings ist hervorzuheben, dass die Digitalisierung der Unterlagen und die Erstellung digitaler Geländemodelle als besondere Leistung bei der Flächenplanung gemessen wird (LOCHER, 2013; HEBEL, 2013). Daraus lässt sich schließen, dass digitale Werkzeuge kein Wettbewerbsvor- oder -nachteil für die Planerinnen und Planern darstellen.

4.1.3 Baunutzungsverordnung (BauNVO)

Eine Einteilung in die allgemeine Art der baulichen Nutzung erfolgt meist noch problemlos, bei einer detaillierteren Betrachtungsweise der besonderen Art kann es aber zu Schwierigkeiten kommen. Da für jede besondere Art ein entsprechendes Maß vorgesehen wird, welches wiederum deutliche Einschränkungen bei der Objektplanung mit sich bringt. Insbesondere im urbanen Umfeld kam es hier in der Vergangenheit aufgrund des hohen Wohnungsbedarfs zu Diskussionen. Durch die Einführung des Baugebietes »urbanes Gebiet (MU)« 2019 konnten diesen entgegengewirkt werden (KÖNIG, 2019). Allerdings verfügen die meisten Kommunen und somit die kommunalen Flächen über bestehende Flächennutzungs- und Bebauungspläne, weshalb bisher kaum Bebauungspläne mit urbanen Gebieten existieren. Wenn es zum

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Einsatz eines urbanen Gebietes kommen soll, müssen zunächst auf Antrag die entsprechenden Pläne geändert und neu aufgestellt werden, dies wird meist durch den Gemeinderat beschlossen und durch die kommunale Verwaltung umgesetzt oder Planer und Planerinnen für die Umsetzung beauftragt. Die Änderung kann mehrere Monate in Anspruch nehmen.

4.1.4 Landesbauordnung Baden-Württemberg (LBO BW)

Im Mai 2019 hat die Landesregierung im Zuge der Beschlussfassung für die Wohnraumoffensive auch verschiedene Änderungen der Landesbauordnung Baden-Württemberg beschlossen. Der hohe Wohnraumdruck und der daraus resultierenden Handlungsdruck auf die damalige Koalition machten diese Einigung zum Vorgehen und eine Anpassung der LBO möglich (MWI BW, 2019). Zu den Änderungen zählen folgende Punkte, welche direkten und indirekten Einfluss auf die Innovationsfähigkeit von Bauwerken haben:

- Die Abstandsflächen bei urbanen Gebieten werden nicht nach der Bemessung bei Wohngebieten und somit mit 0,4 der Wandhöhe, sondern gemäß Kerngebieten mit 0,2 der Wandhöhe berechnet (§ 5 Abs. 7 Nr. 2 LBO). Hierdurch erfolgt eine erste Lockerung für nicht der starren Struktur entsprechenden Bebauung.
- Durch die Einführung des Absatz 3 in § 26 LBO ist eine Erleichterung beim Holzbau erfolgt, da nun ein Nachweis der Standsicherheit brennbarer Baustoffe ausreichend ist.
- Bisher mussten alle Wohneinheiten barrierefrei nutzbar sein sowie ausreichende Stellplätze bzw. Fahrradstellplätze pro Wohneinheit erbaut werden, dies gilt aber nach §§35, 37 LBO BW nicht mehr für Vorhaben zur Schaffung von zusätzlichem Wohnraum, beispielsweise durch die Aufstockung von Gebäuden.
- Die Fahrrad-Stellplatzpflicht bei Wohnungen wurde gemäß §§35, 37 LBO BW aufgeweitet und muss entsprechend des Bedarfs geplant werden und nicht nach einem festgesetzten Schlüssel.
- Durch den Zusatz von §51 Abs. 5 LBO BW wird bei den Gebäudeklassen 1 - 3, Wohngebäude bis 7 Meter Fußbodenhöhe des oberen Geschosses das vereinfachte Baugenehmigungsverfahren gefördert.
- Durch die Anpassung in §126 BGB ist nun auch nach §53 Abs. 2 LBO BW eine digitale Einreichung des Bauantrags und der Bauvorlagen möglich.
- Die Baugenehmigung bedarf gemäß §58 Abs.1 Satz 3 LBO BW der Schriftform, diese kann aber nun auch digital erfolgen.
- Um Elektromobilität zu fördern, wurde zusätzlich eine Ermächtigungsgrundlage aufgenommen.

Diese Anpassungen der Landesbauordnung in Baden-Württemberg sind ein erster Schritt zur Auflockerung gewisser rechtlicher Einschränkungen und erleichtern somit bereits heute einige innerstädtische Vorhaben (AK BW 2019). Dennoch sind nach wie vor Einschränkungen vorhanden, auch wenn diese teilweise etwas aufgeweitet wurden. Die digitale Abwicklungsmöglichkeit des Baugenehmigungsverfahrens ist ein weiterer kleiner, aber positiver Schritt hin zu durchgängiger, performativer und digitaler Stadtplanung.

4.2 Regulatorische Prozessanalyse anhand des Leichtbau-Anwendungsfalls »Flexibles Bauen«

Als potenzielle Innovationsfelder zur Überwindung der derzeitigen Barrieren wurden folgende Anwendungsbereiche identifiziert: »flexibles Bauen«, wie beispielsweise temporären multifunktionalen Hubs, »adaptives Bauen« im Bestand und »aktivierendes Bauen«, z.B. Flächenaktivierung bisher nicht vorhandener Flächen durch bspw. Überdeckelungen. Im nachfolgenden Absatz wird der anfangs ausgewählte Anwendungsbereich des Leichtbaus im urbanen System »flexibles Bauen« hinsichtlich der vorgestellten regulatorischen Rahmenbedingungen untersucht. Der Anwendungsbereich ist einer von drei, welcher auf Basis der in der Studie »Leichtbau im urbanen System« entwickelten Anwendungsfälle für die Umsetzung der Leichtbau-Philosophie der Funktionsintegration entwickelt wurde.

Unter flexiblen Bauen werden überwiegend temporäre Bauwerke verstanden, welche je nach Bedarf ganz oder teilweise rückgebaut und an einem anderen Ort wieder aufgestellt werden können. Beispiele hierfür könnten Wohncontainer oder andere einzelne Elemente im Rahmen eines Multifunktionshubs sein, welche aufgrund einer bestimmten aktuellen Lage einen zeitweise erhöhten Wohnraumbedarf decken können ohne Flächen langfristig zu binden. Dennoch ist das hier definierte »flexible Bauen« baurechtlich nicht den

Fliegenden Bauten, welche in §69 der LBO BW geregelt werden, zuzuordnen, sondern wird im Beispiel des Wohncontainers als bauliche Anlage gemäß LBO BW §2 behandelt. Somit gelten auch die Vorgaben des Flächennutzungsplanes und des Bebauungsplanes gemäß Baugesetzbuch, welche das flexible Bauen insbesondere hinsichtlich seiner Nutzung und Abmessung einschränken, nicht aber wie fliegende Bauten nur auf 5 Jahre begrenzt sein dürfen (CONVIS 2017). Die Aufhebung des Flächennutzungsplanes und des Maß und der Art der baulichen Nutzung, zu mindestens in Teilgebieten, bis hin zu einer Nutzungsneutralität würde die Innovationskraft für flexibles Bauen stärken. Die Einführung performativer Kriterien, beispielsweise kurzfristiges Schaffen von zeitlich begrenztem Wohnraum, könnte ein Werkzeug sein, um Regulatorien entsprechend einer gewissen Verhältnismäßigkeit auszuhebeln.

Insbesondere bei einem flexiblen Multifunktionshub treffen verschiedene Regulatorien aufeinander, so sind nicht nur wie oben erwähnt das Bau GB und die LBO relevant, sondern im Falle der Erstellung von Parkflächen, unabhängig davon, ob diese für Car-Sharing oder bestimmte Antriebsarten vorgesehen sind, ist die Straßenverkehrsordnung maßgebend.

Die nachfolgenden Tabellen kennzeichnen rechtliche Hemmnisse (IST, oben) sowie Potenziale (SOLL, unten) für Anpassungen der rechtlichen Rahmenbedingungen im Bereich des flexiblen Bauens:

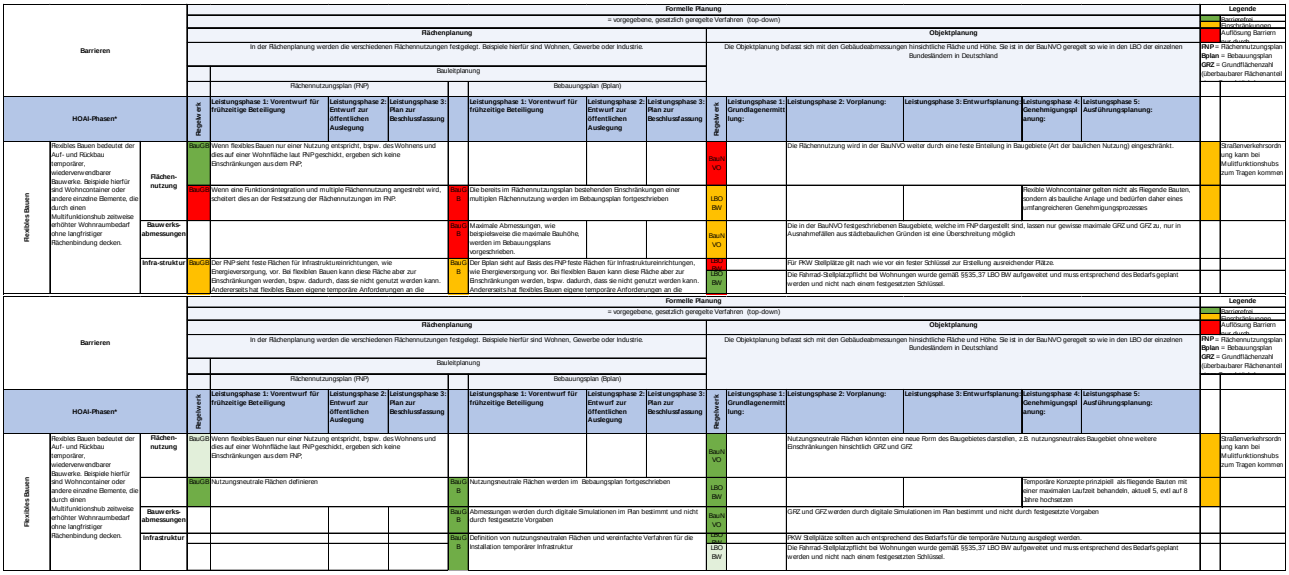


Abbildung: Ausschnitte der Prozessanalyse hinsichtlich Innovationshemmnissen und -potenzialen zwischen IST und SOLL [eigene Darstellung]

5 NATIONALE UND INTERNATIONALE PRAXISBEISPIELE

Nachfolgend wurden zunächst auf Basis einer Literaturrecherche und eines beteiligten Forschungsprojektes mehrere Praxisprojekte zusammengetragen, welche bereits umgesetzt sind und erste innovative Ansätze für städtebauliche Veränderungen aufzeigen. Diese Beispielprojekte beziehen sich dabei meist nur auf Teilaspekte performativer Regulierung und Planungsansätze. Im Gegensatz dazu zeigen die Fallstudien eine höhere Komplexität und Ansätze einer Leichtbau-Funktionsintegration. Die vorgestellte nationale Fallstudie ist ein Konzept des Ideenwettbewerbs »Mobilitätskonzepte für den emissionsfreien Campus« mit Fokus auf einen temporären und modularen Mobilitäts-Hub mit zusätzlichen Wohnmodulen in Leichtbauweise. Es bezieht sich bei den Planungen auf Campusebene, dabei wird deutlich, dass auch der Campus auf Stadtsystemebene mit verschiedenen Teilsystemen ganzheitlich betrachtet werden muss.

5.1 Fallstudie »Mobile Climate Living Lab (MoCLi)« - DHBW Stuttgart, Deutschland

Die Duale Hochschule Baden-Württemberg Stuttgart wurde mit dem Projekt »Mobile Climate Living Lab (MoCLi)« bei dem Ideenwettbewerb »Mobilitätskonzepte für den emissionsfreien Campus« für Ihre Originalität prämiert. Anlass für das Projekt gab der Neubau der Fakultät Technik, welcher bereits fertiggestellt ist und absichtlich ohne Parkplätze geplant wurde, sowie der Neubau der Fakultät Wirtschaft, welcher ab 2030 erstellt werden soll. Die Fläche des zukünftigen Standortes des Fakultät Wirtschaft gegenüber der neuen Fakultät Technik ist aktuell eine Brachfläche und bietet daher die Möglichkeit temporär einen Mobility and Living Hub aufzubauen. Der Hub besteht aus sechs Elementen: einer Smart Parking Area

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

für Elektro-, Hybrid- und Wasserstofffahrzeuge sowie Ridesharing und automatisiertes Einparken, einem E-Mobility & Sharing Bereich mit Ladesäulen mit Energiespeicher für verschiedenen Antriebsarten sowie Carsharing-Stellplätze, einer Mobilitätsstation mit Infopoint, Lebensmittel-Abholstation, Packstation, Abfallstation und Sanitärräume, einer Bike Area bestehend aus zwei Bike Towern, einer RegioRadStuttgart Station sowie einer Fahrradservicestation, einem Konzept für duales Wohnen für 44 Studierende in 22 Wohnmodulen sowie urbanem Freiraum als Kommunikations- und Begegnungsraum sowie Schnittstelle zwischen Stadt und Hochschule.

Abbildung: Beispiele internationaler Praxisprojekte auf Basis performativer Planungs-, Bau- und Nutzungskriterien [eigene Darstellung]

Für alle sechs Elemente wurden bereits Ideen für entsprechende Reallabore mit entwickelt. Zudem gab es bereits Gespräche mit dem Referat für Städtebau, Wohnen und Umwelt und dem Baurechtsamt, welche dem Vorhaben positiv entgegenstehen. Für die dualen Wohneinheiten wurde bereits ein Kooperationspartner für die technische Umsetzung gewonnen, zudem entsprechen die Planungen alle der gültigen LBO BW. Ziel des Vorhabens ist es ein Showroom und Vorreiter für andere Kommunen zu werden, hierbei ist vor allem der Aspekt der temporären Flächennutzung und somit der Rückbaubarkeit des Hubs hervorzuheben.

6 ERGEBNISSE

In Kapitel 6 werden die Kernerkenntnisse der Analyse zusammengefasst, Handlungsbedarfe abgeleitet sowie ein SOLL-Prozessmodell mit Prozessmustern vorgestellt:

6.1 Kernerkenntnisse

Die vorliegende Analyse zeigt auf, dass es nicht ausreichend ist, städtebauliche Vorhaben wie bisher zu fördern, um disruptive Innovationen zu erlangen. Hierfür bedarf es einer Änderung der Rahmenbedingungen auf gesetzlicher, prozessualer, ausschreibender, planender und ausführender Ebene, welche gleichermaßen in verschiedenen Ausprägungen Bund, Länder und Kommunen betreffen. Bereits bestehende Instrumente, wie beispielsweise städtebauliche Verträge, sollten besser kommuniziert und ausgeschöpft werden sowie häufiger zum Einsatz kommen, da diese bereits erste kleinere Handlungsspielräume für Innovationen bieten.

Darüber hinaus bedarf es für eine interdisziplinäre Planung von Technologie, Erstellung und Lebenszyklusbetrachtung in der Gesetzgebung, neue Instrumente und Werkzeuge. Durch gemeinsame übergreifende Strategien in der Landespolitik, zum Beispiel von Wohnraumoffensive, Strategiedialog Automobilwirtschaft und Strategiedialog Bauen und Wohnen, könnten regulatorische und prozessuale Innovationen unterstützt, entsprechende Freiräume geschaffen und neue Prozesse etabliert werden. Hierfür könnten der vermehrte und vereinfachte Einsatz von Reallaboren, Experimentierfeldern und Innovationszonen ein erster Schritt zu disruptiven Innovationen im Städtebau sein.

6.2 Handlungsbedarfe

Aus den Kernerkenntnisse und der Analyse des Anwendungsbereichs „flexibles Bauen“ können Handlungsbedarfe für die langfristige Förderung städtebaulicher Innovationen abgeleitet werden. Der

höchste Handlungsbedarf liegt in der Umsetzung und Etablierung einer durchgängigen digitalen Planung und Bauantragstellung sowie Dokumentation. Zudem muss ein Umdenken kommen, es muss zukünftig vom Anwendungsfall her gedacht werden und nicht wie der Weg dorthin gestaltet sein muss.

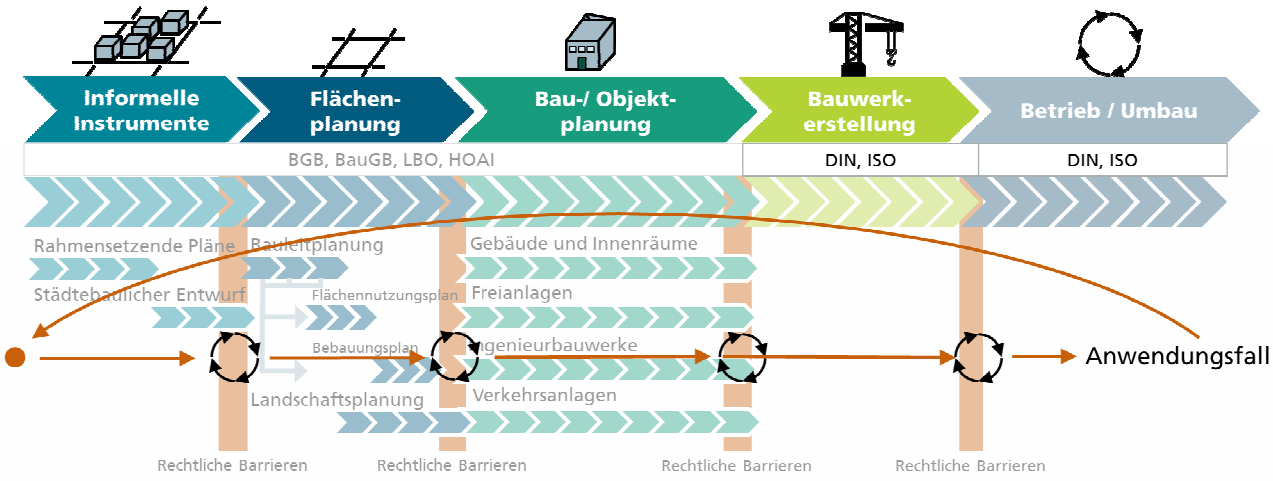


Abbildung: Vorverlagern von Leistungskriterien („Frontloading“) im Planungs- und Bauprozess [eigene Darstellung]

Ein wesentliches Steuerungsinstrument dafür sind die Einführung performativer Leistungs- und Prozesskriterien. Diese müssen in der frühen Ausschreibung festsetzt werden und dürfen nicht einschränkende Kriterien, welche vorab die Art und Weise des Prozesses festlegen, sein. Im Optimalfall schaffen sie Raum für Innovation und gleichzeitig Anreize diese zu nutzen. Darüber hinaus sollten nutzungsneutrale Flächen und Nachverdichtungen als Experimentierräume in Flächenplan integriert werden, da bisher Flächen entsprechende feste Nutzungen zugewiesen werden (z.B. §31 BauGB). Ein weiterer Handlungsbedarf bezieht sich u.a. auf die Planungsämter. Hier sollte ein digitales 3D-Kataster eingeführt werden, welches wiederum 3D-Flächennutzungspläne etabliert, denn nur so können auch Nutzungen in zweiter Ebene Berücksichtigung finden.

6.3 SOLL-Prozessmodell

In der Studie »Leichtbau im urbanen System« wurde bereits an drei städtischen Anwendungsfällen gezeigt, wie Leichtbau mit seiner Philosophie der Funktionsintegration zu städtischen Innovationen beitragen kann. Der dort entwickelte Anwendungsfall »Mobilitäts-Hub«, auch als Multifunktionshub zu verstehen, beinhaltet viele Aspekte des hier analysierten Anwendungsbereichs „flexibles Bauen“. Bereits in der Studie wurde deutlich, dass nur durch Interdisziplinarität und miteinhergehender Funktionsintegration Innovationspotenzial für den urbanen Raum geschaffen werden kann. Zudem wurde deutlich, dass die digitale Planung unerlässlich für zukunftsfähige Stadtplanung ist, welche Innovationen nicht nur zulässt, sondern fördert. Doch sowohl die dort aufgeführten Anwendungsfälle wie auch die hier benannten Anwendungsbereiche scheitern an den Grenzen formeller und informeller Steuerungsinstrumente und ihrer regulatorischen Rahmenbedingungen. Zur Überwindung dieser Barrieren wurden bereits heute mögliche Instrumente herangezogen, welche ihre eigenen SOLL-Prozesse voranstellen.

Aus dieser Analyse ergibt sich, dass für flexibles Bauen insbesondere der Typ »Reallabor« in Betracht kommt. Reallabore geben in einem zeitlich beschränkten Rahmen die Möglichkeit verschiedene stadtgestaltende Maßnahmen zu erproben. Dies geschieht meist unmittelbar im urbanen Raum und bezieht die Bürger und Bürgerinnen vor Ort mit ein (GUTACHTEN REALLABORE, 2020). Ein Beispiel für Reallabore ist die in Kapitel 5 erläuterte Fallstudie »Mobile Climate Living Lab«, zudem wäre in diesem Fall aber auch eine Experimentierklausel für eine temporäre Nutzung denkbar.

6.4 Performative Prozessmuster als Handlungsanreiz

Zukünftig sollte es nicht mehr den einen linearen Prozess, welcher sich aktuell eng an den Leistungsphasen der HOAI orientiert, geben, da dieser wieder von Einschränkungen geprägt wäre. Vielmehr sollten nachfolgend beschriebenen Handlungsfelder in einen flexibel anpassbaren Prozess integriert werden. Auf Basis der Analysen und Erkenntnisse aus Experteninterviews gestaltet sich ein neuer Prozess immer anhand der Prinzipien Digital, Iterativ, Dynamisch (DID).

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Insbesondere aus den Fallstudien und den Expertenmeinungen geht hervor, dass zukünftige Ausschreibungen keine Wegkriterien mehr vorgeben dürfen, sondern sich über Zielkriterien definieren. Hier wurde bereits das Beispiel der Emissionseinsparungen genannt, es soll z.B. in 10 Jahren 40% weniger Emissionen gegenüber heute geben. Dabei ist es unerheblich, wie dieses Ziel erreicht wird. Somit ist die Forderung klar, dass vom Anwendungsfall und dem Ziel des Vorhabens hergedacht werden muss, anstatt den Weg dorthin vorzugeben. Durch eine offene Gestaltung der Zielerreichung werden Innovationspotenziale gefördert. Die drei genannten Kriterien, durchgängige digitale Planung (I), iterativer und dynamischer Prozess (II) sowie die Steuerung über Zielkriterien (III) bilden die Grundlage jedes zukünftigen städtebaulichen Vorhabens. Darüber hinaus sollten weitere Aspekte ebenfalls zwingend integriert werden.

Ein großes Potenzial zur Innovationssteigerung liegt in der Anwendung performativer Kriterien. Diese erlauben eine Vielzahl neuer Spielräume, wie sie bereits in den Beispielprojekten teilweise angedeutet wurden. Hierzu zählt zum Beispiel die Integration eines Grauwasserrecyclings, im Gegenzug dazu erhält der Bauherr die Genehmigung für eine größere Gebäudehöhe bzw. zusätzliche Stockwerke. Durch solche Kriterien oder weitere, z.B. jedes Vorhaben muss besser sein als das letzte fertiggestellte Bauwerk, entsteht auf Seiten der Kommune ein starker Hebel, welcher für schnellere Wohnraumschaffung bei maximaler Energie-, Ressourcen- und Flächeneffizienz sorgt.

Die nachfolgende Abbildung zeigt die insgesamt acht bisher identifizierten Handlungsfelder für innovative urbane Leichtbauvorhaben noch einmal auf. Gleichzeitig wird mittels der Darstellung eines Ampelssystems deutlich, in welch geringem Maße die einzelnen Handlungsfelder heutzutage umgesetzt werden bzw. werden können.

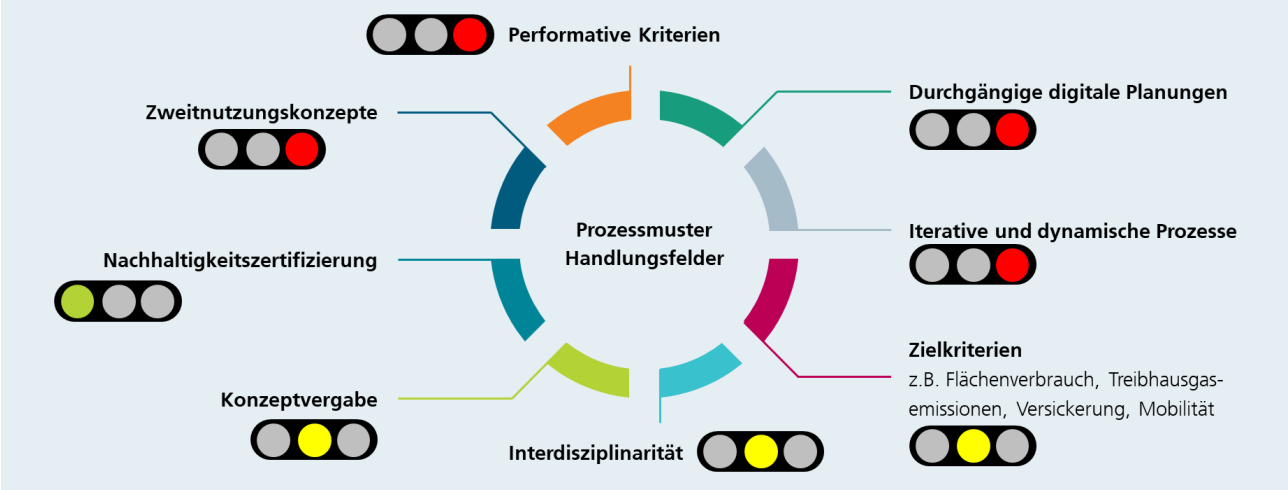


Abbildung: Erfolgsfaktoren für innovative und performative Bauvorhaben im urbanen System (mit Ampelsystem) [eigene Darstellung]

7 RESULTIERENDE HANDLUNGSEMPFEHLUNGEN

Mit den Handlungsempfehlungen soll ein Anstoß geschaffen werden, um Prozessinnovationen für urbanen Leichtbau zu befördern. Dezididierte Handlungsempfehlungen für die einzelnen Akteure werden hier nicht aufgelistet. Bereits heute stehen einige Möglichkeiten zur Verfügung, die innovativere und zukunftsfähige Bauvorhaben zulassen. Oftmals fehlt Kommunen aber das Wissen darüber und die passende Beschreibung für den Ausschreibungstext. Die obere Baurechtsbehörde hingegen müsste weitere Lockerungen und Vereinfachung der Verfahren veranlassen, um einen Anreiz für die Förderung innovativer Bauvorhaben darzustellen. Folgende Empfehlungen wurden abgeleitet:

- Entwicklung themenspezifischer Handlungsleitfäden auf Basis laufender Projekte: Ableitung eines Referenzrahmens,
- Aufbau einer Taskforce »Innovationsregulierung für Planen & Bauen« mit Vertreterinnen und Vertretern aus den drei Ebenen Land, Bund und Kommunen,
- Eine landesweite Clearing-/Beobachtungsstelle für Beratung und Erfassung praktischer Herausforderungen und Hemmnisse von Kommunen bei der Ausschreibung und Durchführung innovativer städtebaulicher Vorhaben,

- Durchführung eines Innovationswettbewerbs »Digitales Planen und Bauen« zu durchgängig digitalen Prozessketten,
- Aufbau eines landeseigenen Testfelds »Sonderzone Bau BW«, auf Flächen des Landes, für Demonstrationen und Erprobungen neuer Technologien, innovativer Konzepte und performativer Kriterien.

Die aufgelisteten Empfehlungen stellen einen ersten Schritt auf dem Weg zu mehr Prozessinnovation im städtebaulichen Ausschreibungs- und Planungsprozess unter Berücksichtigung des urbanen Leichtbaus dar.

8 FAZIT

Aus der Analyse der formellen Rahmenbedingungen ergibt sich, dass es heutzutage viele Einschränkungen, aber bereits auch einige kleinere Freiräume für Innovationen gibt. Diese Freiräume finden sich in Themen wie bspw. städtebaulichen Verträgen und Reallaboren und werden noch viel zu wenig eingesetzt, bzw. sind den Kommunen oftmals nicht als innovationsförderndes Instrument geläufig. Da es sich hierbei um kurzfristig umzusetzende Instrumente handelt, sollten die oberen Baubehörden dringend die kommunale Ebene mit Fördermittel motivieren, diese auch umzusetzen.

Dennoch müssen die Länder und der Bund langfristig eine umfangreiche Überarbeitung der formellen Rahmenbedingungen angehen. Der Bund ist hier vor allem für eine Modernisierung und Flexibilisierung des BauGB und der HOAI verantwortlich, das Land Baden-Württemberg für eine Anpassung der LBO BW. Wie auch bei zukünftigen Ausschreibungen ist es bei solchen Vorhaben sehr wichtig, alle beteiligten Akteure mit einzubinden.

Zukünftig kann es nicht mehr den einen Prozess und den festen Satz an Kriterien geben, viel mehr müssen individuelle, innovative und lokalspezifisch angepasste Formate etabliert werden. Ein erster Schritt ist die Weiterentwicklung von Reallaboren, Experimentierklauseln und Innovationszonen durch die Einführung einer Sonderbauzone BW, welche Landeseigentum ist, und Testraum für innovative Vorhaben. Darüber hinaus müssen innovative Ansätze finanziell mehr unterstützt werden. Bei Wettbewerben und Fördermittelvergabe ist es notwendig, Akteure verschiedener Disziplinen in Gremien zu bündeln.

Durchgängige digitale Prozesse bei städtebaulichen Vorhaben müssen Schritt für Schritt aufgebaut werden. Hier können Konzepte wie City Information Modelling zukunftsfähige und interkommunale Lösungen bieten. Zu klären sind bei einer solch umfangreichen Transformation der Prozesse, wo welche Verantwortlichkeiten liegen, wer welche Daten hat und liefert, wie Zugangsrechte geregelt werden und vieles mehr. Ist es aber einmal aufgebaut, bietet es die Möglichkeit neue städtebauliche Vorhaben schnell und innovativ umzusetzen.

9 REFERENZEN

Architektenkammer Baden-Württemberg (AK BW): Merkblatt Nr. 61-4: Kurzkommentierung zur LBO-Novelle 2019: Kurzkommentierung zur LBO-Novelle 2019: Änderung der Landesbauordnung für Baden-Württemberg zum 1. August 2019. Stuttgart; 2019.

Baugesetzbuch. 9. Auflage. Baden-Baden, Berlin, Wien, Zürich: Nomos; Beuth; 2019.

Bundesministerium für Wirtschaft und Energie (BMWi): Freiräume für Innovationen – Das Handbuch für Reallabore. Berlin, 2019.

CONVIS Consult & Marketing GmbH: Daseinsvorsorge in der Regionalplanung und Möglichkeiten ihrer formellen und informellen Steuerung; BMVI-Online-Publikation 3/2017; Mai 2017.

Gutachten Reallabore - Überblick über internationale regulatorische Ansätze und ihre Umsetzbarkeit in deutsches Recht. Mannheim; 2020.

Farwick H, Landherr W, Halfmann M, Edmaier, Christine, Wartzeck S et al.: Richtlinien für Planungswettbewerbe RPW 2013.: Kommentierung und Handlungsempfehlungen. Berlin; 2014.

Hebel JP. Honorarordnung für Architekten und Ingenieure - HOAI 2013 (E-Book): Textausgabe mit Einführung und Anmerkungen zu den wichtigsten Neuerungen. 3rd ed. s.l.: Bundes-anzeiger Verlag; 2013.

König H, Roeser T, Stock J, Petz H.: Baunutzungsverordnung: Kommentar. 4. Auflage. München: C.H. Beck; 2019.

Locher U, Seifert W.: HOAI 2013: Textausgabe; Verordnung über die Honorare für Architekten- und Ingenieurleistungen; 2013. Available from: URL: http://www.jurion.de/.

Ministerium für Wirtschaft, Arbeit und Wohnungsbau Baden-Württemberg (MWi BW): Landesregierung beschließt Eckpunkte für Wohnraumoffensive und Änderung der Landesbauordnung_ Ministerium für Wirtschaft, Arbeit und Wohnungsbau Baden-Württemberg; 2019.

Schwimmer, Edith; Schaufler, Claudius; Braun, Steffen; Schatzinger, Susanne: Leichtbau im urbanen System. Stuttgart, 2019.

Werner U. VOB: Vergabe- und Vertragsordnung für Bauleistungen, Teil A und B. 34. Auflage, Stand: 1.1.2018. München: dtv; 2018.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

🏆 *reviewed paper*

Long-range, Seamless Traffic Density Monitoring using Fibre Optic Acoustic Sensing

Martin Litzenberger, Carmina Coronel, Kilian Wohlleben, Herbert Döller, Hans-Bernhard Schweiger, Gaëtan Calbris

(Dr. Martin Litzenberger, AIT Austrian Institute of Technology GmbH, Giefinggasse 4, 1210 Wien, martin.litzenberger@ait.ac.at)
(Dr. Carmina Coronel, AIT Austrian Institute of Technology GmbH, Giefinggasse 4, 1210 Wien, carmina.coronel@ait.ac.at)
(Kilian Wohlleben, MSc., AIT Austrian Institute of Technology GmbH, Giefinggasse 4, 1210 Wien, kilian.wohlleben@ait.ac.at)
(Dr. Herbert Döller, Dr. Döller Vermessung ZT GmbH, Johannesgasse 15/1, A-1010 Wien, office.zwettl@doeller.biz)
(DI. ARCH. Hans-Bernhard Schweiger, Dr. Döller Vermessung ZT GmbH, Johannesgasse 15/1, A-1010 Wien, office.zwettl@doeller.biz)
(Gaëtan Calbris, PhD, Febus-Optics, Technopole Hélioparc 2, avenue du Président Pierre Angot, 64000 Pau, gaetancalbris@febus-optics.com)

1 ABSTRACT

Accurate real-time traffic sensing is of key importance, especially in the urban environment to be able to optimise traffic flow by intelligent traffic systems (ITS). Often the high density of traffic sensors, needed to achieve an accurate real-time monitoring of important arterial roads, is difficult to implement due to technical contraints or because of high installation cost. Furthermore, existing traffic sensing technology uses sensors that are only able to measure traffic flow on a cross-section of the road where they are installed (typically on a junction), giving no information on the situation in between. An alternative "seamless" measuring technology, is to use floating car data, with Google Maps being the most prominant example. This technology allows to derive traffic information over wide road sections, however it is unable to deliver real-time information, and it relies on the “cooperation” of the data providers (the fleet owner or the mobile phone users). Fiber optic acoustic sensing (FOAS) is a new alternative technology that allows a seamless, real-time monitoring of the road traffic situation over large distances of up to 50 km using the existing telecom fiber optic cable infrastructure.

In our previous work we presented an algorithm and results for traffic flow and average speed computation from FOAS raw data at a specific location along a highway and compared it to reference traffic data [1],[2]. In this paper we demonstrate the potential of the seamless nature of the technique by evaluating the traffic density over a length of 25 km of the monitored highway for different days and times of the day.

Keywords: ITS, traffic density measurement, traffic situation monitoring, fiber optic, acoustic sensing

2 INTRODUCTION

Even with an upcoming transition to electric mobility and a modal shift from individual to public transport in the future, roads will stay the backbone of transportation in the urban environment for years to come. Therefore, permanent traffic monitoring is crucial to ensure optimal traffic flow. The data provided by real-time road traffic monitoring provides information regarding traffic jams or accidents. With such information, traffic management centres are enabled and supported to react quickly to incidents and intelligent transportation system (ITS) measures, such as the closure of a lane or temporary usage of the hard shoulder, can automatically be imposed. Accurate real-time traffic situation sensing is especially important in the urban environment to allow optimizing the traffic flow with intelligent traffic systems (ITS). Often the large number of traffic sensors, needed to achieve an accurate real-time monitoring of important arterial roads, is difficult to implement due to technical constraints or because of installation cost.

Different technologies are currently used for traffic monitoring systems where sensors are either installed overhead, under, or next to the road to detect traffic flow [3]. Such sensors could be laser scanners [4], infrared [5], radar [6], [7], ultrasonic [8], [9], magnetic [10], [11], acoustic [12] or video cameras [3], [6]. Passing vehicles can cause changes in the magnetic field that are then processed to measure the flow of vehicles [10], [11]. Acoustic-based monitoring measured by a microphone array were also proposed [12]. Another method for traffic monitoring is through crowdsourcing of smartphone connection data [13] or from fleets of vehicles equipped with GPS systems ("floating car") [14]. Google Maps is the most prominant example of the crowd sourcing approach. However, it is unable to deliver true real-time information, it relies on traffic models and needs the "cooperation" of the data providers, i.e. the mobile phone users.

Sensors installed under the road surface come with the disadvantage of high cost due to constant need for repair and maintenance while sensors placed overhead or next to the road such as cameras are susceptible to adverse weather conditions [3].

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Fiber optic acoustic sensing (FOAS), also often termed distributed acoustic sensing (DAS), is a technology that allows a seamless, real-time monitoring of vehicle trajectories on a road over large distances of up to 50 km without additional roadside installations. It uses one unused optical fiber (“dark” fiber) of a fiber optic cable already installed in the ground for data- and communication-networks (telephone, internet), as a distributed sensor. The advantage is that the fiber cable infrastructure typically installed at high density in the urban environment can be reused, as it is, for traffic sensing by connecting an optical "interrogator" instrument to one end of an unused fiber. The technique allows the detection of very small disturbances of the optical fiber cable, such as the mechanical strain caused by microscopic deformations from vibrations of the cars running nearby. Probing the fiber with a laser pulse of high repetition frequency (2 kHz) allows to analyse the vibration spectrum produced by nearby vehicles, distinguishing them from other vibration sources and tracking their time-location trajectories along the cable.

Existing traffic sensing technology uses sensors that are only able to measure traffic flow at a certain point of the road (typically on a junction), lacking information on the situation of large road sections in between those points. Such sensors are only able to measure vehicle flow (vehicles/minute), whereas the important traffic parameter vehicle density (vehicles/km) cannot be accessed. FOAS technology allows to measure a “snapshot” of the vehicle positions along the whole length of a road at a given time, therefore providing the important traffic density parameter.

FOAS measurement results on road traffic flow have already been presented in smaller studies in the urban environment and over relatively short distances of 1000 m and were compared to measured vehicle counts [15]. In this work, we present fiber optic acoustic sensing (FOAS) for road traffic monitoring over a long distance of 25 km providing average speed and vehicle density results for heavy vehicles along the road.

3 FIBER OPTIC ACOUSTING SENSING

The FOAS system works by sending short laser pulses through a fiber optic cable where the light is scattered via Rayleigh scattering and the light returning to the source is analysed to infer information. In FOAS systems, optical fibers with a length up to 50 km, with a repeater device after 50 km even up to 100 km, can be used. The fibers used are typically already installed in the ground, parallel to a highway, for telecommunication purposes where it can be kilometers long and any disturbances along the fiber can be measured. An interrogator device connected to one end of the fiber transmits a series of laser light pulses into the fiber cable, as shown in Figure 1.

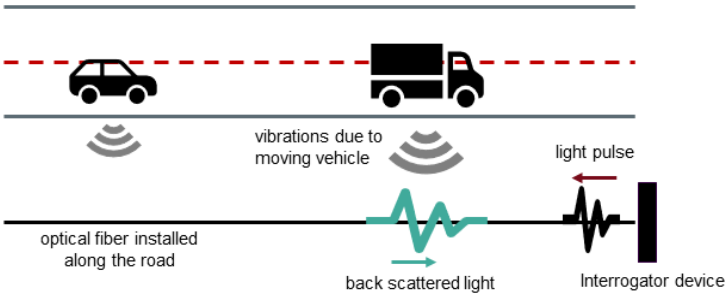


Fig. 1: Principle of the FOAS measurement for traffic situation monitoring.

In the glass of the optical fiber there is an effect present that causes a continuous back scatter of the light along the fiber. Rayleigh scattering is caused by inhomogeneities in the glass and for the sake of simplicity one can depict the Rayleigh scattering effect as light being reflected on a myriad of microscopic mirrors embedded in the glass. Therefore, for a single laser pulse being coupled into the fiber, instead of many distinct reflected pulses a continuously distributed signal is returned from the fiber. The scattered light has the same frequency as the impinging light wave and can be analysed by optical means. The vibrations generated by the passing cars and trucks stretch and compress the optical fiber affecting its optical path length. This induces a measurable phase shift in the back scattered light which is sensed by interferometric methods. Probing the fiber with a laser pulse of high repetition frequency (2 kHz) even allows to analyse the

vibration spectrum produced by nearby vehicles, distinguishing them from other vibration sources and tracking their time-location trajectories along the cable. In this work we demonstrate that with these changes in the signal induced by passing vehicles, relevant traffic information can be derived over large distances.

4 FOAS TRAFFIC MONITORING SETUP

We have performed traffic density measurement on a highway in a mountainous region of Austria with two separated carriageways, each with two lanes plus a hard shoulder, where the fiber optic cable was installed next to the road in a distance of up to 10 m from the roadside. The monitoring was done over a length of 25 km with traffic data measurements extracted every 500 m from the raw FOAS signal, making up a total of 50 “virtual” traffic sensors. The monitored highway section contains several bridges and tunnels. The processing algorithm has been described in [1] and is briefly summarised as follows: From the image representation of the spectral power of raw FOAS signals (see example in Fig. 2) the trajectories of the vehicles running on road, visible as the white lines, are identified by thresholding of the spectral power diagram. The incident angles of the trajectories represent the vehicles' speed, the number of trajectories in a certain section along the x-axis of Fig. 2 represent the vehicle density as numbers of vehicles per section length. We have used image processing techniques, specifically Hough transformation, to extract the angles from the image data. The average speed and the vehicle density were computed from patches of 1 minute’s time and in sections of 500 m. The white rectangle inset in Fig. 2 at x=5 km, indicates the size of such a patch. As the fiber optic cable follows the road layout rather accurately, the fiber length given in the result figures equals the monitored road length. Previous comparison to data from induction loop counters [2] revealed that the FOAS signal mainly contained the truck trajectories. The explanation is given by the fact that the fiber optic cable is situated relatively distant, up to 10 m, from the roadside. Taking the width of the hard shoulder into account, this adds up to a distance of almost 13 m from the cable to the first highway lane. Vibrations of small and light vehicles are therefore less likely to be picked up by the FOAS system in this setup.

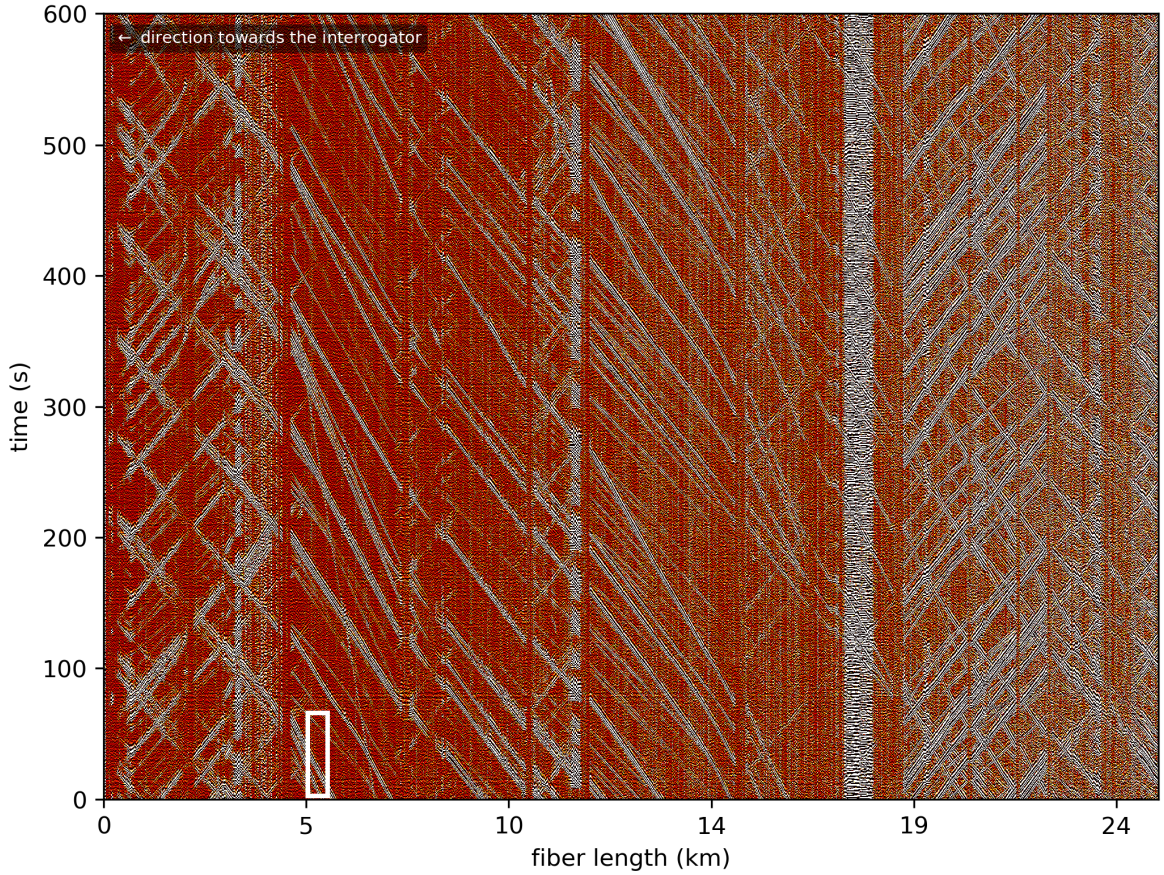


Fig. 2: Image representation of FOAS signal spectral power produced from raw FOAS data, showing vehicle trajectories on a highway over 25 km length. The y-axis represents the time, the x-axis the position along the fiber cable length.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

5 RESULTS

Fig. 3 shows examples of the traffic situation monitoring along the full length of the 25 km road at different time instances. The results are given as traffic density in vehicle counts per 500 m of road and as the average speed of these vehicles for (a) a weekday morning (7 a.m.) and (b) evening (6 p.m.), and (c) for a weekend evening. Both driving directions are accumulated in these plots. The speed results were obtained from trajectories within a 1-minute time window (cf. white rectangle inset in Fig.2).

Previous investigations [2] compared FOAS measurements to reference traffic sensor data. This is only possible at a location where such a reference sensor is installed. However, there is no such possibility for validation over the whole length of a road, where traffic sensors, such as induction loop counters, are installed only very sparsely, typically every 10 km. We have therefore performed plausibility checks on the results obtained from FOAS to validate the data.

Although the FOAS signal mainly represents heavier vehicles and trucks, the difference in the traffic situation between weekday and weekend can clearly be seen by comparing Fig. 3 a,b with 3 c. While on weekdays the measured vehicle density varies between 2 to 6 vehicles per 500 m of road, the weekend exhibits a maximum of 3 vehicles/500 m and most of the road shows no heavy vehicle traffic at all. This is consistent with the fact that trucks are not allowed on roads in Austria on weekends before Sunday 10 p.m., with a few exceptions for the transportation of critical goods.

The measured average vehicle speed varies over the length of the observed road (cf. Fig 3a,b). In the range from x=0 to 15 km, the highway exhibits a series of 3 long tunnels with a speed limit of 100 km/h for passenger cars, whereas in the range x=17 km to 25 km, there is an open road with a speed limit of 130 km/h. The truck speed limit is 80 km/h over the whole length. In the region between 15 km to 17 km the road exhibits a strong upwards slope. The average speed results reflect the situation very well: Assuming that the heavy vehicles that are detected by FOAS are composed of real trucks (with a 80 km/h speed limit) and other heavier passenger vehicles (with 100 km/h or 130 km/h speed limit, respectively), the observed speed ranges of [70..100] km/h in the tunnel section, and [80..120] km/h in the open road region are plausible. In the section of the upwards slope the average speeds of vehicles drops considerably below 70 km/h, which is consistent with heavy trucks driving uphill.

6 CONCLUSION

In this paper we demonstrated the potential of fiber optic acoustic sensing (FOAS) for traffic situation monitoring applications using existing fiber optical infrastructure for telecommunication. The result of the investigation focuses on trucks and heavy vehicles in general, as the fiber cable in this specific test-site is installed at a larger distance from the roadside (10 meters), such that passenger cars do not provide sufficiently strong vibration amplitude to be detected by FOAS. The result was validated by plausibility checks and shows that traffic density (vehicles/km) and average speed can be estimated over a length of 25 km using a single, existing fiber optical cable, for the heavy vehicle classes.

FOAS systems only require the installation of an interrogator device connected to one end of an existing fiber-optic cable. Therefore, the presented solution promises low-cost road-side maintenance and installation as no devices need to be installed directly at the road. An additional advantage of a FOAS-based traffic situation monitoring system is its long-range capabilities, providing traffic data seamlessly at an extremely high spatial resolution up to 100 m and better. With fiber optic infrastructure becoming more and more available in the modern urban environment for data transmission purposes, the technique can be a candidate to monitor traffic situation in real time in dense urban road networks. As fiber optic cables are expected to be installed very close or even under the road surface in urban scenarios, the sensitivity of the FOAS traffic monitoring is expected to be extended to light passenger vehicles. Under such conditions FOAS will be able to replace traffic sensors where fiber optic cable infrastructure is existing and the installation of other sensor devices is problematic or too costly.

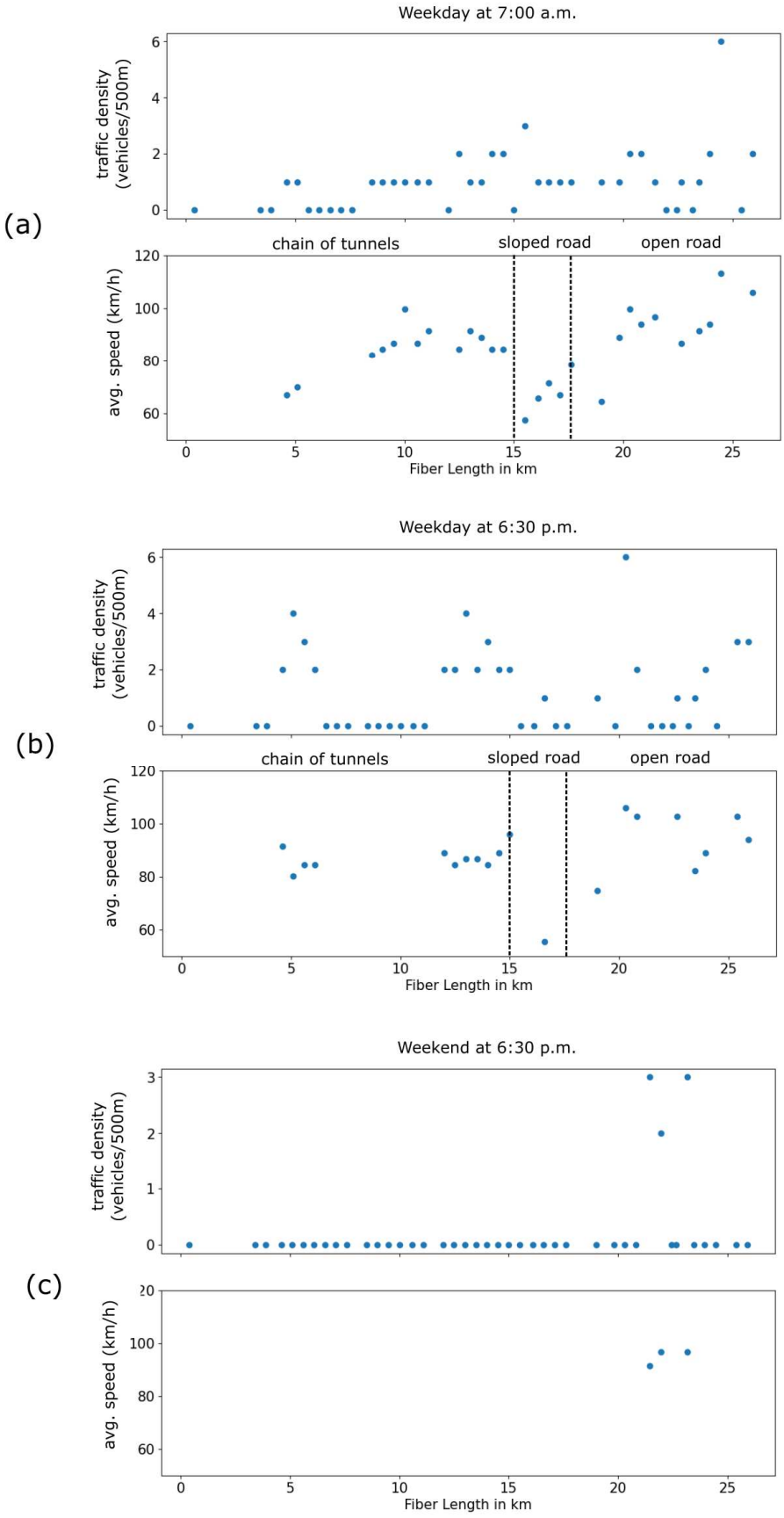


Fig. 3: Average 1-min. speed and traffic density per 500 m for 3 different time instants. The specific road features that explain the differences in the average speeds observed, are indicated in a and b (see text).

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

7 REFERENCES

[1] Wiesmeyr Christoph, Carmina Coronel, Martin Litzenberger, Herbert Josef Döller, Hans-Bernhard Schweiger, und Gaetan Calbris. "Distributed acoustic sensing for vehicle speed and traffic flow estimation". In 2021 IEEE international intelligent transportation systems conference (ITSC), 2596–2601, 2021. https://doi.org/10.1109/ITSC48978.2021.9564517.

[2] M. Litzenberger, C. Coronel, K. Bajic, C Wiesmeyr, H. Döller, H. Schweiger, G. Calbris, "Seamless Distributed Traffic Monitoring by Distributed Acoustic Sensing (DAS) using existing Fiber Optic Cable Infrastructure", in "REAL CORP 2021 Proceedings ", 26 (2021), ISBN: 978-3-9504945-0-1; S. 1215 - 1218.

[3] J. Guerrero-Ibáñez, S. Zeadally, and J. Contreras-Castillo, "Sensor Technologies for Intelligent Transportation Systems," Sensors (Basel), vol. 18, no. 4, Apr. 2018, doi: 10.3390/s18041212.

[4] N. Gallego, A. Mocholi, M. Menendez, and R. Barrales, "Traffic Monitoring: Improving Road Safety Using a Laser Scanner Sensor," in 2009 Electronics, Robotics and Automotive Mechanics Conference (CERMA), Cuernavaca, Morelos, Mexico, Sep. 2009, pp. 281–286, doi: 10.1109/CERMA.2009.11.

[5] T. M. Hussain, T. N. Saadawi, and S. A. Ahmed, "Overhead infrared sensor for monitoring vehicular traffic," IEEE Trans. Veh. Technol., vol. 42, no. 4, pp. 477–483, Nov. 1993, doi: 10.1109/25.260764.

[6] A. Roy, N. Gale, and L. Hong, "Automated traffic surveillance using fusion of Doppler radar and video information," Mathematical and Computer Modelling, vol. 54, no. 1–2, pp. 531–543, Jul. 2011, doi: 10.1016/j.mcm.2011.02.043.

[7] H.-S. Lim, H.-M. Park, J.-E. Lee, Y.-H. Kim, and S. Lee, "Lane-by-Lane Traffic Monitoring Using 24.1 GHz FMCW Radar System," IEEE Access, vol. 9, pp. 14677–14687, 2021, doi: 10.1109/ACCESS.2021.3052876.

[8] O. Appiah, E. Quayson, and E. Opoku, "Ultrasonic sensor based traffic information acquisition system; a cheaper alternative for ITS application in developing countries," Scientific African, vol. 9, p. e00487, Sep. 2020, doi: 10.1016/j.sciaf.2020.e00487.

[9] Y. Jo, J. Choi, and I. Jung, "Traffic Information Acquisition System with Ultrasonic Sensors in Wireless Sensor Networks," International Journal of Distributed Sensor Networks, vol. 10, no. 5, p. 961073, May 2014, doi: 10.1155/2014/961073.

[10] J. Pelegri, J. Alberola, and V. Llario, "Vehicle detection and car speed monitoring system using GMR magnetic sensors," in IEEE 2002 28th Annual Conference of the Industrial Electronics Society. IECON 02, Sevilla, Spain, 2002, vol. 2, pp. 1693–1695, doi: 10.1109/IECON.2002.1185535.

[11] H. S. Fimbombaya, N. H. Mvungi, N. Y. Hamisi, and H. U. Iddi, "Performance Evaluation of Magnetic Wireless Sensor Networks Algorithm for Traffic Flow Monitoring in Chaotic Cities," Modelling and Simulation in Engineering, vol. 2018, pp. 1–11, Oct. 2018, doi: 10.1155/2018/2591304.

[12] Y. Na, Y. Guo, Q. Fu, and Y. Yan, "An Acoustic Traffic Monitoring System: Design and Implementation," in 2015 IEEE 12th Intl Conf on Ubiquitous Intelligence and Computing and 2015 IEEE 12th Intl Conf on Autonomic and Trusted Computing and 2015 IEEE 15th Intl Conf on Scalable Computing and Communications and Its Associated Workshops (UIC-ATC-ScalCom), Aug. 2015, pp. 119–126, doi: 10.1109/UIC-ATC-ScalCom-CBDCom-IoP.2015.41.

[13] M. Lewandowski, B. Płaczek, M. Bernas, and P. Szymała, "Road Traffic Monitoring System Based on Mobile Devices and Bluetooth Low Energy Beacons," Wireless Communications and Mobile Computing, vol. 2018, pp. 1–12, Jul. 2018, doi: 10.1155/2018/3251598.

[14] V. Astarita, V. P. Giofré, D. C. Festa, G. Guido, and A. Vitale, "Floating Car Data Adaptive Traffic Signals: A Description of the First Real-Time Experiment with 'Connected' Vehicles," Electronics, vol. 9, no. 1, Art. no. 1, Jan. 2020, doi: 10.3390/electronics9010114.

[15] E. Catalano, A. Coscetta, E. Cerri, N. Cennamo, L. Zeni, and A. Minardo, 'Automatic traffic monitoring by ϕ-OTDR data and Hough transform in a real-field environment', Appl. Opt., AO, vol. 60, no. 13, pp. 3579–3584, May 2021, doi: 10.1364/AO.422385.

🏆 *reviewed paper*

Low-Cost-Workflow zum Laserscanning mit Smartphone und Tablet zur Effizienzsteigerung im Garten- und Landschaftsbau

Jonas Straub, Olaf Schroth

(Jonas Straub, jonas@garten-straub.de)
(Prof. Dr. Olaf Schroth, Hochschule Weihenstephan- Triesdorf, Am Weihenstephaner Berg 5, 85354 Freising, olaf.schroth@hswt.de)

1 ABSTRACT

Unter LIDAR (Light Detection and Ranging) Scanning wird eine Scanningmethode verstanden, welche auf Messung der Zeit zwischen Absenden und Auffangen des reflektierten Laserstrahls basiert (Petschek 2019). Die Technologie wird inzwischen in vielen Bereichen eingesetzt und ist unter anderem in einigen der neuesten Smartphones und Tablets seit 2020 verbaut. Aufgrund des niedrigen Investitionsaufwandes steht die Technologie der breiten Bevölkerung zur Verfügung und kann so auch von kleineren Firmen eingesetzt werden. Gerade für den Garten- und Landschaftsbau besitzt diese Technologie großes Potential, da die erreichbare Genauigkeit der Scans für die Planung im Garten- und Landschaftsbau ausreicht wie dieser Beitrag zeigt. Für kleinere Objektplanungen, z.B. ein Haus mit Garten wie hier im Beispiel, können die erforderlichen Flächen ausreichend mit den in mobilen Geräten verbauten low cost LIDAR-Scannern erfasst werden. Zudem sind die mobilen Endgeräte einfach zu bedienen.

Die Ergebnisse des Scans können deshalb zur Dokumentation, als Planungsgrundlage für die herkömmliche 2D-Planung sowie für die 3D- Planung verwendet werden und bieten dadurch einen großen Mehrwert.

Keywords: Digitalisierung im Handwerk, Nachhaltigkeit durch Effizienz, Effizienzsteigerung, Low Cost, LIDAR Scanning

2 GENAUIGKEITSBETRACHTUNGEN FÜR LASERSCANNER IN MOBILEN GERÄTEN

Für eine Verwendung des Scanners im Arbeitsalltag spielt dessen Genauigkeit eine entscheidende Bedeutung. Da die Begrifflichkeiten Genauigkeit, Präzision und Richtigkeit oftmals unterschiedliche Verwendung finden, werden sie für die weitere Verwendung folgendermaßen entsprechend ihrer Verwendung in der Vermessungskunde definiert:

	Richtigkeit	Präzision	Genauigkeit
englisch	trueness, accuracy of the mean	precision	accuracy
Aussage	Abstand des Mittelwerts vom Referenzwert	Streuung von Einzelwerten um den Mittelwert	Abstand eines Einzelwerts vom Referenzwert
-	Lageparameter	Streuparameter	beides
-	Datensatz	Datensatz	Einzelwert
Fehlerart	Systematische Fehler	Zufällige Fehler	beide
Kenngröße	Mittelwert	Standardabweichung	-

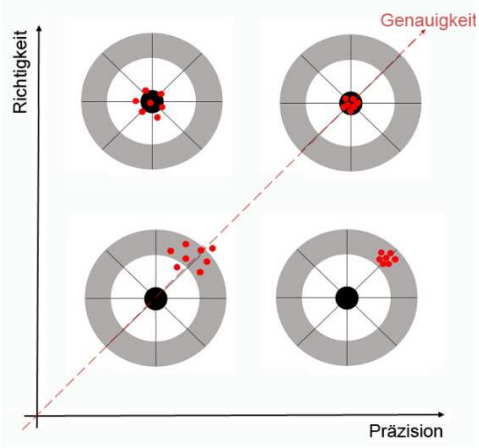


Abbildung 1: Abgrenzung, Zusammenhänge und zugrunde liegende Fehlerarten der Begrifflichkeiten Richtigkeit, Präzision und Genauigkeit (Quelle: https://mpl.loesungsfabrik.de/blog/methodenvalidierung/richtigkeit-genauigkeit-praezision; Abgerufen am 19.09.2022)

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Die Präzision gibt damit den zufälligen Fehler einer Reihe von Messungen an, wohingegen die Richtigkeit ein Mass für systematische Fehler ist. Die Genauigkeit ergibt sich aus der Kombination von Richtigkeit und Präzision.

Es existieren bereits einige Untersuchungen und Messungen im Zusammenhang mit der Präzision und Anwendbarkeit des LIDAR-Scanners in verschiedenen Szenarien, welche zunächst vorgestellt werden. Bei einer Untersuchung der Fähigkeiten des Scanners im Rahmen einer Architekturaufnahme (Spreafico et al., 2021) wurde festgestellt, dass die erzeugten Ergebnisse eine nach den allgemein anerkannten italienischen Standards (Präzision +/-2 cm, Genauigkeit +/-4 cm,) ausreichende Genauigkeit für die Kartierung im Maßstab 1:200 haben. Das iPad wurde somit als vielversprechend im Rahmen von architektonischen Vermessungen bezeichnet, da es tragbar, kostengünstig, schnell und einfach zu bedienen ist.

In Gollob et al. (2021) wurde die Technologie im Hinblick auf die Waldinventur untersuchte, mit dem Ergebnis, dass die App „3D- Scanner Pro“ mit einer Erkennungsrate von 97,3 % für die Anwendung am besten geeignet ist. Bedeutend sind außerdem die Messungen von Díaz Vilariño et. al. (2022), welche die Präzision beim mobilen Kartieren von Indoor und Outdoorbereichen untersucht haben. Hierbei wurde auch die App „3D- Scanner Pro“ verwendet, wobei sowohl im Indoor- als auch im Outdoorbereich ähnliche gute Genauigkeiten erreicht werden konnten.

Bei Messungen im Rahmen der Geowissenschaften wurden festgestellt, dass kleine Objekte mit einer Genauigkeit von ±1 cm erfasst werden, während größerflächige Bereiche (130 × 15 × 10 m) mit einer Genauigkeit von ±10 cm abgebildet werden können (Luetzenburg et al, 2021). Bei einer Untersuchung der relativen Genauigkeit der Scandateien ist R.Tamimi zu dem Ergebnis gekommen, dass pro 200 Feet (60.96 m) ein Foot (0.30m) Abweichung zu erwarten ist (Tamimi, 2022).

3 SOFT- UND HARDWARE

Für die Erstellung der Scans wurde ein IPad Pro der zweiten Generation verwendet. Generell sind LIDAR Scanner nur in den IPad und IPhone Pro Geräten seit 2020 verbaut. Unterschiede der Scanner zwischen den einzelnen Geräten konnten bislang nicht festgestellt werden. (Luetzenburg et al, 2021)

Genaue technische Daten wurden bisher nicht von Apple veröffentlicht, jedoch gibt es bereits einige Untersuchungen, welche den LIDAR- Scanner als „solid-state LiDAR“ charakterisieren (Murtiyoso et al, 2020). Mittlerweile gibt es eine Vielzahl an unterschiedlichen Apps für unterschiedliche Anwendungszwecke, welche den LIDAR-Scanner nutzen. Für die Aufnahme von großflächigen Gebieten, folglich auch für den Garten- und Landschaftsbau, hat sich die „3D- Scanner App“ von Laan Labs bewährt. Im Vergleich zu anderen Softwarelösungen ist die App kostenlos und eignet sich gut für die Erstellung von Planungsgrundlagen und des Aufmaßes sowie zur Dokumentation.

Die Umgebung kann entweder als Punktwolke oder als Dreiecksvermaschung abgebildet werden. Zweiteres hat sich für die weitere Verwendung im Arbeitsalltag bewährt, da das erstellte Netz automatisch mit aufgenommenen Fotos der Hauptkamera texturiert wird.

Neben dem LIDAR-Scanner ist die App außerdem in der Lage, die verbaute „TrueDepth“ Kamera zur Erstellung von 3D- Modellen zu verwenden. Ursprünglich hauptsächlich für die Gesichtserkennung entwickelt, kann diese auch zum Scannen von Kleinteilen verwendet werden (Vogt et al., 2021). Für den Garten- und Landschaftsbau ist diese Funktion jedoch nicht von Bedeutung, weshalb im folgenden lediglich auf die Verwendung des LIDAR- Scanners eingegangen wird.

4 ÜBERPRÜFUNG DER GENAUIGKEIT

Grundsätzlich fallen, je nach eingestellter Auflösung des Scans, die erreichbare Genauigkeit und die insgesamt aufgenommene Fläche unterschiedlich aus. Insgesamt ist die Aufnahmeleistung auf ca. 1,5 GB bzw. ca. 1,5 Millionen Vertex begrenzt. Folglich gilt: Umso kleiner das Aufnahmeraster ist, desto höhere Genauigkeiten ermöglicht der Scan, desto kleiner wird jedoch auch der Aufnahmebereich (vgl. Abb. 1 und Abb. 2). Bei dem Probescan konnte mit der kleinsten möglichen Auflösung ein Bereich von ca. 150 m² aufgenommen werden. Mit Vergrößerung der Rasterweiten können umfangreichere Gebiete aufgenommen werden (bis zu ca. 1000 m²), wobei hierbei die Qualität des Scans sinkt und keine so hohen Genauigkeiten mehr erreicht werden können.

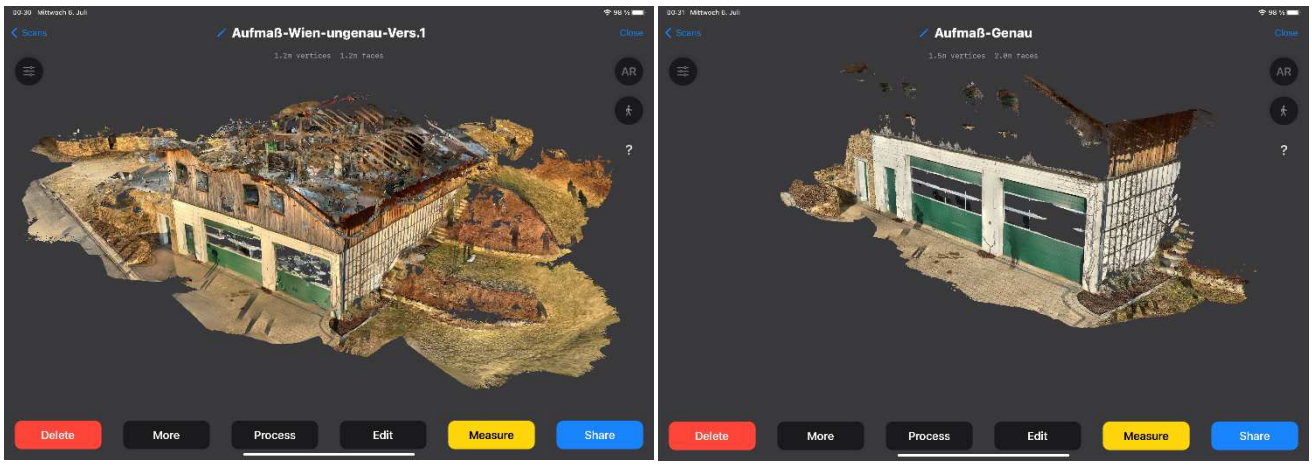


Abbildung 2: Vergleich Aufnahmebereich bei 20 mm Auflösung (links) und 5 mm Auflösung (rechts)

Die vorliegenden Untersuchungen lassen darauf schließen, dass die Technik für die meisten Anwendungszwecke im Garten- und Landschaftsbau eine ausreichende Genauigkeit erreicht. Bei den Messungen wurden jedoch hauptsächlich das erzeugte Netz bzw. die erzeugte Punktwolke mit der Realität verglichen. Für viele Anwendungen sind aber visuelle Marken (z.B. Pflasterwechsel, Farbwechsel o.ä.), welche nicht durch die Geometrie alleine abgebildet werden können, entscheidend.

Wichtig ist daher, ob die Dreiecksvermaschung richtig mit den entsprechenden Fotos texturiert wurde. Aus diesem Grund wurden zwei Scans, einmal mit maximal möglicher und einmal mit minimal möglicher Auflösung, angefertigt und die jeweiligen Längen mit den realen Maßen verglichen. Diese wurden per Maßband aufgenommen. Als Festpunkte wurden sowohl geometrische als auch visuelle Marken verwendet, was bedeutet, dass mögliche Fehler nicht zwingend auf eine Abweichung das Gitternetzes zurückzuführen sind, sondern ebenso durch eine fehlerhafte Texturierung entstehen können.

Bei den Probemessungen mit der kleinsten möglichen Auflösung (5mm) wurde eine durchschnittliche Abweichung von 0,58 cm pro m ermittelt.

Maße des Scans Rasterweite 5mm	**Maße in Realität**	**Abweichung in cm**
0,96 m	0,97 m	1
2,24 m	2,26 m	3
3,07 m	3,09 m	2
3,96 m	3,98 m	2
4,96 m	4,98 m	2
13,74 m	13,81 m	7
	Gesamte Länge: 29,09 m Abweichung gesamt: 17cm	0,58 cm pro m Abweichung

Tabelle 1: Durchschnittliche Abweichung bei minimaler Rasterweite

Mit der maximal möglichen Rasterweite von 20mm wurde eine durchschnittliche Abweichung von 1,82 cm pro m ermittelt.

Maße des Scans Rasterweite 20mm	**Maße in Realität**	**Abweichung in cm**
0,99 m	0,97 m	2
2,25 m	2,26 m	1
3,04 m	3,09 m	5
3,91 m	3,98 m	7
4,92 m	4,98 m	6
13,49 m	13,81 m	32
	gesamte Länge: 29,09m Abweichung gesamt: 53 cm	1,82 cm pro m Abweichung

Tabelle 2: Durchschnittliche Abweichung bei maximaler Rasterweite

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

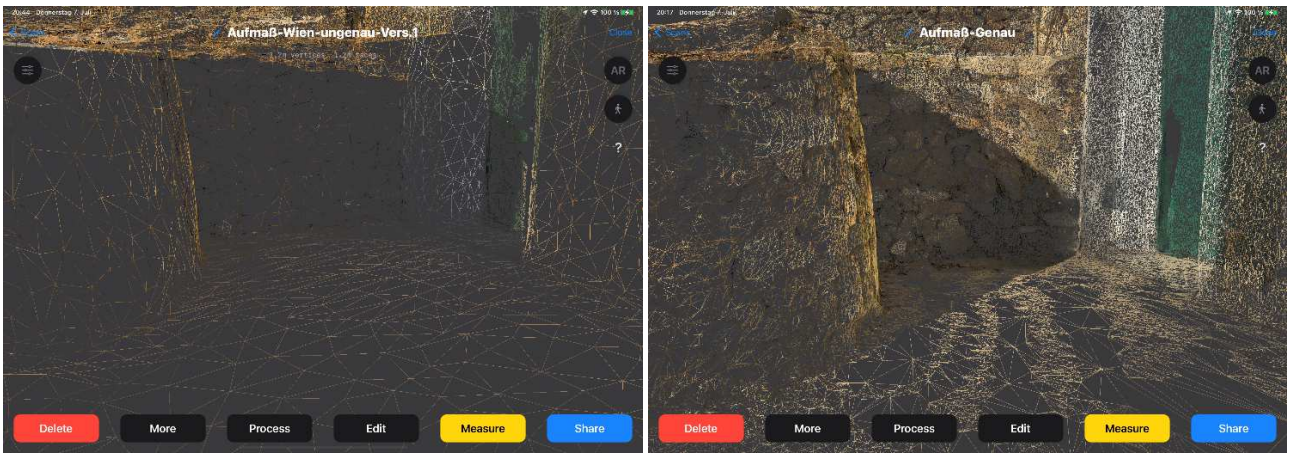


Abbildung 3: Vergleich des Detailgrades bei 20 mm Auflösung (links) und 5 mm Auflösung (rechts)

Nach diesen Messungen ist zu vermuten, dass die Technologie für die meisten Anwendungsfälle im Garten- und Landschaftsbau eine ausreichend hohe Genauigkeit erlaubt. Dazu werden im Folgenden typische Anwendungsfälle genauer betrachtet.

5 DOKUMENTATION UND WEITERVERARBEITUNG DER SCANERGEBNISSE

5.1 Dokumentation

Der Baustellendokumentation kommt im modernen Bauwesen große Bedeutung zu. Durch die Verwendung des LIDAR- Scannings können verschiedene Baustände einfach und unkompliziert festgehalten und abgespeichert werden. Dadurch sind alle Abhängigkeiten, Maße und Details in einem Scan enthalten und können jederzeit abgerufen werden. Gerade die einfache und schnelle Verwendung ist hierbei von großem Vorteil, da so jeder Baustellenbeteiligte in der Lage ist, 3D-Dokumentationen zu erstellen.

Auch wenn Laserscanner im Hochbau bereits vielerorts zur Dokumentation eingesetzt werden, ist diese Technologie kompliziert in der Bedienung und mit hohen Kosten verbunden. Gerade im Garten- und Landschaftsbau wird aus diesem Grund zumeist auf fotografische Aufnahmen zurückgegriffen.

5.2 Verarbeitung des Scans in 2D

Die Erstellung konventioneller Planungsgrundlagen ist erfahrungsgemäß einer der Problempunkte im Arbeitsprozess von Garten- und Landschaftsbaufirmen, denn bisherige moderne Vermessungstechnik ist nach wie vor kostspielig und steht so vor allem größeren Betrieben zur Verfügung.

Mit der hier verwendeten Kombination aus low-cost Hard- und Software ist es möglich aus dem 3D-Modell eine 2D-Draufsicht zu generieren. Dies ermöglicht wiederrum, dass der Scan direkt auf dem Tablet als 2D Planungsgrundlage verwendet werden kann. Dadurch ist ein durchgängiger Planungsworkflow möglich. Vor Ort können das Planungsgebiet aufgenommen, erforderliche Zeichnungen angefertigt und das fertige Endergebniss direkt an die Kunden bzw. Baustellenbeteiligten exportiert werden. Der Prozess von der Aufnahme bis hin zur fertigen Planungsgrundlage dauert, je nach Größe des Gebietes, zwischen fünf und fünfzehn Minunten und verkürzt den herkömmlichen Prozess der Grundlagenermittlung immens.

Dieser Workflow bietet somit Firmen, welche nach wie vor Handzeichnungen anfertigen, die Möglichkeit Ihre bisherige Arbeitsweise auf eine weitaus effektivere Art digital fortzuführen. Durch die Kombination der technischen Hilfsmittel eines aktuellen Tablets gelingt es somit, dass die traditionelle Handzeichnung wieder Aktualität erlangt und gleichzeitig mit CAD- und BIM-Prozessen kompatibel ist.

5.3 Verarbeitung des Scans in 3D

Da die Scans das Planungsgebiet mit Maßen und Zusammenhängen abbilden, eignen sich die Scans gut als 3D-Planungsgrundlage im Sinne der 3D-Planung oder BIM (Muertha et al. 2018; Urech et al. 2020). Zwar gibt es mittlerweile auch auf dem Tablet 3D-Planungsprogramme (z.B. SketchUp), jedoch ist für ein effektives Arbeiten der Export auf einen passenden PC bzw. Mac notwendig.

Da die Dateien oftmals relativ groß sind, ist für die Verwendung manchmal außerdem eine Vergrößerung der Netzweite vonnöten. Die im Kapitel zuvor beschriebene Genauigkeit kann dann aber nicht mehr erreicht

werden. Für den Garten- und Landschaftsbau sind die 3D-Planungsgrundlagen in den meisten Anwendungsfällen ausreichend genau und können zudem mit anderen 3D-Daten (beispielsweise von Tachymetern) ergänzt werden.

6 AKTUELLE PROBLEMSTELLUNGEN

Zum aktuellen Zeitpunkt sind die Sensoren des IPhones nicht für das Scannen optimiert, wodurch im größeren Maße Driftfehler entstehen (ca. 1 Foot auf 200 Feet). Driftfehler entstehen durch die Akkumulation von Fehlern des verbauten Gyroskops und des Beschleunigungsmessers, wodurch sich die berechnete Position von der realen Position unterscheidet. Mithilfe eines handelsüblichen Dreiachsengimbels können diese siginifikant verringert werden (Tamimi, 2022). Viele mobile Scanstationen verwenden für eine bessere Genauigkeit Techniken wie das Loop Closing. Dadurch wird durch Schleifenschluss ein zuvor bereits eingescannter Bereich erkannt und so die Fehler herausgerechnet.

In naher Zukunft ist deshalb davon auszugehen, dass diese Verbesserungsmöglichkeit auch bei mobilen Endgeräten zum Einsatz kommt.

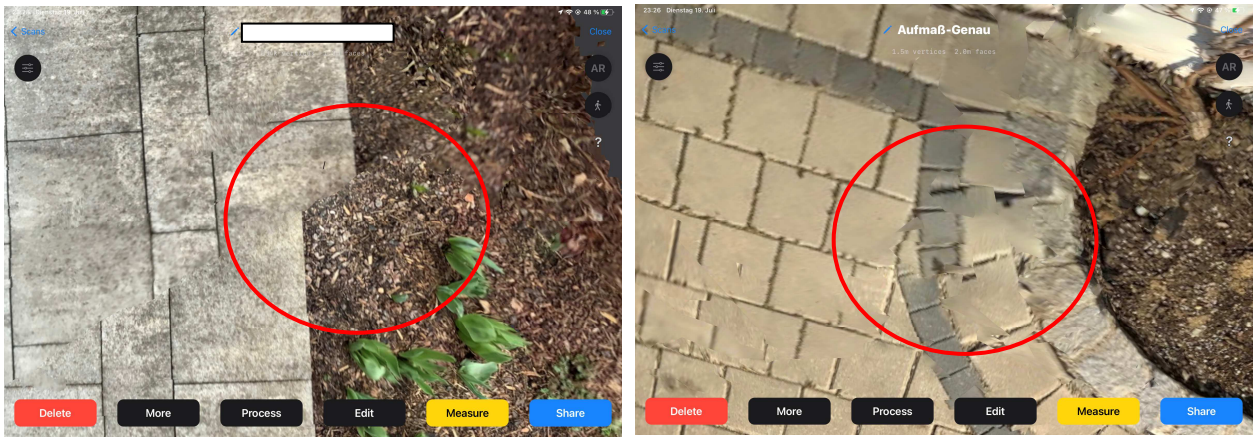


Abbildung 3: Fehler beim 3D-Scan

Bei der Nutzung traten in den gekennzeichneten Bereichen Probleme auf, wie in der Abbildung 3 zu sehen ist. Dabei wurden Sektionen des Scans falsch im Kontext angeordnet.

In der Literatur wurde dieser Punkt bislang nicht behandelt. Nach eigenen Untersuchungen kann jedoch die Vermutung aufgestellt werden, dass weniger die Texturierung, sondern Trackingfehler die Ursache für die auftretenden Abweichungen sind. Diese entstehen wahrscheinlich aufgrund der einheitlichen Oberfläche, beispielsweise des Pflasters. Weiterhin ist bekannt, dass auch Reflexionen zu Fehlern in Laserscans führen. Diesbezüglich ist jedoch noch weitere Forschung notwendig, um mögliche Fehlerquellen und Lösungen zu untersuchen.

Durch die Fehler entstehen deutliche Abweichungen von der Realität, wobei diese jedoch meistens relativ offensichtlich sind. Doppeltes oder gar mehrfaches Scannen eines Gebietes kann helfen, für alle Bereiche brauchbare Daten zu erhalten.

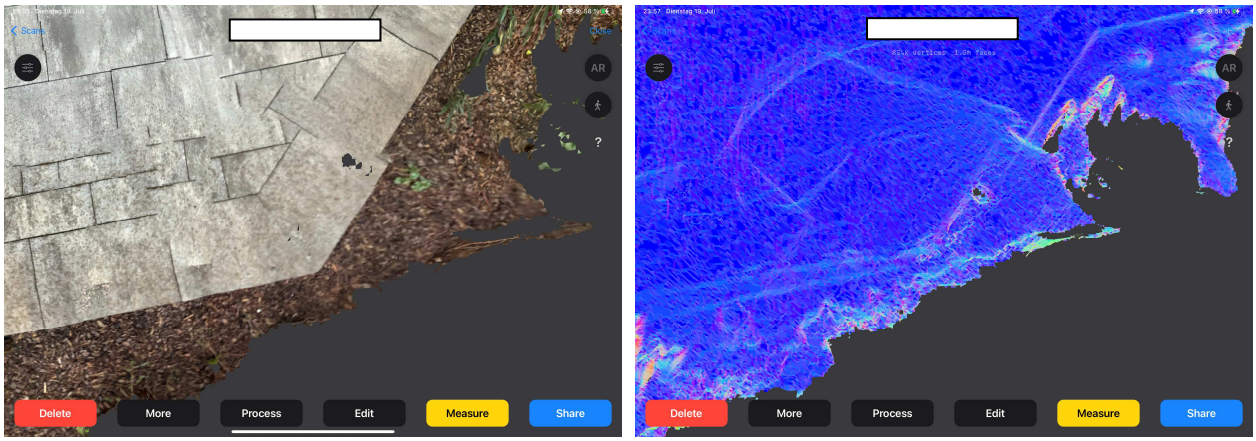


Abbildung 4: Trackingfehler; Links texturiert, rechts Höhenprofil

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

7 FAZIT

Neue mobile Standardgeräte ermöglichen es, ein zentimetergenaues, digitales 3D Abbild der Umgebung zu erstellen und diese Umgebung direkt als Planungskontext zu verwenden. Auch wenn die Technologie erst im Anfangsstadium steckt, kann bereits jetzt gesagt werden, dass sie das Potential hat, die Arbeitsweise im Garten- und Landschaftsbau zu verändern. Nicht nur, dass der herkömmliche Workflow der 2D-Handzeichnung digitalisiert und dadurch wesentlich effektiver gestaltet wird, sondern auch, dass der gleiche Scan direkt in das 3D- Planungsprogramm eingelesen bzw. zur Dokumentation des Urzustandes genutzt werden kann, zeigt, wie die Technik bereits zum jetzigen Zeitpunkt der Branche in Sachen Digitalisierung und Effizienzsteigerung helfen kann.

Während die Technologie für den Garten- und Landschaftsbau aufgrund verschiedener Faktoren besonders gut geeignet ist, ist eine Verwendung in anderen Branchen mit ähnlichen Anforderungen an Genauigkeit und Projektgröße ebenfalls denkbar. Die Anwendungsmöglichkeiten sind vielseitig, denn der Scanner funktioniert sowohl innen als auch außen und in den nächsten Jahren ist zudem mit einer rasanten Weiterentwicklung der Hard- und Software zu rechnen. Es ist zu vermuten, dass in Zukunft weitere teure Vermessungstechnik durch handelsübliche Tablets und Smartphones ersetzt werden wird. Für den Garten- und Landschaftsbau bietet sich bereits jetzt die Möglichkeit, von der Miniaturisierung und Integration von LiDAR Scannern in mobilen Geräten zu profitieren.

8 QUELLEN

Díaz Vilariño, Lucia & Tran, Ha & Frías, Ernesto & Balado Frias, Jesus & Khoshelham, Kourosh: 3D MAPPING OF INDOOR AND OUTDOOR ENVIRONMENTS USING APPLE SMART DEVICES. The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences. XLIII-B4-2022. 303-308. 10.5194/isprs-archives XLIII-B4-2022-303-2022, 2022.

Gollob, C., Ritter, T., Kraßnitzer, R., Tockner, A., Nothdurft, A.: Measurement of Forest Inventory Parameters with Apple iPad Pro and Integrated LiDAR Technology. Remote Sens., 13, 3129. https://doi.org/ 10.3390/rs13163129, 2021.

Luetzenburg, G., Kroon, A., Bjork, A.: Evaluation of the Apple iPhone 12 Pro LiDAR for an Application in Geosciences. Nature Scientific Reports, 11:22221, https://doi.org/10.1038/s41598-021-01763-9 Murtiyoso, A., Grussenmeyer, P., Landes, T., & Macher, H. (2021). First Assessments Into the Use of CommercialGrade Solid State LIDAR for Low Cost Heritage Documentation. ISPRS-International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, 43, 599-604. https://doi.org/10.5194/isprs-archives-XLIII-B2-2021- 599-2021, 2021.

Murtha, T., Golden, C., Cyphers, A., Klippel, A., & Flohr, T.: Beyond Inventory and Mapping : LIDAR , Landscape and Digital Landscape Architecture. In E. Buhmann, S. M. Ervin, S. Hehl-Lange, & J. Palmer (Eds.), Digital Landscape, 2018.

Petschek, P.: Grading BIM. landscapingSMART. 3D-Machine Control Systems. Stormwater Management. Birkhäuser, 2019.

Tamimi, R.: RELATIVE ACCURACY FOUND WITHIN IPHONE DATA COLLECTION. The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences. XLIII-B2-2022. 303-308. 10.5194/isprs-archives XLIII-B2-2022-303-2022, 2022.

Urech, P. R. W., Dissegna, M. A., Girot, C., & Grêt-Regamey, A.: Point cloud modeling as a bridge between landscape design and planning. Landscape and Urban Planning, 203. https://doi.org/10.1016/j.landurbplan.2020.103903, 2020.

Vogt, M., Rips, A., Emmelmann, C.,. Comparison of iPad Pro®'s LiDAR and TrueDepth Capabilities with an Industrial 3D Scanning Solution. Technologies . https://doi.org/10.3390/technologies902002, 2021

🏆 *reviewed paper*

Making Indian Cities Resilient during and after Covid-19 Pandemic through Flexible Planning Approach

Papiya Bandyopadhyay Raut, Sandeep Kumar Raut

(Papiya Bandyopadhyay Raut, Assistant Professor, School of Planning and Architecture, 4, Block-B, I.P. Estate, New Delhi-110002, India, papiyabraut@gmail.com)
(Dr. Sandeep Kumar Raut, Associate Town and Country Planner, Town and Country Planning Organisation, E Block, Vikas Bhawan, I.P. Estate, New Delhi-110002, India, dr.sandeepraut@gmail.com)

1 ABSTRACT

In the advanced scientific world of information in the innovative medical knowledge age, the Covid-19 pandemic raised many questions of human existence at the dawn of the twenty first century. On top of it, countrywide lockdown to save humanity at the cost of a shrinking economy shattered the hope of survival of many. The paper is an attempt to find a flexible way forward for post Covid-19 city planning and management by analysing the impact of real time mobility data of Mumbai and Delhi. It also proposed the Integrated Spatial Hierarchical Emergency Functional System (ISHEFS) to integrate the horizontal and vertical functions of the city and various stakeholders/ government departments in a single platform for efficient and effective recovery from the future pandemic. It highlights the establishment of the ISHEF system at neighbourhood and city level and how it will provide for the collection and analysis of spatial and factual ground level information in order to establish a common ground to address the pandemic situation for effective governance and community empowerment.

The ISHEF System provides the flexibility to take decisions on the ground by understanding and analysing the existing situations. Hence, the paper discusses the flexibility of the ISHEF System which enables the field team to observe and analyse the real time challenges of transforming objectives and methodology to suit to the real time field situations and to be able to act in the shorter period of time as fast as possible to provide the solutions. The present hierarchical model will demonstrate successful city solutions for building a flexible, rapid, efficient and effective resilient city.

Keywords: Real Time Mobility Data, Resilient Cites, Hierarchy of city functions, Flexible Neighbourhood Planning, Post Covid-19 Cities

2 BACKGROUND

In late 2019, an unknown virus started spreading its dangerous impact in Wuhan, Hubei Province of China and in January 2020, through widespread news it started its threat to humanity and soon captured the minds of millions across the world, especially in cities. On 11th February 2020, the World Health Organisation (WHO) called this novel coronavirus 'Covid-19' and the very next day WHO published operational Planning Guidelines to support country-preparedness and response. In reality, it was too late to realise that was a pandemic, as within only a period of six to seven months more than 17 million population confirmed cases of Covid-19 (July, 2020) and 600,00 million people died (WHO Interactive Timeline). India was no exception. 50 percent of Covid-19 cases of India were reported from only four megacities (Mumbai, Delhi, Chennai and Ahmedabad), hence it is evident that cities were the epicentre of the pandemic COVID-19.

Non existence of medicine or vaccine left no option but to completely shut down cities and for the government authorities across the world to announce lockdown strategies. This unwanted model of complete lockdown, with supply of only essential goods and services; travel restrictions within snd between cities and countries; social distancing, was adopted throughout the world as well as in India to minimise the impact of Covid-19. This model to save humankind from the Covid-19 disease has changed the dynamism of movement and functions of cities and as a result, many industries like tourism, aviation, hospitality, entertainments, sports, manufacturing, transports etc are experiencing tough time. The year 2020 experienced the deepest global recession in a decade with a global estimated GDP of -5.2 percent. India experience was even worse as -23.5 GFP from April to June and -7.5 GDP from July to September, 2020. Apart from health emergency, the Covid-19 pandemic put forth the greatest economic and social challenges for years to come.

The circumstances of unemployment, poverty, social distancing, slow economic recovery and physiological trauma put the question of survival and sustainability of our cities to urban planners, policy makers and managers. Moreover, innovation of communication and information technologies promoted 'work-from-home', online transaction andf virtual meeting and completely changed the behaviour of urban communities,

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

leading to the adaptation of the virtual world and, gradually towards the transformation of urban structure. The paper is an attempt to understand the impact of the Covid-19 pandemic in two cities, Delhi and Mumbai, in order to evolve the Integrated Spatial Hierarchical Emergency Functional (ISHEF) System to make our cities resilient. By analysing the impact of Covid-19 on these two cities, the paper also discusses the steps taken by the government authorities in suggesting future strategies to cope with similar kinds of epidemics.

This is not the first time that cities are experiencing emergency epidemic situations. There were many such instance when cities were the centres of epidemic, for example, yellow fever (1800) in Philadelphia, cholera outbreak in London (1854) and Naples (1884), Spanish flu (1981) in North America, Plague in Surat (1994), SARS (2002) in South East Asia, Bird flu in European cities (1959, 1991), China (1996), Hong Kong (1997) and in India (2020). These epidemics in the past have forced urban planners and policy makers to frame effective urban policies, better hygiene and social services, and improvement of health and medical infrastructure. These past epidemics acted as real-time test-bed laboratories for urban planners and actors to learn many lessons. These epidemics have also given us various examples of innovative solutions and resilience, like the use of city map or spatial analysis to identify the ground zero for London cholera and the construction of a sewerage system for better sanitation for London.

Expansion of city area, concept of urban renewal, land acquisition and social housing dominated during the end of the 19th century in Naples. Naples provides a good example of resilience by framing the urban policy preparation and adoption of the Code of Hygiene and Public Health and the establishment of a law for cleansing the city by Naples municipality. The concept of Garden City by Ebenezer Howard; geometric architectural design by Le Corbusier by giving more importance to light and air; the modern concept of 'Happy City' propagated by Charles Montgomery in his book, "Happy City: Transforming our lives through Urban Design" in 2013, are some of the examples of 20th and 21st centuries which depict the pandemic and epidemic influence of our city planning and the need to design and transform towards better and safe places for human civilisation to thrive the as well. However, the impact of COVID-19 has raised many questions to sbout effective, efficient and sustainable planning and design of our cities. Hence, in order to tackle future pandemics and to judge urban vulnerability to pandemics, there is a need to understand present behaviour of Covid-19. Its spatial pattern and its dynamics affected vulnerable populations and localities. Our preparedness for resilience efforts, our responses, resilient building strategies and adaptation measures etc are important to study and to prepare a resilient model for human survival.

Presently after two years of fear, distress, social distancing, uncertain future and shrinking economy, India is on the path of fast recovery with the announcement of vaccine and also herd immunity. A serological survey conducted by the Delhi government shows that about 95 percent of Delhi's population have already developed antibodies against the Covid-19 virus. But with the mutation of the Covid-19 virus in other parts of the world, it is difficult to predict the behaviour of Covid-19. Apart from paucity of funds faced by WHO to have equitable distribution of vaccines, the major question put before humanity is, how safe the vaccines of Covid-19 are. Hence, it has become even more important for the pharma companies and decision makers to earn credibility of the masses by by creating transparency and joining hands together through interdisciplinary institutions, governments and organisations at world level because the impact of Covid-19 has proven that we are now living in an interdependent world.

As a planner it is evident that to cope with situations like the Covid-19 pandemic there is a need to establish vertical and horizontal integration among various government departments to result in effective time bound decision and action. The more well-knit coordination and cooperation will be established among the various government departments, the more effective establishment of the resilience city will be achieved.

3 METHODOLOGY

The basic methodology adopted is quantitative collection of various observations and suggestions in meetings and discussion forums and self-observation of facts and situational analysis. In order to evolve a ISHEF system for post COVID-19 city resilience strategies, the impact of Covid-19 on two cities Delhi and Mumbai are observed and analysed. These two megacities have been chosen as case studies because of the fact that:

- Both cities experience rapid increase in Covid-19 cases in spite of Delhi being the national capital of India and Mumbai financial capital of India.

- Both cities are power houses of eminent personalities and dominated by high density to low density community locations.
- Both cities are also important tourist destinations and have a large commuting population.
- Both have adopted stringent method to curb the impact of the Covid-19 pandemic.

Due to the limited availability of data the study is based on various discussions and interviews of government officials and health workers and lessons learned during the period of high impact of Covid-19.

In order to understand the socio-economic impact on the cities of Delhi and Mumbai, real time spatial and temporal data through 'Google Mobility Change data' (GMCD), are analysed to measure the Health Index of these two cities. GMCD are analysed to understand the trends in mobility over the time period of COVID-19 from 15th March, 2020 to 20th January, 2021. The percentage change of mobility with reference to the places like retail and recreation; market and pharmacy; parks; public transport; workplaces; residential areas are compared with the base line days. Base line days are the median value from the 5 weeks real time data registered during the normalcy days which are from 3rd January, 2020 to 6th February, 2020. Based on this base line, positive and negative data of Delhi and Mumbai are analysed to access the spread of infection and impact on socio-economic condition. Socio-economic conditions of the city are based on the mobility pattern. Thus, the real time mobility data pattern reflects the impact of the epidemic on the city. If the value is different from the base line data (positive or negative) then the impact of the epidemic is greater. This reflects that the Health Index of the city is poor, as real time data reflects difference from the normal travel behaviour of the local residents. With this assumption, the real time data of Mumbai and Delhi cities are analysed to determine the Health of the City.

4 THE IMPACT OF COVID-19 IN DELHI AND MUMBAI

4.1 Mumbai

Mumbai, the financial capital of India is a coastal city. With a population of 20.6 million persons in 2021 Mumbai, the capital of Maharashtra, is experiencing a decadal population growth rate of 11.94 percent, during 2011-2021. With a population of 30.1 million persons in 2021 Delhi, a land locked city and the national capital of India, registered a decadal population growth rate of 37.28 percent during 2011-2021 (www.Macrotrends.net; United Nation population projections data of Mumbai Metropolitan region and Delhi Urban Agglomeration). Both cities are connected with national and international airports and about 46.8 million (Mumbai) and 68 million (Delhi) national and international people commuted daily during 2019 (timesofindia.indiatimes.com; 10th January, 2020). This reflected how both the cities are well connected with the outside world. However, with the first covid-19 case reported from Delhi in 2nd March, 2020 and 11th March 2020 in Mumbai, both cities experienced decline in national and international travellers, followed by the announcement of the lockdown of 80 cities including Delhi and Mumbai on 22nd March, 2020. With the announcement of a nationwide lockdown from 25th March 2020 the connectivity with the outside world came to a complete halt. Even though in order to stop the spreading of the epidemic, the Delhi government ordered the disinfection of public places and closure of schools, colleges and cinema halls on 12th March, 2020. Similarly, the Maharashtra Government announced outbreak of an epidemic and invoked the provision of the Epidemic Diseases Act, 1897 on 13th March, 2020 and closed all public facilities in urban areas on 14th March, 2020.

The analysis of Google Mobility Change Data (GMCD), shows that with the announcement of the nationwide lockdown on 22nd March 2020, substantial reduction of all mobility results in places like retail and recreation; groceries and pharmacies; parks; transit stations; and workplaces. However, the real time data shows that people are spending more hours at home. During the first unlock period on 1st June 2020 the major decision of reopening retail stores, restaurants, the hospitality sector, hair salons and malls had only a minimal change in the travel behaviour. The real time data also shows that Delhi has manifested a sharp rise in mobility trends in various places, in contrast to Mumbai which experienced a only a gradual increase in mobility trends. Thus, Mumbai faced a stronger impact of the epidemic Covid-19 as compared to Delhi.

Both cities Delhi and Mumbai are reflecting an 80 percent and 90 percent sharp decline in the mobility respectively after the announcement of the country wide lockdown on 22nd March, 2021. The reduction of mobility was at its peak i.e. 90 to 92 percent from 18th April to 3rd May, 2020, of about half a month, in

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Delhi. However, Mumbai experienced the highest decline of resident's activities, i.e. 90 to 93 percent from 22nd March to 4th June 2020, of about two and half months. Subsequently, the mobility data shows the gradual reduction from the baseline data from 4th May and 5th June, 2020 in Delhi and Mumbai respectively. On 20th January, 2021 Delhi and Mumbai are reflecting 38 and 45 percent decline in travel trends respectively (Figure 1 and 2).

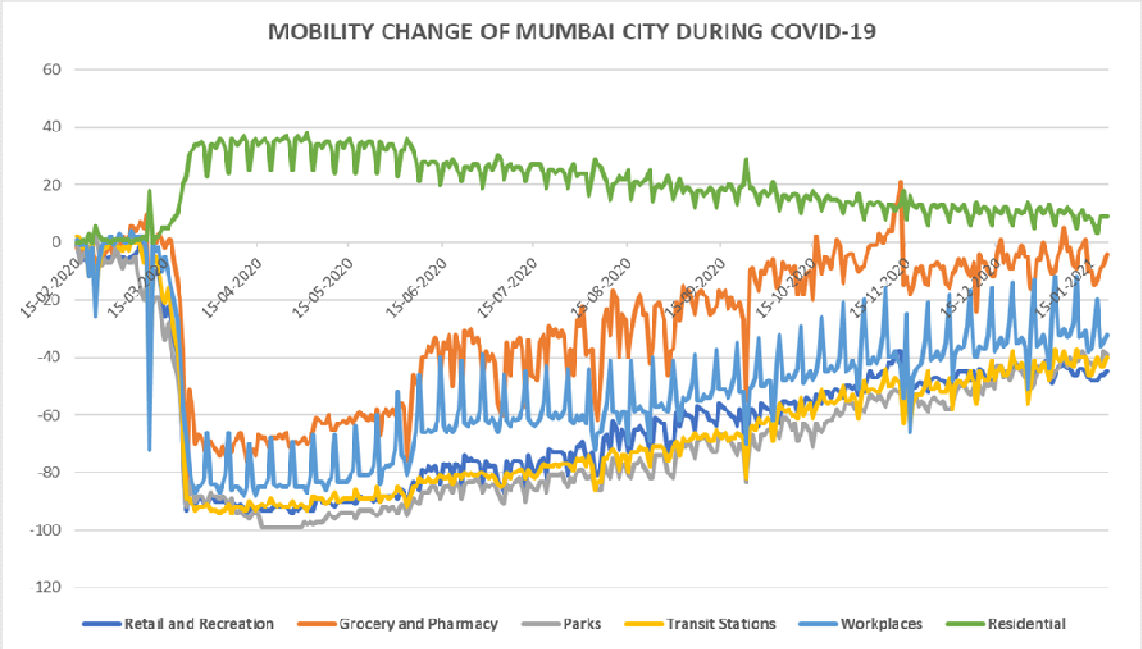


Fig 1: Real time Mobility change data of Mumbai from 15th March, 2020 to 20th January, 2021 (Source: COVID-19 Community Mobility Report, 2021 January 22.)

The analysis of real time mobility data in correlation with the increased number of Covid-19 cases in the city depicts that while Delhi and Mumbai have witnessed highest Covid-19 cases the reduction of mobility within the city is at its peak. As Mumbai has a longer peak curve than Delhi, it reflects that Mumbai suffered a stronger impact of Covid-19 and taken more time to control the epidemic. Thus, Delhi's strategies to tackle Covid-19 are more effective and resilient as compared to Mumbai. One of the Delhi government's social strategy is to provide free food, by setting up over 500 hunger relief camps for people who have been left stranded due to nationwide lockdown.

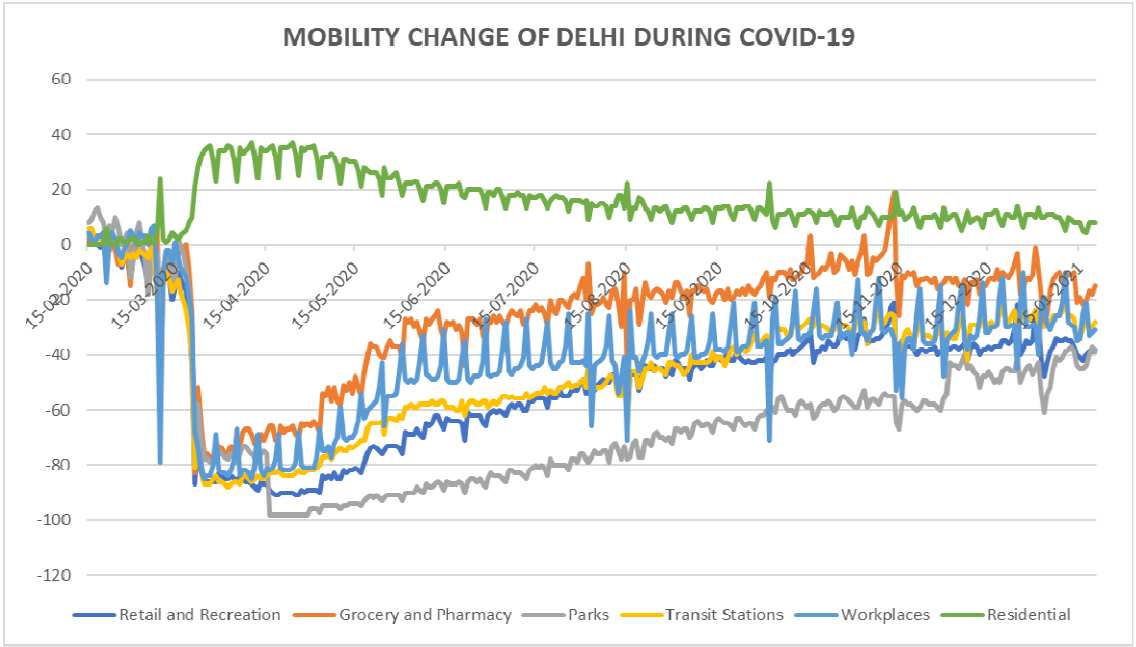


Fig 2: Real time Mobility change data of Delhi from 15th March, 2020 to 20th January, 2021 (Source: COVID-19 Community Mobility Report, 2021 January 22).

As regards land-use both the cities are witnessing that the mobility trends in workplaces, parks and transit stations are decreasing towards normalcy at a slow pace as compared to grocery and pharmacy and residential areas. This reflects that more and more of the urban community are selecting to 'work from home' options. Moreover, many companies are permanently adopting the policy to work-from-home.

The analysis of interviews of different people in Mumbai and Delhi reflect that 82 and 65 percent respondent respectively will prefer the Work-from-Home culture permanently. The 75 to 80 percent of the planner community of Delhi and Mumbai respectively believe that the demand of location specific office spaces and travel demand will be reduced and thus the pattern of mobility will change in future.

4.2 Lesson learned

- The present alarming situations could be the warning from which to draw lessons for the next global emergency. This raises many questions of the modern urban community system over the traditional rural community system.
- Unsafe drinking water, crowded housing, lack of health professionals, poor infrastructure and chronic diseases play a major role in making the indigenous community more vulnerable to Covid-19.
- Location of first cases was reported from major urban centres and rural communities which are more self-sufficient than other and support traditional way of life.
- Isolation means lack of recreational, education and employment opportunities. Isolation also has an impact on an individual's holistic mental health and wellness like psychological, emotional abuse and jealousy.
- The countrywide lockdown model, in fact the biggest lockdown in the world, had brought our country to suffer the consequences of deep uncertainty and economic crises.
- The current extreme situation forced the planner and urban expert to think about all spatial planning theories of sustainable urban development or to recognise the need to evolve a new innovative solution model of sustainability.
- Digital infrastructures and technologies for virtual connectives and analysis of real time data need strengthening.
- In order to control the spread of epidemic, there is a need to have a single platform to coordinate the decisions taken by different agencies or government bodies.

5 BUILDING URBAN RESILIENCE

For a planner it is evident that to cope with a situation like the Covid-19 pandemic there is a need of vertical and horizontal integration of various government departments to result into effective and time bound decision and action taking. The more coordination and cooperation will be established among the various government departments, the more effective the resultant establishment of resilience city will be achieved.

The establishment of an Integrated Spatial Hierarchical Emergency Functional (ISHEF) System during the epidemic within the city will ensure the systematic spatial and hierarchical arrangement of essential goods and services. The emergency functions of the city are:

- Health and medical services;
- Food distribution system;
- Hygienic water distribution network system;
- Efficient sanitary network system;
- Transportation and communication system;
- Network of Real time data design centres;
- Emergency Governance system; and
- Network of trained local volunteers system.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

All these emergency functions of the city should be in hierarchical arrangement spatially in such a way that an identified epidemic city/ locality/ neighbourhood should act like a self-sufficient cluster on the one hand and also hierarchically connected to the supply of goods and services on the other hand, so that the epidemically impacted community should not feal isolated mentally on the one hand, and restricted in its movement physically on the other hand, to control the further spread of the epidemic.

To identify the interested citizen keen to work/ help in epidemic situation it is necessary to establish a core citizen group (CCG) network which may be called 'Swasth fielder' (SF). The Swasth Fielder will be chosen from different areas of the city and from different communities who are willing to help and have some basic education and off course have interest in taking active part in the Epidemic Emergency support group (EESG) and Government. These CCG will work with City level EESG and respective government official in more effective ways to analyse content and solve epidemic related problems. Under the National Disaster Authority, it is suggested to establish a Neighbourhood Disaster Resilience Technology Centre (NDRTC) at neighbourhood level and a City Disaster Resilience Technology Centre (CDRTC) at City level of all cities. This NDRTC will have a real-time data analysis centre and a Geographic Information System (GIS) Web 2.0 technology lab which will:- (a) Provide access to GIS and real time data design system; (b) Provide and communicate data and information to higher order or city level EESG or lower order or neighbourhood level SF; (c) Store and analyse real time data for future predictions and overall management of supplies of essential goods and services and also simulate emergency alert situations ; (d) Educate/ communicate and also provide transparency between local community and government. and (e) adopt efficient and coordinated decision making and participatory planning processes. For the higher level NDRTC is connected with City Disaster Resilience Technology Centre (CDTC).

The Swasth Fielder will feed/ communicate the most vulnerable community related data to NDRTC at neighbourhood level. These Swasth Fielders should be identified and also be provided training to collect data especially from the urban poor and slum areas for inclusive public participation. Thus, this is the practical solution to the digital divide and to reduce the gap between planning professionals and local public. Town and Country Planning Organisation will help establish real-time-data base Centres and GIS Web 2.0 technologies lab and also to impart training to urban planner and city managers for the same purpose. The School of Planning and Architecture (SPA) should take a lead role to identify Swasth Fielder and also to impart training to these SF and other ground level officials. The National Disaster Authority (NDA) should establish coordination among administrative systems of various government departments and also to impart training to various level of government officers/ officials. The Disaster Management Agency will establish a single platform for the Epidemic Emergency Support Group (EESG) and the Core Citizen Group and also provide the coordination support to TCPO, SPA, NDA, health professionals, NGOs, various government departments and other professionals (like, software engineers, data scientist, regional analysists etc). (Figure 3)

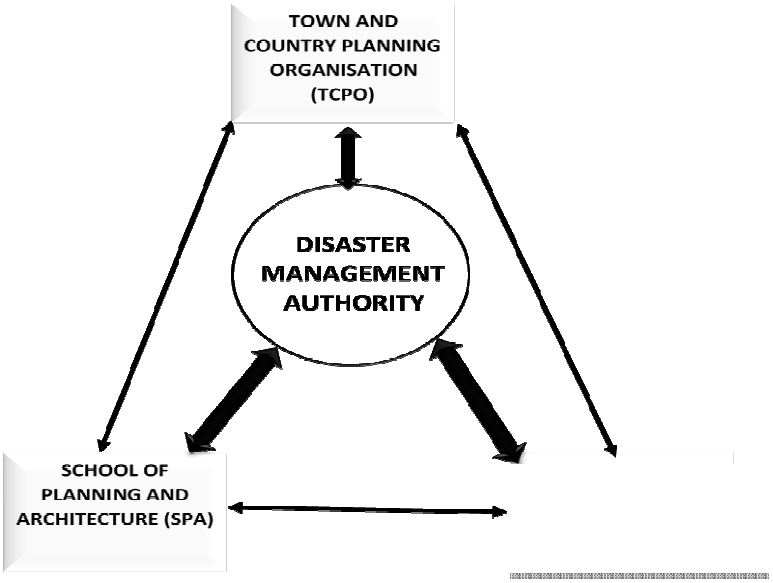


Figure 3: Implementation of ISHEF System (Source: Author, August, 2022).

The pathways for Urban Resilience are developed through the ISHEF System. At the time of epidemic the proposed ISHEF System should create a single platform for information storage and dissemination. The ISHEF System will ensure the following steps at the time of epidemic situations:

- Prepare real-time-base maps for responsive implementation of recovery plan.
- Identify locations with the most needed.
- Quantify the number of people who need assistance.
- Strengthen the food system of the city and define the city capacity to provide food.
- Identify the stakeholder and measure its adaptive capacity
- Establish effective partnership with organisation
- Provide reliable source of information.
- Strengthen networks with neighbourhood leaders (SF).
- Single platform to meet the challenges to integrate all information collected/ deiminated by the SF.
- Provide solution to emergency requirement of space and capable of giving answers to urgent decision-making questions like
    - How to approach the city spaces?
    - How much public or private spaces are required to redesigning the city?
    - epidemic effected area and with which shortened roots?

6 CONCLUSION

Overall, by understanding the impact of the Covid-19 pandemic in Mumbai and Delhi and some of the major lessons learned, the paper tries to frame the concept of Integrated Spatial Hierarchically Emergency Functional (ISHEF) System to increase the resilient capacity of cities. No doubt various models of sustainable urban development and resilient cities are available, however the current situation of the Covid-19 pandemic has raised many more questions for the success of a resilient system. At present, the proposed ISHEF System is the first insight to access, collect, analyse and transfer spatial information providing innovative, sustainable, participatory solutions for effective governance and community empowerment at the time of a Covid-19 like pandemic in the future. By analysing the Google Mobility Change real time data, the paper tries to understand the impact of Covid-19 on the cities of Mumbai and Delhi. The paper suggests possible ways of establishing a ISHEF System for the management of future pandemic situations through a community based local Neighbourhood Disaster Resilience Technology Centre (NDRTC) at neighbourhood level and a City Disaster Resilience Technology Centre (CDRTC) at city level. The establishment of NDRTC will give the local urban community a free hand to communicate its problems at the time of an epidemic to higher or decision-making authorities. The paper is an attempt to understand the impact of the Covid-19 pandemic on two cities (Delhi and Mumbai) in order to evolve the Integrated Spatial Hierarchical Emergency Functional (ISHEF) System to make our cities resilient. By analysing the impact of Covid-19 on these two cities, the paper also discussed the steps taken by the Government Authorities by suggesting future strategies to cope with a similar kind of epidemic in future.

Note: For real time data of Google Community Mobility Report https://www.google.com/covid19/mobility/ ; covid19india.org; Ministry of Health and Family Welfare https://www.mohfw.gov.in/; and WHO Coronavirus disease (COVID-19) Dashboard https://covid19.who.int/ , were used.

7 REFERENCES

AGARWAL, P & Vaidya, H., Can COVID-19 Fill the Void of City Governance for Urban Transformation? UN Habitat and National Institute of Urban Affairs, 2020.

Cities in Transition, World Bank Urban and Local Government Strategy, The World Bank Infrastructure Group Urban Development, 2000.

Delhi, India Metro Area Population 1950-2021. Retrieved from https://www.macrotrends.net/cities/21228/delhi/population

DHASMANA, I, October 14, Covid-19 impact: India's GDP may contract 10.3% in FY21, says IMF, Business Standard 2020. Retrieved from https://www.business-standard.com/article/economy-policy/imf-scales-up-india-s-gdp-contraction-to-10-3-from-4-5-for-fy21-120101301086_1.html

Encyclopaedia Britannica, Garden city. Retrieved from https://www.britannica.com/topic/garden-city-urban-planning
Express Web Desk, , Bird flu outbreak in four states, Centre issues advisory to contain spread. The Indian Express, New Delhi, 2021 January 6. Retrieved from https://indianexpress.com/article/india/bird-flu-india-rajasthan-kerala-7135498/
Histroy.com, Yellow fever breaks out in Philadelphia, 1793. Retrieved from https://www.history.com/this-day-in-history/yellow-fever-breaks-out-in-philadelphia
India continues saving lives and loverhood recording more COVID-19 recoveries while lifting restrictions. Retrieved from https://www.who.int/india/emergencies/coronavirus-disease-(covid-19)
Mayor of London, February, 2020 London City Resilience Strategy 2020, London Greater London Authority.
Mumbai, India Metro Area Population 1950-2021. Retrieved from https://www.macrotrends.net/cities/21206/mumbai/population
Leo, L. (2020 January 29), How Surat fought an epidemic 26 year ago. Mint. Retrieved from https://www.livemint.com/news/india/how-surat-fought-an-epidemic-26-years-ago-11580229286908.html
Perry, C.A. et al., Neighbourhood and community planning: Regional plan of New York and its environs, New York1929.
RAUT S.R.; Raut, P. B., Smart Sustainable E-Solutions for Implementation and Enforcement of Smart Cities in India. REAL CORP 2016 Proceedings/ Tagungsband. ISBN 978-3-9504173-0-2 (CD), 978-3-9504173-1-9 (print).
RAUT, S.K. and Raut P.B., Implementation Challenges for Establishing Smart Urban Information and Knowledge Management System. Sustainable Smart Cities in India: Challenges and Future Perspectives, Ed. SHARMA P. and Rajput S., Springer, pp. 59-72.
Report on National Mission on Sustainable Habitat (Climate Change), Ministry of Urban Development, Government of India, 2008.
Statista.com, Estimated quarterly impact from the coronavirus (COVID-19) on India's GDP growth in financial year 2020 and 2021. Retrieved from https://www.statista.com/statistics/1103120/india-estimated-impact-on-gdp-growth-by-coronavirus-epidemic/
The New York Times, 7 Dead of Cholera In Naples, pp12, 1973. Retrieved from https://www.nytimes.com/1973/08/30/archives/7-dead-of-cholera-in-naples-italyacts-to-prevent-spread.
Wilhelm Krull, Debates on Issues of Our Common Future, Eight Symposia of the Volkswagen Foundation, 2000.
Wikipedia.org, Broad Street Cholera outbreak, 1854. Retrieved from https://en.wikipedia.org/wiki/1854_Broad_Street_cholera_outbreak#
Wikipedia.org, Spanish Flu. Retrieved from https://en.wikipedia.org/wiki/Spanish_flu
Wikipedia.org, 2002-2004 SARS outbreak. Retrieved from https://en.wikipedia.org/wiki/2002%E2%80%932004_SARS_outbreak
Wikipedia.org, Global spread of H5N1, Retrieved from https://en.wikipedia.org/wiki/Global_spread_of_H5N1
Wikipedia.org, Le Corbusier. Retrieved from https://en.wikipedia.org/wiki/Le_Corbusier
Wikipedia.org, Happy City, Retrieved from https://en.wikipedia.org/wiki/Happy_City
Wikipedia.org, CIVID-19 Pandemic in India, Retrieved from https://en.wikipedia.org/wiki/COVID-19_pandemic_in_India
World Bank, Global Economic Prospects, June 2020, World Bank, Washington, DC, USA, 2020.
World Health Organisation, Strengthening Preparedness for COVID-19 in Cities and Urban Settings: Interim Guidance for Local Authorities. Geneva, 2020. Retrieved from https://www.WHO/2019-nCov/Urban_preparedness/2020.1
WHO Interactive Timeline. Retrieved from https://www.who.int/emergencies/diseases/novel-coronavirus-2019/interactive-timeline

🏆 *reviewed paper*

Mobile Territories as a New Unexplored Layer towards Sustainable Mobility: the Case of Istanbul 1850-2022

Esin Ekizoglu

(Phd Candidate in Architecture, Dipl. Architect, Esin Ekizoglu, University of Paris, Ensa Paris Val de Seine, Laboratory EVCAU, Laboratory ICT, 3 Quai Panhard et Levassor, 75013 Paris, esin.ekizoglu@paris-valdeseine.archi.fr)

1 ABSTRACT

Everyone is enveloped by a “bubble” of information that accompanies them in the urban space of the 21st century. Each one is equipped with an individualised technical object, manages his/her own information bubble. These objects and information bubbles act as tools for socio-spatial reading of territories thanks to the Internet of Things.

We have sought to launch a reflection on the cartographic reading of mobility in territories via mobile technical objects. This paper proposes to deepen this reflection according to a cartographic methodology around the case of Istanbul: how the global technical knowledge transformed into a technical object is assimilated to the logic of the axes of mobility, makes it possible to read the transformation of Istanbul. According to this logic, what scenarios of sustainable urban mobility systems are possible for Istanbul in the future?

We hypothesised that technical objects could lead us to the development of mobile territories. These moving territories would allow us to map the sustainable mobility networks of the future and would constitute a continuity with those of the past.

Our results showed that non-visible factors such as digital traces of individualised technical objects create mobile territories. These territories are like a tool to better understand the organism of the city with its inhabitants as urban designers over time.

Keywords: Istanbul, mobile territories, individualized technical objects, mobility systems, transportation

2 INTRODUCTION

The integration of geolocated information with the Internet of Things opens the way to understanding the physical territory and its current modes of mobility. The connectivity obtained thanks to the Internet becomes a defining characteristic of the urban condition of the 21st century. (Mitchell, 2003, p.11) When this connectivity is considered as a tool to understand the movements of populations, the design and the management of urban areas can allow us to realise the invisible layers of physical territories that form "urban dark matter". (Malleson et al., 2018, p.616) If these layers are related to the modes of mobility existing in the territories, they are transformed "into keys for territorial readings". Their otherwise unpredictable history certainly appears and communicates with the future of 21st century cities.

As André Corboz says, the territory is not a given but results from various processes. (Corboz, 1983, p.14) The human interventions that are part of it do not represent the totality of the process. Our interest in the various modes of use of the travel networks of the citizens of the city of Istanbul will guide us throughout our work. While knowing that the physical, mobile and connected bodies of citizens form new territories, the different modes of travel chosen by these citizens will be closely examined following a remote reading via the study of their physically invisible and digital traces. (de Souza e Silva and Sutko, 2019; Licoppe, 2017, p.122)

3 STATE OF `THE ART

We assume that in our study, it is important to be aware of the mobility systems of the city of Istanbul that bring us to the basics of the city's travel networks. We know that the urban spaces of Istanbul drawn by these travel networks have undergone several metamorphoses over time until 2022. The links between the networks, the ways of moving over short distances and the transport systems on the major infrastructures are studied in this transformed context. (Lévy, 2001, p.20) First of all, our readings of the traces of individual technical objects need above all the pivotal elements of the history of the movements of the physical bodies of the citizens of the city. Then it is possible to link the history of the structuring axes of Istanbul's mobility systems to the traces of new individual technical objects used by their citizens.

3.1 Getting around in Istanbul: structuring axes between 1839 and 1988

Three events have marked the history of Istanbul mobility systems. The first is the beginning of a regular steam ferry service since the mid-1850s, the second is the establishment of rail transport systems such as streetcars, tunnels (as part of the system) and commuter trains in the 1870s. The last is the operation of a large electric tram system in 1914. (Tekeli, 2010, p.23)

These three mobility systems did not appear suddenly. There was a whole series of events that marked the history of urban mobility in Istanbul and allowed it to evolve.

We can briefly look at the great waves that have shaped Istanbul's current mobility systems by analysing them in three phases. The first driving wave began with the Tanzimats (“reorganisation” in Ottoman Turkish was an era of reforms in the Ottoman Empire) in 1839, the second in the 1930s with the appearance of new master plans and the last in the 1950s with the significant urban expansion of the Istanbul conurbation.

Concerning the first wave which begins with the modernisations of the Tanzimats in 1839 and which ends in 1908, it is important to underline that the aim was to develop an urban imaginary based on Western culture and technology. (Çelik, 1986, p.135; Dupont and Mayeur-Jaouen, 2016, p.59) Even if the design and reconstruction projects had not achieved the ambitious objectives of the managers, permanent changes to the urban fabric were recorded. (Çelik, 1986, p.213) In addition, these modifications formed the basis of the current structuring lines of mobility. If we look at the master plan proposed by Helmuth von Moltke, we can see that his desire to think of the city as a set of coherent elements resulted in several projects that still exist today.

The second wave in the 1930s, after the establishment of the Republic of Turkey, was marked by the master plans of consultants of French and German origin. The recommendations of Agache, Elgötze and Lambert in areas such as growth, integration, historic preservation and the creation of regions have not been implemented, but their reports have survived to our days. It was also at that time that Henri Prost's recommendations played a vital role. Seeing the population grow rapidly, he decided to develop an underground metropolitan network project. (Angel, 1993) His projects related to this underground network for Istanbul are still relevant. (Çelik, 1986, p.217)

The third and last wave which drew the city of Istanbul and which draws it currently began with the Nedeco report in October 1951. The technical assistance office Nedeco of the Netherlands presented a survey on the question of navigation in Istanbul. The proposal was presented as a metropolitan project limited to both sides of Haliç (Golden Horn) and sought to solve mobility problems. The report was based on the guidelines of Henri Prost's plan. (Witteveen & G.S. Bos, 1951; Çelik, 1986, p.217) On the other hand, in the second half of the 20th century, it was the Turkish urban architects who dealt directly with the urban problems of Istanbul. In 1961, the Municipality of Istanbul formed a new planning office which had the task of studying a metropolitan master plan from Tekirdag to Gebze-Izmit for a maximum period of 20 years. (Angel, 1993) Between 1961 and 1988 the municipalities tried to find solutions with soft mobility systems in order to satisfy the needs of the inhabitants of Istanbul. They focused mainly on city planning through bus lines. However, these solutions were not satisfactory for a city that kept growing. A new page has opened for the city with “Metro İstanbul” which was established in 1988 by the Istanbul Metropolitan Municipality to operate urban rail systems.

3.2 Crossing the Bosphorus: users in action

The start of a regular steam ferry service made it possible to cross the Bosphorus with public transport in the mid-1850s for the very first time. It is the foundation of “Boğaziçi Şirket-i Hayriye” (Ahmed Ihsanet and Partners, 1914) which managed this transport network. (Orhanlu, 1966, p.109) Before the mid-1850s the attention of urban planners of the time was rather focused on the structure of the Ottoman capital between the more traditional side of Istanbul and that of Galata (Fig.1). It was Haliç (the Golden Horn) which was more central to the territorial occupations.

The second major step for the direct crossing of the Bosphorus is long after the founding of the Republic of Turkey. The opening of the Bosphorus Bridge and its peripheral boulevards on October 29, 1973 began this second phase which leads us to the territorial issues of today. The European part (Beyoğlu at the time) and the Asian part of the city were attached to each other by a fast road connection with a strong structuring axis. (Tekeli, 2010, p.66) We can say that it was from then on that the citizens of Istanbul faced more than one

choice of public transport to cross the Bosphorus. In terms of urban planning, from then on it was easier to visit the Asian side of Istanbul. The creation of this very first large-scale infrastructure paved the way for the construction of today's major surface and underground railway projects.

Many researchers are interested in multimodal transport systems around the theme of morphological transformations in history and the major infrastructure axes of Istanbul. (Dökmeci and Berköz, 1994, p. 189; Yazgi and Dökmeci, 2006 Ozus et al. 2011, p.331; Kırmızı and Çalışkan, 2012; Kolcu and Dökmeci, 2013, p. 477) It is nevertheless rarer to find research that focuses on the inhabitants of Istanbul and their ways of living and travelling via existing infrastructures in order to establish better proposals for future mobility systems. These studies are very often either in the form of surveys carried out among citizens (Tuna et al., 2014), or in the form of observations of the use of infrastructures, for the understanding of its use by the inhabitants.(Ilicali et al., 2014, p. 413)

4 STUDY SET UP: MOBILE TECHNICAL OBJECTS AND CARTOGRAPHIC APPROACH

According to the cartographic approach that we have implemented, we have mainly examined the physical movements of the inhabitants of Istanbul recorded digitally via the individual technical objects. Bringing new images obtained through technical objects into dialogue, deducing representations and finally providing reproducible solutions (Mortamais, 2018) to travel problems are at the heart of the implementation of the study.

Our study was developed in two phases. During the first phase, we compared the visual and perceptible characteristics of the geolocated data of the Istanbul megalopolis from 2007 to 2022. These data were obtained and studied via the users of the OpenStreetMap website who freely shared the traffic data of their individual technical objects (Smartphone and/or laptop and/or navigation assistant) and who have used the city's public transport. Usually, when internet users uploaded and shared their GPS tracks on the OpenStreetMap site, most of them also tagged their GPS tracks with text descriptions, such as movement type, date or other relevant information. on the GPS traces. (Li, 2014, p.69) We only studied the traces whose additional information was relevant.

For the realisation of the first phase, we limited ourselves to a work area of 115 km2 which is centered on the Galata and Kadiköy districts as well as the historic peninsula of Istanbul (Fig.1). We retained 144 journeys in total for our investigation. We studied journeys that included at least two different modes of transport. This is why we have studied 108 journeys in detail. We have also eliminated the different journeys of the same person. We eliminated 35 journeys because these routes belonged to the 9 people who had already shared their journeys. Finally, we selected 73 journeys, 18 of which were experienced and shared after the Covid-19 health crisis.

The second phase of the study was dedicated to a chronological work on the development of the city's mobility infrastructures (1850-2022). The two phases were studied together simultaneously. The logics of infrastructure development strategy before the new communication and information technologies were confronted with those after them.

Fig.1: The territorial area studied as part of the research in the megalopolis of Istanbul.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

5 RESULTS

5.1 "Momentary appearances" as a new research approach

We found that the "images produced through the intermediary of the individual technical objects" that we had hypothetically identified are visible in the form of "momentary appearances". (Sontag and Blanchard, 2008, p. 217) Ephemeral appearances give rise to the results obtained thanks to technical objects as partners in scientific exploration. The results belong to the citizens of the city.

Our investigation is accomplished using the free software QGIS. Reading the traces of the routes allowed us to understand that 50% of the journeys shared on OpenStreetMap for our study area between 2007 and 2022 belonged to tourists. Among the journeys studied, the most used mode of transport was travelling by car (28% of journeys). The second most used mode of transport was tram/metro/train (24.6% including 17.8% tram and metro; 6.8% train). The bus followed the tram/metro/train just after (15%). Ferry use followed bus (13.6%) with bicycle (2.7%) and plane (2.7%) travel. (Figs. 2 and 3).

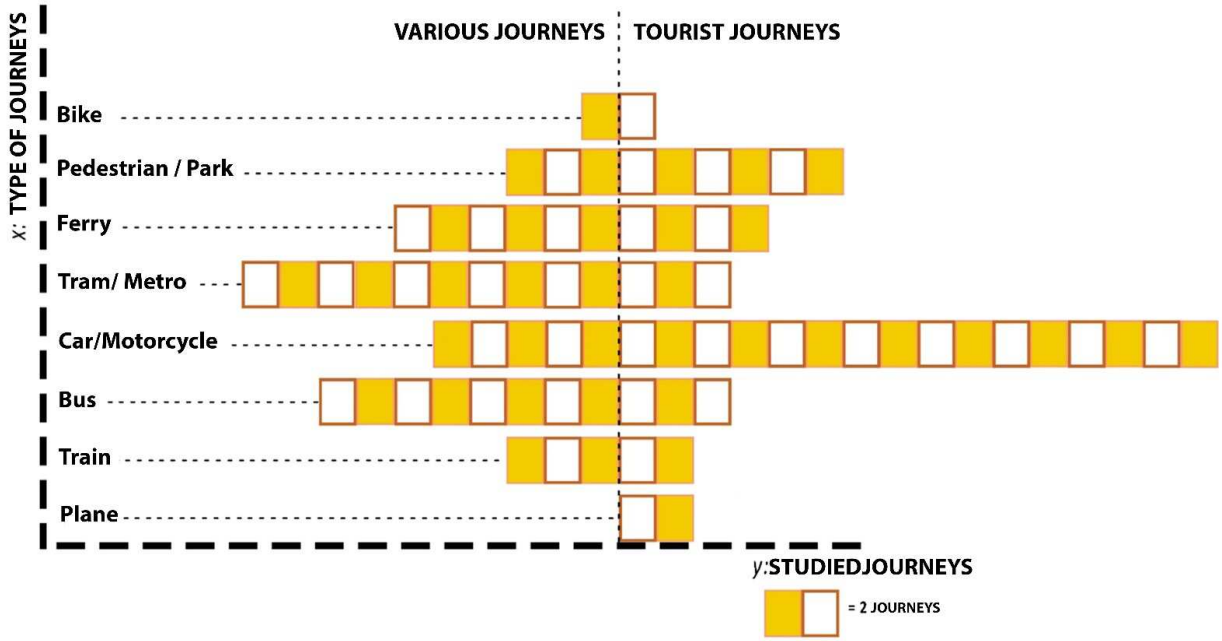


Fig. 2: The nature of the journeys shared by citizens by theme and by nature studied in 2022.

The combinations in the modes of transport are very clear when we read the journeys. Among these most interesting journeys were those made by ferry, tram/metro, car and at the same time on foot (Fig.3). The follow-up of these journeys showed us the territorial nodes taken by the citizens. We have seen that these nodes were not always marked by the presence of stops (tram bus stops, etc.). Some pedestrian behaviours were repetitive and contributed to node morphologies.

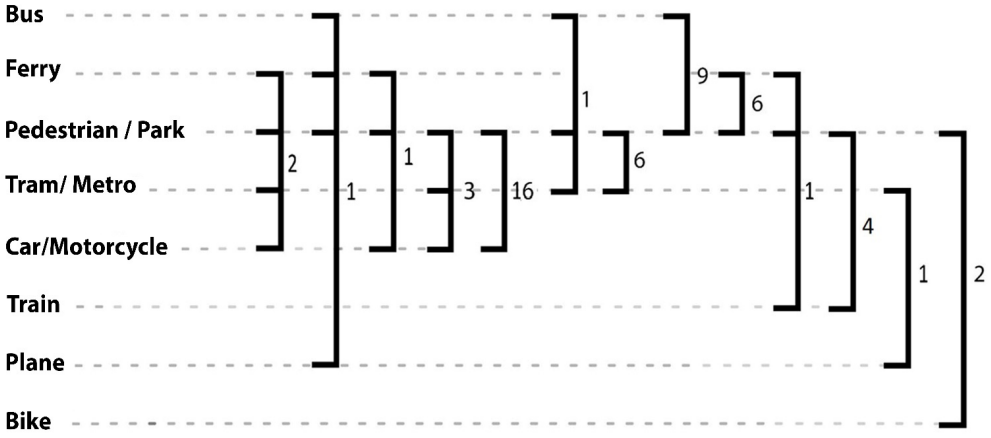


Fig. 3: The nature of the journeys chosen by citizens.

We distinguish many pedestrian journeys (a total of 52 journeys). We counted all the pedestrian journeys whatever their importance/percentage in a single path. Figure 2 shows the qualitatively correct number of pedestrian journeys (9 journeys); these journeys are marked mainly by walking.

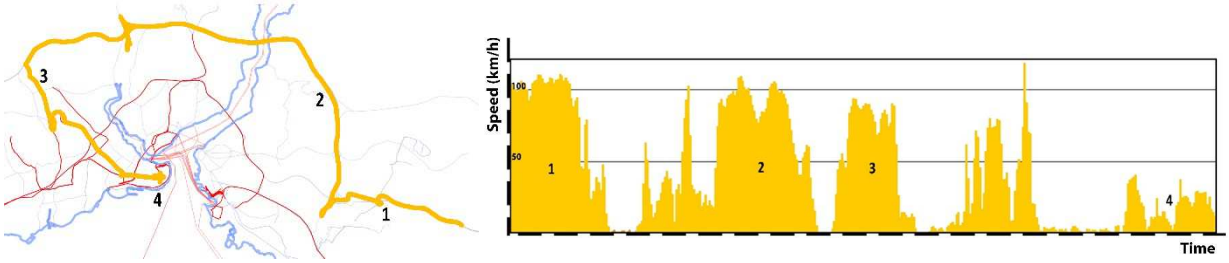


Fig. 4: Example of a journey recorded in OpenStreetMap in 2012.

In the example above we can understand that the trip is made by car. The arrival in the Istanbul conurbation is marked by a drop in speed (1). There are some obstacles inside the agglomeration (2,3). The destination – the historic peninsula of Istanbul – (4) is reached by bypassing the city to the north.

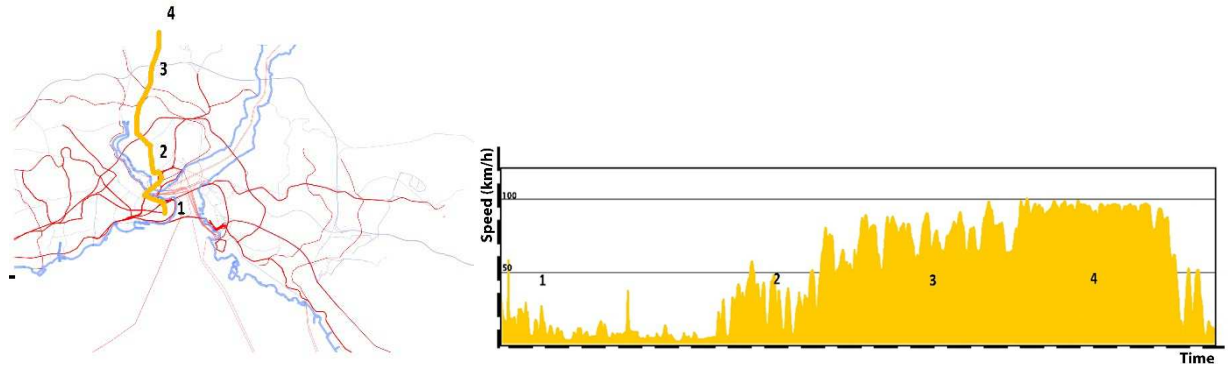


Fig. 5: Example of a journey recorded in OpenStreetMap in 2019.

In the example above we can understand that the journey is made by car and by bus. The person in motion departs from the historic centre, more specifically from Topkapi, for the new Istanbul airport which is inaugurated on October 29, 2018. The arrival in the peri-urban area of Istanbul is marked by an increase in speed (1 -2-3 -4). The moving person takes the bus to go to the airport there are some stops we can read them thanks to the speed-time graph (2).

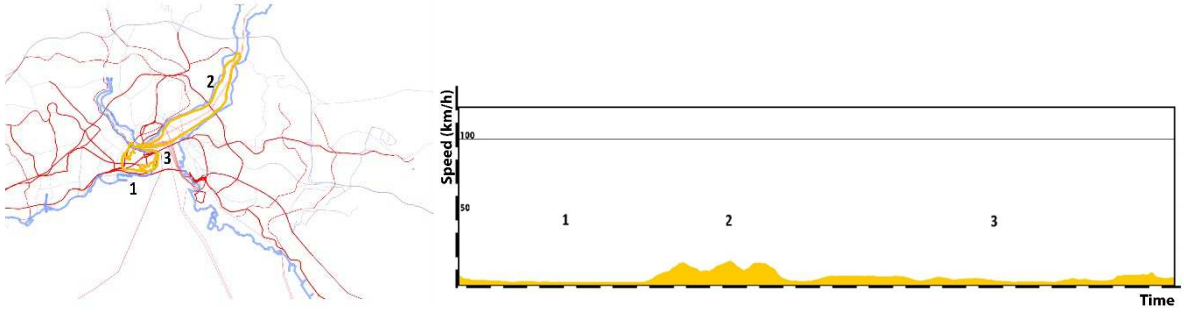


Fig.6: Example of a journey recorded in OpenStreetMap in 2019.

In the example above we can understand that the journey is made on foot (1-3) and by ferry (2). The moving person leaves from the historic centre, more specifically from the Eminönü pier, to walk and then by boat along the Bosphorus (2). As a whole, it is a tourist journey that took place in 2019 before the Covid-19 health crisis. The person who records his journey returns to Eminönü by ferry, then moves to his starting point on foot in the historic district of the megalopolis (3).

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

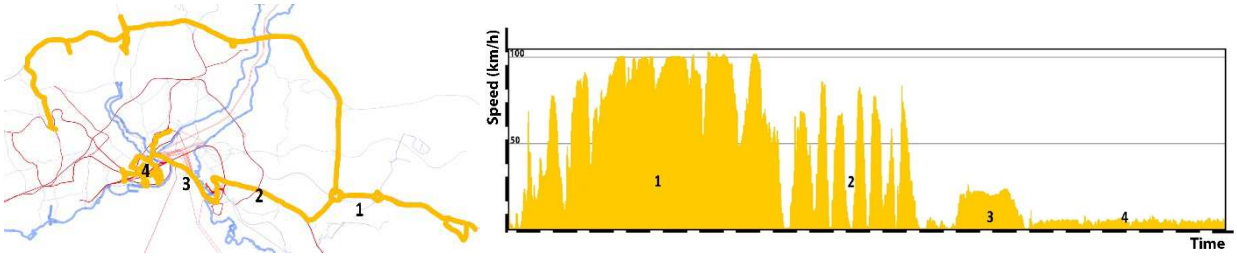


Fig. 7: Example of a journey recorded in OpenStreetMap in 2015.

In the example above, an extract from a trip of several days focused on Istanbul, we can understand that the first part of the journey is made by car (1) then by metro (2- line M4 Kadıköy-Tavşantepe inaugurated at the end of 2012), by ferry (3) and on foot (4). The trip to the south is achieved in a way thanks to the opening of the M4 metro at the end of 2012. It is a journey of several days made in 2015.

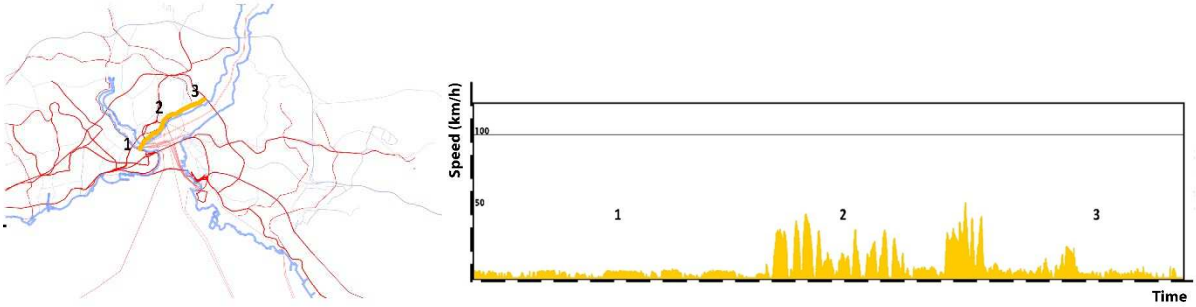


Fig. 8: Example of a journey recorded in OpenStreetMap in 2022.

The example above is very recently recorded on the OpenStreetMap free sharing platform. We can understand that the journey is pedestrian (1-3) and made by tram, via the T1 (2). The moving person starts from the historic centre on foot, more specifically from Karaköy. Then it continues along the Bosphorus using the tram to Kabatas. This mobility system, as a network, is not continuous. We presume that this is why the person making the journey continues his/her journey on foot (3) after getting off at the Kabatas stop. We are sure that the person took the tram, because the georeferenced plot of his journey and the speed-time relations of the graph coincide with the plot of the T1 tram and the number of stops where the speed of the person in question is 0 km/h (2).

5.2 Research, an urban look before and after Covid-19

The Covid-19 health crisis has marked a cultural break in all areas of urban life. This break was visible in our results. From March 2019 to January 2022, downloads of journeys on OpenStreetMap decreased. Regarding the megalopolis of Istanbul, we studied 18 journeys after the health crisis (in our studied territorial area which is 115 km2). The crisis has drastically changed the data obtained. Among the producers of the 18 journeys there are very few tourists (only 3 journeys). We see an increase in trips made by tram/metro.

Figure 3, which shows “the nature of the routes chosen by citizens. by theme and by nature in 2022" was drawn like Figure 9 in 2019 (March data): 54.6% (compared to 50% between 2007-2022) of shared journeys on OpenStreetMap in the study area between 2007 and 2019 belonged to tourists. Among the journeys studied, the most used mode of transport was travel by car (48.6% of journeys compared to 28% between 2007-2022). The second most used mode of transport was the bus (28.6% of trips compared to 15% between 2007-2022). The ferry followed the bus just after (22.9% against 13.6% between 2007-2022). The use of metro/tramway and train came last (8.6% of metro and tram journeys and 5.7% of train journeys compared to 17.8% tram and metro; 6.8% train between 2007-2022) with cycling (1.8% of trips compared to 2.7% between 2007-2022).

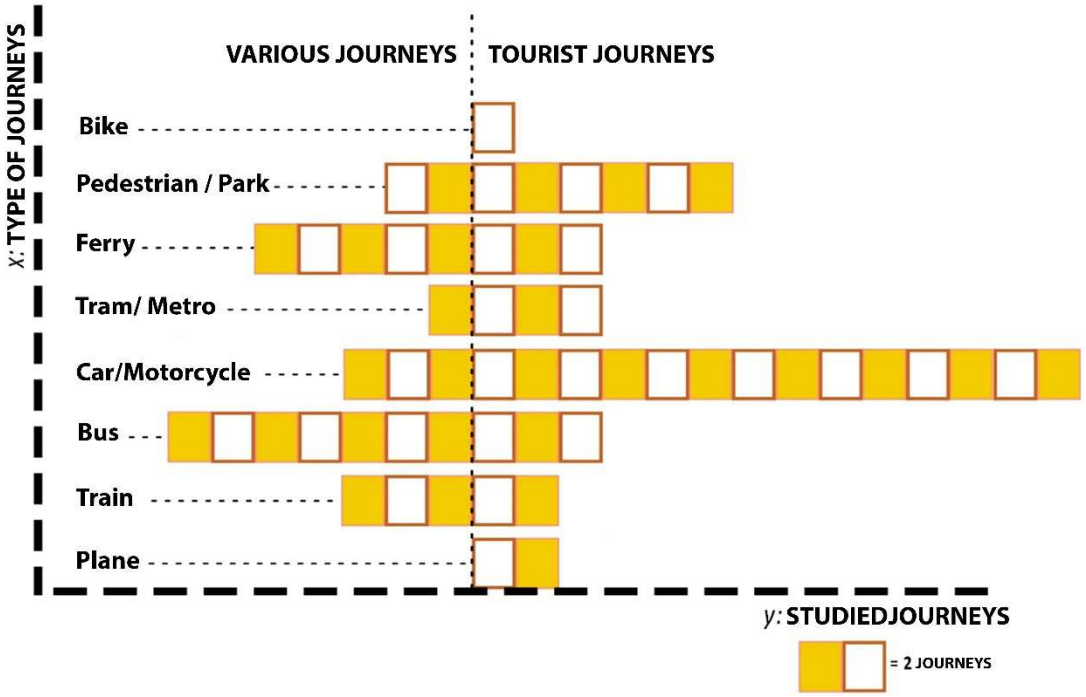


Fig. 9: The nature of the journeys chosen by citizens. by theme and by nature studied in 2019.

Before the health crisis, it was possible to find “test” journeys where the ownver of the journey wrote comments before sharing it. With Covid-19, several walking journeys with specific comments have been uploaded to the OpenStreetMap platform. These comments were no longer intended to carry out essays but to make critiques of the urban space. The profile of the designers was also different. We studied 3 critical journeys of urban morphology between March 2019-January 2022. The journey “K_pr__olsayd_.gpx 2020” which was downloaded on August 6, 2020 at 7:32 p.m. particularly caught our attention. From the title, which means “if there had only been a bridge”, the designer criticised the urban space and showed his disappointment with the planning. He had to bypass “Kurbagali Dere” to be able to cross it. (Fig.10)

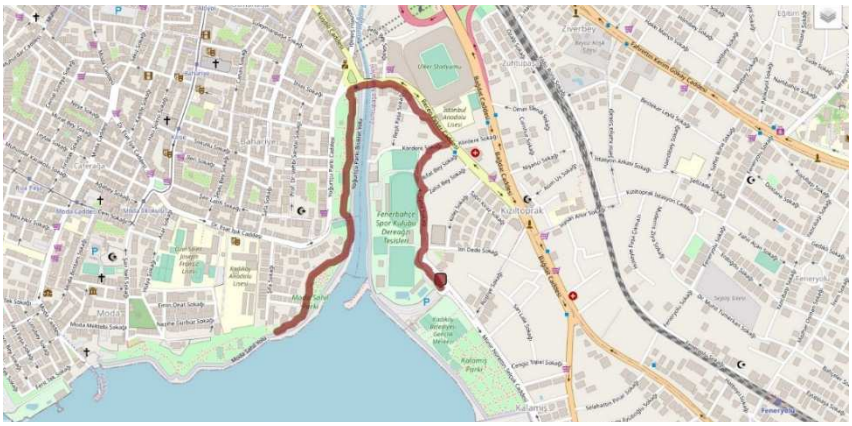


Fig. 10: Example of a citizen's critique of urban space. using OpenStreetMap.

Following our analyses of geolocated traces, we see that from 2009 the territorial goal is to have continuity in the layout of public transport axes. These traces superimposed on the major axes of infrastructure remind us of the master plan proposed by Helmuth von Moltke. Parallel connections between the Asian side and the European side of Istanbul increase by 150% in just 8 years. The arrival of Marmaray in 2013 (the railway linking, partly underground, the Istanbul districts of Fatih and Üsküdar across the Bosphorus), already predicted by Strom, Lindman and Hilliker in 1902, can also be considered as a major change in the history of the Istanbul conurbation (Fig.11). The stages of development of travel networks are organised and designed according to the different rail and road type mobility systems which essentially require material and financial resources. (Fig.11, Fig.12)

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

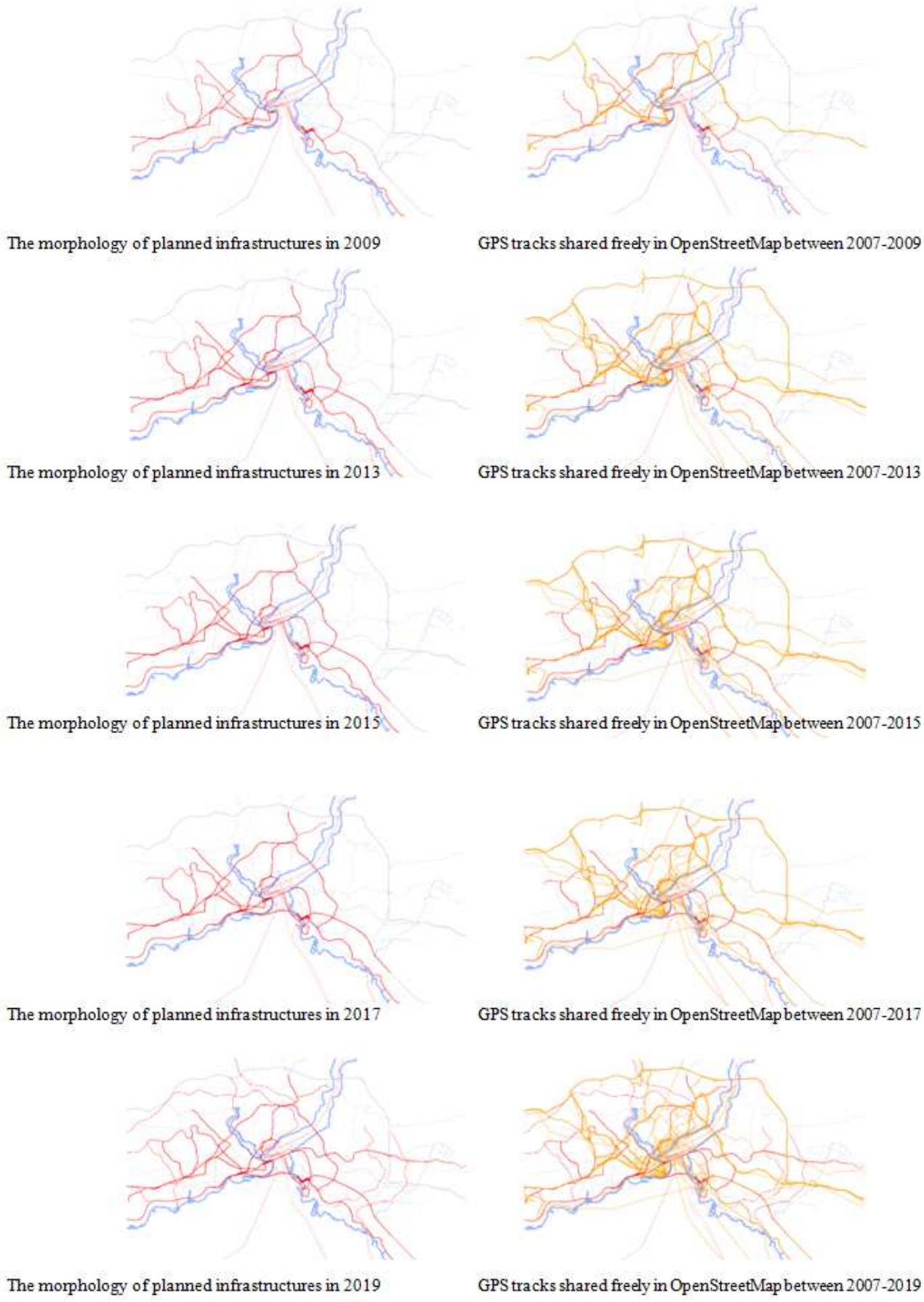


Fig. 11: The chronological development of the development of mobility infrastructures in the megalopolis of Istanbul with the superposition of traces of shared journeys on OSM. The infrastructure plan (red lines) includes networks such as metro, tram, train and primary road axes. Tracks shared on Openstreetmap are yellow.

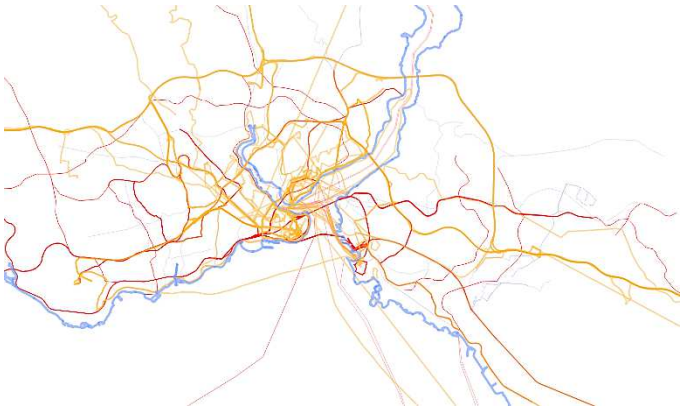


Fig. 12: GPS tracks shared freely in OpenStreetMap between 2007-January 2022.

The authors of these traces, passing through the territorial area that we have studied, use at least two means of transport.

6 DISCUSSION: WHICH SCENARIOS FOR TOMORROW?

With the Tanzimats which began in 1839, the aim of planners was to link the two sides of the Golden Horn. Today's urban issues are located on both sides of the Bosphorus. According to the results of our study, we understand that there is a real difficulty in crossing the Bosphorus. However, it has great potential. Increasing the parallel connections between the two sides is a solution (Fig. 13: a, b, c, 2, 3). In addition, the traces studied by the inhabitants have shown us that it is also necessary to sew these parallel links with radiating structuring axes of mobility (Fig. 13: 1, 4, 5). In the figures below, plots a, b and c refer to bridges and peripheral boulevards which are in a situation of formation and reinforcement. Line 1 is Metro 4 inaugurated in 2012. Line 2 is Marmaray inaugurated in 2013. Line 3 is Avrasya Tunnel inaugurated in 2016. Line 4 is Metro 5 inaugurated in late 2017. Line 5 is the tramway 5 which is currently in development. Lines 6 and 7 represent the axes of recent developments started to develop with the new Istanbul airport. (Fig.5) When we look at the traces shared between 2007 and 2022 we understand that the importance of these axes (1, 2, 3, 4 and 5) is already underlined by the choices in the movements of the inhabitants of Istanbul (Fig. 13). Axes 6 and 7 seem to be a response from local actors to allow users to move freely in a logic of radiant movement.

The actors of the urban space manage, at a certain moment, to understand the needs of the users. However, having studied some journeys in detail (like the one from 2015, Fig.7), we understand that they underestimate the potential of soft journeys. We believe that thinking about the city of the future with soft travel has the ability to allow the megalopolis of Istanbul a better future. Designing small interventions, in the form of intermodality, taking into account the importance of soft mobility systems along both sides of the Bosphorus can certainly meet a part of the needs of users (densification of the network for example). The potential of the Bosphorus can be exploited by considering water as a unifying element and not a physical limit. It should be thought of as a centre of natural and gentle linear intermodality.

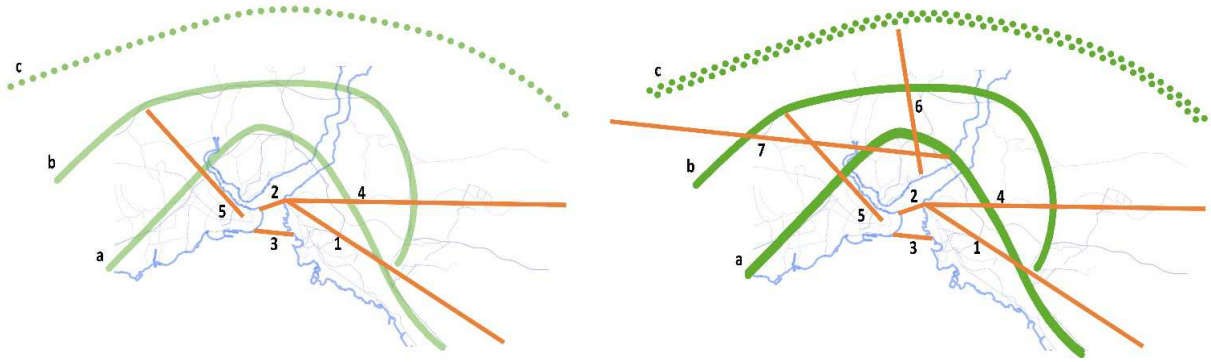


Fig. 13: The two stages of the axes of development of the agglomeration of the city of Istanbul.The first stage corresponds to 2017 and the second to 2023.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

7 CONCLUSION: "SOFT" DISTANCES TOWARDS INTELLIGENT MODELING AND OPTIMISATION

Non-visible urban factors such as digital traces of individualised technical objects create territories of mobility. These territories can be understood as a tool to better understand the organisation of the city with its inhabitants as urban designers.

In the case of Istanbul, more than 150 years have passed since the creation of the Tanzimats. During this long period, the city's transport network has developed, new roads and squares have been designed. Today's Istanbul has spread over a very large area. This city is now accompanied by new information and communication technologies (NICT). In addition to the internal and rich functioning of this city, the digital traces of the inhabitants also seem to bring new knowledge about the territory in which Istanbul is inserted as well as new ideas to design other elements of mobility.

A new field of possibilities has opened up through the use of the individual technical object (Porada, 1993; Hatchuel, 2006). The new use has diverted the function of these objects by making them "everyday tools" for city users. Used in a collaborative and open-access way, these tools are certainly affecting the work of designers.

8 REFERENCES

ARON, Aron. Henri Prost ve Istanbul'un ilk nazım planı, Planlama, Ankara 93/1-4, 1993.

ÇELIK, Zeynep. The remaking of İstanbul: Portrait of an Ottoman city in the nineteenth century. Seattle: University of Washington Press, 1986.

CORBOZ, André. Le territoire comme palimpseste. Diogène, p. 14-3, 1983.

DE SOUZA e SILVA, Adriana; SHELLER, Mimi. Mobility and locative media. Mobile communication in hybrid spaces. London: Routledge, 2014.

DE SOUZA e SILVA Adriana; SUTKO, Daniel. Digital cityscapes. New York: Peter Lang, 2009.

DUPONT, Anne-Laure and MAYEUR-JAOUEN, Catherine Verdeil Chantal, Histoire du Moyen-Orient: du XIXe siècle à nos jours, Paris : Armand Colin, p.59, 2016.

DÖKMECI, VEDIA AND BERKÖZ, LALE. TRANSFORMATION OF ISTANBUL FROM A MONOCENTRIC TO A POLYCENTRIC CITY. EUROPEAN PLANNING STUDIES, VOL. 2, NO 2, 1994.

ILICALI Mustafa et al. Multimodal transportation issues in Istanbul: A case study for traffic redistribution due to long span bridge rehabilitation. Advanced Materials Research, vol. 831, p. 413 417, 2013.

KIRMIZI, Zikrullah and TUNALI ÇALISKAN Fehime. İstanbul ulaşım zaman dizini. İstanbul: Cinius Yayınları, 2012.

KOLCU, Ismail Hakan and DÖKMECI, Vedia. Analysis of factors impacting land use in transforming Istanbul historical city center. International Journal of Electronics, Mechanical and Mechatronics Engineering (IJEMME). Vol. 3, no 1, 2013.

LEVY, Pierre. Qu'est-ce que le virtuel ? Paris : Ed. La Découverte, 2001.

LI, Xun. Using complexity measures of movement for automatically detecting movement types of unknown GPS trajectories. American Journal of Geographic Information System. 3(2): 63-74, 2014.

LICOPPE, Christian. Mobilités et rencontres dans les espaces publics urbains à l'âge des médias positionnels, coutures, plis et rencontres avec des « inconnus pseudonymes ». La découverte/Réseaux. N° 200, pp. 117-143, 2016.

MALLESON, Nick et al. The characteristics of asymmetric pedestrian behaviour: A preliminary study using passive smartphone location data. Transactions in GIS; 22: 616–634, 2018.

MITCHELL, William J. Me++, The Cyborg self and the networked city. Cambridge: the MIT Press, 2004.

MORTAMAIS, Elizabeth. Objectivités, autour du livre de Lorraine Daston et Peter Galison. Séminaire ACN (Architecture et Culture Numérique), De l'Objectivité et du digital, Production des données et conceptions numériques, 21november, 2018.

OZUS, Evren; TURK, Sevkiye and DÖKMECI Vedia. Urban restructuring of Istanbul. European Planning Studies, vol. 19, no 2, 2011.

SONTAG, Susan. Sur la photographie, œuvres complètes I, 1973, Villeneuve-d'Ascq, 2008.

TEKELI, İlhan. İstanbul ve Ankara için kent içi ulaşım tarihi yazıları, 1. baskı, Eminönü, Istanbul: Tarih Vakfı Yurt Yayınları, (İlhan Tekeli toplu eserler, 9), p.23, 2010.

TUNA, O., Tanla B., Uzel E. et al. A research on traffic trends in urban transport: the case of province of Istanbul, Transist 7ème Symposium et salon international sur les technologies de transport 19 - 20 décember, Istanbul Congress Center, 2014.

WITTEVEEN, W.G. & Bos G.S. (1951). Le problème de la circulation au centre de la ville d'Istanbul, Etude préliminaire, deventer: bureau d'études néerlandais pour travaux d'ingénieurs à l'étranger NEDECO.

YAZGI, Burçin and DÖKMECI, Vedia. Analysis of different urban forms in Istanbul. In ERSA conference papers, European Regional Science Association, 2006.

🏆 *reviewed paper*

Mobilstationen als Stadtbaustein der Energie- und Verkehrswende

Christian Larisch, Jannik Wendorff, Maximilian Birk, Sarah Hermens

(Christian Larisch, M.Sc, RWTH Aachen University - Lehrstuhl und Institut für Städtebau, larisch@staedtebau.rwh-aachen.de)
(Jannik Wendorff M.Sc, RWTH Aachen University - Lehrstuhl und Institut für Städtebau, wendorff@staedtebau.rwh-aachen.de)
(Maximilian Birk, M.Eng., RWTH Aachen University - Lehrstuhl und Institut für Städtebau, birk@staedtebau.rwh-aachen.de)
(Sarah Hermens, M.Sc., RWTH Aachen University - Lehrstuhl und Institut für Städtebau, hermens@staedtebau.rwh-aachen.de)

1 ABSTRACT

Der Klimawandel und die darauf reagierenden Klimaschutzziele bedingen notwendige Transformationsprozesse in allen gesellschaftlichen und technologischen Bereichen. Die Sektoren Energie und Mobilität sind aufgrund ihres signifikanten Anteils an den Treibhausgasemissionen bei der Transformation hin zu einer nachhaltigen Lebens- und Produktionsweise von herausragender Bedeutung.

Die flächendeckende Transition des Energienetztes, beispielweise von einem Wechselstrom- hin zu einem effizienteren Gleichstromsystem, ist eine enorme Herausforderung auf vielen Ebenen. Es gilt Nischen zu finden, in denen sich neue Strukturen etablieren und als Vorreiter hin zu einer breiteren Verwendung von Gleichstromsystemen dienen können. Ladeinfrastruktur für E-Mobilität, deren flächendeckender Ausbau aufgrund des stetigen Zuwachs von E-Mobilitätsangeboten breit forciert wird, würde durch signifikante Effizienzgewinne im besonderen Maße von einer direkten Gleichstromversorgung profitieren und sich somit als eine solche Nische zur experimentellen Umsetzung von Gleichstrominfrastrukturen auf Quartiersebene anbieten.

Die notwendigen Eingriffe in das Mobilitäts- und Energiesystem haben dabei tiefgreifende Auswirkungen auf den urbanen Raum. Infrastrukturelle Transformationsprozesse werden als Bestandteil der Stadtplanung trotzdem selten proaktiv aufgenommen und integrativ gestaltet. Besonders vor dem Hintergrund der stetigen Zunahme der Flächenkonkurrenz im öffentlichen Raum und teils fehlender gesellschaftlicher Akzeptanz neuer Technologien, eröffnet die Berücksichtigung städtebaulicher und gestalterischer Aspekte ein vielversprechendes Werkzeug Transitionsprozesse gesellschaftlich akzeptiert und mehrwertstiftend umzusetzen sowie gleichzeitig die Qualitäten des öffentlichen Raums zu erhöhen.

Dieser Beitrag diskutiert die Potenziale und Synergien der Kombination von Ortsnetzstationen mit Ladeinfrastrukturen im Kontext von Mobilstationen. Durch wegfallende Umwandlungsprozesse von Gleich- zu Wechselstrom können Energieverluste minimiert werden. Diese Effizienzsteigerungen können – nicht nur vor dem Hintergrund aktuell stark steigender Energiepreise – in Mobilstationen gebündelt einen wertvollen Beitrag zur nachhaltigeren Ausgestaltung des Mobilitätssytems leisten. Mobilstationen sind hierbei als mögliche Keimzellen der Transition des Energie- und Mobilitätssystems zu verstehen und können durch eine entsprechende baukulturelle Ausgestaltung und Integration auch städtebauliche Mehrwerte generieren.

Keywords: Infrastruktur, Verkehrswende, öffentlicher Raum, Energiewende, Mobilstation

2 HERAUSFORDERUNGEN FÜR MOBILITÄT UND ENERGIE

Der Klimawandel als gemeinsame, zeitkritische Menschheitsaufgabe verlangt die rasche Transition bestehender Systeme in Richtung nachhaltiger Alternativen. Elementare Bestandteile dieses Wandels bilden die Veränderung des Mobilitätsverhaltens und des Energiesystems. Beide Aspekte haben dabei einen signifikanten Einfluss auf Planung, Gestaltung und Funktion von Städten. Emissionen des Verkehr- und Energiesektors sind für einen signifikanten Teil der klimaschädlichen Treibhausgasemissionen verantwortlich. Der Wechsel hin zu einer dezentralen Energieversorgung auf Basis erneuerbarer Energieträger sowie die Umstellung des Stromnetzes von Wechsel- hin zu einer effizienteren Gleichstromversorgung stellt das Stromnetz vor große Herausforderungen und Umstrukturierungsprozesse, die neben erheblichen finanziellen Investitionen auch signifikante bauliche Eingriffe in die Energieinfrastrukturen auf städtebaulicher Ebene notwendig machen.

Im Bereich Verkehr und Mobilität bedarf es eines Umdenkens und –steuerns von einer planerisch wie gesellschaftlich intentierten Dominanz des motorisierten Individualverkehrs (MIV) hin zu einer Verkehrswende mit einer konsequenten Förderung des Umweltverbundes, sowohl zur Reduzierung der Emissionen im Verkehrssektor, als auch zur Steigerung der Lebens-, Aufenthalts- und Gestaltungsqualität im

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

städtischen Raum. Durch den stetigen Zuwachs von E-Mobilitätsangeboten gewinnen auch Ladeinfrastrukturen und deren Planung, Gestaltung und Betrieb an Bedeutung.

3 TRANSFORMATION DES VERKEHRSSEKTORS

3.1 Mobilität, Energie und Klimawandel

Die Rahmenbedingungen für den Verkehr im urbanen Raum haben sich in der jüngeren Vergangenheit erheblich verändert (vgl. Bläser et al. 2015: 516). Triebfedern sind neben dem Klimawandel u. a. anhaltende Diskussionen zur Reduzierung des Flächenverbrauchs, stetige gesellschaftliche Veränderungen sowie der demographische Wandel und steigende Energiepreise (vgl. ARL 2011: 1; Bartholomew u. Ewing 2013: 6). Der Verkehrssektor ist in Deutschland einer der größten Treibhausgasemittenten und muss zum Erreichen des Pariser Klimaschutzabkommens seine Emissionen in den kommenden Jahren signifikant reduzieren. Bis 2030 sollen die Emissionen in Bezug auf das Jahr 2019 fast halbiert werden (-48 %) (vgl. UBA 2022a). Noch deutlicher werden die im Bundesklimaschutzgesetz verankerten Ziele: Hier wird eine Treibhausgasneutralität bis 2045 formuliert (vgl. ebd.). Für den Verkehrssektor, welcher bis heute stark auf fossilen Energieträgern aufbaut und sich durch einen stetig steigenden Verkehrsaufwand auszeichnet, stellt die notwendige Transformation hin zu mehr Nachhaltigkeit eine große Herausforderung dar (vgl. Statista 2022a; UBA 2022b).

Erste Tendenzen eines Systemwandels sind jedoch zu erkennen: Der Marktanteil von ökologisch vorteilhafteren Hybrid- und Elektrofahrzeugen lag 2019 bei 8,39 % - knapp das Vierfache des Marktanteils von 2016 (1,85 %) (vgl. UBA 2022c). Der Trend zum Elektroantrieb wird sich in den kommenden Jahren, nicht nur aufgrund der langfristig steigenden Benzinpreise, weiter fortsetzen. Auch im Radverkehr ist ein steigender Marktanteil von E-Bikes zu beobachten (vgl. Statista 2022b). Damit einhergehend ist, neben der Reduzierung der lokalen Emissionen, die steigende Nachfrage nach entsprechender (Lade-)Infrastruktur – eine Aufgabe für die Stadt- und Verkehrsplanung.

3.2 Mobilstationen als Schnittstelle

Mit Stärkung und Ausbau des Umweltverbundes besteht eine steigende Notwendigkeit von multimodalen Umstiegspunkten im urbanen Raum (vgl. Bläser et al. 2015: 518). Als multimodale Schnittstellen leisten Mobilstationen einen wichtigen Beitrag zur nachhaltigeren Abwicklung des Verkehrs und bieten Ansatzpunkte für den Ausbau der immer notwendigeren Ladeinfrastruktur z. B. bei den klassischen Nutzungsbausteinen Bike- und Car-Sharing, sowie bei Radabstell- oder Stellplatzanlagen (vgl. Bläser et al. 2015: 519-520). Der Begriff „Mobilstation“ ist in der Fachliteratur dabei nicht abschließend definiert. Andere Begriffe wie Mobilitätshub, Mobilitätsstation oder Verknüpfungsanlagen werden im vorliegenden Beitrag als Synonyme verstanden. Das Zukunftsnetz-Mobilität NRW hat im Rahmen seines Handbuchs Mobilstationen Nordrhein-Westfalen vier wesentliche Grundaufgaben von Mobilstationen formuliert:

Verknüpfung von Verkehrsangeboten

- Kommunikation und Marketing
- Information/Service
- Treffpunkt/Aufenthaltsbereiche

Die Verknüpfungsfunktion von Verkehrsangeboten bildet hierbei den Kern, welcher um weitere Funktionen ergänzt wird und sich dadurch vom reinen intermodalen Verknüpfungspunkt abgrenzt (vgl. Zukunftsnetz-Mobilität NRW 2017: 8). Die an Bedeutung gewinnende Ladeinfrastruktur kann unter Service subsumiert werden, sollte allerdings nach Meinung der Autoren künftig eine zentralere Rolle bei der Ausgestaltung von Mobilstationen einnehmen.

3.3 Mobilstationen als Anker im Quartier

Mobilstationen fungieren als Stadtbausteine zur verträglicheren Abwicklung des Verkehrs und als Infrastrukturen zur Verringerung der Abhängigkeit vom MIV. Die Mehrwerte eines höheren Anteiles des Umweltverbundes im Modalsplit, sowie geringerer lokaler Emissionen durch E-Mobilität für die Stadtentwicklung, sowie die örtliche Lebensqualität wurde in zahlreichen Publikationen bereits hinreichend erörtert: Beispielhaft seien an dieser Stelle Bartholomew & Ewing 2013 und Gehl 2016 genannt. Die

räumliche Bündelung von Stellplätzen und Infrastrukturangeboten an Mobilstationen – auch im Kontext der immer populäreren Idee der Quartiersgarage und verwandter Konzepte - und die damit einhergehenden Potenziale für die Ausgestaltung des öffentlichen Raumes sollen an dieser Stelle jedoch noch mal hervorgehoben werden (vgl. Aichinger 2019: 165 u. 172; UBA 2017: 8).

Vielmehr sollen folgend kurz die Funktionen von Mobilstation für Quartiere und Nachbarschaften dargelegt werden. Mobilstationen sind, wie in Kapitel 3.2 beschrieben, neben ihrer Funktion als intermodaler Umstiegspunkt, Orte sozialer Interaktion und Aufenthaltsbereiche. Sie sind, variierend nach Nutzungsintensität, integraler Bestandteil des Alltags, auch abseits reiner Mobilitätszwecke. Zur Maximierung des Einzugsbereiches respektive zur Minimierung des zurückzulegenden Weges sollten Mobilstation zentral innerhalb von Quartieren oder an gut erreichbaren ÖV-Haltepunkten errichtet werden. Wegelängen haben einen signifikanten Einfluss auf die Nutzung des öffentlichen Verkehrs und daraus abgeleitet auch auf die Frequentierung von Mobilstationen (vgl. BMVIT u Walk-space.at 2012: 113; Bartholomew u. Ewing 2013: 32). Aus diesen zentralen Lagen ergibt sich gleichzeitig ein Gestaltungsanspruch: Eine qualitative Ausgestaltung kann den öffentlichen Raum und das Ortsbild aufwerten und somit einen wertvollen Beitrag zur städtebaulichen Integration von Verkehrsinfrastruktur leisten (vgl. Bläser et al. 2015: 521).

4 TRANSITION ENERGIESYSTEM

4.1 Wandel des Energiesystems Strom

Aktuell ist das deutsche Energiesystem hauptsächlich durch zentrale Großkraftwerke charakterisiert. Diese erzeugen planbar große Mengen an Wechselstrom, welcher über verschiedene Spannungsebenen durch die Region transportiert wird (vgl. Hofman 2019: 98; Dalheimer 2011: 1). In Anbetracht der Bestrebungen zur Eindämmung des Klimawandels sind große Einsparungen von Treibhausgasemissionen im Energiesektor zu realisieren. 2019 hat die deutsche Bundesregierung mit dem Klimaschutzgesetz erstmalig ihr nationales Klimaschutzziel verbindlich festgehalten. Für die Energiewirtschaft wird eine Treibhausgasreduktion um über 60 % bis zum Jahr 2030 angestrebt (vgl. BMUV 2022). Durch den Bedarf nachhaltiger Energiequellen steigt die Bedeutung der Erzeugung regenerativer Energie. Die in der Regel deutlich dezentraler verorteten nachhaltigen Energieerzeugungsanlagen stellen dabei das bestehende Energienetz, auch aufgrund ihrer volatilen Einspeisecharakteristik, vor große Herausforderungen. Gleichzeitig lässt die angestrebte Elektrifizierung des Mobilitäts- oder Wärmesektors den Bedarf nach elektrischer Energie weiter steigen. Studien prognostizieren eine mögliche Vervierfachung des Stromverbrauchs in Deutschland bis 2050 (vgl. Fraunhofer IEE 2019). Die Transformation des bisherigen Energiesystems erscheint hinsichtlich neuer Einspeisecharakterstika, sowie eines stark wachsenden Energieverbrauchs unvermeidbar. Die russische Invasion in der Ukraine und die damit einhergehenden Veränderungen für die Energieversorgung wirken wie eine Art Katalysator für den notwendigen Wandel im Energiesektor, dies zeigt auch der signifikante Anstieg der Energiepreise in den letzten fünf Monaten (vgl. Statistisches Bundesamt 2022: 45ff.).

4.2 Potenziale dezentraler (Gleichstrom-) Energienetze

Neben den bereits angesprochenen regenerativen Energieerzeugungsanlagen, wie z. B. Photovoltaik- (PV), Windkraft- oder Biogasanlagen, erfahren auch weitere Energieinfrastrukturen eine hohe Bedeutung für die Energiewende: Speichertechnologien auf Gebäude-, Straßen- oder Quartiersebene ermöglichen es beispielsweise den (regenerativen und dezentral) erzeugten Strom zu speichern und nutzbar zu machen. Ergänzend zu den neuen Infrastrukturen der Energieerzeugung und –speicherung drängen neue Verbraucher in das Energiesystem. Die E-Mobilität benötigt beispielsweise private wie öffentliche Netzanschlüsse und Infrastrukturen, die eine hohe Ladeleistung und damit einen schnelleren Ladevorgang ermöglichen. Wie eingangs angesprochen, ist das aktuelle Energiesystem durch Wechselstrom geprägt. Viele der neuen Technologien für die Energie- und Verkehrswende produzieren, speichern oder verbrauchen jedoch Gleichstrom. Anders als Wechselstrom, welcher durch seine Entstehung mittels rotierenden Elektromagneten eine wiederkehrende Änderung der Fließrichtung der Elektronen charakterisiert ist, weist Gleichstrom eine konstante Bewegungsrichtung der Elektronen über die Zeit auf (vgl. Clausert u. Wiesemann 2005: 18ff.). U. a. die aktuell notwendige (mehrfache) Umwandlung von Wechsel- zu Gleichstrom und andersherum, führt zu großen Verlusten im bestehenden Energiesystem. Gleichstromnetze bieten in der Theorie ein hohes Potenzial, die regenerativ erzeugte Energie in dezentral aufgestellten Netzen effizienter zu nutzen. In

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Gebäuden mit gekoppelten Gleichstromtechnologien (Gleichstromnetz, Photovoltaikanlage und Batteriespeichern) kann ein Energieeinsparpotenzial von über 15 % realisiert werden (vgl. Pantano et al. 2016: 6). Die flächendeckende Transition hin zu einer Gleichstromversorgung in Deutschland ist allerdings aufgrund der starken Lock-in-Effekte des aktuellen Systems sehr beschwerlich. Es gilt vielmehr Nischen zu finden, in denen sich neue Systeme etablieren und anderen Ansätzen als Vorbild dienen können.

4.3 Städtebauliche Integration von Energieinfrastrukturen

Die aktuellen und zukünftigen Bestandteile dezentraler Energiesysteme stellen nicht nur aus energietechnischer, sondern auch aus städtebaulicher Perspektive eine Herausforderung dar. „Grundsätzlich hat jeder Eingriff im Stadtraum eine Auswirkung auf dessen Funktion und Ästhetik“ (Besier 2016: 408). Die hohe Anzahl neuer Infrastrukturen gilt es mehrwertstiftend und gesellschaftlich akzeptiert in unsere Städte zu integrieren. So sollen, wie z. B. bei der der Windkraft, wahrnehmbare Protestbewegungen vermieden werden (vgl. UBA 2019: 66f.). Erste Ansätze, wie beispielsweise Quartiersspeicher städtebaulich integriert werden können, existieren bereits (z. B. vgl. Stratmann et. al 2021). Bei der städtebaulichen Integration von technischen Infrastrukturen sind grundsätzlich zwei Gestaltungsprinzipien denkbar: Eine dezente, einfügende Integration sowie eine stadtbildprägende Integration (z. B. vgl. Besier 2016). Während der erste Ansatz die Erhaltung des Stadtbildes priorisiert, fördert Letztgenannter den gesellschaftlichen Austausch über die neuen Stadtbestandteile. Der Integrationsansatz ist entsprechend den stadtplanerischen und gesellschaftlichen Zielen zu wählen.

5 SYNERGIEN VON VERKEHRS- UND ENERGIEINFRASTRUKTUR

Der Anteil der erneuerbaren Energien, insbesondere der aus der Erzeugung mittels Photovoltaik, hat in den letzten Jahren zugenommen. Dies hat Auswirkungen auf den Preis des Stroms durch die EEG-Umlage und die Belastung der Verteilnetze (vgl. Primus 2014: 29). Durch den Abruf von Strom durch Nutzende (Konsumierende) und die Einspeisung von überschüssigem Strom in das Netz (Produzierende) kommt es zu zwei Stromrichtungen (vgl. BMWI 2019) (siehe Abb. 1).

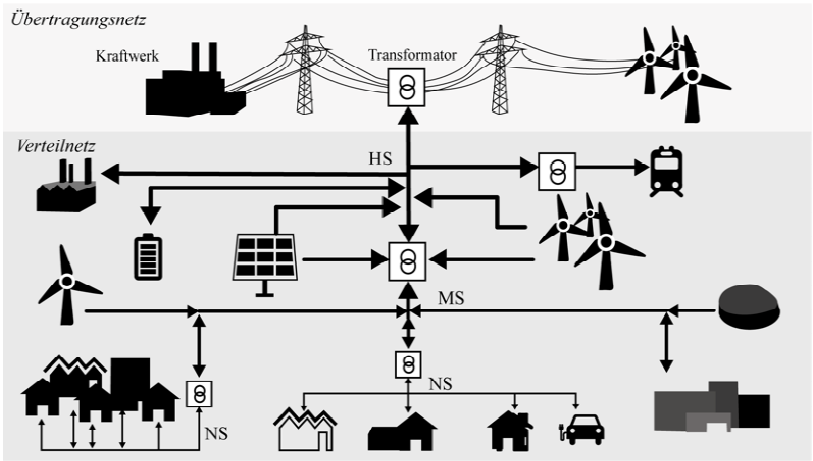


Abb. 1: Veränderung der Stromwege durch erneuerbare Stromerzeugung (Eigene Darstellung nach E.DIS AG o. J.: 31)

Das in Kapitel 4.1 aufgezeigte Wachstum an dezentralen Energieerzeugern, die nicht zu jeder Zeit dieselben Energiemengen in das Netz einspeisen, stellt das Stromnetz vor Schwierigkeiten (vgl. ebd.). Daher bedarf es u. a. Anpassungen auf der Verteilebene; Ansätze für die Mittel-und Niederspannungsebene wie ein Smart Grid oder intelligente Ortsnetzstationen sind in diesem Zuge aufgekommen (vgl. Primus 2014: 30).

Ein Smart Grid ist ein Ansatz, um die Erzeugung und den Verbrauch von Strom durch moderne Kommunikationstechnik wirksamer zu koordinieren, um die Überschüsse besser ins Netz einzubinden und für eine gute Netzauslastung zu sorgen (vgl. BMWI 2019). In einem solchen System können aus erneuerbaren Energien erzeugte Überschüsse beispielsweise zu Zeiten, in denen die Energie nicht benötigt wird, in Batterie-Technologien zwischengespeichert werden (vgl. ebd.). Intelligente Ortsnetzstationen spielen dabei eine entscheidende Rolle. Diese können durch zusätzliche Technik Netzzustände ermitteln und diese über moderne Kommunikationstechnik weitergeben, sodass der Lastfluss in dem Gebiet gesteuert und Energiemengenaustausche vorgenommen werden können. Zudem ist es so möglich, auftretende Störungen oder Fehlermedlungen aus der Ferne zu beheben (vgl. Primus 2014: 43).

Ortsnetzstationen können entsprechend einen Startpunkt für die Energietransition darstellen. In Abbildung 2 ist am Beispiel der Stadt Aachen die Dichte der Ortsnetzstationen im Stadtgebiet aufgezeigt.

Wie in Kapitel 3 beschrieben, zeigt sich ein Trend zur Elektrifizierung der Verkehrsmittel. Allerdings ist die bestehende Ladeinfrastruktur aktuell hierfür noch ungenügend. Die deutsche Bundesregierung fördert daher den Bau von einer Million Ladestationen bis 2030. Elektrofahrzeuge bzw. die in diesen verbauten Batterien können zu einer wichtigen Komponente der Energiewende werden. Die Batterien können als mobile, temporär verfügbare Zwischenspeicher von Energieüberschüssen Last- und Einspeisespitzen aufnehmen. Dadurch begünstigen und attraktivieren Sie den Ausbau und den Einsatz der Technologien (vgl. BMWK o. J.).

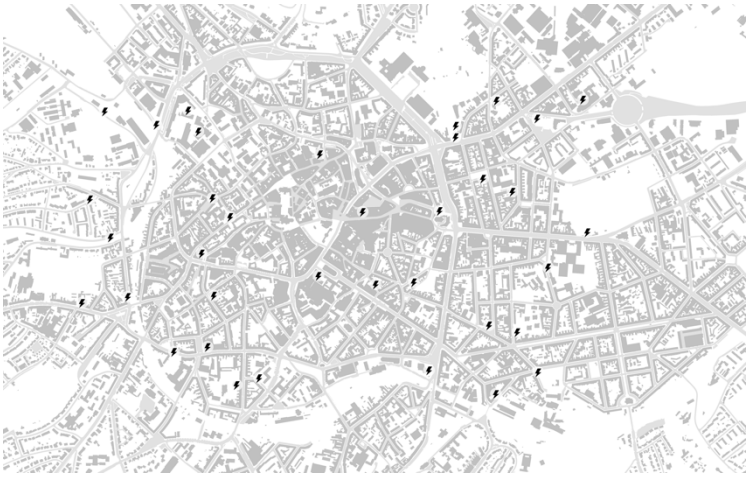


Abb. 2: Standorte Ortsnetzstationen in der Stadt Aachen (Eigene Darstellung nach Reiners o. J.)

Die Kopplung der beiden Bausteine Mobilität und Energie bietet die Möglichkeit, dezentral erzeugte Energie besser nutzbar zu machen. Daraus ergibt sich der Ansatz, diese aus energetischer Sicht wichtigen Punkte für die Quartiere mit dem Thema Mobilität zusammen zuführen und an solchen Stellen eine Mobilitätsstation zu errichten. Diese bieten zum einen einen Netzanschluss für die immer mehr an Bedeutung gewinnende Ladeinfrastruktur und zum anderen das Potenzial, selber Energie erzeugen zu könnten. Ein intelligentes Management möglicht eine Zwischenspeicherung von Energie in Elektrofahrzeugen zur Abfederung von Lastspitzen.

Der Ansatz, eine Mobilitätsstation mit einer Ortsnetzstation zu einem Energy-Mobility-Hub zu koppeln, um Synergieeffekte zu bündeln, wird im folgenden Kapitel konkretisiert. Bei der Lage der Ortsnetzstationen muss im Einzelfall überprüft werden, ob die Standorte lediglich aus energetischer Sicht sinnvoll erscheinen oder ob sie auch den Anforderungen aus verkehrsplanerischer und städtebaulicher Sicht gerecht werden. Eine integrierte Betrachtung könnte bei der Planung von Neubauquartieren frühzeitig Synergien für die Stadtbausteine Energie und Mobilität sicherstellen. Des Weiteren besteht die Möglichkeit, oftmals versteckte Infrastrukturen wie die Ortsnetzstationen im öffentlichen Raum stärker sichtbar zu machen und deren Nutzen hervorzuheben.

6 BAUSTEINE UND AUSGESTALTUNGSMÖGLICHKEITEN VON MOBILSTATIONEN

Mobilstationen als infrastrukturelle, multifunktionale Stadtbausteine bedürfen einer zweckmäßigen und gleichzeitig sensiblen Integration in den städtebaulichen Kontext. Planung, Dimensionierung und Gestaltung von Mobilstationen müssen dabei insbesondere die Aspekte intendiertes Mobilitätsangebot, Nachfragepotenzial und Mobilitätsbedarf sowie städtebauliche Verträglichkeit auf Basis einer spezifischen Standortanalyse und Potenzialabschätzung berücksichtigen. Neben der Notwendigkeit einer solchen passgenauen Gestaltungslösung für jeden Standort erscheint gleichzeitig eine Standardisierung einzelner Gestaltungselemente durch modularisierte Ausstattungsmerkmale zur Erhöhung von (Planungs-) Effizienz, Wiedererkennung, Corporate Design und Etablierung qualitativer (Mindest-) Standards sinnvoll. Auf Basis modularisierter Angebots-, Ausstattungs- und Gestaltungselemente lassen sich verschiedene Stationstypen konfigurieren, die jeweils auf die Spezifika des Standortes reagieren können. Relevante Standortmerkmale sind u. a. ÖPNV-Anbindung, Einwohnerdichte, PKW-Besitzquote, Dienstleistungen und Gewerbe (vgl. Bläser et al. 2015: 519 ff.).

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Anhand dieser Merkmale kann ein theoretisches Nachfragepotenzial abgleitet und damit ein passender Stationstyp mit spezifischen Angebots- und Ausstattungsmerkmalen zugeordnet werden. Mittels eines hierarchisierten Systems unterschiedlicher Stationstypen kann ein funktionales Stationsnetz von Mobilstationen etabliert werden. Das Konzept von modularisierten und hierarchisierten Stationstypen findet sich u. a. in IGES 2021, ARUP (o. J.), CoMoUK 2019 und Zunkunftsnetz Mobilität NRW 2017. Die vom Zukunftsnetz Mobilität NRW identifizierten Grundfunktionen: Verknüpfung von Verkehrsangeboten, Kommunikation und Marketing, Information/Service, Treffpunkt/Aufenthaltsbereiche (vgl. Zukunftsnetz Mobilität NRW 2017: 8) bedürfen einer gestalterischen und je nach Ausprägung auch städtebaulichen Auseinandersetzung mit dem Ziel, die Funktionalität der Mobilstation zu ermöglichen und gleichzeitig den umgebenden Stadtraum qualitativ und gestalterisch aufzuwerten (vgl. Bläser et al. 2015: 521). Die Adaption an die verschiedenen Raum- und Siedlungstypen und den draus abgeleiteten Angebots- und Ausstattungsmerkmalen erfordert und ermöglicht eine große Bandbreite verschiedener architektonischer und städtebaulicher Gestaltungsmöglichkeiten.

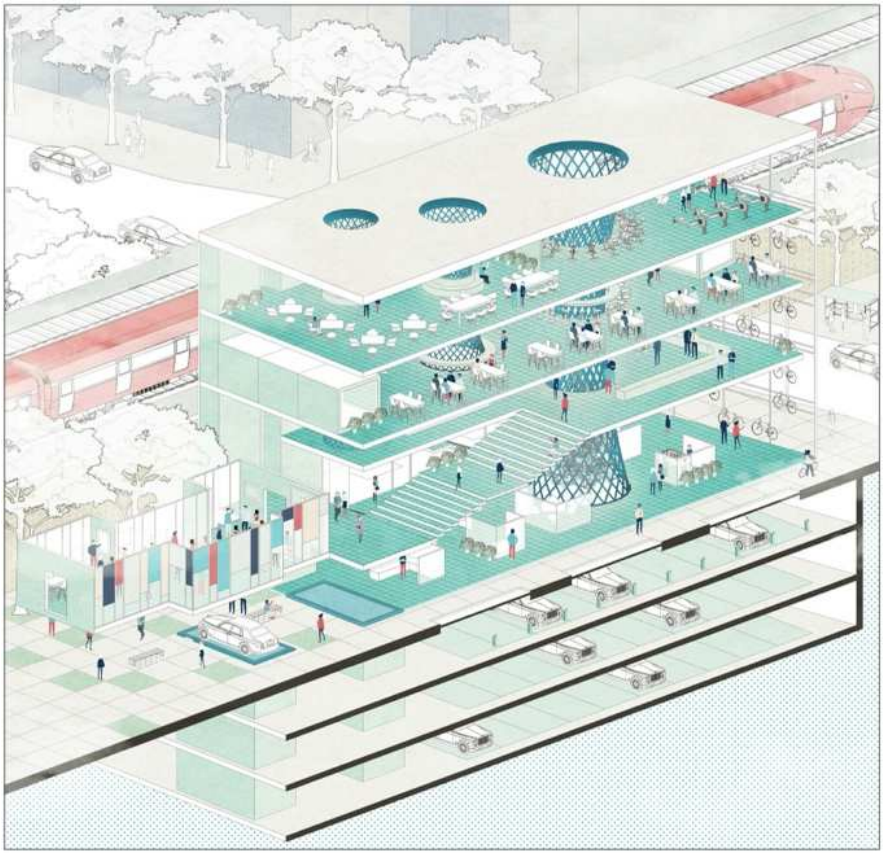


Abb. 3: Entwurf einer Mobilstation am Bahnhof Aachen Schanz am Standort einer Ortsnetzstaion (Jialun Yao, Shihui Li, Zixi Zhao)

Als Beitrag zur Diskussion um die vielfältigen Gestaltungsmöglichkeiten – und Potenziale von Mobilstationen, die sowohl Verkehrs- als auch Energieinfrastrukturen städtebaulich integrieren, wurden im Rahmen einer Lehrveranstaltung am Lehrstuhl für Städtebau der RWTH Aachen experimentelle Entwürfe in verschiedenen räumlichen Kontexten entwickelt. Abbildung 3 und 4 zeigen exemplarisch die Vielfalt der Entwürfe inkl. deren spezifischen Antworten auf den jeweiligen städtebaulichen Kontext.

Der folgende Entwurf einer Mobilitätsstation ist für die Ortsnetzstation am Bahnhof Aachen Schanz (SPNV Haltepunkt) entworfen worden. Das Konzept umfasst sowohl verkehrstechnische, als auch energetische Aspekte. Das Gesamtenergiekonzept des Entwurfes setzte sich aus diversen Energieerzeug-ungsarten (wie beispielsweise PV- und Windkraftanlagen) zusammen. Das Gebäude, welches direkt an den Bahnsteig angrenzt, fungiert zudem als multimodaler Knoten. Es verbindet den Bahnsteig mit Park- und Lademöglichkeiten für unter-schiedlichste Fahrzeuge. Zudem bietet darüber hinaus weitere städtebauliche Mehrwerte, wie beispiels-weise einem Fitnessstudio, Restaurants und Cafés.

Der nachfolgende Entwurf ist für ein Quartier am Stadtrand mit offener Bauweise erarbeitet worden. Das energetische Konzept sieht hierbei PV-Anlagen auf dem Dach der Station vor, sowie Lademöglichkeiten für

verschiedene Fahrzeuge. Bei Bedarf könnte die Station noch mit einem Quartiersenergiespeicher erweitert werden. Die Station bietet zudem Stellplätze für PKW und Fahrräder. Daran grenzt ein Spielplatz für das Quartier an.

Abb. 4: Entwurf Mobilstation im kleineren Maßstab (Dominique Reyes Viteri , Sandra Agnieszka Kik).

Die verschiedenen Entwürfe zeigen mögliche Bestandteile einer Mobilitätsstation auf. Allgemein lassen sich diese in drei Kategorien unterteilen: Energie, Mobilität und Städtebau (siehe Abb. 5). Unter die Kategorie Energie fallen z. B. PV- oder Windkraftanlagen. Unter Mobilität lassen sich Parkplätze für unterschiedlichste Fahrzeuge, ÖV Haltepunkte als auch Sharing-Angebote und Lademöglichkeiten subsumieren. Städtebauliche Komponenten beleben den Ort und und laden zum Verweilen ein. Darunter fallen beispielsweise gastronomische Angebote, Spielplätze, Grünelemente oder auch Co-Working Spaces.

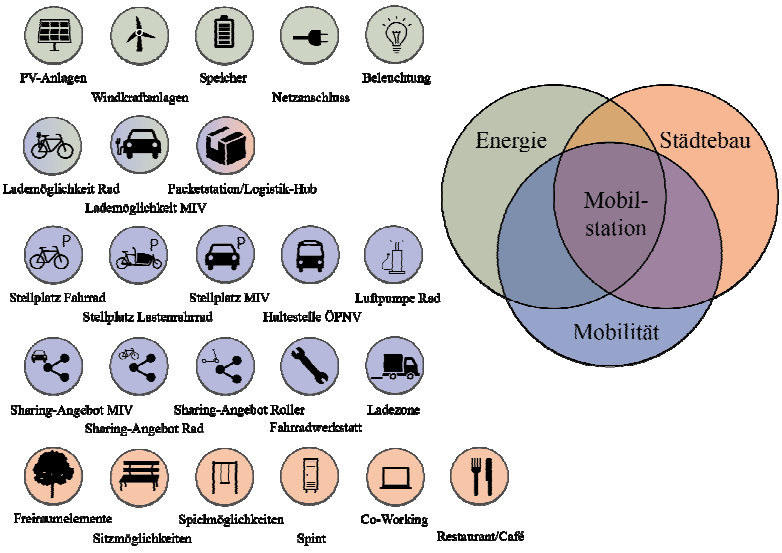


Abb. 5: Bausteine Mobilitätsstation (Eigene Darstellung nach Arup o.J.:7)

Die Bandbreite an möglichen Nutzungsbausteinen und die gezeigten Ausgestaltungsvarianten zeigen die Vielfältigkeit von Mobilstationen und die Möglichkeiten, diese qualitativ städtebaulich in verschiedene räumliche Strukturen zu integrieren. Die Entwürfe verstehen sich dabei aber explizit nicht als anzustrebendes Gestaltungsideal, sondern als visueller Debattenbeitrag hin zu einer funktionalen und gestalterischen Sektorenkopplung im städtebaulichen Kontext.

7 FAZIT

Der Handlungsbedarf in den Bereichen Mobilität und Energie ist offenkundig. Mobilstationen als systemische und städtebauliche Schnittstelle zwischen den beiden Sektoren bilden in Kombination mit Ortsnetzstationen einen vielversprechenden Ansatzpunkt zur Weiterentwicklung des Energienetzes und zum notwendigen Ausbau der E-Mobilitätsinfraktur. Die in Kapitel 4 und 5 aufgezeigten energetischen Einsparpotenziale durch wegfallende Umwandlungsprozesse, sowie die höhere Geschwindigkeit bei Ladeprozessen wirken vielversprechend und können als Pull-Faktoren fungieren. Speziell Ersterem kommt

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

im Kontext der Energiepreisentwicklung und den gesteckten Klimaschutzzielen eine besondere Bedeutung zu.

Die räumliche Bündelung technischer Infrastruktur in Kombination mit den baukulturellen Anforderungen von zentralen Quartiersbausteinen birgt ein enormes Potenzial zur räumlichen Integration bisher versteckter Energieinfrastruktur. Damit einhergehend erhöhen sich jedoch auch die Anforderungen an Stadt- und Verkehrsplaner. Ortsnetzstationen und ggf. ergänzende kleinteilige Bausteine zur Energiegewinnung und -speicherung rücken durch die Bündelung mit Mobilstationen aus ihren räumliche Nischen ins Zentrum des Quartiers – oder an andere vergleichbar gut erreichbare und verkehrsplanerisch sinnvolle Lagen. Neben den gestalterischen Herausforderungen ergibt sich auch die Notwendigkeit, etwaige Emissionen zu minimieren und so die Akzeptanz dieser Quartiersbausteine nicht zu gefährden. Dies gilt insbesondere für besonders prominente Lagen, wie z. B. Quartiersplätze.

Hinsichtlich einer möglichen Umsetzung und den genauen Einsparpotenzialen im Kontext der E-Mobilität besteht weiterhin Forschungsbedarf. Speziell die Integration in Bestandsstrukturen ist stark abhängig von der Lage der derzeitigen Ortsnetzstationen und deren städtebaulicher Integration. Eine Bündelung adressiert langfristig die bestehenden Herausforderungen in den Bereichen Energie und Mobilität und bietet bei einer adäquaten Umsetzung vielfältige Potenziale für die Lebensqualität in unseren Städten und zur Erreichung der gesteckten Klimaschutzziele.

8 ACKNOWLEDGEMENTS

Diese Arbeit wurde im Rahmen des Forschungskollegs "ACCESS!", das durch das Förderprogramm "NRW Forschungskollegs" des Ministeriums für Kultur und Wissenschaft des Landes Nordrhein-Westfalen unterstützt wird (FK 321-8.03.07-127598), das BMWK-geförderte Projekt 5Gain (FK 03EI6018D) und das BMBF-geförderte Projekt DC-Sozio-Ökonomik (FK 03SF0592) erstellt.

9 LITERATURVERZEICHNIS

AICHINGER, WOLFGANG: Straßenräume für Fußgängerinnen und Fußgänger gestalten. In: Ute Bauer (Hrsg.): So geht's - Fußverkehr in Städten neu denken und umsetzen. Berlin, pp. 163-174, 2019.

ARL (AKADEMIE FÜR RAUMFORSCHUNG UND LANDESPLANUNG) (Hrsg.): Postfossile Mobilität und Raumentwicklung. Positionspapier aus der ARL Nr. 89. Hanno¬ver, 2011.

ARUP: Future Mobility Hubs. Abgerufen von: https://www.arup.com/perspectives/publications/research/section/future-mobility-hubs (zugegriffen am 18.07.2022), o. J..

BARTHOLOMEW, KEITH; Erwing Reid: Pedestrian- and Transit-Oriented Design. Washington DC, 2013.

BESIER, STEPHAN: Städtebauliche Integration und Gestaltung der Infrastrukturanlagen von Stadt- und Straßenbahn. In: Informationen zur Raumentwicklung (4), S. 407–420, 2016.

BLÄSER, DANIEL; Frensemeier, Eva; Garde, Jan; Jansen, Hendrik: Städtische Mobilstationen Funktionalität und Gestaltung von Umsteigeorten einer intermodalen Mobilitätszukunft. In: Proff, Heike (Hrsg.): Entscheidungen beim Übergang in die Elektromobilität. Wiesbaden, pp. 515-532, 2015.

BUNDESMINISTERIUM FÜR VERKEHR, INNOVATION UND TECHNOLOGIE (BMVIT), Walk-space.at: Fußverkehr in Zahlen. Wien, 2012

BUNDESMINISTERIUM FÜR UMWELT, NATURSCHUTZ, NUKLEARE SICHERHEIT UND VERBRAUCHERSCHUTZ (BMUV): Bundes-Klimaschutzgesetz. Abgerufen von: https://www.bmuv.de/themen/klimaschutz-anpassung/klimaschutz/bundes-klimaschutzgesetz, (zugegriffen am 22.07.2022), 2022.

BUNDESMINISTERIUM FÜR WIRTSCHAFT UND ENERGIE (BMWI): Was sind eigentlich "Smart Grids"?. In: Energiewende dirket. Ausgabe 05/2019, Abgerufen von: https://www.bmwi-energiewende.de/EWD/Redaktion/Newsletter/2019/05/Meldung/direkt-erklaert.html (zugegriffen am 22.07.2022), 2019.

BUNDESMINISTERIUM FÜR WIRTSCHAFT UND KLIMASCHUTZ (BMWK): Elektromobilität in Deutschland. Abgerufen von: https://www.bmwk.de/Redaktion/DE/Dossier/elektromobilitaet.html (zugegriffen am 22.07.2022), o. J..

CLAUSERT, HORST; Wiesemann, Gunther: Grundgebiete der Elektrotechnik 1. Gleichstromnetze, Operationsverstärkerschaltungen, elektrische und magnetische Felder. 9. Auflage. Oldenbourg Wissenschaftsverlag München, 2005.

COMOUK: Mobility Hub Guide. Abgerufen von: https://como.org.uk/wp-content/uploads/2019/10/Mobility-Hub-Guide-241019-final.pdf, (zugegriffen am 22.07.2022), 2019.

DALHEIMER, MATHIAS: Power to the People – Das Stromnetz der Zukunft. Berichte aus dem Fraunhofer ITWM, Nr. 200, 2011.

E.DIS AG, zit. n. Primus, Illo-Frank: Netzstationen. Hrsg. v. Rolf Rüdiger Cichowski. Anlagentechnik für elektrische Verteilungsnetze. 2. Auflage, Berlin; Offenbach: VDE-Verl. - Frankfurt, M.; Berlin; Essen: EW Medien und Kongresse, o. J.

FRAUNHOFER-INSTITUT FÜR ENERGIEWIRTSCHAFT UND ENERGIESYSTEMTECHNIK: Das Barometer der Energiewende. Endenergiebedarf 2050 nach Szenarien 2018 und 2019. Abgerufen von: https://www.herkulesprojekt.de/de/Barometer/barometer_2019/endenergiebedarf2050.html (zugegriffen am 06.07.2022), 2019.

GEHL, JAN: Städte für Menschen. 3. Auflage in deutscher Fassung. Berlin: Jovis Verlag, 2016.
HOFMANN, LUTZ: Elektrische Energieversorgung – Band 1 Grundlagen, Systemaufbau und Methoden, Berlin, Boston: DeGruyter Oldenbourg, 2019.
INSTITUT FÜR GESUNDHEITS- UND SOZIALFORSCHUNG (IGES): MobistaR - Grundlagenpapier für Mobilitätsstationen in städtischen Randlagen. Abschlussbericht. im Auftrag von Senatsverwaltung für Umwelt, Verkehr und Klimaschutz Berlin. Abgerufen von: https://www.berlin.de/sen/uvk/_assets/verkehr/verkehrspolitik/forschungs-und-entwicklungsprojekte/mobistar_grundlagenpapier_iges.pdf (zugegriffen am 27.07.2022), 2021.
PANTANO, STEPEN, May-Ostendorp, Peter, Dayem, Katherine, 2016. Demand DC : Adoption Paths for DC Power Distribution in Homes. DC Distribution 101, pp. 1- 12. 2016.
PRIMUS, ILLO-FRANK: Netzstationen. Hrsg. v. Rolf Rüdiger Cichowski. Anlagentechnik für elektrische Verteilungsnetze. 2. Auflage, Berlin; Offenbach: VDE-Verl. - Frankfurt, M.; Berlin; Essen: EW Medien und Kongresse, 2014.
REINERS, DETLEV (Hrsg.): Stromnetz-Karte. Abgerufen von: https://www.flosm.de/html/Stromnetz.html?lat=50.7669074&lon=6.06548209&r=13468.793&st=0&sw=cabledistributioncabinet,powerbay,powerbusbar,powercompensator,powerconverter,powerline380k,powerline400k,powerline420k,powerline750k,powerline765k,powerlinedchigh,powerpole,powersubstation,powerswitch,powertower,transformer (zugegriffen am 18.07.2022), o. J..
STATISTA: Anzahl der Personenkraftwagen in Deutschland nach Kraftstoffarten von 2017 bis 2022. Abgerufen von: https://de.statista.com/statistik/daten/studie/4270/umfrage/pkw-bestand-in-deutschland-nach-kraftstoffarten/ (zugegriffen am 19.07), 2022a.
STATISTA: Absatz von E-Bikes in Deutschland von 2011 bis 2021. Abgerufen von: https://de.statista.com/statistik/daten/studie/152721/umfrage/absatz-von-e-bikes-in-deutschland/ (zugegriffen am 19.07.2022), 2022b.
STATISTISCHES BUNDESAMT (Destatis): Preise Daten zur Energiepreisentwicklung. - Lange Reihen von Januar 2005 bis Mai 2022. Abgerufen von: https://www.destatis.de/DE/Themen/Wirtschaft/Preise/Publikationen/Energiepreise/energiepreisentwicklung-pdf-5619001.pdf;jsessionid=D27C3117EEA43AAA83C46F9E6608A1A3.live722?__blob=publicationFile (zugegriffen am 28.07.2022), 2022.
STRATMANN, ANTONIA; Wendorff, Jannik; Hermens, Sarah: Städtebau und elektrische Speicher – ein Zusammenspiel im Energiequartier. In: Schrenk, M.; Popovich, V. V.; Zeile, P.; Elisei, P.; Beyer, C.; Ryser, J.; Stöglehner, G. (Eds.) (2021): CITIES 20.50 - Creating Habitats for the 3rd Millennium: Smart – Sustainable – Climate Neutral, 2021.
UMWELTBUNDESAMT (UBA) (Hrsg): Straßen und Plätze neu denken. Des¬sau-Roßlau, 2017.
UMWELTBUNDESAMT (UBA) (Hrsg.): Entwicklung und Umsetzung eines Monitoringsystems zur Analyse der Akteursstruktur bei Freiflächen-Photovoltaik und der Windenergie an Land. Teilbericht: Methodik zur Erhebung der Akteursstruktur. Abgerufen von: https://www.umweltbundesamt.de/sites/default/files/medien/5750/publikationen/2021-04-16_cc_16-2021_methodikbericht_uba-akteursvielfalt.pdf, 2019.
UMWELTBUNDESAMT (UBA): Klimaschutz im Verkehr. Abgerufen von: https://www.umweltbundesamt.de/themen/verkehr-laerm/klimaschutz-im-verkehr#nutzfahrzeuge (zugriffen am 15.07.2022), 2022a.
UMWELTBUNDESAMT (UBA): Fahrleistungen, Verkehrsleistung und "Modal Split“. Abgerufen von: https://www.umweltbundesamt.de/daten/verkehr/fahrleistungen-verkehrsaufwand-modal-split#fahrleistung-im-personen-und-guterverkehr (zugegriffen am 19.07.22), 2022b.
UMWELTBUNDESAMT (UBA): Marktdaten: Bereich Mobilität. Abgerufen von: https://www.umweltbundesamt.de/daten/private-haushalte-konsum/konsum-produkte/gruene-produkte-marktzahlen/marktdaten-bereich-mobilitaet#motorisierter-individualverkehr (zugegriffen am 22.07.2022), 2022c.
ZUKUNFTSNETZ-MOBILITÄT NRW: Handbuch Mobilstationen Nordrhein-Westfalen. 2. aktualisierte und überarbeitete Auflage. Köln, 2017, Abgerufen von: https://www.zukunftsnetz-mobilitaet.nrw.de/downloadFile/RG93bmxvYWRzL0hhbmRidWVjaGVyLUxlaXRmYWVkZW4vSGFuZGJ1Y2ggTW9iaWxzdGF0aW9uZW4gMi4gQXVmbGFnZS5wZGY= (zugegriffen am 18.07.2022), 2017.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

🏆 *reviewed paper*

Multiple-Criteria Decision Analysis of Urban Planning Methods towards Resilient Open Urban Spaces

Dimitra Chondrogianni, Yorgos J. Stephanedes, Panagiota-Georgia Saranti

(Dr. Dimitra Chondrogianni, University of Patras, Ypatias 1, Rio, d.chondrogianni@gmail.com)
(Professor emeritus Yorgos J. Stephanedes, University of Patras, Ypatias 1, Rio, yjste@upatras.gr)
(PhD Candidate Panagiota-Georgia Saranti, University of Patras, Ypatias 1, Rio, psaranti@gmail.com)

1 ABSTRACT

Cities are dynamic systems that need to plan for development with resilience, while facing an increasing set of multidimensional challenges and emerging operating trends (e.g. Smart Cities) (Schmitt, 2015). In the framework of new Urban Strategies (Digital Europe Program, 2021-2027; Green Deal, 2019), local authorities play a key role in making the right decisions for covering current and future needs.

Public/outdoor urban spaces are vital parts of cities as they define citizens' quality of life and the ability of cities to respond to urban challenges. In this context, this research aims to support the decision-making process for shaping, designing and managing public/outdoor urban spaces by using measurable and multicriteria indicators to evaluate alternative climate-sensitive design and regeneration plans of urban areas within risk and uncertainty.

Emphasis is placed on both supply and demand for outdoor urban areas. Demand is studied by disaggregate analysis for identifying citizens' needs through questionnaire survey. Supply side is placed at the center of the research by developing a multiple-criteria assessment methodology of urban planning methods. The main evaluation criteria involve the bioclimatic impact of the studied methods, the air pollution detected in microclimate as well as financial cost for their implementation and operation.

In particular, questionnaires' results revealed that citizens prefer open spaces as they provide a feeling of freedom and the chance to be closer to nature. Based on these, citizens visit open spaces with green areas, incoorporating nature based solutions, as well as places that support walkability and green mobility. In addition, simulation and cost assessment results regarding the studied methods showed the planning solutions involving medium size plants and greenery are low cost interventions, creating favorable microclimate conditions and leading to medium CO_2 concentration.

The benefit of the current research is in the innovative, interdisciplinary and holistic approach of a complex real-word problem combining different research areas, such as environmental science, bioclimatic urban planning and decision-making process. The multiple-criteria analysis of urban plans leads to a model of the decision-making process on open urban spaces to enhance citizens' quality of life and to ensure urban resilience as well as cities' operational and sustainable future.

Keywords: decision-making process, urban planning methods, multicriteria analysis, resilience, open urban spaces

2 INTRODUCTION

As Batty (2008) argues, cities are complex, dynamic systems, which are constantly growing from the unstoppable desire for space. As the phenomenon of urbanization is becoming increasingly intense but also complicated, the attempt to become managing is continuous and is often expressed through the development of urban models. With half of the world's population living in urban areas (WHO, 2014), addressing and mitigating the impact of phenomena that are associated withclimate change on urban processes is critical. The future of urban areas can bedesigned based on a dynamic system framework, including global relations, localpowers and emerging trends and needs in cities, e.g. smart cities (Schmitt, 2015). Identification of urban planning needs are key to improving the effectiveness ofconstruction and management policies in urban areas and require quick and riskaverse decisions, the results of which can only be evident in the future (Chondrogianni & Stephanedes; 2021).

The concept of urbam public space is multifaceted and complex and its problematic has been the subject of study among many disciplines such as economy, sociology, politics and spatial planning. These sectors perceive and approach the concept of public space differently, and at the same time, they all complement each other for a better understanding of the complex concept (Osmidopoulou, 2019). It is therefore evident that the public urban space is a complex concept with multiple meanings, utilities and definitions while an essential component of the structure, organization and design of cities. Open public space plays a decisive

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

role in shaping a city while being called upon to form urban fabric by giving life, diversity and meaning to it. Resilient cities target implementing regeneration plans for their open public spaces that are manageable and shaped with main objective the maximization of cities' benefits in terms of economic and environmental impact, sustainability and resilience (Chondrogianni & Stephanedes; 2021).

In this framework, the main objective of this research is to propose a multiple-criteria decision analysis of urban planning methods in order to suppoer the involved stakeholders in creating and providing resilient open urban spaces, in which a range of developing risks could be managed, and new challenges could be met city. To achieve it as case study area of an open urban space was selected and a multiple-criteria assessment methodology for pontential urban planning interventions was developped.

3 MATERIALS AND METHODS

Recognizing the needs and desires of users in the study area was attempted by drawing up a suitable questionnaire. This chapter describes the method used to collect data on users' needs. Initially, the reasons that have prompted us to choose the use of questionnaires to identify users' needs and the collection of demand data for urban outdoor spaces and the study area specifically.

Following the user needs' identification, the development of alternative regeneration scenarios incorporating the desired set of methods and guidelines of bioclimatic urban design of open urban spaces is decided. For the analysis and evaluation of the urban planning methods, the microclimate of the scenarios is simulated using ENVI-met model and software. The model allows simulating the microclimate of an area so that the effects of urban design are measurable and comparable. For visualization and analysis of simulations results, Leonardo software is used.

Added to the microclimate simulations, the financial cost of each urban method was estimated too. Cost is a defining parameter in the multiple-criteria decision analysis and the identification of the general construction and maintenance cost was of high priority in this research.

Regarding the case study area, the open space of Patras Old Port in Greece has been selected. The urban space of Old Port is the main connecting area between city and sea but remains degraded as its complex design has been debated over several years (Architectural Competition "Rehabilitation of Old Port of Patra", 2016). This outdoor space was considered suitable for the development of regeneration scenarios and the microclimate simulations as it is a "blank" space without altitude variations, free in perimeter from urban structures which can act as a base ("white canvas") for experimentation. In this area of Mediterranean climate high humidity conditions are stable owing to the extended water element.

3.1 User needs' identification process

To identify user needs and preferences, one of the usual research methods is the use of a questionnaire which is supplemented by research subjects. The questionnaire is a research medium made up of a series of questions and is the means of communication between the researcher and the respondents, in a direct or indirect way, depending on the method of data collection. One of the most important factors in any research is the design of the real questionnaire. The questions and instructions should be easy to understand and follow. The design of the questionnaire took into account the basic principles as recorded by Javeau to serve the needs of the research and to ensure the validity of the results (Javeau, 2000).

For analysing the demand side in the urban spaces, a set of questionshas been developed; 150 citizens responded by identifying the places they visit the most and the reasons for their preference, their main inefficiences and their impact on citizens' daily life.

3.2 Urban regeneration scenarios in case study area

The developed regeneration scenarios aim to incorporate the urban planning methods and guidelines for supporting users' preferrences as identified through the questionnaires and achieving thermal and air comfort conditions in open spaces as well as limited CO2 concentration, identified through literature review. Based on these data and references, the studied methods can be included in three general categories: Vegetation, Geometric structure, Material (Chondrogianni & Stephanedes; 2021).

In the first scenario, small interventions, from the categories of geometric structure and vegetation were selected based on the current situation and the existing materials. As it is presented in the masterplan (Fig. 1)

indicates the interventions, Tree canopy with big trees (M1) and Green Fences with medium vegetation (M2) or larger trees (M4) for wind protection have been seleced.

Figure 1: Masterplan of Scenario 1

In Scenario 2, the vegetation and geometric structures of the open space remain the same as in Scenario1. The proposed interventions focus on the construction and coating materials, as it is shown in the masterplan of Figure 2. The material have been selected based on their main characteristics and their ability to create more favorable microclimate conditions, and mitigate climate change phenomena, such as the urban heat island. For example, M5 indicates the use of medium vegetation combined with brick/cobblestone pavement, M10 refers to the use of white concrete as pavement while covering a surface with water is represented in M8.

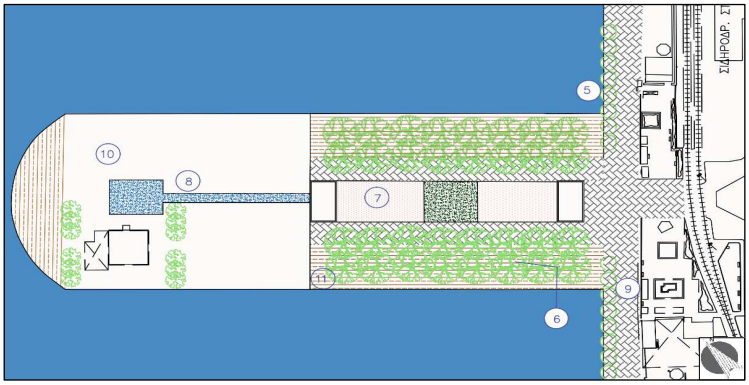


Figure 2: Masterplan of Scenario 2

In Scenario 3, more complex planning solutions have been developped with interventions that combine methods from the three categories. For example, the masterplan (Fig. 3) illustrates the use of medium palm trees over wooden pavement (M13), the creation of a Public Passage between buildings with a green roof, and a pavilion with facades (M17) or the design of a Closed Plateau (M18) combining the use of geometric structures, vegetation and materials (brick/cobblestone) for wind protection and thermal comfort.

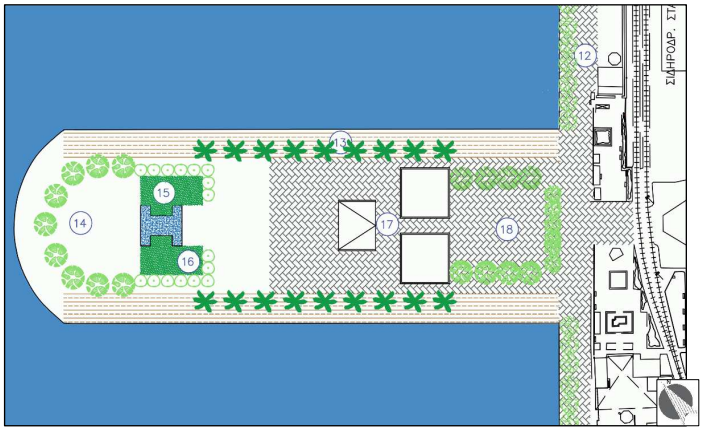


Figure 3: Masterplan of Scenario 3

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

The planning methods, implemented in the three scenarios and indicated with numbers 1-18 in Figures 1-3 are summarized and described in Table 1 as M1-M18 with their main characteristics (e.g., name, category, height, albedo). Through this recording, added urban structures/vegetation/materials with common/similar characteristics as those designed in the masterplans and analyzed in the microclimate simulations can be comparatively evaluated.

Code	**M1**	**M2**	**M3**	**M4**	**M5**	**M6**
Name	Tree Canopy	Medium Vegetation	Open square-Concrete	Green fence	Medium Vegetation II	Tree Canopy II
Category	Vegetation	Vegetation	Geometric structure/ Material	Vegetation	Vegetation/ Material	Vegetation/ Material
Height	9m	2m	9m	5m	2m	9m
Aperture diameter	9m	2m	-	4m	2m	9m
Sheet type-LAD	Deciduous, oval leaves	Dense vegetation	-	Deciduous, low LAD	Dense vegetation	Deciduous, oval leaves
Construction material	-	-	-	-	Brick/ cobblestone pavement	Wooden pavement
Albedo	-	-	0.3	-	0.5	0.8
Orientation	N-S	NW	-	NW-SE	NE	N-S
Green roof-facade	-	-	-	-	-	-
Code	M7	M8	M9	M10	M11	M12
Name	Square II-Terre battue	Water surface	Brick / cobblestone pavement	White concrete pavement	Wooden pavement	Green Fence II
Category	Geometric structure/ Material	Material	Material	Material	Material	Vegetation/ Material
Height	9m	0.5m	-	-	-	7m
Aperture diameter	-	10m	-	-	-	5m
Sheet type-LAD	-		-	-	-	Deciduous, low LAD
Construction material	-	Water	-	-	-	Brick/ cobblestone pavement
Albedo	0.8	-	0.5	0.8	0.8	0.5
Orientation	-	-	-	-	-	NW
Green roof-facade	-	-	-	-	-	-
Code	M13	M14	M15	M16	M17	M18
Name	Tree planting	Tree planting II	Low Vegetation	Water Surface-Fountain	Public Passage	Closed Plateau
Category	Vegetation/ Material	Vegetation/ Material	Vegetation	Material	Geometric structure/Vegetation	Geometric structure/ Material/Vegetation
Height	5m	5-7m	0.2-2m	2m	3-9m	5-9m
Aperture diameter	5m	5m	2m	10m	6m	30-40m
Sheet type-LAD	Medium palm tree, medium LAD	Deciduous, high LAD	Dense	-	-	Deciduous, low LAD
Construction material	Wooden pavement	White concrete pavement	-	-	Metal &concrete	Brick/ cobblestone pavement
Albedo	0.8	0.8	-	-	0.5-0.8	0.5
Orientation	N-S	-	-	-	NW-SE	N-S-E-W
Green roof-facade	-	-	-	-	Green roof & green wall	-

Table 1: Methods and characteristics of bioclimatic urban planning

3.3 Microclimate simulations of urban planning scenarios

In this research, it is decided the use of simulations, for evaluating the three basic regeneration scenarios of the study area, by ENVI-met across all year seasons, taking into considearation that microclimate and air pollution conditions created by urban planning methods in open spaces differ significally over the seasons. More specifically, one day of extreme weather conditions in winter and one in summer were simulated, as well as 24 hours of medium prevailing conditions in spring and in autumn. The duration of each microclimate simulation was 24 hours, and the time interval of each simulation was 1 hour.

The most extreme values of air temperature (oC), wind speed (m/s), wind direction and relative humidity (%) recorded in winter and summer of 2019 for the case study were input to the microclimate simulations

(AccuWeather, 2019; Chondrogianni & Stephanedes; 2021). Added to the extreme weather conditions, two more microclimate cases for each regeneration scenario were defined and simulated. In these cases, the average prevailing air temperature (min-max), the average wind speed and direction, and the average relative humidity (%) recorded in Patras during spring and autumn were the simulation inputs (AccuWeather, 2019; Chondrogianni & Stephanedes; 2021). The exact values of microclimate parameters used in the research simulations are presented by season in Table 2.

Season	Low temperature (°C)	High temperature (°C)	Wind speed (m/s)	Wind direction	Relative humidity (%)
Winter	-2	8	4.8	NE	57
Summer	25	38	4.3	SE	65
Spring	19	26	4.4	SW	55
Autumn	13	19	4.1	NE	62

Table 2: Microclimate input values to the simulation models by season

3.4 Financial cost estimation

Following the evaluation of the various methods of designing outdoor urban spaces for their contribution to urban durability, through the microclimate simulations, it is crucial to assess the financial costs of each one as the cost-profit analysis is a widely used method to support the decision -making process in urban regeneraion plans (Tudela et al., 2006).

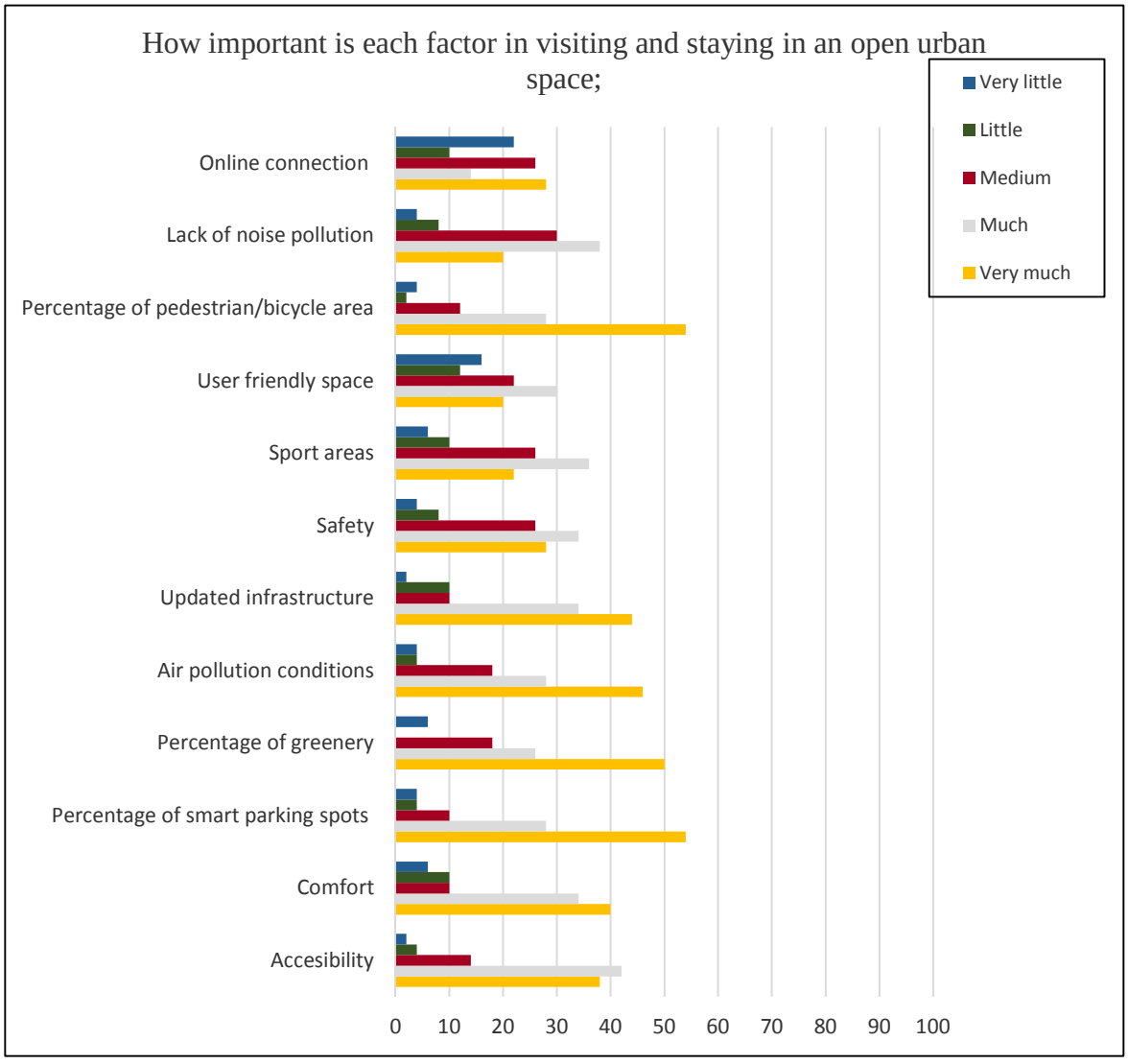


Figure 4. User preferences on public spaces

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

It is therefore necessary to note that the choice of an urban intervention is based on both the existence of the financial resources required for construction and for the maintenance of the intervention for the future so that the public benefits of the regeneration process of an outdoor urban space to be ensured.The main objective of the processes is to create public spaces for the citizens, with a pleasant microclimate and reduced air pollution conditions that can be constructed economically and be maintained effectively as the results of users needs‘ questionnaiers revealed.

CO_2 Concentration						Bioclimatic Index
M1- Tree canopy						
	Winter	Spring	Autumn	Summer	404,53	0.66
AV.	404,64	403,48	402,72	407,25		
M2- Medium Vegetation						
	Winter	Spring	Autumn	Summer	404,36	1
AV.	404,64	402,04	403,02	407,75		
M3- Open square-Concrete						
	Winter	Spring	Autumn	Summer	404,29	0.69
AV.	404,60	402,75	402,74	407,06		
M4 -Green fence						
	Winter	Spring	Autumn	Summer	404,66	0.85
AV.	404,62	403,65	402,91	407,46		
M5- Medium Vegetation II						
	Winter	Spring	Autumn	Summer	404,75	0.93
AV.	404,74	403,58	403,15	407,53		
M6-Tree canopy II						
	Winter	Spring	Autumn	Summer	404,27	0.41
AV.	404,55	403,39	402,74	406,39		
M7- Terre battue pavement						
	Winter	Spring	Autumn	Summer	404,47	0.71
AV.	404,56	403,55	402,89	406,90		
M8- Water surface						
	Winter	Spring	Autumn	Summer	404,15	0.53
AV.	404,51	403,15	402,69	406,27		
M9- Brick/cobblestone pavement						
	Winter	Spring	Autumn	Summer	404,77	0.81
AV.	404,88	403,84	402,86	407,61		
M10- White concrete pavement						
	Winter	Spring	Autumn	Summer		0.48
AV.	404,51	403,42	402,74	405,99	404,17	
M11- Wooden pavement						
	Winter	Spring	Autumn	Summer		0.39
AV.	404,88	403,84	402,86	407,61	404,77	
M12- Green Fence II						
	Winter	Spring	Autumn	Summer		0.59
AV.	404,67	404,54	402,99	407,44	404,91	
M13- Tree planting						
	Winter	Spring	Autumn	Summer		0.88
AV.	404,49	403,79	402,52	406,96	404,44	
M14- Tree planting II						
	Winter	Spring	Autumn	Summer		0.76
AV.	404,33	402,92	402,48	391,82	400,39	
M15- Low vegetation						
	Winter	Spring	Autumn	Summer		
AV.	400,36	389,35	402,18	400,36	398,06	0.34
M16- Water Surface II-Fountain						
	Winter	Spring	Autumn	Summer		0.45
AV.	399,94	402,72	397,74	406,27	401,67	
M17- Public Passage						
	Winter	Spring	Autumn	Summer		0.62
AV.	404,57	404,15	402,75	407,64	404,78	
M18- Closed Plateau						
	Winter	Spring	Autumn	Summer		0.57
AV.	404,59	403,74	402,79	407,60	404,68	

Table 3: CO_2 concentration in the microclimate and Bioclimatic Index of the urban planning methods

4 RESULTS AND DISCUSSION

4.1 Users’ preferences and needs

From the questionnaires’ results, the most important are referring to the factors that define citizens’ choice to visit an urban public space. The Figure 4 shows the results regarding this parameter. The factors that affect the choice and preference of users to visit and remain in an outdoor urban area are mainly the greenery rate, the percentage of sidewalks/bike lanes and the quality of the air they inhale. In addition, users seem to be

interested in accessibility, mobility and the level of safety in these areas. Finally, about half of the respondents want to access the internet and have electrically interconnected infrastructure.

4.2 Bioclimatic Index and CO_2 concentration results

The evaluation of the urban planning methods regarding the thermal and air comfort has been analyzed and presented in previous research concluding that medium size vegetation combined with natural coating materials create the most favorable microclimate conditions in seaside Mediterranean urban spaces (Chondrogianni & Stephanedes, 2021).

In addition, the CO_2 concentration in the microclimate of urban methods has been analyzed in previous research (Chondrogianni & Stephanedes, 2022) and showed that the method of low vegetation, including shrubs and grasslands as well as the water surface II-fountain (M15, M16) operate significantly more beneficial to reducing CO_2 concentration in microclimate, and therefore contributing more effectively in urban resilience to climate change. In the opposite, the public passage (M17) and green fence II (M12) lead to larger values of CO_2 concentration in the urban microclimate. In these methods, the lack of intense wind movement and circulation due to the narrow passage between the building in M17, combined with the dense green structure of M12, providing to wind protection, lead to higher CO_2 concentrations in the level of the pedestrians (+1.7m).

The microclimate simulation results are presented briefly in Table 3.

4.3 Financial cost results

The financial cost is estimated through the cost of construction for the minimum quantity and maintenance cost of each intervention for one year. For example, the cost fot the method M1-Tree canopy is calculated in detail in Table 4.

M1-Tree canopy					
		Unit cost	Ελάχιστη Ποσότητα	Σύνολο	Συν. Κόστος (€)
	Construction cost/tree	1000€/tree	6	6000	7392
	Labor cost	30€/hour	40	1200	
	Maintenance cost /year	32€/tree	6	192	

Table 4: Financial cost of the urban planning methods

The total costs per method are presented briefly in Table 5.

Code	Urban Planning Method	Cost per method (€) (Construction and annual cost)
M1	Tree canopy	7392
M2	Medium Vegetation	1030
M3	Open square-Concrete	1380
M4	Green fence	3040
M5	Medium Vegetation II	2310
M6	Tree canopy II	10942
M7	Terre battue pavement	4500
M8	Water surface	6970
M9	Brick/cobblestone pavement	1260
M10	White concrete pavement	1515
M11	Wooden pavement	3550
M12	Green Fence II	3600
M13	Tree planting	6590
M14	Tree planting II	4555
M15	Low vegetation	1830
M16	Water Surface II-Fountain	10190
M17	Public Passage	6600/11440
M18	Closed Plateau	5660

Table 5: Financial cost of the urban planning methods

include planting with high and large trees and their cost for placement is significantly higher than smaller trees. In addition, high costs are found in the construction of a green roof or green wall in M17-public passage, as they require special water supply systems and vegetation support on buildings, as well as the construction and maintenance of fountain (M16-Water Surface II-Fountain). The most economical interventions are M2-Medium Vegetation and M9- Brick/cobblestone pavement. In general, interventions related to soil coating either with some material or water, with the exception of the Terre battue pavement

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

(M7) can be selected for a small area as they are more economical while low and medium vegetation interventions are the least costly (M5- Medium Vegetation II, M15- Low vegetation).

5 CONCLUSIONS

Evaluating and implementing planning solutions for public urban spaces is a complex process that is best supported by a multiparameter approach that supports decision makers on selecting and implementing masterplans that have a positive impact in urban resilience and citizens' quality of life.

This research focused on the standardization, classification and multi-criteria analysis of urban planning solutions, commonly proposed for designing bioclimatic open spaces and improving urban microclimate and resilience. Their asssessment involved their contribution in thermal comfort, reducing air pollution, specific CO2 concentration, and their financial cost for construction and maintenance.

Further research should work on the extendibility and transferability properties of the research results through the identification and evaluation of additional types of urban planning methods in multiple locations across Europe with different climate conditions. Finally, more classes of planning scenarios could be simulated and rated, across a wider range of criteria and parameters.

6 REFERENCES

AccuWeather (2019). Weather conditions in Patras, Greece. Available at: https://www.accuweather.com/el/gr/patras/176765/february-weather/176765?year=2019 (accessed 10 January 2020).

ASHRAE (1989). Standard 62-1989, 6.1.3 Ventilation Requirements. American Society of Heating Refrigerating and Air-Conditioning Engineers.

Chondrogianni D., Stephanedes Y. J. (2022). Estimating the impact of urban planning methods in the air pollution of the open spaces' microclimate". International conference "Conference on Environmental Management, Engineering, Planning and Economics", Mykonos.

Chondrogianni D., Stephanedes Y. J. (2021). Evaluation of urban planning methods aiming at urban resilience to climate change and risk management in smart city framework. PhD Thesis, University of Patras, Greece.

European Commission (2019) A European Green Deal. Available at: https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal (accessed 15 March 2020).

Javeau C (2000) Research on questionnaires. Dardanos. Athens.

Osmidopoulou S. (2019) The contribution of the public urban space to the achievement of resistant cities. Basic approaches, reflections and examples. Aristotle University of Thessaloniki Polytechnic School, Department of Spatial Planning and Development Engineering.

SADAS-PEA (2016) Architectural Competition "Rehabilitation of Old Port of Patra". Available at: https://www.sadas-pea.gr/apotelesmata-architektonikou-diagonismou-ideon-gia-tin-anaplasi-paleou-limena-patron/ (accessed 9 September 2018).

Schmitt G. (2013) Information Cities. The Future Cities Laboratory: Singapore and Zurich. ETH-Novatlantis, August 2013.

Tudela A., Akiki N., Cisternas R. (2006) Comparing the output of cost benefit and multi-criteria analysis: An application to urban transport investment. Transportation Research Part A Policy and Practice 40(5):414-423.

WHO (2014) Global Health Observatory (GHO), Urban health. Available at: https://www.who.int/data/gho (accessed 12 October 2018).

🏆 reviewed paper

Navigating the City: Women's Perspective of Urban Mobility in the City of Johannesburg

Mueletshedzi Helen Phosho, Trynos Gumbo

(Mueletshedzi Helen Phosho, Dept of Urban and Regional Planning, University of Johannesburg. Cnr Siemert & Beit Streets, Doornfontein 0184 Johannesburg, South Africa, phoshomueletshedzihelen@gmail.com)
(Prof Trynos Gumbo, Dept. of Urban and Regional Planning, University of Johannesburg. Cnr Siemert & Beit Streets, Doornfontein 0184 Johannesburg, South Africa, tgumbo@uj.ac.za)

1 ABSTRACT

Infrastructure is a vital basis for supporting sustainable and inclusive socioeconomic growth in cities since it substantially affects access to education, employment, and other services. On the contrary, cities are designed without a consideration of all members of the society. Scholars note that a lack of mobility in cities can lead to geographical segregation, exacerbating inequalities by limiting access to opportunities for women and other marginalised groups in urban areas. Building infrastructure in cities that is gender-blind can lead to the social and economic exclusion of a large section of the population. There is a gap in literature on how gender roles influence the feeling of safety, inclusion and accessibility in cities. Recent research has highlighted the need to explore how specific urban contexts influence the feeling of safety, inclusion and accessibility of different genders in cities. This paper aims to explore Women's experiences of urban mobility in the city of Johannesburg. It followed a case study design to extract meaning from the experiences of women in the city of Johannesburg and adopted a qualitative method approach to the perception of safety and how it influenced mobility of women. Data was collected through a series of in-depth interviews with women who navigate the city daily mainly by foot or public transport and it was analysed using thematic analysis. Policies on safety and inclusive spaces within Johannesburg were also reviewed. The results show that the movement of women and the marginalised groups is limited to certain spaces in the city due to safety concerns. The paper also discusses the gendered nature of the city and how it impacts the mobility of women. Overall, it recommends putting in place policies that promotes safety and inclusiveness for all urban residents. Urban planning practices should create welcoming spaces that create positive perceptions about the cities.

Keywords: urban mobility, inclusiveness, gendered cities, Johannesburg.

2 INTRODUCTION AND CONTEXTUALISATION

Both the urban and rural populations expanded simultaneosly for several decades in South Africa, with the rural population somewhat increasing at a faster rate than the urban population (URBANET, 2020). However, in 1987 this trend changed, and urban population surpassed rural residents as the majority, sparking a fast increase in population in South Africa's cities which was quickly followed by a decline in the number of rural residents, a pattern that has persisted ever since (URBANET, 2020). The rapid urbanisation poses a great challenge in South African cities as the infrastructure is unable to cope with the influx of people moving to these cities from other African countries and Asian countries. Some of the challenges that cities in South Africa face include the establishment of a sufficient transportation infrastructure, given that a sizable section of the country's population relies on public transportation (The Practice Group, 2018). The most affected of these are the metropolitan cities such as Johannesburg, Tshwane, Cape Town, Ekurhuleni amongst other. Due to the apartheid system of governance which imposed a system of racial segregation, many settlements for the black majority in the country are located on the urban outskirts, which means that people from these communities travel long hours to access services and opportunities. This tends to limit mobility of women and other marginalised groups such as the elderly, people with disabilities, LGBTQI community and migrants from other Sub-Saharan Africa countries. Insecurity and the fear of physical or sexual violence in public spaces and when using public transportation are some of the key factors that come to play (Loukaitou-Sideris, 2014). Johannesburg is a city with many opportunities to improve one's livelihood, including job opportunities, access to education, health care and services. Many people come to this city in order to take advantage of these chances and build a prosperous future for themselves. Johannesburg, on the other hand, is a difficult city to traverse (Dirsuweit, 2002). Johannesburg is a city that is spatially divided. It is a city where activities are spread out (Miller, 2008), therefore getting to them would necessitate some type of mobility or transportation. A spatially dispersed city increases residents' movement within the city. As a result, residents' ability to fully utilise all the benefits of the city depends on them being able to move to various points within the city. Scholars note that a lack of mobility in cities can lead to

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

geographical segregation, exacerbating inequalities by limiting access to opportunities for women and other marginalised groups in urban areas (Blumenberg, 2004; Blumenberg & Manville, 2004; Grengs, 2010; Hadiyati, Tan & Yamu, 2021). The Department of Cooperative Governance and Traditional Affairs (CoGTA) introduced policy initiatives such as the Integrated Urban Development Framework (IUDF) to promote "liveable, safe, resource-efficient cities and towns that are socially integrated, economically inclusive and globally competitive, where residents actively participate in urban life" (IUDF, 2016). Some of the policies to promote safety for women may include the National Strategic Plan (NSP) which aim to address violence against women and 'creating an enabling environment in which women can feel safe' (Johnstone, 2021). In South Africa, there is a gap in knowledge on how the gender roles influence the travel spatial patterns and decisions, thus a need to research how the urban context influences the feeling of safety, inclusion and accessibility. Existing literature on safety and security of women in Johannesburg discusses Women's perceptions of danger and fear within the city outlining the areas and identifying the spaces in Johannesburg where women feel unsafe (Gordon, 2012; Pain, 1997). However, there is limited literature that discusses the experiences of Women's mobility and the things that limit their urban mobility in the city of Johannesburg. This paper thus focuses on understanding the experiences of women and how they navigate in Johannesburg. This paper starts by looking at the conceptual and theoretical framework whereby the term urban mobility will be defined in detail and the gendered nature of cities will be explained. It then moves on to look at the inequality and the mobility trends situation in the city of Johannesburg. The latter section presents the findings of this study; and lastly the paper presents the solutions that can be implemented to address urban mobility challenges that women face in Johannesburg and other South African cities.

3 CONCEPTUAL SYNOPSIS

Traditionally, urban mobility has been about "moving people from one location to another location within or between urban areas". This was based on a principle of people needing access to opportunities, housing alongside other urban services. Urban mobility in this paper refers to the ease with which people can move between destinations in urban areas with the help of the transport network and services available (EU Sustainable Urban Mobility, 2020). One can also define 'urban mobility' as catch phrase for all aspects of movement in an urban setting which includes all modes of transportation such as non-motorised transport and motorised transport and the spatial arrangements of these in a built environment (Gumbo et al 2022; Risimati et al 2021). Urban mobility has to do with accessibility (Gumbo & Moyo, 2020), which can be translated to providing adequate travel conditions that allows all urban residents to access and integrate into cities. Studying urban mobility from a gendered perspective is essential since having access to safe transportation is closely related to achieving the Sustainable Development Goals of the 2030 Agenda (SDGs). It may guarantee that women have equal chances for leadership in political, economic, and public life, as well as for effective participation (SDG 5.5). As a result, Women's unique requirements must be taken into account while planning for urban growth. Often due to differences occurring in socially constructed gender roles, women are predisposed towards certain travel characteristics that are distinct from those of men. These variations in travel patterns may result from a variety of factors, including different roles, safety concerns, reduced income, and reduced bargaining and decision-making capacity. Johannesburg is a focus area where, despite recent initiatives by the government to innovate urban mobility, the dynamics of transportation and infrastructure remain significantly gendered and thus limiting Women's movements within the city.

4 STUDY AREA

The scope of this study focuses on the city of Johannesburg, which is located in the province of Gauteng in South Africa, as shown in the figure below (Figure 1). The city of Johannesburg is one of the three metropolises of this province. It is bordered by Tshwane Metropolitan City to the north, Ekurhuleni Metropolitan City to the east, Sedibeng District to the south, and West Rand District to the west. It is the capital of Gauteng, which is the South African province with the biggest population comprising approximately 24 percent of the overall population. According to the (COJ IDP, 2020/21), Johannesburg is home to 5.74 million people, and it is approximately 16645 km2 in extent. The city population has grown on average by 2.91 percent per annum in the last decade which is close to double the growth rate of the national rate (1.57%). The city is a financial and economic powerhouse on a worldwide scale. Despite inward migration, its economy has expanded more quickly than South Africa as a whole, and it has increased

employment rates relative to the national average. Johannesburg also has one of the greatest levels of inequality in the world with a Gini co-efficient of 0.62, along with high rates of unemployment and poverty. Despite implementing a number of initiatives and regulations to become denser over the past 20 years, the city has expanded in a very sprawling manner. The city's spatial structure, however, is marked by a number of shortcomings, including low land use diversification, geographical inequity, fragmentation, and disconnection, as well as strain on the environment.

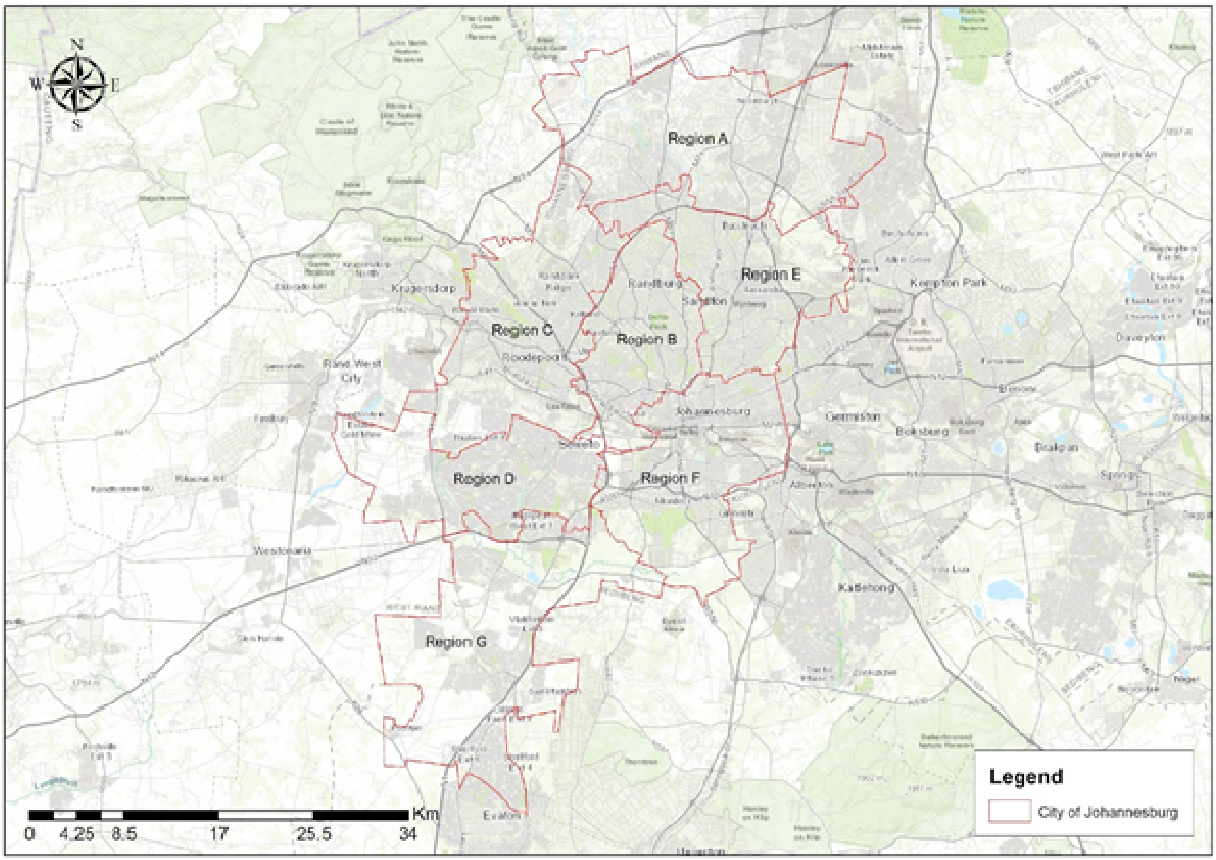


Figure 1: City of Johannesburg map (Source: Author, 2021)

The city of Johannesburg is divided into seven administrative regions as depicted in Figure 1 above. The regions in the city are also divided by wealth and status of its residents. “The poor mostly live in the southern suburbs or on the peripheries of the far north, and the middle- and upper class live largely in the suburbs of the central and north" (Smith, 2013). As Murray (2004, 17) observes: ‘The spatial morphology of the extended metropolitan region (Johannesburg) has polarised around two compartmentalised extremes: on the one hand, the spaces of affluence are healthy, functional and largely the exclusive preserve of the white upper- and middle-classes; on the other, the overcrowded spaces of confinement are distressed, dysfunctional and where the overwhelming majority of black urban residents live and work . . . ’.

As Dirsuweit (2002) notes that Johannesburg is a difficult city to navigate. The first challenge relates to the accessibility of the city. The city of Johannesburg is spatially divided. It is a city where activities are frequently dispersed across a wide area, necessitating some kind of transit or long-distance movement to get to them (Miller, 2008). Further, the way in which the city’s movement systems work and the design of the city tend to favour the male population as opposed to all the citizens of the city. This makes mobility of the female population in the city a challenge. Another reason that makes Johannesburg a difficult city has to do with people's perception of violence in the city (Dirsuweit, 2002). Violence in public spaces is evident and affects citizens' perception of the city. Perceptions of danger in the city pose a challenge to movement within the city, as women may restrict their movements due to this perception of danger (Pain, 1997). Both make getting around the city a challenge, especially for women.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

5 METHODOLOGY

This study aimed at investigating the experience of women within Johannesburg, thus it adapted the qualitative method approach to fully explore the research question: 'To what extent does the perceptions of safety in the city influence the mobility of women in the City of Johannesburg?'. The study aimed at understanding the challenges that women face when navigating the public realm of Johannesburg. A case study design was adopted and applied to extract meaning from the experiences of women living in the city of Johannesburg Metropolitan Municipality. The study was conducted through a series of engagements with women who engage with the city. The kind of data required for this research was that of daily experiences of mobility patterns. This would be information regarding Women's perceptions of Johannesburg and their perceptions of mobility in the city. The research required data on the mode of transportation used. The data was captured through a series of in-depth interviews with 30 females. Such data included general information whereby the researcher was able to extract information as well as building up a relationship with the respondents. The interviews also allowed participants to become familiar with the researcher and the research aims in order to understand what was required from them and to allow respondents to feel comfortable with the researcher to reveal detailed experiences of mobility within the City of Johannesburg. Interviews took the form of semi-structured in-depth interviews of approximately twenty minutes each. In the interviews, the participants were asked general questions such as where they are from, their age and how long they have lived in Johannesburg. Participants were asked to tell the researcher about their perceptions of Johannesburg. These perceptions referred to what they had thought about the city. The researcher also enquired what respondents' current perceptions are of the city. The final set of questions of the first interview related to perceptions of mobility in the city as a women. Here, participants were asked how they feel about movement in the public realm of Johannesburg. Participants were selected on the basis of being females who have access to the city of Johannesburg and navigate Johannesburg mainly by foot and by public transit. Participants were also required to be from a place of origin that is other than Johannesburg. Thirty participants were selected for this study. The interviews took place between the 25 of September 2019 and the 05 November 2019.

6 FINDINGS

There are challenges that women face in their movements in cities, and these challenges are not unique to the city of Johannesburg. A lack of safe transportation to and from work is linked to almost 16% lower labour force participation of women in developing countries, according to the United Nations' International Labour Organisation. In many cities, there are issues of inaccessible or unsuitable transport which negatively impacts a person's quality of life (Harrisberg, 2020). This disproportionately affects women and girls in terms of harassment, getting to school and accessing jobs. Female urban mobility issues in South Africa are primarily associated with unplanned, informally constructed urban areas that concentrate vulnerable people on city outskirts (Harrisberg, 2020. This results in females having to travel long, unsafe and expensive trips to inner cities or areas of economic opportunities.

6.1 Gendered Nature of Cities

The built environment is often defined as created by men for men. This includes buildings, their environment, land use patterns and design aspects of the public realm (Abada, 2013). Females are associated with maintaining family and households. The private sphere is constantly practiced as a space reserved for women. Here, they should spend most of their time and be able to work freely. On the other hand, men were considered the breadwinners and stronger than women (Hayden, 1980; Dredd, 1997; Quihato, 2009). Now that women work alongside men, these roles have changed. They often have other responsibilities besides taking care of the family. Women are also more active in the city. Women are constantly travelling around the city, studying and working. The question arises whether cities have developed and evolved to accommodate these changing roles for women (Miran and Young, 2000). Cities should be designed to accommodate both men and women (Rasoul et al., 2002). Different groups of the urban population perceive the city differently and therefore have different needs from the city (UN-Habitat, 2014). Scruton and Watson (2010) reveal the complexity of urban spaces. They argue that all places play a special role for different people and therefore have different meanings for different people. Quijado (2009) discusses how women create strategic relationships with the city. They often plan where, when and how to achieve their goal. Women often need a grocery store or daycare (if they have small children) close to where they work and

live. This allows them to travel through space and get all the supplies they need. Women also need a sense of security that varies depending on the environment. In some cases, women may feel safer in crowded places than in quiet ones, and vice versa. Feeling safe can also include features of the environment, such as the presence of a guard or the presence of sunlight or trees. Another important aspect is street lighting and maintenance of roads and sidewalks. This makes women feel comfortable in the place and creates a sense of security (Schmucky, 2012). Miran and Young (2000) discuss the relationship of women with the urban environment. They realise that it is suitable for places where women interact with each other. In this way, women adapt to their surroundings and often act differently depending on the nature of the space they occupy. In the same way, spaces change their appearance and shape with the presence of women. Another aspect discussed by these authors is the concept of gendered urban boundaries, which are described as places in the city where women are seen and places where they are not. This is related to the physical shape and appearance of the space and other factors such as space and time of day (Miran and Yang, 2000).

6.2 Uncomfortable City

Many women have expressed feelings of discomfort. This is because some of them are frequently subjected to different sorts of violence and harassment in public places, and aggressions such as intimidating staring and passing comments have become a norm in the city (Shah & Raman, 2019). Most of this violence happens when they are walking the streets and when in taxi ranks trying to catch a taxi, which happens to be the most used mode of transport in Johannesburg. The feeling of discomfort is expressed mainly by the women who rely on public transport to get to their destination in the city. They expressed that they are careful of what they wear when they go to the city. Short clothing is generally out of the question for these women as they are fearful of being sexually harassed, thus they opt to wear clothing that are long enough to avoid being harassed by the males in the city.

6.3 Inaccessible city

Studies show that men and women use public transport in different ways (Hanlon, 1998; Sánchez, & González, 2016; Goel. et al,. 2022; and this is as a result of their distinct economic and social activities. Mostly due to their social roles and their economic situation, women tend to travel more using public transport than their male counterparts. It is common for women to have more domestic responsibilities, such as taking care of children, running household errands, and maintaining family and community ties. However, women face real or perceived threats of violence on public transportation, such as sexual harassment and these are one of the most significant mobility constraints affecting women disproportionately (Kacharo, Teshome & Woltamo, 2022). It is common for women to experience verbal and non-verbal gender-based violence in public transportation, including groping, catcalling, inappropriate comments, assault, and even rape. Safety is one of the main factors that influences Women's mobility in many cities. In many cities, women regularly pay more to use e-hailing services and private taxi services to avoid harassment on public transport (Zhen, 2021). Equal access to public transport is about making the transport system usable for women and meeting their need for safe, efficient and sustainable mobility. However, due to poor transport planning, women often do not have equal access to public transport, making full access to the city inaccessible and limited to many women in cities. According to UN Women, 'public transport is an essential enabler in accessing the public sphere, without which women may be kept away from all essential economic, social, and political activities'. Women should be able to move about the city and access a variety of destinations by using public transportation. In the City of Johannesburg, there are a variety of public transportation that are available. These include the Metrobus, Rea Vaya, Gautrain, mini-bus taxis which are relatively affordable to most users. The study uncovered that many of the participants did not know how to access some of the modes of transportation. In the case of the Rea Vaya and the Metrobus, they did not know how or where they could buy tickets to use these services. The process of accessing these modes was a process which they would entirely avoid as they understand that they would have to use two to three of these buses and walking to reach their final destination. Thus, they would rather stick to using the mini-bus taxis as they only used one to reach their final destination. Flexibility has been cited many times with the mini-bus taxis as the preferred mode of transport by many participants. Participants who are unfamiliar with how the public transportation system works put them at a significant disadvantage and significantly limits their mobility within the city.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Another concern for participants is that they are unfamiliar with the city, having moved from another place and not lived in Johannesburg for an extended length of time. When they are unfamiliar with the route to a certain area, these participants are afraid of travelling by minibus taxi. The challenge is whether they exit at the correct location. As a result, those who want to travel for pleasure may prefer to stay at home. Women's preliminary views frequently prevent them from fully experiencing the city. When people are in some regions, they feel secure and comfortable, but not in others. The participants highlighted that before they can embark on the journey to the city, they firstly assess the risks involved and also try to map the exact routes that they would use when walking in the city and they plan the time they would walk in these areas. This judgment is based on space characteristics such as lighting (when it is dark), crowdedness, and public waste maintenance, as demonstrated by some of the respondents who are afraid to walk in Johannesburg after dark.

Another issue with access within Johannesburg it is the spatially segregated city. The activities are often placed far from each other which usually would require a sizeable time to travel between the location of these activities. It is important to note that spatial isolation of the urban poor (and mismatch between housing and jobs) in cities is not unique to Johannesburg. Cities in Brazil, Mexico, Chile and Colombia face similar problems. The way a street segment is arranged in relation to other street segments in an urban system influences people's use and perception of space. For instance, people tend to choose a route with less angular deviation or the straightest route as it is less confusing (Dalton, 2003; Hidayati, Tan &Yamu, 2020). Hillier et al., (1993) note that streets that are better connected to other streets are more accessible, attracting more people and becoming a possible location for socioeconomic activities. These types of streets attract many women as many activities are clustered in a single area. In contrast, because of the lack of other pedestrians and limited public activities, a separated street with only one link to other streets, such as a dead-end, is likely to be seen as unsafe (Nguyen and van Nes, 2013). Because traditional planning and design of a built environment rarely take these considerations into account, the existing spatial structure unintentionally reinforces the socio-cultural constructions that enable gendered mobility (Terraza et al., 2020). The city turned to Transit-Oriented Development to address the spatial isolation issue, which emphasises creating compact, walkable, mixed-use, mixed-income communities centred around high-quality public transportation. Additionally, the city has undertaken urban renewal projects in the inner city in order to encourage mixed land use.

6.4 Unsafe and insecure City

Many participants concluded that they generally feel unsafe walking in Johannesburg's public spaces. Participants say they feel safe walking in certain areas, bearing in mind their caution. Participants who travel on foot as their primary means of transportation do not appreciate the experience of walking during rush hour. Instead of feeling reassured by the presence of other people, they see crowds as an opportunity for pickpocketing. This is due to the presence of many pedestrians walking on the sidewalks, making it a challenging task to keep an eye on your belongings. During peak hours, participants are also cautious of vehicles that do not stop at stop signs. Some participants also indicated that as long as they practice caution, the city may be safe. This applies to all kinds of transportation, particularly walking. Another prevalent theme across participants, whether they feel comfortable in general or not, is that they feel better travelling in groups. A common factor that makes participants feel safe is their familiarity with the space. All participants stated that when they get to know a place, they feel safe in that place. Familiarity with a long stay in the city has a strong connection. Participants who have lived in the city for a long time generally feel more comfortable in their surroundings than participants who have lived in the city for only a few years. Many participants discussed how they did not feel safe in an unfamiliar area. Some may choose to avoid these spaces entirely because of the unknown. The participants have the same perception regarding public transport. They may choose not to travel if they fear using a particular mode of transport with which they are unfamiliar. Participants moving through the spaces, whether or not they are familiar with the spaces, feel safer in public spaces when the Johannesburg Metro Police Department (JMPD) or security personnel are present. Familiarity with a room increases the feeling of security. Participants who live in a certain area feel safer moving around the area than someone who does not live in the area. Participants living in Johannesburg feel safer to move around than those living elsewhere. Another outstanding feature that makes participants feel secure is when travelling with a companion. Participants tend to feel safer in public spaces when doing so with friends. This sense of security increases with the number of friends travelling and also increases when a male friend is present. This understanding makes it clear that companies can have gender biases, as

participants often feel safer when travelling with a male companion. They reported that the company trip seems "safer, shorter and generally more comfortable". This applies to travel by all means of transport. Participants also believe they could explore Johannesburg more if they travelled with a companion. Finding company for the move can be difficult as the participants' friends or family may not want to travel as much as the participant chooses to. Participants usually only have limited time. If they are available to explore the city, there may not be the time for their friends to join them. This complicates their mobility in the city. In terms of safety related to different modes of transport, participants feel more secure when travelling by private transport. Reasons why participants did not like their experience in Johannesburg CBD were verbal harassment from men and worrying about their belongings in the crowded spaces. The women interviewed cited security as a key issue regarding the limited access to Johannesburg and the high level of gender-based violence against women in the city. This study identified cases of sexual harassment of women in Johannesburg while using public transport and waiting for public transport. Poor infrastructure, including street lighting, public toilets and comfortable sidewalks, makes travelling by public transport extremely inconvenient and dangerous. Long distances were also found to be a major barrier to Women's mobility in Johannesburg.

6.5 Fear of Traveling at Night – A Restrictive City

Some participants' behaviour is affected by travel time, but not all. According to some participants, traveling at a certain time of the day has a significant impact on their experience. Johannesburg residents generally described walking in the area after dark as a pleasant experience. The duration of the trip is another factor all participants must take into account, along with the time of day. It was more common for participants to consider the duration of their journey at night. Many participants reported feeling unsafe traveling long distances at night. Women suffer more from physical conditions. This affects the roads or modes of transport that many women choose. For example, trying to be safe when alone at night. The participants talk about the careful planning that girls often do before an evening outing. They usually carefully plan out the evening, the mode of transport they are going to use, which routes is it going to take, if they are walking which streets they will use to get to their destination and who they will be walking or travelling with. Many women say that the last mile is the hardest. Streets can be dimly lit and empty. Some women take detours and avoid parks to walk along busy and wide streets. Others go through their keys, making the intruder think they live nearby and the neighbours are watching. In the tunnel, the girls look for safe islands. They try to avoid long waits at the lower metro station and, if necessary, prefer to join proven groups.

6.6 Economical Exclusive City

Some of the issues that interviewed women highlighted was the issue of affordability. According to the United Nations Development Program's (UNDP) Human Development Report, women compose the vast majority of the world's poor. This is more noticeable in cities. Most women stated that some of the reasons why they do not explore the city is mostly due to financial constraints. They spend most of their money attending to the household needs such as taking care of the family amongst others as they were single and sometimes unemployed mothers, and independent females who moved to Johannesburg to look for economic opportunities. Women lack access to the same resources as males, and their ability to be economically active is limited because, in virtually all civilizations, they still bear the majority of childcare and reproductive obligations (Allen, 2018).

7 ADDRESSING WOMEN'S MOBILITY AND ACCESSIBILITY TO CITIES

Women find it difficult to move around cities on a daily basis. This is due to poor design of urban spaces, which only takes into account the needs and mobility patterns of people in general. Women have different needs and experiences in urban spaces, which affects their use of these spaces. This is overlooked by urban planners who take into account general needs and specific mobility patterns as the universal model. Access to transport, both public and private, is critical to Women's rights and equality. Limited or inadequate access to transportation can limit Women's quality of life, education, employment, cultural opportunities, and leisure time. Thus, when addressing Women's mobility and accessibility in the context of cities, a holistic approach should be taken. Below are some of ideas that have been proposed to address the challenge of mobility of females in cities.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

7.1 Active Participation of females in the transport sector

The transportation industry is still heavily dominated by men. Only 8% of employees in the Sub-Saharan African transport business are female, a figure that is progressively increasing slowly over time (Shawa, Sossa & O'Higgins, 2020). This has an impact on how Women's voices (as road and transportation users) are heard. Incentives for transportation services are insufficient to meet the needs of female service customers. Evidence from South Africa suggests that an increase in female legislators correlates with progressive legislation that addresses Women's mobility needs (Dominguez Gonzalez, 2018). Similarly, exposing young girls to STEM disciplines and promoting paid internship programmes by transportation companies can be game changers (Dominguez Gonzalez, 2018).Programmes that promote females in the transportation sector should be implemented. For instance, the South African Network for Women in Transport (SANWIT) was introduced to improve the proportion of women in the transportation sector in South Africa. The South African Network for Women in Transport (SANWIT) concept was born out of a need to break existing barriers for entry into the sector and to demystify existing myths.

7.2 Inclusivity through needs assessment and provision

Aside from including Women's perspectives in the redesign of public transportation, it is important to identify Women's mobility constraints outside of transportation systems (Dominguez Gonzalez, 2018). Despite the availability of accessible transportation, women were afraid to go about due to their fear of the unknown, according to one study. The limits on Women's mobility are multifaceted, and solutions must be multifaceted and cross-sectoral as well. To boost Women's mobility, such solutions must involve unconventional ways, such as relocating some of the services to be convenient to women and other marginalised groups.

7.3 Gender-informed infrastructure and transport services

Gender sensitive infrastructure design necessitates a consultative approach with women in order to understand and solve their special demands, one of which being safety concerns (Dominguez Gonzalez, 2018). Women's mobility differences and requirements have been translated into applicable infrastructure and traffic planning in Vienna, Austria: stations and waiting areas were renovated to allow clear views of the surrounding region, systems were streamlined to make them more user-friendly, route pavements were made larger, and walkways were added (Dominguez Gonzalez, 2018). Countries such as Mexico, Brazil, India, and Japan have pushed women-only cars to boost safety among female public transportation riders. This strategy could be a short-term answer for increasing Women's mobility in places where sexual harassment and violence are common. It does not, however, address the underlying causes of violence against women. More innovative and holistic approaches to improving gender dynamics are needed, such as community interventions in transportation systems that inform transport users and operators how to intervene in cases of harassment.

7.4 Spatial Planning

Concepts like co-design, human-centred design, and inclusive master planning emphasise the necessity for these spaces to be created with participation from all users. Building a strong sense of empathy for the people you are planning for and which is essential, as is realizing that what constitutes quality of life varies from location to place, community to community, and over the course of a person's life. A very customer-centric approach to planning and design is frequently used by public transportation agencies to do this, but it is rarely used across cities with gendered urban design that takes into account female patterns of time management and simultaneous task completion. Fundamentally, accessibility must be taken into account in planning and design in order to be hospitable and beneficial to the entire population. This is crucial if planners want communities to take ownership of, responsibility for, and pride in their common areas. Cities can be made more inclusive for everyone by incorporating more mixed land uses, better and more accessible public transportation (which can accommodate a variety of travel patterns and multi-journey trips), safety and security, and the co-location of social infrastructure, or the "city of short distances."

7.5 Create safe spaces

Comfort is influenced by a number of elements, such as good lighting, areas for individuals and groups to sit, and weather protection. However, the most crucial component of welcoming and secure settings is still

prospect and refuge (Jain, 2021). It's crucial to be able to observe your surroundings while maintaining your privacy, especially if you're among other ladies or kids. The presence of other people, which relates to Jane Jacobs' concept of "eyes on the street", is a crucial factor in comfort. One of the most crucial elements influencing Women's preferences and decisions about transportation in the country is personal safety. Better physical infrastructure cannot only support non-motorised mobility, but also enhance last or first-mile connectivity for public transportation (Jain, 2021). Examples include wide pathways with adequate lighting, removing dark corners and view-obstructing structures, public restrooms, women-specific safe parking spaces, and adequate seating arrangements.

Jane Jacobs emphasised the value of covert surveillance of the urban environment in 1961. According to her "eyes on the street" theory, unofficial observation in lively public areas can help individuals feel comfortable even when they are around strangers. Restaurants or stores that foster a friendly environment can be built close to public transportation hubs to create active community areas. This bottom-up approach to community planning can build networks of shared care and offer covert surveillance for women (Jain, 2021). The prevalence of sexual harassment may increase as a result of overcrowding. Women have a shorter window of time to commute by public transportation due to safety concerns. The smaller "safe window" might lead to more traffic during particular hours, which decreases the dependability and safety of public transportation. By increasing the frequency of short-distance mobility services and developing a flexible fee structure to assure multi-journey tickets, transportation services must be improved in order to minimise congestion (Gulati, 2015). Women drivers offering GPS-enabled night-time taxi services may increase safety during off-peak periods.

It is possible to address safety issues by stepping up surveillance at important transportation hubs. This can be secured by placing more women in positions of authority within the transportation industry, actively monitoring CCTV with a focused task force, and using GPS tracking services. However, it is challenging to track down intermediate forms of public transportation like mini-bus taxis services, which is the most used form of public transport in South Africa because they are not properly registered. Policies that regulate and ensure registry of every vehicle in the cities are available, but enforcement of these policies are very rare. Thus, there needs to be a stronger emphasis on the enforcement of those policies in the country.

7.6 Accessible spaces in City

Women's inclinations for mobility vary across the globe. It is important to consider parks, plazas, streets, and other public areas as a cohesive whole when planning (and designing) them. A wonderful park can only be as secure and welcoming as the dark, winding alley that leads up to it. However, public areas should be reachable by all modes of transportation, including on foot. All users desire navigation that is clear, numerous, and readable. Exits that are visibly marked and well-lit, safe spaces integrated into public areas, and ways to make emergency contacts are all crucial. To boost Women's mobility and access to economic opportunities, a comprehensive strategy is required. It would need to consider the three factors of infrastructure design, transportation services that are appropriate for Women's demands and decision-making processes, and mobility constraints (Gulati, 2015). Women should not have to worry about being harassed or attacked in public. They ought to have mobility choices that satisfy security requirements. Women should no longer be denied equal rights by the transportation system. It should be one that gives them enough power that designing for female users becomes standard practice rather than an exception. In addition to increasing the economic and social prospects for women, increased mobility is crucial for reducing environmental harm and urban congestion. Particularly during the epidemic, having insufficient access to secure transportation can worsen Women's "hidden hurdles" to employment and hinder their ability to access other services like health or education (Gulati, 2015). In order to realise their entitlement to the city and promote inclusive urban development, women must reclaim public places.

7.7 Measures to change men's attitude towards women

In the today's world, it has been noted that women are generally treated as second class citizens (Kambarami, 2006; Phadke & Roy, 2017), who are not able to make their own decisions. Those that dare to express themselves openly are punished and judge by society (Merry, 2003; Javed, 2012). Thus, there is a need to change people's attitudes and the way they view women in societies so that women can feel safe in both the public and private spaces. These attitudinal changes can start from an individual's upbringing.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Women (as mothers) need to teach children at a younger age about behavioural codes in the form of what is an acceptable behaviour and what is not acceptable to women. These attitudinal changes also need to be introduced to the country's educational system since 'educational institutions convey a gender stereotypical attitude in subtle ways' (Javed, 2013). Ethics need to be introduced as part of the school curriculum for young students, they need to be taught life skills such as how to approach, treat and respect women and other marginalized groups. Men in general need to be educated on the importance of treating women as their equals in society.

8 CONCLUSION

An inclusive city is one where all citizens have equal access to explore and enjoy the city without discrimination. It is a city where all its residents feel they belong. This is a city that residents love and want to be a part of. The purpose of this study was to understand women as a group in Johannesburg in terms of their mobility and experiences of mobility in the city. The results showed that most women do not enjoy the experience of moving around Johannesburg either by public transport or walking. Thus, urban planning procedure should be used to create a more pleasant city for women and the other disadvantaged minority groups. Urban design should be addressed in a way that creates positive thoughts about the city, so that instead of women being afraid and nervous about moving in the city, they feel confident and excited about moving in the city.

9 REFERENCES

Abada, N., 2013. Understanding women-friendly cities: distilling elements from United Nations designated cities.

Allen, H., 2018. Approaches for gender responsive urban mobility. Sustainable Transport: A Sourcebook for Policy-makers in Developing Cities Module 7ª. Recuperado de http://cort. as/-JuZP.

City of Johannesburg (2020), Integrated Development Plan 2020/21 Review, Johannesburg: COJ

Department of Cooperative Government and Traditional Affairs Towards an Integrated Urban Development Framework(2014) 20–25

Dirsuweit, T., 2002. Johannesburg: fearful city?. In Urban Forum (Vol. 13, No. 3, pp. 3-19).

Dominguez Gonzalez, K., Machado, A.L., Bianchi Alves, B., Raffo, V., Guerrero, S. and Portabales, I., 2020. Why Does She Move?.

Goel, R., Oyebode, O., Foley, L., Tatah, L., Millett, C. and Woodcock, J., 2022. Gender differences in active travel in major cities across the world. Transportation, pp.1-17.

Gulati, N., 2015. How can placemaking help create safer cities for women. Project for Public Spaces, 28.

Güney, Y.İ., 2014. Gender and urban space: An examination of a small Anatolian city.

Gumbo Trynos and Moyo Thembani (2020) Exploring the Interoperability of Public Transport Systems for Sustainable Mobility in Developing Cities: Lessons from Johannesburg Metropolitan City, South Africa, Sustainability, 12, 5875; 1-16; https://doi:10.3390/su12155875

Gumbo Trynos; Moyo Thembani; Ndwandwe Bongumusa; Risimati Brightnes; Mbatha Siphiwe (2022) Urban Public Transport Systems Innovations in the Era of the Fourth Industrial Revolution: Perspectives, Reflections and Conjectures, Springer Nature Switzerland AG, https://link.springer.com/book/10.1007/9783030987176

Harrisberg, K. (2020). 'Feature-Women and Girls Bear Brunt of Africa 'Transport Poverty'', Reuters, 13 November [Online]. Available at: [Accessed 25 July 2022]

Hanlon, S., 1998, July. Where do women feature in public transport?. In Women's Travel Issues Second National ConferenceDrachman Institute of the University of Arizona; Morgan State University; Federal Highway Administration.

Hayden, D., 1980. What would a non-sexist city be like? Speculations on housing, urban design, and human work. Signs: Journal of Women in Culture and Society, 5(S3), pp.S170-S187.

Hidayati, I., Tan, W. and Yamu, C., 2020. How gender differences and perceptions of safety shape urban mobility in Southeast Asia. Transportation research part F: traffic psychology and behaviour, 73, pp.155-173.

Hidayati, I., Tan, W. and Yamu, C., 2021. Conceptualizing mobility inequality: Mobility and accessibility for the marginalized. Journal of Planning Literature, 36(4), pp.492-507.

Hillier, B., Penn, A., Hanson, J., Grajewski, T. and Xu, J., 1993. Natural movement: or, configuration and attraction in urban pedestrian movement. Environment and Planning B: planning and design, 20(1), pp.29-66.

Johnstone, S. (2021). 'Gender Sensitive Planning and Urban Design for Cities to Respond to GBVF', Local Government Bulletin, Vol 6, Issue 1. Available at: https://dullahomarinstitute.org.za/multilevel-govt/local-government-bulletin/archives/volume-16-issue-1-march-2021/gender-sensitive-planning-and-urban-design-for-cities-to-respond-to-gbvf (Accessed: 07 July 2022)

Kacharo, D.K., Teshome, E. and Woltamo, T., 2022. Safety and security of women and girls in public transport. Urban, Planning and Transport Research, 10(1), pp.1-19.

Kambarami, M., 2006. Femininity, sexuality and culture: Patriarchy and female subordination in Zimbabwe. South Africa: ARSRC.

Loukaitou-Sideris, A., 2014. Fear and safety in transit environments from the Women's perspective. Security journal, 27(2), pp.242-256.

Lloyd, J., 2020. The non-sexist city: Then and now. Contentious Cities, pp.126-136.

Merry, S.E., 2003. Rights talk and the experience of law: implementing Women's human rights to protection from violence. Human rights quarterly, pp.343-381.

Miller, R.G., 2008. To Save a City: The Berlin Airlift, 1948-1949 (Vol. 68). Texas A&M University Press.

Nguyen, T.M. and Van Nes, A., 2013. Identifying the spatial parameters for differences in gender behaviour in built environments: The flaneur and flaneuwe of the 21st century. TRIA-Territorio della Ricerca su Insediamenti e Ambiente. Rivista internazionale di cultura urbanistica 10,(1) 2013.

Pain, R., 1997. Whither Women's fear? Perceptions of sexual violence in public and private space. International Review of Victimology, 4(4), pp.297-312.

Phadke, S. and Roy, A., 2017. Women walk out: Tired of being harassed and treated as second class citizens, Indian women are taking to the streets. Index on Censorship, 46(4), pp.50-53.

Risimati Brightnes, Gumbo Trynos and Chakwizira James (2021) Spatial Integration of Non-Motorised Transport and Urban Public Transport Infrastructure: A Case of Johannesburg, Sustainability, 13, 11461; 1-17, https://www.mdpi.com/2071-1050/13/20/11461

Sánchez, M.I.O. and González, E.M., 2016. Gender differences in commuting behavior: Women's greater sensitivity. Transportation Research Procedia, 18, pp.66-72.

Shah, S. and Raman, A., 2019. What Do Women and Girls Want from Urban Mobility Systems. New Delhi: Ola Mobility Institute.

Shawa, K.C., Sossa, P. and O'Higgins, N., 2020. Report on employment in Africa (Re-Africa): tackling the youth employment challenge.

Smith, D., 2013. Johannesburg Rebuked Over 'World-Class City'Advert. The Guardian.

Terraza, H., Orlando, M.B., Lakovits, C., Lopes Janik, V. and Kalashyan, A., 2020. Handbook for Gender-Inclusive Urban Planning and Design.

Wekerle, G.R., 1980. Women in the urban environment. Signs: Journal of Women in Culture and Society, 5(S3), pp.S188-S214.

Werland, S., 2020. Diffusing sustainable urban mobility planning in the EU. Sustainability, 12(20), p.8436.

Zhen, S., 2021. Rethinking public transportation for Women's safety and security. Bonn, Germany.

Dalton, R.C., 2003. The secret is to follow your nose: Route path selection and angularity. Environment and Behavior, 35(1), pp.107-131.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

🏆 *reviewed paper*

New Forms of Urban Data and their Potential for Municipal Decision Making

Chhavi Arya, Nina Müller, Karina Pallagst, Martin Berchtold

(M.U.R.P., Chhavi Arya, TU Kaiserslautern, RU-dvmP, Pfaffenbergstraße 95, 67663 Kaiserslautern, chhavi.arya@ru.uni-kl.de)
(MSc, Ing. Nina Müller, TU Kaiserslautern, RU-IPS, Pfaffenbergstraße 95, 67663 Kaiserslautern, nina.mueller@ru.uni-kl.de)
(Prof. Dr.-Ing. Karina Pallagst, TU Kaiserslautern, RU-IPS, Pfaffenbergstr 95, 67663 Kaiserslautern, karina.pallagst@ru.uni-kl.de)
(Jun.-Prof. Martin Berchtold, TU Kaiserslautern, RU-dvmP, Pfaffenbergstr 95, 67663 Kaiserslautern, martin.berchtold@ru.uni-kl.de)

1 ABSTRACT

In recent years, cities have been exposed to many disruptive influences. Among them is the digital revolution, which has also begun to transform urban space via the economy and society. The now ubiquitous and continuous connectivity has reached a large part of humanity, thanks to the mass distribution of smartphones, free Wi-Fi networks and the resulting access to information, social networks and audio-visual entertainment [1]. Digitalisation took on a particular importance in the context of pandemic-related impacts.

The need for digital connectivity increased, especially in the fight against COVID-19, as city governments around the globe used contact tracking (Bluetooth proximity data) from smartphones to detect infection contacts and reduce infection rates. The resulting form of urban data is new to municipal use and points to the hidden potential of other forms of data. Through the use of today's technologies, municipalities can collect their own data in many areas, generating a new understanding of complex urban dynamics aiding spatial decision-making with higher transparency [2].

Disruptive influences, uncertainty, crises and climate catastrophes require a more evidence-based and a bottom-up spatial planning process. In regard to solving more complex problems and increasing the speed and agility required by the city administrations, it is important to investigate how new data forms can affect spatial planning decisions. The German planning system referred to in the paper (section 2) is very hierarchically organised, as are its processes. Local, fast-moving and contextual data collection could counteract the inertia of the planning system.

In general, the use of data to understand urban systems is not a new phenomenon, but nevertheless necessary. The increasing complexity and constant change of cities now requires the use of more real-time and comprehensive data sets to complement censuses and surveys [3]. The temporal limitations of the latter seem only suitable for representing static or semi-static urban phenomena, as they do not take into account the subtleties of urban dynamics or the impact of real-time activities on various urban systems and the daily lives of citizens [4]. At the same time, improving the quality of life of the inhabitants is the ultimate goal of a city. While urban planning has an impact on the quality of life in cities, the citizens too have an important role in developing a city. It is thus essential to consider them in the decision making process.

But which data forms and sources are capable of meeting these challenges and what new information and opportunities do they offer? Specifically in regard to the German planning system which follows a bureaucratic approach of decision -making, it is important to find out the planning decisions which can be supplemented with new data forms at the municipal level. In this regard, the paper targets urban datasets that can add significant value to municipal decision-making processes and spatial development strategies (section 3).

The paper focusses on examining the emerging datasets and their application in spatial planning. For this purpose, an overview of the data landscape is shown (section 4), which highlights the new data forms (Figure 1). Qualitative literature analysis was used to investigate municipal decision-making and spatial planning decision-making processes in Germany. Drawing on the results, a SWOT-analysis will be used to display the potentials and limitations of new forms of urban data for spatial development (section 5). The conclusion (section 6) highlights this potential for municipal decision making.

Keywords: German Planning System, Urban Analytics, Urban Data Sources, Spatial-Planning Decisions Processes, New Data Forms

2 SPATIAL PLANNING IN GERMANY

The chosen framework for decision-making processes in spatial planning is the German planning system. The following paragraphs showcase the German context of spatial planning and the respective planning

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

culture [5]. In order to understand the decision-making processes, first the German planning system is briefly explained and then the processes of decision-making in municipalities.

2.1 Planning system

In Germany, the planning system is a hierarchical system and has its administrative competences mainly at the local level [5]. These hierarchical, spatial levels are interconnected and interdependent due to the subsidiarity principle, the countercurrent principle and federalism [6]. Although the paper refers to the municipal level (cities and villages), it should be noted that due to the dependencies mentioned, a narrow consideration of this spatial level is only possible to a limited extent.

Legal foundations such as the Federal Spatial Planning Act and the Federal Building Code, but also EU directives, regulate the tasks, duties and competencies of the spatial planning levels and the instruments available for this purpose. In addition to the formally regulated instruments (e.g. binding land-use plan or preparatory land-use plan), there are also informal instruments for procesess of consensus-building such as masterplans and integrated development plans, which provide guidelines and strategic goals and thus influence the control of urban development [7]. Like the hierarchical system, spatial planning instruments are interrelated and need to be coordinated. Informal planning processes and tools, in addition to the lengthy, formal planning processes, can facilitate cooperation between stakeholders and lead to faster results and should be seen as complementary to formal tools [5].

The goal is to create a coordinated, strategic and integrated planning process that is guided by the goals, principles and other requirements of spatial planning [8] and that controls spatial developments in the medium to long term in the interest of the common good. In order to achieve this goal, all relevant stakeholders (e.g. public agencies) and specialist planning must be involved in the decision-making process [9], and a transparent data basis is required as a foundation for decision-making.

2.2 Municipal Decision Making Processes

Decisions made by a municipality must be politically legitimised. This also applies to planning and spatial decisions, e.g. on future urban development. The content-related and thematic processing of a problem or an issue naturally takes place via the responsible experts. Within their work, it is important to find the best possible alternative through analyses and scenarios, to provide the politicians with all the necessary information in this regard [10]. An example could be the question of maintaining a swimming pool. Closing the swimming pool can save costs of the municipality. At the same time, an important infrastructure in the leisure and sports sector is lost. Therefore, the effects are not only aimed at the municipal budget, but also at aspects of health and the climate for the municipality and its citizens (cooling in summer, fresh air corridor, sports training). The task of the spatial planner is enabling the politicians (e.g. city council) to decide in the interests of the general public by preparing decisions, despite the lack of their own processing [10]. The basis for all research and preparation is information and data, e.g. on socio-economic development and land use, as well as on effects of different scenarios.

As mentioned above, the decision itself must be made in the interest of the general public, i.e. the residents. The political legitimacy of the members of a city council is based on the representation of the citizens. In the interests of the residents and in accordance with applicable law, the best alternative must be found from among existing scenarios. This is done as part of a decision-making process in which various indicators or even entire scenarios are weighed against each other [11].

Since there are no universally valid indicators with fixed benchmarks for many questions and problems, a decision cannot simply be made logically. In addition, similar problems must also be individually classified and addressed by the prevailing local context. In this respect, urban data offer the opportunity to gain an objective, local and holistic understanding.

The planning decision-making process thus consists of an approximation of the best alternative, taking into account aspects such as economic viability, future viability and sustainability, as well as democracy (e.g. through participation). In the absence of a generally applicable scheme that fits all individual cases specific to a region, an individual solution must be found. In this process, actual, local information is crucial to provide adequate place-based development.

But which data sets should be considered? Which data sources are important? How should data be collected and how should data protection issues be dealt with?

3 URBAN DATA LANDSCAPE

Data protection is considered a fundamental right in Germany and is implemented through the European data protection regulation (DSGVO) and supplementary national laws [12]. As the process of digitisation is currently underway, data is being seen as an enabler of development. The Data Protection Laws in this regard set a boundary for the use of data without compromising the personal identity of a person directly, or indirectly. The section below discusses the types of data and their potential, keeping in view the overarching presence of Data Protection Laws.

3.1 Data Landscape

Today's cities are engines of a new data economy. The proliferation of technologies in the urban fabrics, such as sensors, wireless telecom networks and building management systems is generating vast troves of data to control energy and demand-based systems like traffic, transport, water supply and so on. Coupled with the growth of sensor and GPS technologies in hand-held devices such as smartphones and travel cards, the amount of data captured by a city- from volumes of energy used, movements of people, traffic, water and waste, social media interactions and multi-modal transport flows- is unprecedented. As such, cities are becoming knowledgeable and controlling in new dynamic ways, responsive to the data generated about them [13]. The Smart City Charter, Germany, first published in 2017 underlines the value of digital transformation to drive sustainable urban development and lays guidelines for cities, counties and municipalities for the application of new technologies for a long term, considered view. Novel analytical practices promise smoother decision-making as part of a more evidence-based and smarter urbanism [14]. While this continuous influx of data points towards the potential of knowing the city in real-time, it is also important to note that as their sources continue to increase in number, the produced data sets increase in diversity. The data from location-based sensor networks or geo-enabled social-media are temporally and spatially grained but they are not originally designed for their application in decision-making in the realm of spatial planning.

This current availability of data from multiple sources is both an opportunity and challenge for spatial planning and decision-making. Whereas there now exists a possibility of employing different data sources which could help overcome the bias of a single source (e.g. incompleteness, small sample coverage, lack of time tags etc.) and potentially provide richer descriptions of urban systems and human behaviour, significant problems of interoperability and integration are also raised [4]. Moreover, the urban data landscape for spatial planning is largely uncoordinated with respect to its producers, consumers and its operators making use of data restricted to limited areas in urban governance. The following section attempts to give a systematic overview of the available urban data sources that can be relevant for municipal spatial decision-making processes and increase an understanding of how data can be made actionable in a public-setting based on the German Planning System.

3.2 Types of Urban Data

The term urban data can be interpreted in many ways. According to the authors José António Tenedório et. al [15], urban data is a graphic and alphanumeric record referring to the urban, with highly accurate scales of analysis, providing information necessary for understanding, knowledge and decision-making in the fields of urbanism and urban planning. This definition emphasises the source of production of data, i.e.-urban as a basis for categorisation. Another definition, by authors Silke Cuno et. al places the importance on the specific effect of a dataset on urban space as a precursor for qualification as urban data. They define urban data as all types of data that are important in the urban context, regardless of the specific data origin, data management, the associated intellectual property rights and licensing requirements. Urban data may include data that extends beyond the direct local context, for example, when needed for a municipal process based on data of supra-regional or global relevance, or simply if it has general effects on the urban space/environment—for example, climate data or financial data [16]. Sidewalk Labs, an urban innovation unit within Google, defines urban data as the data collected in the "city's physical environment, including the public realm, publicly accessible spaces, and even some private buildings." It further consists of three subcategories: Type 1- data collected from public spaces like streets and parks, Type 2- data from publicly accessible private spaces like stores and building lobbies or courtyards and Type 3- data from private spaces

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

not controlled by those who occupy them, such as office thermostats [17]. It clarifies urban data as produced by physical spaces, anchored by geography and differentiates it explicitly from 'Transaction Data' as information provided by people about themselves on websites, mobile phones and paper documents. On the other hand, the city of Bonn, Germany, considers urban data as a broad term that includes all data held, used or made available by urban actors (public administration, public institutions, municipal companies), private actors (e.g. companies, associations, citizens) or other actors, regardless of the context in which they were created and the type of survey [18]. According to that definition, urban data thus includes static and dynamic data (e.g. sensor-based real-time data, IoT) as well as citizen or user-generated data.

For the purpose of this paper, urban data is considered to encompass all data for cities that

- is georeferenced,
- is produced or consumed by public actors such as government administration and municipal companies; and private actors such as citizens or private companies.
- can be used to infer spatial conditions and improve understanding of spatial environment.

Based on their source, the types of urban data can be – A) Government Official Data, B) Company Generated Data, C) Machine Generated Data and D) User-Generated Data.

A) Government Official Data refers to the data primarily collected by the government for its administrative task and official record-keeping. These include official statistics, survey data, the data obtained from citizen registration offices and real estate cadastres. They are essentially characterised by their relatively high quality in terms of accuracy, completeness, validity, and general truthfulness of the content [4]. A part of this data is also available as Open Data that is freely available for anyone to access, use, modify, and share.

B) Company-generated Data refers to all the data that is generated by a company for its research and development purposes. It can be related to consumer behaviour, market trends, transactional research on company products and business insights. This data can contain trade secrets and personal data. However, the company generated data can be anonymised and be made available as Open Data depending upon the company policy and legal arrangements. An example of this kind of data would be transactional data in banks and health and fitness data in smartphone application operators.

C) Machine-generated Data encompass the data being collected by sensing devices, sensor networks and surveillance systems embedded in the urban environments. The examples of this category would be pedestrian counts, traffic and pollution levels, RFID Records, Infra-Red and CCTV surveillance data. These data sources are generally connected to machines in the Internet of Things category.

Type of Data	Urban Dataset	Source
A) Government official data	Census records Citizen registration data Real-estate records Land-uses	Federal and State Statistical Offices Statistic Department Housing Department Planning Department
B) Company-generated data	Data on consumer behaviour (Credit card usage data, market trends)	Consumer facing organisations
C) Machine-generated data	Sensor data (Pedestrian Counts, Traffic, Pollution levels) CCTV surveillance RFID records Infra-Red surveillance	Urban sensing devices Wi-Fi hotspot adaptors CCTV cameras RFID devices Infra-Red cameras
D) User-generated data	Crowdsourced data Social media content Surveys Bluetooth traces Wi-Fi traces GPS traces Other internal phone sensor data IP addresses Smartphone application data	Open Street Map, Blogging websites Twitter, Instagram, Facebook, Flickr Smartphone applications using Bluetooth Wi-Fi Adaptors GPS Trackers Smartphone company Network Provider Smartphone applications

Table 1: Types of urban data based on their source. Source: Own depiction

D) User-generated Data refers to all types of data that is generated by humans. This data can be sourced from social media websites, Local Based Sensor Networks, micro-blogging posts, pictures and videos. The growing penetration of smartphones, development of Social Web 2.0 and widespread internet connectivity has led to an increased amount of content generation actively, passively and even semi-actively. The actively generated data comprises of social media posts, crowdsourced data (e.g. OpenStreetMap) and online surveys.

The passively generated data on the other hand would the data produced by micro sensors in the smartphones such as Wi-Fi, GPS and Bluetooth traces, IP Addresses and other internal phone sensor data that is generally being produced in the background as the smartphone applications are running. The third category of semi-actively generated data refers to the smartphone application data for which the permission of data collection is given once and it keeps acquiring the required information over a span of time.

4 ANALYSING NEW FORMS OF DATA IN MUNICIPAL DECISION MAKING

As demonstrated earlier in this paper, municipal decisions in Germany are largely determined by complex and intertwined multi-level hierarchical processes. The structures and frameworks provide limited scope for flexibility. Especially for urgent problems, (such as during the pandemic) when quick decisions were needed, daily updated, user-generated data was key for situation-adapted reactions and decisions. The focus of this paper is therefore on the use of new forms of urban data, as a driver for more efficient and evidence-based decision making in spatial planning.

The previous section provided a classification for urban data based on their source which is a necessary step to set the context for identifying new forms of urban data. These data forms are fundamentally integrated datasets that can generate improved understanding of the complex urban systems by combining the strengths of traditional static/semi-static datasets with those of other dynamic sources of urban data. The overview provided is not exhaustive and can accommodate more data sources as the time proceeds. However, to eliminate silo-thinking in the decision-making processes, it is important to explore the combination of different datasets arising from various sources for their potential in evidence-based decision-making. In 2017, the KOSIS Association Urban Audit tested a new data source, OpenStreetMap (OSM), as an alternative for calculating the variable “length of the designated cycle network” [19]. It also confirmed some of the challenges with the current method of acquiring data directly from cities. While the city noted the heterogeneity between the datasets collected from OSM and the city, the advantage provided by a constantly updated dataset overweighed the disadvantages.

Building on these advantages, the city of Darmstadt used the mobile phone data from Telekom in 2019 to analyse commuter flow from the surrounding towns of the city. The city was provided with a dataset containing only origin and destination information of the commuters with a high spatial and temporal resolution while ensuring the anonymity of the individuals. It guaranteed that no conclusions could be drawn about individual mobility behaviour [19]. The resulting analysis could not just inform about the quarters attracting high influx and neighbouring towns with high commuter migration, but potentially point towards possible interventions for managing the high daily commute. Augmentation of public transport during peak hours, new transport infrastructure planning for high commute neighbouring towns, reduction in particulate matter through better traffic control and others were added on solutions resulting from the analysis [19].

The new forms of urban data have limitations of integration and challenges occurring from methodological, technological and political perspectives/ However, their potential for substantiating complex spatial analysis is unprecedented. Although, a few cities have already embarked on the journey of establishing data platforms, exploring such datasets and building digital twins, other municipalities are yet to turn their focus on data-driven decision making. A SWOT analysis from the context of the municipal decision-making processes is shown in the next paragraph.

5 SWOT ANALYSIS

Combining the knowledge of municipal decision process and data types as well as data landscape, the method of SWOT analysis is used to investigate the opportunities and risks of new forms of urban data for municipalities.

The SWOT analysis demonstrates that the strengths and identified opportunities of new forms of urban data can be capitalised for hyper-local spatial planning through a technically robust architecture for integration and analysis in the municipalities. In order to take advantages of the opportunities, the weakness identified needs to be mitigated through accessibility, interoperability and standardisation of urban datasets. While technological infrastructure is a means of using these data forms, an overarching supportive system of political will, regulatory framework and data-confidentiality is also required to mitigate the threats of unethical data usage.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Strengths	Weaknesses
Eliminate bias arising from a single data source The datasets are dynamic in nature, i.e., spatially and/or temporally grained Bottom-up planning process/perspective, in case of user-generated data	datasets are originally not designed to be used for spatial planning decision-making, can have differences arising from varying timelines, geospatial levels and missing APIs.
Opportunities	**Threats**
Optimisation of urban services Resilient decision-making Possibility of complex system analysis Hyper-local spatial planning Insights for demography, diversity, age and gender-sensitive spatial planning	Need supportive policies, regulatory framework and software architecture for data integration Dependent on the political will and thus susceptible to change Need for management of data confidentiality, security and citizen trust

Table 2: SWOT Analysis of new forms of urban data. Source: Own depiction

The Venn diagram in this section builds on the listed strengths and opportunities to bring out these new data forms and how they can be used by municipalities. It visualises the four urban data categories discussed in the previous section of the paper. The overlapping six sets denote the new forms of urban data and their use in municipal decision-making related to spatial planning. The diagram gives importance to the central dataset- Government official data as a precursor for any integration which is explained below.

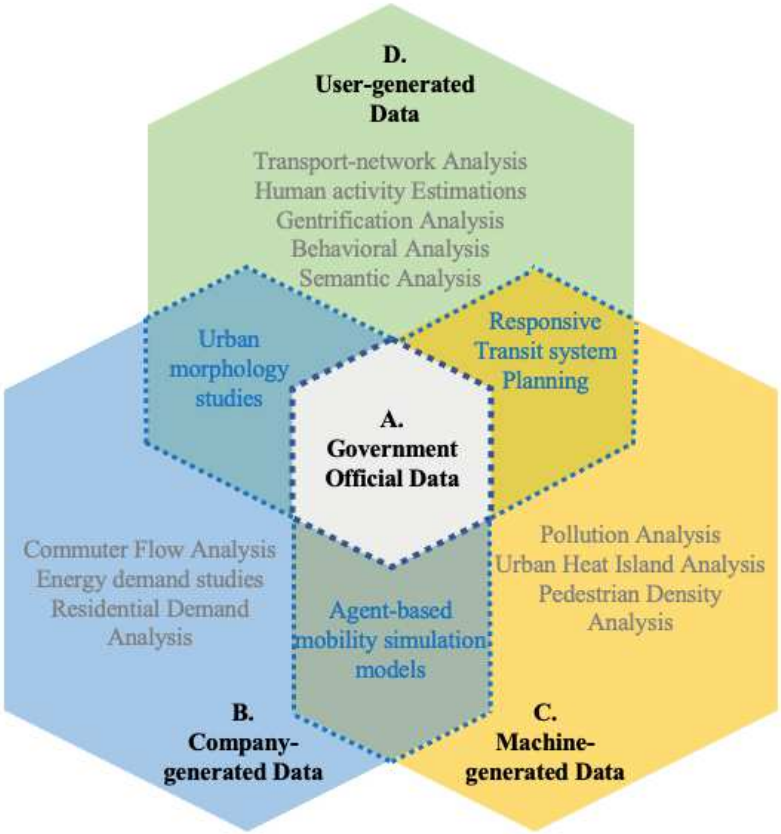


Figure 1: New forms of urban data. Source: Own depiction

The set of User-generated data denotes the data from the social-media websites that carries digital imprints of a user in terms of emotions, opinions and activity patterns. Combining city real estate plans (e.g. Points of Interests) with the geotagged social media such as geotagged photos and check-ins can be used for human-activity estimation in a city. This analysis can be used for transport and tourism planning. A semantic analysis through text-mining of the geotagged posts can help for crisis management during city events, as a further step of human-activity estimations. Geotagged posts over a period of time can also give an estimation of outsiders and residents of a neighbourhood and can help in identifying neighbourhood change which when

augmented with Census data can yield gentrification analysis. A further integration of user-generated data with company-generated data such as mobile-phone records and supplemented by real estate and land-use data opens the possibility of urban morphological studies, as denoted in the overlapping subset of sets A, B and D (Figure 1). Identification of spatial structures, their usability and accessibility can help in planning cities that are sensitive to the needs of a certain gender and age-group.

Similarly, machine-generated data such as sensors monitoring pollutant counts and temperatures when integrated with real-estate data can yield pollutant analysis and heat-island effects in a city. When combined with points of interests of a city on a map, Wi-Fi-beacons log the IP- addresses of the connected devices could give an estimation of pedestrian density. These datasets can help a city in retrofitting pedestrian infrastructure in neighbourhoods and furthermore in planning commercial spaces which are proven to be thriving through pedestrian accessibility. A new form of data as denoted in the overlapping subset of sets A, C and D (Figure 1), Combining the pedestrian activity from sensor, along with the electronic travel card data (which can give origin and destination stamps) can help in removing redundancy in the public transit routing of a city and, in turn, making the transit system responsive to the demands.

Company generated data, in terms of mobile phone data can give a commuter flow analysis, as discussed earlier in the paper in the case of Darmstadt, Germany. This data, though with extreme potential, contains personal information and needs pre-processing to make it usable for urban analytics. Census data combined with the energy consumption data of households can give an insight into fuel-poverty in a city, demanding necessary policy actions. The fine-grained information characteristics of company-generated data combined with the high-coverage sensor data can help in agent-based modelling for various urban systems as denoted in the overlapping subset of sets A, B and C (Figure 1). This particular category holds potential for solving critical problems through detailed simulation of urban dynamics.

6 CONCLUSION

Considering ongoing trends such as digitalisation and existing research on urban analysis, combined with current challenges (for instance the pandemic, demographic change, the climate or the energy crisis) reveals the complexity under which municipalities have to operate. The need for information is increasing when taking current, adaptive, and strategic decisions. New forms of urban data can be used to meet this need.

New forms of urban data enable municipalities to make more robust, resilient planning decisions by taking into account larger and more recent datasets. This allows decision-making processes to be more informed and, ideally, increase not only the quality of the underlying information, but also the transparency and accountability of decision-making.

Through new forms of urban data, new hypotheses and use cases can be tested and reviewed. In addition, the long-term recording of activities (urban morphology studies) can provide strategic insights, for example, for people-centred and demand-driven development of urban infrastructures, mobility services or public open spaces.

However, it is important for municipalities to observe standards, data protection and data integration interfaces in order to be able to use new forms of urban data and harness their potential. Long term activity recording can yield strategic insights.

Based on the findings presented in this paper, further research requirements need to be reflected, which can be summarised in the following four points.

- Data collection in general needs to be further investigated. There is still uncertainty about how municipalities and governments collect data, what new sources can be tapped for this purpose, and which aspects in terms of technology and users respectively citizens need to be considered.
- Furthermore, municipalities should apply a monitoring and research component when collecting and using new forms of urban data, thus their findings can provide guidance for other municipalities. In particular, the implementation of the use of this data through political legitimation and specifications, as well as technical implementation (e.g., taking data protection into account) are of interest here.
- City labs, innovation hubs and pilot projects should be provided as laboratories for practical application and research under real-life conditions. In this way, standards, implementation methods

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

and acceptance can be reviewed, potentials of usability can be unlocked, thus systems and applications can be further developed.

- Further research needs to be done on how to integrate datasets from various sources to provide an analytical base for decision-making. In the context of spatial planning decision-making, a decision support system could be the way forward.
- Finally, current societal challenges point to the fact that more flexible and agile decision-making processes are needed in municipal decision making. As speed cannot be the only decisive factor, it is necessary at the same time to maintain standards (in terms of data collection and accessibility) and to support the quality requirements and the responsibility of governmental actions.

To conclude, new forms of urban data offer the potential to secure the ability of municipalities to act in a future-oriented way which is adapted to fast changing societal requirements, yet more research is needed in this respect.

7 ACKNOWLEDGEMENT

The research conducted here takes place within the framework of an interdisciplinary research project. The „Ageing Smart“ project is funded by the Carl Zeiss Foundation.

8 REFERENCES

[1] Economic Commission for Latin America and the Caribbean (ECLAC), “Digital technologies for a new future(LC/TS.2021/43),” United Nations, Santiago, 2021.
[2] A. Psyllidis, A. Bozzon, S. Bocconi and C. T. Bolivar, “Harnessing Heterogeneous Social Data to Explore, Monitor, and Visualize Urban Dynamics,” in Proceedings of the 14th international conference on computers in urban planning and urban management, Cambridge, CUPUM, 2015, pp. 1-22.
[3] P. H. Mckenna, “Disruption in Smart Cities/Regions: Navigating Pathways and Directions for Success,” 05 2021. [Online]. Available: https://www.researchgate.net/publication/351401384_Disruption_in_Smart_CitiesRegions_Navigating_Pathways_and_Directions_for_Success. [Accessed 10 08 2022].
[4] Achilleas Psyllidis, “Harnessing Heterogeneous Social Data to Explore, Monitor, and Visualize Urban Dynamics,” Cambridge, USA , 2015.
[5] K. Pallagst, “Planungssysteme,” in Handwörterbuch der Stadt- und Raumentwicklung, vol. GW560, A. f. R. u. Landesplanung, Ed., Hannover, 2018, pp. 1761-1770.
[6] H. Elgendy, International Manual of Planning Practice, 6 ed., ISOCARP, J. Ryser and T. Franchini, Eds., Bukarest: ARTIX PLUS SRL, 2015, p. 138.
[7] A. Muenter and M. Reimer, “Country Profiles Germany,” 2021. [Online]. Available: https://www.arl-international.com/knowledge/country-profiles/germany#overview. [Accessed 29 07 2022].
[8] R. Danielzyk and M. Sondermann, “informal planning,” 2018. [Online]. Available: https://nbn-resolving.org/urn:nbn:de:0156-55999064. [Accessed 29 07 2022].
[9] d. V. m. &. C. KG, Ed., Raumordnungsgesetz, München, 2016, pp. §2-4.
[10] d. V. m. &. C. KG, Ed., Baugesetzbuch, München: dtv Verlagsgesellschaft mbH & Co. KG, 2016, pp. §3, §4.
[11] D. Fürst , Handbuch Theorien und methoden der Raum- und Umweltplanung, 3 ed., D. Fürst and F. Scholles, Eds., Dortmund: Verlag Dorothea Rohn, 2008, p. 22 ff..
[12] F. Scholles , Handbuch Theorien und Methoden der Raum- und Umweltplanung, D. Fürst and F. Scholles , Eds., Dortmund: Verlag Dorothea Rohn, 2008, p. 309 ff..
[13] BfDI, “Die Grundlagen des Datenschutzrechts,” Der Bundesbeauftragte für den Datenschutz und die Informationsfreiheit, [Online]. Available: https://www.bfdi.bund.de/DE/Buerger/Inhalte/Allgemein/Datenschutz/GrundlagenDatenschutzrecht.html. [Accessed 26 07 2022].
[14] R. Kitchin, “Data-driven, networked urbanism,” in The Programmable City, County Kildare, Ireland, 2015.
[15] Jens Kandt, “Smart cities, big data and urban policy: Towards urban analytics for the long run,” Cities, vol. 109, no. 102992, 2021.
[16] Jose Antonio Tenedorio, Methods and Actions of Geospatial Technology in sustainable Urbanism, Hershey PA, USA: IGI Global, 2021.
[17] Silke Cuno, “Data Governance and Sovereignty in Urban Data Spaces Based on Standardized ICT Reference Architectures,” Data, vol. 4, no. 16, 2019.
[18] S. Labs, “Master Innovation and Development Plan,” Sidewalk Labs, 2019.
[19] Smart City Bonn, “Urban Data Platform,” 2020. [Online]. Available: https://www.bonn.de/microsite/smartcity/digitale-angebote/inhaltsseiten/digitaltag-2020/urban-data-platform.php. [Accessed 7 July 2022].
[20] KOSIS Association Urban Audit , “Quality of Life: Establishing New Data Sources,” City of Mannheim, city printing house, Mannheim, 2019.
[21] Granell C., “Emerging approaches for data-driven innovation in Europe: Evaluation of sandbox experiments on the governance of data and technology,” Publications Office of the European Union, Luxembourg, 2022.

🏆 *reviewed paper*

Online SP-off-RP Travel Surveys for Identification of Target Group Specific Measures and Uptake Potentials in Rural Municipalities – Learnings from the Pilot Case Feldkirchen/Donau

Tobias Haider, Christoph Kirchberger

(Tobias Haider, mobyome KG, Margaretenstraße 79/2, 1050 Wien, tobias.haider@mobyome.at)
(Dipl.-Ing. Christoph Kirchberger, mobyome KG, Margaretenstraße 79/2, 1050 Wien, christoph.kirchberger@mobyome.at)

1 ABSTRACT

Planning processes are often fed with various streams of data, experiences and knowledge from different stakeholders involved. Especially the user perspective and acceptance of possible solutions can be measured through different qualitative or quantitative approaches. To allow a certain level of objectivity, comparability and accuracy, structured and standardized quantitative data collection methods are needed to collect mobility behaviour data. In this context questions regarding financial and capacity-related feasibility of certain innovative methods for local municipalities in rural context arises.

This paper discusses possible scenarios for enhanced collection of mobility behaviour data (stated and revealed) to enable target group specific development of mobility measures in rural contexts. On the example of a "Mobilitätswerkstatt" and an accompanying travel survey via the "mobyome-App" realized in Feldkirchen/Donau (Federal state of Upper Austria), outcomes and possible use of data and insights are discussed. Further on the trade-offs between usability, length of the travel survey, representativity and financial feasibility will be explored.

The mobyome-App, developed by the team of mobyome KG[1] – an impact-oriented company based in Vienna and Linz (both Austria), tries to combine an SP-off-RP approach on trip-leg level with an Web-App interface which allows to keep the technological burden as low as possible.

As the mobyome-App was used in the rural municipality of Feldkirchen/Donau[2], around 5% of the inhabitants fully participated in the data collection. In the paper first insights on detailed response rates, identification of possible user groups for future mobility services like ridesharing-applications or the willingness for behaviour change will be discussed. On the example of Feldkirchen/Donau, the paper will showcase possible (future) analyses based on the obtained data.

Keywords: Survey, Behaviour change, Mobility, Rural, Web-App

2 BACKGROUND

The success of a radical shift in the mobility behaviour in Austria to meet national (e.g. Austria's 2030 Mobility Master Plan[3]) and international goals (e.g. the Paris agreement) on climate protection will be decided in rural areas, where also a large share of THG-emissions are generated.

Substituting the private car in rural areas by a well-integrated system of alternative mobility solutions like demand responsive transport, Car-Sharing or ridesharing (when trying to reach comparable levels of comfort, flexibility, ..) based on an attractive public transport and dense network for active mobility appears to be an immense challenge in implementation.

2.1 Common data basis

To allow the strategic coordination of a complex network of necessary actors to build up this system (local municipalities, federal administration, regional mobility management, private initiatives, …), a regular local data basis on the status quo and changes in mobility behaviour are essential (see also Aschauer 2019 for further argumentation). This demand side - data enables evidence based planning processes (for example like showcased in the ACTIVE8[4] project, see Hackl et al. 2019), impact measurements of implemented alternatives and learning process in general.

[1] https://www.mobyome.at/ueber-uns
[2] See https://feldkirchen-mobil.at/ for further insights including mobility-info sheet and analysis of status-quo
[3] https://www.bmk.gv.at/en/topics/mobility/mobilitymasterplan2030.html
[4] https://projekte.ffg.at/projekt/1412825

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

The availability of detailed and large datasets (<5% of inhabitants) on municipal/local level in rural areas in Austria, using a trip-leg approach including geocoding, is scarce, only several singular surveys are known like Melinda[5], Smart Survey[6] or SmartMo/MASI-Active[7].

2.2 New tools for travel survey – recent developments

Looking into the "technological side" of recent developments in the field of travel surveys, smartphone based approaches gained more and more attention – especially when showcasing drastic changes in mobility behaviour during various COVID-19 phases (e.g. MOBIS[8], MOBICOR[9] or TravelVU[10]). Still there is a certain insecurity in the possible response rate using smartphone based approaches (Molloy 2021).

From the methodological setup chosen in travel surveys, the combination of stated preference (SP) with revealed preference (RP) of route and/or mode choice is still a novel and innovative approach. Rudolf and Straub (2021) showcase their approach on the MyTrips application, where fast parallel calculation of alternative routes for the individual RP-experiment where essential.

Technologies like smartphone-based data collection or web-based interviews can be seen as enablers for more detailed and objective travel surveys. As smartphone-based solutions need higher early investment setting up the specific system, marginal costs stay low due to high levels of automation and easy scalability while keeping the survey load low (depending on the level of amount days to be validated) for participants.

For the usage on local level, web-based interviews can offer a good trade-off between cost, survey load and data quality / level of detail / automation possibilities (see Hubrich 2017, 255f). The mobyome Mobility-App try's to focus on this hypothesis, adding also the possiblity to gain information on stated preferences regarding existing (but not yet used) and possible (to be implemented) mobility options.

2.3 Mobyome – an impact oriented company

As mobyome focuses on generated impact before financial benefit, measuring this impact of activities is a core necessity for all projects. Mobyome develops visions, ideas and tools for a new understanding of alternative mobility solutions in small towns and rural communities. We cooperate with like-minded people from politics, research, business and civil society and support communities with our expertise.

3 PILOT-CASE FELDKIRCHEN

In the following chapter an insight into one application-example of the mobyome Mobility-App in the context of a Mobilitätswerkstatt[11], realized by mobyome together with local partners in the first half year of 2022, will be given.

3.1 Local context

Feldkirchen/Donau is a municipality with 5 426 inhabitants (2022[12]), located in Upper Austria, 20 km into the west from Linz, the capital of the federal state. Main public transport links are the local train line Linz-Aigen-Schlägl and bus lines to Linz, Aschach and Berg.

The municipality is part of the "Klima- und Energie-Modellregion Urfahr West" (KEM UWE)[13], a regional intermediary institution which supports climate friendly activities and gives access to funding possibilities. The described process was financed aswell as supported by the municipality itself and the KEM UWE as a lead project.

[5] https://www.fhv.at/forschung/business-informatics/laufende-projekte/melinda/
[6] https://www.ait.ac.at/loesungen/sensing-travel-behavior/smart-survey/
[7] https://boku.ac.at/fileadmin/data/H03000/H85000/H85600/Forschung/KOMOD/1130_SmartMo_Masi_Activ_.pdf
[8] https://ivtmobis.ethz.ch/mobis/en/
[9] https://www.infas.de/neuigkeit/mobilitaet-und-corona-wie-veraendert-sich-der-alltagsverkehr/
[10] https://en.trivector.se/sustainable-transport/our-travel-habits-during-corona-cycling-is-increasing/
[11] https://www.mobyome.at/angebot/mobilitaetswerkstatt
[12] https://www.statistik.at/blickgem/G0201/g41606.pdf
[13] http://www.regionuwe.at/

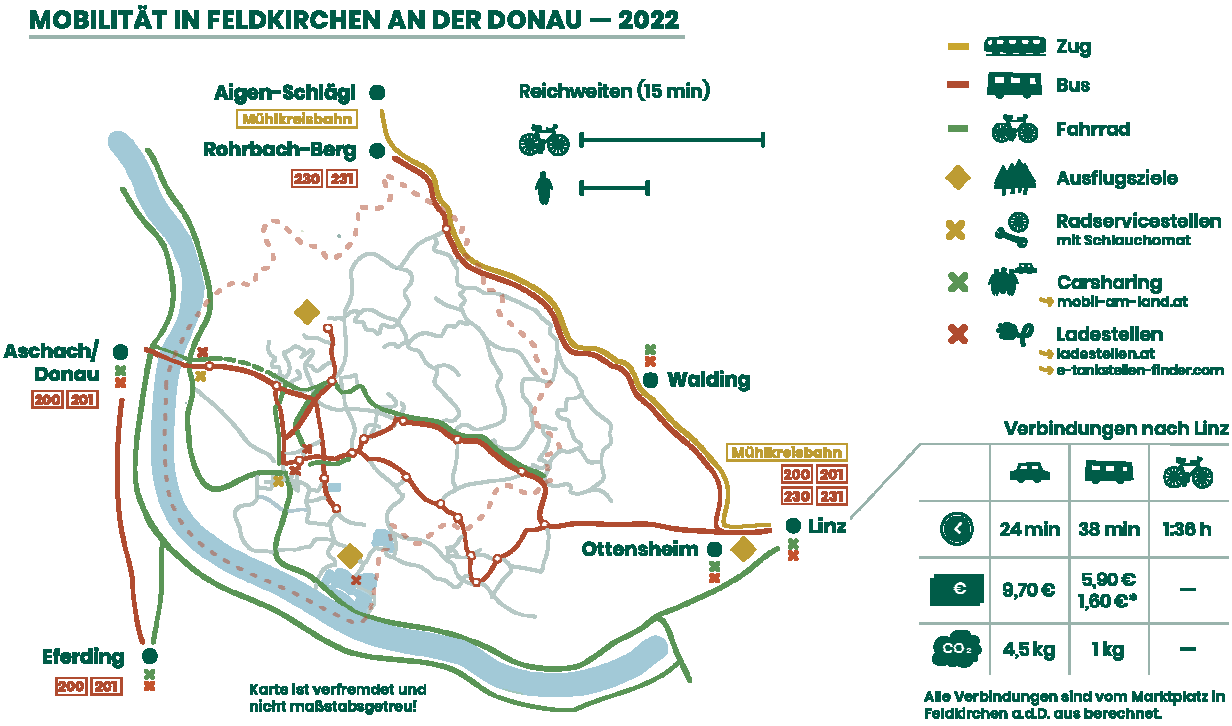


Figure 1: Cutout of Mobilitätsinfoblatt

3.2 General Mobilitätswerkstatt process

The Mobyome Mobilitätswerkstatt consists of several tools (including the Mobility-App) and formats which all aim at the following goals:

- Create awareness of one's own mobility and the associated costs
- Getting to know alternatives for personal mobility and making the consequences visible
- Collectively and better present and communicate existing mobility offers
- Identify gaps for a sustainable transport system
- Creating an understanding of the collective dimension of mobility

Figure 2: On-Site event

The format and tools which were / will be applied in the Mobilitätswerkstatt Feldkirchen/Donau are, (M) marks if the Mobility-App is also used during the events :

- 20.01.2022 | Stakeholder Kick-Off workshop (M)
- 01.04.2022 | Event-stand (M)

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

- 20.04.2022 | Intro-Presentation
- 01.03.2022 – 31.05.2022 | Mobility-App
- 05.-07.05.2022 | 3-days On-site event (M)
- 30.09.2022 | Final report
- 27.09.2022 | Final presentation

The Mobility-App can be seen as central backbone of the Mobilitätswerkstatt as all formats try to activate participants for the survey in the Web-App or it is used directly in the event using a live-analysis of the result concerning only the participants present on site (in a special workshop-setting representation). Accompanying to the formats stated above, intensive PR work via Social media, local newspaper, poster series was realized. Also multipliers were involved, re-posting the calls for participation.

3.3 Mobility App

3.3.1 Basic Setup and Approach

The Mobility-App is a web-based application, fully self-developed and designed by the mobyome team. The tool is accessible without installation via various devices and browsers, not being depended on operating systems and their limitations. The flexible and highly automated backend, using several external datasets like VAO[14] or basemap[15], allows a easy setup for all 2.093 municipalities in Austria.

Main objective and hypothesis of the Mobility-App is not to reach a representative sample to be able to extrapolate the overall mobility behavior from the subsample, but to gain deeper insights on target groups with high potential for behavior change.

The application consists of two types of views: the participants-frontend and the analysis view which can be accessed by the survey managers for single municipalities and/or workshops facilitators.

3.3.2 Survey elements of the mobyome Mobility-App

The survey implemented in the participant-frontend of the Mobility-App consists of

- the self-reporting of routes, modes and start/end time for trip-legs of an typical day for the participant (routine-trips) via an interactive online-map using multimodal routing for easier usability (revealed preference)
- questions on alternative existing options (based on VAO, mobil-am-land.at, ...) for single personal trip-legs, following a cascading logic for choosing sustainable alternatives until either one option is chosen by the participant or all relevant options are declined. (stated-preference)
- questions on alternative possible options (Car-Sharing, demand-responsive transport, ...) for single personal trip-legs, following a cascading logic for choosing sustainable alternatives until either one option is chosen by the participant or all relevant options are declined. (stated-preference)
- detailed information on available household-vehicles (also connected to information given in the trip-legs)
- basic demographic and household information
- contact information if the participant wants to stay informed or/and adjust/access his answers / results still later on

The survey includes several informative texts which are connecting results of the single participants with available overall statistics on cost or emissions in Austria or the municipality as a benchmark. Basically the given framework can be easily adapted and connected to new data sources for even higher levels of automation.

[14] https://www.verkehrsauskunft.at/
[15] https://basemap.at/

3.4 Insights on response rates, outcomes and possible automated analyses

3.4.1 Participant statistics

Overall 4,6% of the population registered in Feldkirchen/Donau fully participated in Mobility-App survey (see Figure 1). Inhabitants older than 65 an younger than 15 are unrepresented in the sample .

Number of participants	Share	Status
376	100%	Survey started
289	77%	Revealed preference realized
268	71%	Analysis finished
260	69%	Stated preference realized
250	66%	Full survey finished

Table 1: Response rates on various survey stages

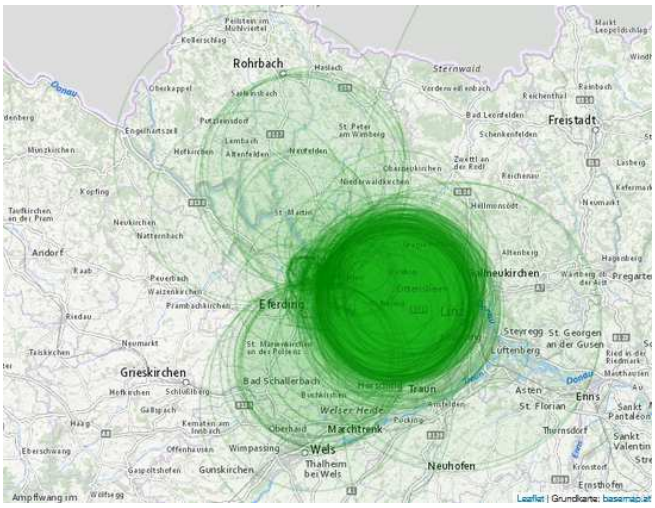


Figure 3: Radius of Action

The share of woman and men in the sub-sample reflects the share in the overall population in Feldkirchen/Donau, one person stating a divers gender status also participated in the survey.

For the average participant it took around 9 minutes to complete the survey, which showcases that the Mobility-App can also easily be used in workshops contexts as the completion doesn't take too much time.

For all 7 main settlement areas at least 20 participants could be activated, also covering decentral parts of the municipality.

3.4.2 Fully automated geographical analyses

The analysis view allows plotting certain mappings based on Leaflet[16], an open sources JavaScript library for interactive maps. This can be used as more qualitative and illustrative basis for discussion processes on site (e.g. to showcase the radius of action based on the stated trips – see figure 3). Further interactive maps like plotting of routes for certain accepted alternatives allow to come up with hypothesis for further, in depth on site analyses like traffic counting, passenger surveys or traffic flow observations.

3.4.3 Target-group specific measures

Based on revealed preference: For reported car-trips, potentials for ride-sharing regarding routes and time can be identified. Participants with stated willingness for ridesharing can be further structured to identify a specific target group with an expected high impact of communicative measures promoting ridesharing offers. This communication can be combined with statistics on local car usage and expenses as directly stated in the Mobility-App by 14% of the participants.

[16] https://leafletjs.com/

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Based on stated preference: As participants accept certain alternatives, for example biking, they are also asked to name possible supporting activities which would allow the realization of this mode change. This entries can be clustered and trip-legs they are connected to analysed (for example where and for which type of users improvements in bike infrastructure could be useful).

3.4.4 Uptake potentials

To identify potentials for behaviour, change within the participants, stated preference data can be used. The lowest acceptance rate was reached by public transport connections (built up from walking and public transport trip-legs) being suggested as alternative for private car trip-legs (48/279). For 144 trip-legs a too long travel time was stated as hindrance from using public transport.

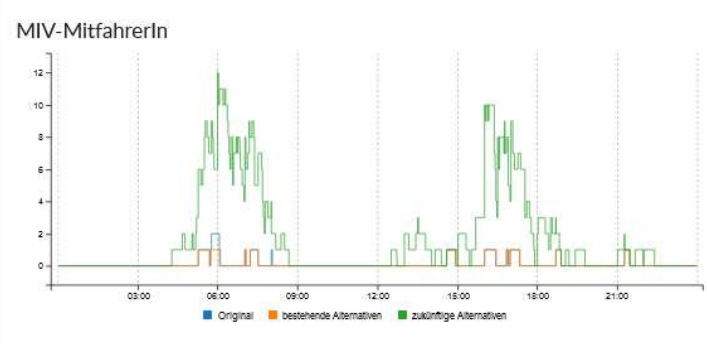


Figure 4 Time wise ridesharing potential.

The highest acceptance rate was reached for demand responsive transport (17 out of 26 trip-legs were substituted), directly followed by ridesharing with 102 out of 161 trips being accepted to be realized by ridesharing instead of using the private car. This potential can be mapped (looking into possible routes for ridesharing) and visualized time wise (see Figure 4 timewise ridesharing potential).

4 LEARNINGS AND REFLECTIONS

During the Mobilitätswerkstatt Feldkirchen various type of data was collected, from structured quantitative data from the Mobility-App towards more qualitative data from interviews and talks with inhabitants.

Only a small amount of possible analysis was realized and still big potential lies in finding further connection in the data. Three main reflections stay open for further discussion, development and collaboration:

4.1 Trade-offs between travel surveys and awareness rising

When combining a travel survey with ideas from awareness rising strategies for behaviour change in one tool, certain trade-off has been taken into account. The Mobility-App had to be well balanced between input asked by the participants and information given back to reduce the perceived survey burden. This on the other hand reduces the amount of data being available on the person itself, for example values, lifestyles etc.

In the further development of the Mobility-App following the experiences with first possible analyses from the data obtained this will have to be balanced out again, maybe taking into account new questions for better segmentation of participants.

4.2 Needed optimisation in algorithms and logic model

The algorithms for setting the SP-off-RP, choosing the order of alternatives which are suggested for participants, still reach certain borders in special cases. Especially the variables for public transport suggestions need to be adapted to create alternatives which show higher acceptance rates here (which will lead to a higher amount of ridesharing suggestions for example).

Further on the logic model for the order of most sustainable alternative for certain trip-legs needs to be adapted, especially readapting the role of motorbikes as alternatives.

1.1 Blended participation – how to better connect the digital and analogue methods?

As stated in 3.2 General Mobilitätswerkstatt process, the Mobility-App was used in analogue settings where participants were asked to fill in the survey. In the workshop settings a discussion of the results, having a

look on the analysis view, was moderated. Until now it is not possible to feed analogue data obtained into the Mobility-App system, linking for example collective mapping exercises during workshops back into the digital world. A possible topic to connect the digital and analogue world could be ideas for improvements for active mobility on certain routes in the street network.

5 CONCLUSION

While large-scale, representative travel surveys like Österreich Unterwegs or surveys realized by federal states still will allow to have a consistent long term comparison on the mobility behavior, new tools are evolving which allow additional, more agile approaches for combined mobility monitoring and awareness rising. To support local municipalities in obtaining a better local data basis for their decisions in the field of mobility-related measures, regional actors and federal states can play an important role in building up monitoring infrastructures (financing the setup costs) for measuring mobility behavior which can be used by the municipalities only covering the marginal cost.

Web-App / online approaches like the mobyome Mobility App, MyTrips or others offer big potential to close this gap, making it possible to obtain necessary data for collective approaches for an integrated alternative mobility system for rural areas.

6 REFERENCES

ASCHAUER, Florian: Development of an innovative combined mobility-activity-expenditure survey and methodological comparisons with traditional disciplinary approaches. Vienna 2019

HACKL, Roland et al.: Promoting active mobility: Evidence-based decision-making using statistical models. In: Journal of Transport Geography. 80. 2019

HUBRICH, Stefan: Fehlereinflüsse und Teilnahmebereitschaft bei Haushaltsbefragungen zum Verkehrsverhalten. In: Schriftenreihe des Instituts für Verkehrsplanung und Straßenverkehr Heft 18/2017. Dresden 2017, 255f

MOLLOY, Joseph et al.: A national-scale mobility pricing experiment using GPS tracking and online surveys in Switzerland. In: Arbeitsberichte Verkehrs- und Raumplanung. Zürich 2021

RUDOLF, Christian; STRAUB, Markus: Mobility surveys beyond stated preference: introducing MyTrips, an SP-off-RP survey tool, and results of two case studies. In: European Transport Research Review volume 13. Vienna 2021

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

🏆 *reviewed paper*

Optimizing Placemaking of Urban Open Spaces Using a Mixed Reality Approach

Arwa Elhoufy, Zeyad El Sayad, Ali Bakr

(MSc. Candidate Arwa Elhoufy, Architectural Engineering Department, Faculty of Engineering, Alexandria University, Alexandria, Egypt, hofyarwa98@gmail.com)
(Assistant Prof. Zeyad El Sayad, Architectural Engineering Department, Faculty of Engineering, Alexandria University, Alexandria, Egypt, zelsayad1@hotmail.com)
(Prof. Ali Bakr, Architectural Engineering Department, Faculty of Engineering, Alexandria University, Alexandria, Egypt, alibakr@alexu.edu.eg)

1 ABSTRACT

The quality and momentum of urban open spaces are key parameters for assessing the social, economic, and environmental aspects of a city. Public spaces need to be permanently attractive to human activity. Studies presume that the use of mixed reality technologies to create changeable upgrading interactive designs and uses of urban open spaces will encourage people to spend more time outdoors and make public spaces more attractive. This paper provides timely and empirical information to help practitioners and researchers better understand MR technology for architecture and urban design, specifically for open spaces used as recreational, social, and economic spaces. The study included a simulation of a developed plaza with models of mixed reality combined with physical elements of the plaza, taking into account the activities and behaviour of the users of the square. The surveys were conducted in Saad Zagloul Square in Alexandria with different social criteria, activities, and formation. The initial results of using mixed reality for urban development and place-making show its approbation of users and citizens. They also show the possibility of developing the experience in an easier way to reach all citizens by using it directly through their mobile devices. Therefore, the public presence and interaction with public open spaces and with the architectural elements, such as the facades of the surrounding buildings and elements of landscape and hardscape is positively affected. This leads to enriching social cohesion, and economic activity, preserving the environment, and enhancing sustainability through the development and changeable designs of spaces without using any materials, thus reducing the ecological footprint of open public spaces in the short and long term. Further research seeks to validate the results by applying the study on more open spaces in Egypt.

Keywords: Interaction, Dematerialization, Multiuse, Urban Open Spaces, Cyberspace

2 INTRODUCTION

Open urban spaces in the twenty-first century require an exploration of the social and spatial implications of new lifestyles, values, and attitudes toward nature and sustainability, while considering the future city life models and the patterns of urban open spaces it may accommodate. Urban planning in public open spaces is threatened by the increase in “virtual” transactions, that eliminate the need for real social interaction, but this is also a piece of evidence that the use of new communication technologies can increase and enhance the use of open public spaces; This may include participating in the productive side of our hardscapes and landscapes. "Cyberspace can be seen as a vast virtual laboratory for the continuous production of new architectural visions." (Novak, 248) The role of urban public spaces may need to be rethought. The social and cultural values of open space include new attitudes towards nature and architecture. The study aims to reveal new insights into ways to serve both new human needs and the design framework of urban open space structures. And to discuss the new role of mixed reality in architecture and urban design. In order to achieve these objectives, a literature review of the role of cyberspace and mixed reality in architecture and urban design and the tools, techniques, and capabilities of them help apply placemaking principles of urban open spaces. Then a case study is applied in a public plaza with simulated mixed reality models with an on-site observation, and people questionnaires. The research is carried out on Saad Zaghloul Square in Alexandria. The research ends with a discussion of the effect of mixed reality on urban design, the challenges facing mixed reality applications with users, and a new concept for applying mixed reality directly to users in urban design.

3 CURRENT PLACEMAKING OF URBAN OPEN SPACES

Placemaking is an efficient way to improve the quality of different places in a neighborhood, and by extension, the community and region in which those places are located as well. Placemaking is a human-centered approach to planning, designing, and managing public spaces. Placemaking can be used to enhance

all the places that make up a gathering place within a community: streets, sidewalks, parks, buildings, and other public spaces. This promotes human interaction and promotes healthier, social and economic development in communities. Placemaking harnesses the wealth, inspiration, and potential of local communities to create superior public spaces that promote the health, well-being, and economic well-being of people. Placemaking is the process of creating quality places. Places with a strong sense of place are classified as Quality Places. These places are attractive to people and businesses. They are lively, active, unique locations, interesting, visually attractive, and often with creative activities and public art. They are people-friendly, safe, and walkable with a variety of uses. There are some key elements of Quality Places such as mixed-uses, broadband-enabled, multiple transportation options, multiple housing options, preservation of historic structures, community heritage, arts, culture, creativity, recreation, and Green spaces. When these key elements are in place then the result is Quality Places that are safe, connected, welcoming, accessible, comfortable, allow authentic experiences, sociable, quiet -unless they are designed to be otherwise-, and Promote and facilitate civic engagement. Creative placemaking is a more desired prosses in placemaking that creates a more often alluring place. In creative placemaking, partners in the public, private, nonprofit, and community sectors strategically shape the physical and social character of neighborhoods, cities, and regions around arts and cultural activities. Creative placemaking revitalizes public and private spaces, revitalizes structures and cityscapes, improves local business viability and public safety, and brings diverse people together to interact, celebrate, and get inspired. placemaking process has to cope with new technologies and current interests using cyberspace to achieve changeable needs with an almost zero ecological footprint in each change to stay continuously attractive.

4 THE ROLE OF CYBERSPACE IN PLACEMAKING

Fascinated by the possibilities of shaping the world, people have always been looking for tools to convey this process. Cyberspace has become one of those tools. Virtual technologies related to communication technology change the cultural, social, and material contexts of human beings, and thus the ideas of architecture itself. Cyber architecture in cyberspace intends to go through the evolution of architecture, leading to the de-materialisation of architecture. In contrast, cyber architecture in physical space defines what architecture is, giving a limitation or boundary to this definition that justifies its presence in physical space. Although architecture has been dematerialised which could lead to a reduction in material waste, there is a limit. We still need to live in real architecture even as notions of dematerialisation and abstraction can help to produce useful and interesting real architecture. It needs to be a decentralised and expanded reality, not a closed simulated reality, where cyberisation is integrated with real-world activity. The question now is how cyberspace could be realised in physical space. It is the physical components that make cyberspace present. Regarding the confusion between the concepts of space and place, places, in the physical world, are filled not only with artifacts, tools, and representations of our work but also with other people and the signs of their activities. The sense of other people's presence and the ongoing awareness of their activity allow us to structure our own activities. Cyberspace provides a ground for testing and visualising; the physical space provides a ground for realisation.

5 MIXED REALITY IN ARCHITECTURE

Mixed Reality is an emerging technology that is capable of blending physical objects with digital content in an interactive and real-time fashion (Almagor, 2016). A head-mounted MR device can present virtual 3D objects on see-through displays, allowing to observe the virtual world to co-exist in the real world right in front of the user's eyes, which makes it way different than VR technology. MR devices constantly track the surroundings with built-in sensors to locate the user's current position and allow real-time interaction between virtual objects and the physical environment. In addition, The MR device receives inputs primarily through hand gestures and voice recognition. Due to its ability to overlay BIM models on real construction sites, the architecture, and construction industry soon began to explore the Possible uses of MR technology since the first MR device was made commercially available. The ability to visualise architectural designs and construction layouts directly on site has the potential to significantly improve the decision-making efficiency compared with using existing technologies such as VR headsets, mobile devices, or computer screens, thereby accelerating the pace of design, lower rework instances, and engaging customers in a new way. With MR technologies, employees can identify risks earlier and accurately validate designs and install conditions from early-stage design through to construction. In addition, there is a $ 4 M estimated savings per year. It is

about a 14 % decrease in construction costs. (A Forrester Total Economic Impact Study Commissioned By Microsoft, November 2021). Since the early industry adoption of MR technology, a limited number of design firms and contractors performed pilot tests with application uses, but only preliminary demonstrations and reviews have been found. There were no comprehensive reviews on using of MR technology in architecture and urban design for users as a final design, not just in decision-making.

Tools and technologies existing in mixed reality are studied in a way to be used as an essential part of urban design for users and not just as a tool for studying the design process. Also presenting the unique capabilities of mixed reality technologies that help in achieving the key elements of creating quality places in a new, innovative, and renewed way.

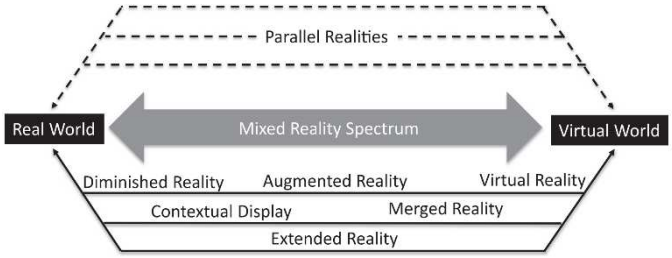


Fig. 1: Mixed-reality spectrum continuum (Bernard C. Kress and Ishan Chatterjee 2020).

5.1 Tools and techniques

To bring mixed reality to site environments, interactivity and safety should be taken into consideration while allowing authentic experience in the space with a sense of engagement. In order to do that some devices were selected to bring MR to the designed spaces. The first commercially available Mixed Reality devices include Microsoft HoloLens and Magic Leap One. Both are stand-alone computer headphones that connect to other devices wirelessly, linking GPS in the HoloLens devices to increase the accuracy of position tracking on site (Xsens, 2018). In addition, Azure Kinect DK is built for mixed reality using AI sensors, or just using the screen of the mobile phone for more broadband enabling. Model format and access MR technology support the most widely used 3D formats in the architecture and construction industry.

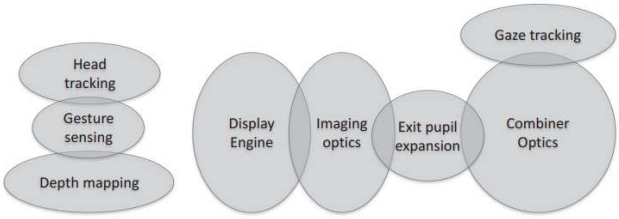


Fig. 2: Functional optical building blocks of an MR system. (Bernard C. Kress and Ishan Chatterjee 2020).

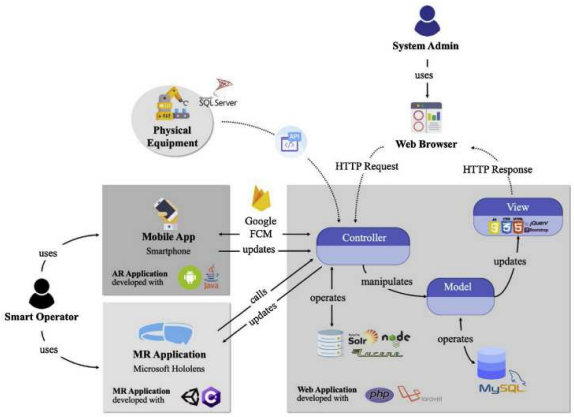


Fig. 3: System architecture (Eleonora Bottani 2021).

For a more detailed technical reference for designers, five MR applications use fbx files as their native file format, which can be exported from a BIM program, which includes Trimble SketchUp, Autodesk Revit, and Autodesk Navisworks, or a 3D modeling program, such as Autodesk 3ds Max and Maya. SketchUp Viewer and Trimble Connect are using SketchUp models as the native file format, and Trimble Connect allows Revit

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

model to be uploaded through an add-in. Such devices have the potential to revolutionide how we design, create spaces, work, communicate, travel, learn, teach, shop, and entertain. Already, market analysts show very optimistic expectations of return on investment in MR, for both enterprise and consumer applications. Hardware architectures and technologies for AR and MR have made tremendous progress over the past five years, fueled by recent investment hype in start-ups and accelerated mergers and acquisitions by larger corporations.

5.2 Unique and essential capabilities

5.2.1 Interactive user interface

For designing an accessible and user connected user design, the MR technology provides various interactive features in the user interface to provide a better experience for a different environment, namely the ability to reset, scale, and respond to voice commands. When using an MR device in a large and complex space, MR Builder and Fuzor AR provide a voice command, and immediately brings the menu back right in front of the user's sight.

5.2.2 Immersive view mode

The MR technology enables an unobstructed immersive view mode that allows observation of designed models at their full-size scale on the site, which is unarguably the most essential toolset for architectural and construction uses. Although 3D Viewer is the only MR application that does not provide an immersive view as a native view mode, it can still achieve immersiveness by scaling a model to a 1:1 scale. At such a scale, the user sees the model at its true size and can physically interact and walk around MR models when it is placed on-site or in a large enough space to accommodate the full-size model. By the automatic model alignment technique, a full-size model is allowed to be immediately placed at its correct position on-site after registering the required reference targets. HoloLive 3D requires and Fuzor AR uses the QR code alignment method, requiring a QR code label model component to be inserted in the BIM model first. Then the same QR code label has to be affixed and printed to the same location in the physical space, either a floor or a wall. After using the MR device to scan the affixed QR code label, the model can be immediately aligned. Lastly, some MR applications require pivot points to be selected for fine adjustment of rotation and movement if needed. This helps designers to guide users in the designed space to follow to design flow and to accurately interact with the design features and planned user journey.

5.2.3 Multiuser collaboration

One of the main purposes of using MR in urban design is to bring people to a common real place for socialising and interacting with others in the open space. The MR technology provides the opportunity for multiple MR device users to inspect the same 3D model together through a collaborative session, which is an essential part of decision-making for a project team between the users. A basic multiuser collaboration session starts with a session host whose MR device will upload the model to the sharing service. If other participants want to join the session, the sharing service will download the model to their MR devices for participation. In such a case, all session participants can inspect the same model together, but they do not know where each other is located relative to the model position. For sharing this information, a co-located collaboration session is required where all participants have to determine a common reference point in the physical space to create a shared coordinate system. When the coordinate system is shared across all MR devices in the session, there will be an avatar representing each participant to indicate their position relative to the model, and their focus point will be presented with a laser beam.

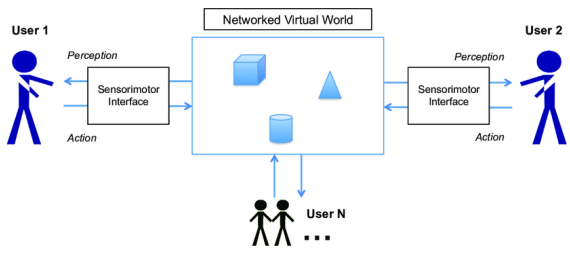


Fig. 4: The conceptual framework of immersive CVE designed for multi-user collaboration. (Weiya Chen 2015).

As shown in Figure 6, the designed model consists of four layers, each layer is affected by the layer below: temporal and spatial coexistence enables awareness of others' activities, which then allows the exchange of opinions and views, the sharing of knowledge and information, and the distribution of operations and work. At the highest level, the final collaboration between multiple actors is enabled by sharing of activities with the balance between assertions and cooperation (negotiation). All these factors with their hierarchy have to be taken into consideration while designing the architectural features and the urban journey for users.

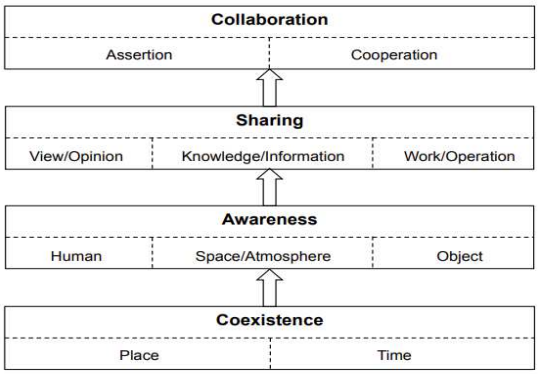


Fig. 5: A hierarchical collaboration model. (Okada 2007).

6 METHODOLOGY

The study aims to reveal the effect of using mixed reality in placemaking urban open spaces and its response from users. The study utilizes many methods to achieve its aim such as on-site observation, user questionnaires, and the use of software programs(3ds Max, Vray, and AutoCAD) to design simulated models in a selected public plaza. To construct the basis for the on-site observation and user questionnaires, a literature review was carried out to reveal the key elements of placemaking and mixed reality techniques discussed in previous research. Data collection is done through handout visitor questionnaires. In some cases, a short interview was held while the user was answering the questionnaire. All questionnaires were filled by the participants while on the plaza for more involvement and relatability to the questions. The questionnaire was formed of questions for users each group of questions refer to a key element of the quality places of placemaking. then these qualities were valued according to the results of the questionnaire. The results from these analyses were then compared with the original plaza qualities.

6.1 Case Study

6.1.1 Site selection and plaza analysis

Saad Zaghloul square is located in Ramleh Station District in Alexandria, Egypt. It is surrounded by Safiya Zaghloul Street, Al-Nabi Daniel Street, Omar Lotfy Street, and El Geish Road. As shown in figure (6) El Raml Station is a neighborhood in Alexandria, Egypt. It features a large public square containing the main station of the Alexandria tramways. It is one of the main centres for tourism, retail, and entertainment in the city. It is helped by the presence of several hotels, restaurants, and entertainment venues. However, huge recreational areas along the seaside caused to loss of the characteristic of the city. Moreover, especially commercial historic entities have lost their functions which caused a deterioration process in historic districts of urban heritage to modern needs. Naturally, citizens tend to choose more liveable and developed areas, so entertainment and commercial dynamics move to more up-to-date places such as shopping malls or just online entertainment or shopping instead of interaction with places and people. This square was chosen for the case study to study the possibility of developing heritage places that express the heritage and culture of the original city using mixed reality techniques to revitalize it while preserving its special character.

As shown in figure (7) the plaza elements were analyzed from main and secondary entrances, circulation paths, and corridors, as well as gathering spots. The main zones of the plaza were also clarified and divided according to their location from being closer to the main path of the commercial part of the city or its attachment to the surrounding buildings, and thus choosing the most appropriate mixed reality transaction for each space.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Fig. 6: Site analysis of Saad Zaghloul Square (Researcher 2022).

Fig.7: Saad Zaghloul Plaza zoning and circulation Diagram (Researcher 2022).

6.1.2 Participants

All participants in the study were visitors using the plaza. Firstly the Microsoft HoloLens was given to the user after locating him in the QR code position, then The questionnaire was handed out and explained personally to each user. visitors gladly participated in the questionnaire as it was a new experiment, hoping the research would be the future cause of improvement. A total of forty questionnaires were handed out, Five of the forms came back with incomplete answers, rendering them invalid. The final sample was 22 percent females, 51 percent males of different ages, and 27 percent of children.

6.1.3 Applied MR Technique

Some devices were selected to bring MR to the designed plaza to evaluate the use of MR technology in architectural design and urban planning in open spaces through the use of commercially available MR applications in a simulated development of Saad Zaghloul plaza. Microsoft HoloLens and a simulated design in VR goggles were used. Both are self-contained systems that communicate with other devices wirelessly.

GPS in the devices was linked to increase position tracking accuracy on site. Model format and access MR technology were supported by the use of fbx files as their native file format, Using Autodesk 3ds Max and SketchUp as the native file format, and Trimble Connect additionally allows Revit model to be uploaded through an add-in.

Fig. 8: Saad Zaghloul Simulated Mixed Reality Developed Plaza (Researcher 2022).

Fig. 9: Simulated interactive MR development of surrounding facades in Saad Zaghloul Plaza (Researcher 2022).

Mixed reality was exploited to make multiple designs for corridors floors and movable virtual ceilings for spaces, as well as making yards with changing design themes according to the interests of the current time. In addition, mixed reality models were used to re-develop and revive the facades of the buildings surrounding the plaza: either by making them interactive with the movement of users or making a design with a different rhythm using the same proportions of the original facade.

Fig. 10: Site Experiment and users surveys (Researcher 2022).

7 RESULTS AND DISCUSSION

The questionnaire was made to reveal three important topics for the analysis of the mixed reality design for the ability to evaluate and develop it. The first section is about the key elements of quality places and the extent to which they are achieved in the original and proposed MR design of the plaza. This was done by asking users questions about if they find it impressive and recreational, could practice different activities, would come with the whole family, feel safe and comfortable, or would like to open their private business

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

nearby, etc. each question scans a key element of the quality places and each question has to be scaled from 1 to 5. As shown in Table 1 the results of evaluating the mixed reality designed plaza were way better according to users.

key elements of Quality Places	New Simulated Designed Plaza Score (1 to 5 Scale)	Original Plaza Score (1 to 5 Scale)
Mixed Use	3.98	1.16
Broadband-Enabled	2.31	3.79
Community Heritage	2.42	2.12
Arts and Culture	2.63	1.25
Creativity	4.19	0.98
Green Spaces	3.79	3.79
Promote and Facilitate Civic Engagement	2.68	1.03
Improves Local Business Viability	3.16	1.21
Cope with New Technologies and Current Interests	4.89	0.00
Safe and Comfortable	1.56	2.76
Sociable and Connected	2.19	2.57
Allowing Authentic Experiences	3.40	2.02
Interaction	3.72	0.84
Overall	3.12	1.80

Table 1: User surveys result on the quality places key elements available in the plaza (Researcher 2022).

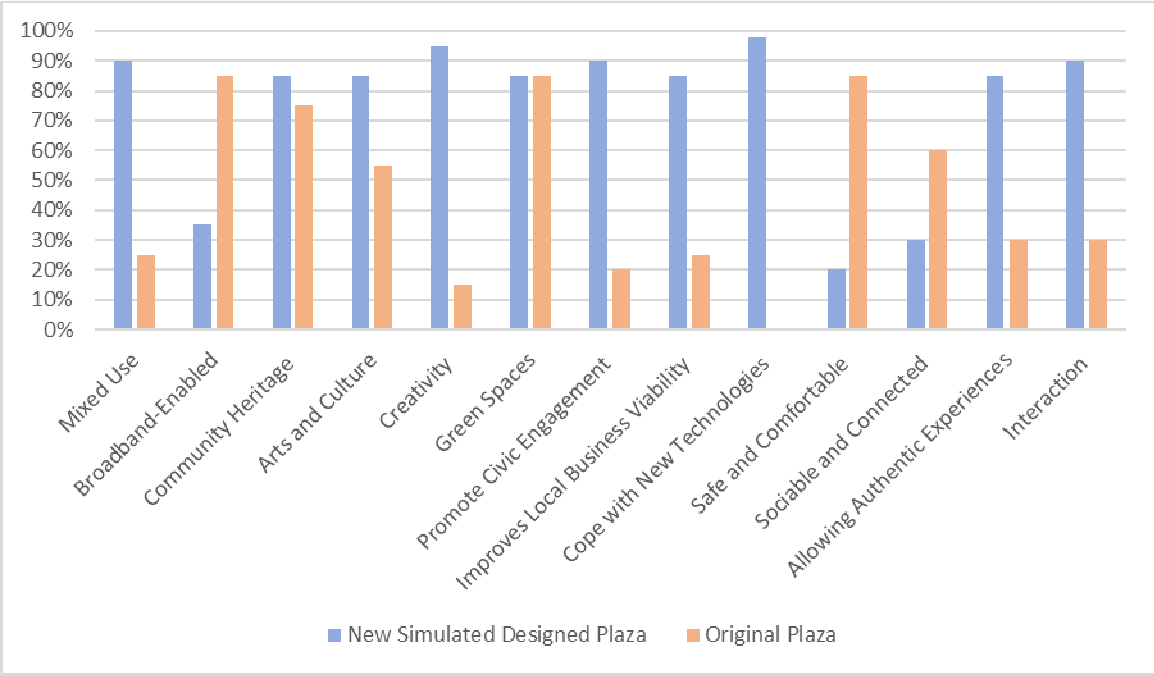


Fig. 11: Chart of the Percentage of quality places key elements available for each design (Researcher 2022).

As for the affecting factors in applying mixed reality in design. Mixed Reality offers many opportunities for architecture and the Urban sector, but also has limitations that determine its actual implementation for users in many aspects, concerning design, environmental, social, and economic factors. The second section of the questionnaire and interviews focuses on the evaluation of these factors and compare the current design and the proposed new one.

	Factors	Mixed Reality Plaza Revival	Physical PlazaRevival
Design Related	Design flexibility	•	○
	Design optimisation	•	•
	Quality issues	○	•
Environment Related	Lower Resources	•	
	Reduced Materials	•	
	Decreasing the Emission of CO2 Less Total Energy	•	○
Social Related	Reducing Workforce	•	
	Jobs Shifting Paradigm		
	Safety	○	•
	New job opportunities	•	
Economic Related	Low Initial Cost	•	
	Reducing Materials Cost	•	
	Reducing Labour Cost	•	
	Cost-reducing	•	
	Unique Architecture	•	○
	Time-saving	•	

Table 2: User surveys result on the affecting factors (Researcher 2022). •: Factor Fully Present, o:Factor Partially Present

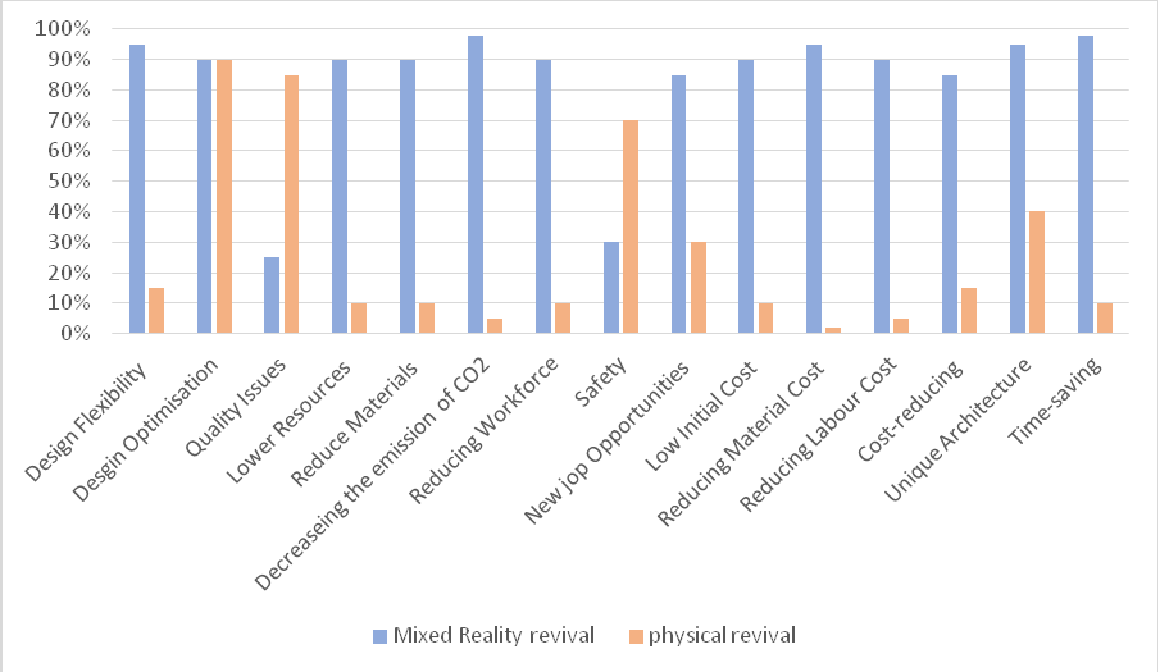


Fig. 12: Chart of the affecting factors of MR on the site (Researcher 2022).

The third section of the analysis depends on presenting the possibilities and challenges of applying this type of design to open public spaces in Egypt o reveal its validity, taking the case study as one example that can be replicated, developed, and adapted to different plazas in the rest of the country.

More than 80% of the plaza visitors received a good user experience evaluation. According to participants' ages the experience was more engaging and attractive for younger ages, which makes sense given the younger generations are more used to connecting to technology and digital interfaces they are more familiar with. older participants were less comfortable and recognizable to new technologies and tools. The site survey also indicated that all users welcome the development of the plaza with different perceptions of development. Older users were less reactive to technological elements but they welcomed that the development was inviting new generations in while maintaining greenery and open areas, as the experience provides for the dematerialised designs of hardscape as well as other urban open spaces elements.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

potentials	challenges
- Multi-designed mixed-used spaces - Increased design flexibility - Time-saving - Ability to use in existing sites - Reducing the current gap between community heritage and coping with New technologies and current interests - Reduced resources and material waste - Reducing the Ecological footprint of urban design - Changeable and upgrading designs - Cost reduction - Reduced workforces and their transportation costs - Opportunities for architects and urban designers to test and apply new innovative designs to users. - Also a free broader opportunity for architecture schools and competitions for multiple unlimited designs according to recent interests.	- Lack of knowledge about technology among the stakeholders - Mixed Reality requires new skills from designers (Designing, operating, control, and Locating in site) - Shortage of tools of mixed reality according to the economic situation of the city. - Lack of Knowledge from users of new technologies - The need of providing more common and public tools to bring mixed reality designs to the public. - The designs could be switched off at any moment so only the physically designed base would be existing.

Table 3: List of potentials and challenges of Mixed Reality design (Researcher 2022).

8 CONCLUSION

This paper provides timely and empirical information to help urban designers and stakeholders better understand MR technology for architecture and urban design, specifically for open spaces used as recreational, social, and economic spaces. The study included a simulation of a developed plaza with models of mixed reality combined with physical elements of the plaza, taking into account the activities and behaviour of the users of the square. The surveys were conducted in Saad Zagloul Square in Alexandria with different social criteria, activities, and formation. The results were analyzed to reveal the validity of using mixed reality for urban development and place-making for users and citizens of Egypt and it shows its approbation with some development according to the economic and cultural situation of the country. They also show the possibility and need of developing the experience in a more simple way to reach all citizens by using it directly through their mobile devices and more public and affordable or free tools like moving screens existing in the plaza for all the public. The study clarified that using Mixed Reality designs in urban open spaces enhances public presence and interaction with public open spaces and with the architectural elements, such as the facades of the surrounding buildings and elements of landscape and hardscape positively affected. Also enriches social cohesion, and economic activity, preserving the environment, and enhancing sustainability through the development and changeable designs of spaces without using any materials, thus reducing the ecological footprint of open public spaces in the short and long term. The design of open spaces is essential for the urban environment, and an understanding of the broad scope of mixed reality in these spaces will help design spaces that encourage public use in different seasons, occasions, and trends for different periods suitable for all age groups with different interests and changing modern uses of spaces leading to improved greatly their ability to live.

9 REFERENCES

Yilei Huang: Evaluating mixed reality technology for architectural design and construction layout, USA, 2020.

Almagor A: Mixed Reality for the AEC Industry: Extending Trimble's Product Capabilities with Microsoft HoloLens, 2016.

Alsafouri S, Ayer SK: A Step-By-Step Procedure for Implementing Mixed Reality Visualization Interfaces in Design and Constructability Review Sessions. Vienna, Heraklion, Greece, 2017.

Alsafouri S, Ayer SK: Leveraging Mobile Augmented Reality Devices for Enabling Specific Human Behaviors in Design and Constructability Review, 2019.

Amira Mohamed Said Ammar, Author: PROSPEC PROSPECTS OF W ALKABILI WALKABILITY IN CI Y IN CITY NEIGHBORHOODSCASE Y NEIGHBORHOODSCASE STUDY: THE CI Y: THE CITY CENTER OF ALEXANDRIA TER OF ALEXANDRIA, Egypt, 2018.

Forrester Consulting Total Economic Impact™ Checklist Commissioned By Microsoft: Planning For Adoption Success Of Mixed Reality Using Microsoft HoloLens 2, 2021.

Eleonora Bottani, Francesco Longo, Letizia Nicoletti, Antonio Padovano, Giovanni Paolo Carlo Tancredi, Letizia Tebaldi, Marco Vetranoc, Giuseppe Vignali: Wearable and interactive mixed reality solutions for fault diagnosis and assistance in manufacturing systems: Implementation and testing in an aseptic bottling line, Italy, 2021.

Bernard C. Kress* and Ishan Chatterjee: Waveguide combiners for mixed reality headsets: a nanophotonics design perspective, Nanophotonics 2021; 10(1): 41–74, 2020.

Bangor, A., Kortum, P., Miller: Determining what individual SUS scores mean: adding an adjective rating scale., Usability Stud. 4 (3), 114–123, Retrieved from https://uxpajournal.org/wp-content/uploads/sites/8/pdf/JUS Bangor May2009.pdf, 2009.
Bernard C. Kress and Ishan Chatterjee: Waveguide combiners for mixed reality headsets: a nanophotonics design perspective Nanophotonics 2021; 10(1): 41–74, 2020.
W. S. Colburn and B. J. Chang: Holographic combiners for head-up displays, " Tech Report No. AFAL-TR-77-110, 1977.
B. Kress: Diffractive and holographic optics as optical combiners in head-mounted displays in Proceedings of the 2013 ACM Conference on Pervasive and Ubiquitous Computing – Ubicomp'13, 2013, pp. 1479–1482.
Lee, J., Cameron, I., Hassall: Improving process safety: what roles for Digitalization and Industry, af. Environ. Prot. 132, 325–339.
Roger Lee: Applied Computing and Information Technology, Volume 788.
De Crescenzio, F., Fantini, M., Persiani, F., Di Stefano, L.: Augmented reality for aircraft maintenance training and operations support. IEEE Comput. Graph. Appl. 31, 96–101, 2011.
Understanding Virtual Reality, Interface, Application, and Design, A volume in The Morgan Kaufmann Series in Computer Graphics, 2003.
Adams, Ernest: Postmodernism and the Three Types of Immersion. Gamasutra. Retrieved 2007-12-26, 2004.
M. A. Golub, A. A. Friesem, and L. Eisen: Bragg properties of efficient surface relief gratings in the resonance domain, Optic Commun., vol. 235, pp. 261–267, 2004.
https://www.lighttrans.com/applications/virtual-mixed reality/waveguide-huds.html, sited in june 2022 .
M. W. Farn: Binary gratings with increased efficiency, Appl. Opt., vol. 31, no. 22, pp. 4453–4458, 1992.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

🏆 *reviewed paper*

Participatory Approaches in the Adaptive Reuse of two Dutch Private-Led Cultural Heritage Projects

Yawei Chen

(PhD Assistant Professor Yawei Chen, Department of Management in the Built Environment, Faculty of Architecture and the Built Environment, Delft University of Technology, Julianalaan 134, 2628 BL Delft, the Netherlands, y.chen@tudelft.nl)

1 ABSTRACT

There is increasing debate concerning citizen participation in the reuse and transformation of heritage sites. However, the question of why and how participatory approaches are explored in private-led heritage adaptive reuse receives limited attention. The paper shows why the communities should play an essential role in the adaptive reuse of heritage sites in the two Dutch cases. The article is theoretically based on debates on social sustainability and community participation in the adaptive reuse of heritage sites. The qualitative investigation consisted of interviews with different actors. The study shows that the adaptive reuse ambitions of the two Dutch heritage sites face difficulty in receiving the support of the local communities. The findings show interest, expectations, and needs gaps between the private heritage and local communities. The investigation indicates that the participation of the local community is lacking, and the mutual understanding between the two is problematic, which has led to the stagnation of the adaptive reuse process of the heritage sites. The paper suggests that the multi-stakeholder processes can identify the key stakeholders and address how to activate key stakeholders to collaborate with available means on shared goals and interests.

Keywords: Heritage, adaptive reuse, participatory approaches, private-led, Community

2 INTRODUCTION

An essential goal of the urban transformation process is to transform a dilapidated urban environment with improved spatial quality and added value to both land and property. However, there is widespread debate about what to do with the existing properties, especially those with historical significance and monumental status. This is not only because the built environments are considered highly durable but also because, for sustainable urban transformation, there is a need to address how resources and materials brought from the past – histories, artefacts and places (Lillevold and Haarstad 2019) are to be reused. Studies have identified the role of heritage in urban development, such as historical significance and symbolic value (Lipe 1984, ICOMOS Burra Charter 2013). They are authenticity that motivates heritage tourism (Waitt 2000; Park et al. 2019), economic rewards (Bullen & Love 2011), and environmental value (Macmillan 2006). In recent years, various studies stressed the social values that "encompass the significance of the historic environment to the contemporary community" (Jones 2017). This concern reflects the local community's understanding of the historical, cultural and social value and the impacts of their adaptive reuse on the heritage sites and the historical environment around them. On various occasions, opposition from the community initiatives led to stagnation in the adaptive reuse of heritage sites.

This paper aims to look into the role of the community in the reuse and transformation of heritage sites when adaptive reuse is involved in private-led heritage projects. This topic has yet to receive sufficient attention from academia. The question is whether the community should play a role in transforming private-owned heritage sites. And if so, how can the community /cities play their part in facilitating the transformation of heritage sites to contribute to a sustainable outcome? This research investigates two heritage sites in the Netherlands undergoing adaptive reuse transformation. It explores the role of the communities within the heritage transformation process and the stagnation stakeholders encounter. The paper is structured as follows: the next section discusses how social sustainability, social value and community are addressed in the governance of heritage transformation, as well as the role of the community and the tension involved in the multi-stakeholder process in the heritage transformation. Section 3 discusses the adaptive reuse of two private-owned heritage in the Netherlands and the uncertainties involved in the multi-stakeholder process. The wishes of different stakeholders are mapped in both cases, and the community's input is highlighted and compared in both cases. Section 4 concludes what role the community plays in the adaptive reuse of private-owned heritage sites and how to incorporate community input into transforming private-own heritage sites to achieve social sustainability.

3 THEORY DEBATE: COMMUNITY INVOLVEMENT AND PARTICIPATION IN THE ADAPTIVE REUSE OF HERITAGE SITES

The role of the community in the urban development process is essential in realising social sustainability. Community is traditionally defined as "groups of people with a common background, interest or identity" (Bray 2006). It is "where one lives and consequently where one finds meaningful community interaction and social relations" (Bradshaw 2008). In urban development, the community can be considered an integral component of the governing process and "a form of organisation through which ordinary people can mobilise their interests in opposition to those of the state, or larger global forces" (Bray 2006). Researchers explored various tangible and intangible values in the adaptive use of heritage sites, among which the social value connects buildings, environments and people. In this section, we first examine why community participation is essential for the sustainable transformation of heritage sites before discussing how social value and participation can be incorporated in the adaptive reuse of heritage to address the role of the community and the tensions within the process related to participation.

3.1 The debate on the role of community in sustainable urban development

Different theoretical perspectives drive the discussion of community involvement in urban development. The first perspective can be related to the right to the city movement, a term Lefebvre coined in 1968 (Lefebvre, 1968; 1996). The right to the city responds to neoliberal urbanism and social injustice (Aalbers and Gibb 2014). While private property is fundamentally about the ability to exclude others from its use (Aalbers & Christophers 2014; Davies 2007), the right to the city is both a critique of and a moral claim against the privatisation and commodification of housing and urban space. The abstract dimension is the right to belong to and co-produce the urban areas. The rights to space is not defined through property rights or expropriation but through use and appropriation. Or, in other words: "the right not to be alienated from the spaces of everyday life" (Mitchell & Villanueva, 2010: 667). Cities should address user value over exchange value, as cities are meant for people, not profit. The right to the city ensures justice and equity through which inhabitants have a right to full participation in urban life as equals (Fincher & Iveson 2008: 9; James 2013). Harvey (2008) also stated that the right to the city is far more than a right of individual access to the resources but rather a collective right that exercises power over urbanisation processes. The right to the city thus projects a concrete claim to integrated social, political and economic rights, the right to education, work, health, leisure and accommodation in an urban context that contributes to developing a healthier relationship between people and space.

The second perspective concerns the significant role of the local community in sustainable urban development, especially the social dimension in the urban sustainability discourse. In area-based urban regeneration, the local community can bring place-based knowledge to the planning process and be incorporated into strategic solutions that are better tailored than top-down intervention (Deakin and Allwinkle 2007; Chen and Qu 2019). Residents feel more connected with their local neighbourhood by getting involved in the locality. Their involvement in local affairs facilitated them in developing skills and social capital to find solutions to enhance local social welfare. Community participation contributes to the goal of social sustainability, which emphasises the "development (and/or growth) that is compatible with harmonious evolution of civil society, fostering an environment conducive to the compatible cohabitation of culturally and socially diverse groups, while at the same time encouraging social integration, with improvements in the quality of life for all segments of the population" (Polese and Stren 2000: 15-16). When linking social sustainability to urban space, it is vital to address, for example, the human dimension in the interaction between residents and the city and the social facets of cities (Caprotti, F; Gong, Z,2017).

The third perspective is related to the intent for social inclusion and the social values created in the multi-stakeholder governance perspective. Some research may connect the community's involvement with the goal of social sustainability, which means contributing to the internal and external stakeholders' development and growth by achieving several objectives such as equity, well-being, social cohesion and inclusion, the opportunity for learning and self-development (Chiu 2003). Swyngedouw (2005) addressed the necessity of citizen involvement in entitlement, status, representation, accountability and legitimacy and the danger of being excluded in upscaling or downscaling or in the governance order. More studies under the multi-actor perspective discussed the shifting power relationships between different types of actors and the (dis)empowerment dynamics (Avelino & Wittmayer 2016). As the essence of the community is solidarity,

common identity and sets of shared norms and values, the governance discourse includes various propositions that attempt to develop the sense of belonging in the communities and bond people together, such as community addressed through networks and partnership, the opening up of decision-making to greater participation, enhancing social capital and community cohesion, engaging citizens in community issues (Taylor 2007; Bradshaw 2008).

The above debates recognise the significance of involving the community in achieving sustainable urban development from different perspectives. While social sustainability addresses the satisfaction of basic human needs and the subsequent continuation for future generations (Littig and Griessler 2005), community involvement provides the opportunity for the local population to participate voluntarily in community politics. It helps develop a more place-based, inclusive, and justice solution for transforming urban areas. Such debates also apply to heritage studies, which identify the close linkage of the adaptive reuse of heritage sites with the social dimension of sustainability (Conejos et al., 2016). Although it was only in the second half of the twentieth century that the social value of heritage became an explicit component of conservation policy and practice, the linkage between heritage sites and the local communities is considered an essential part of community identity. Heritages have symbolic value and spiritual associations for the location and thus help communities create an attachment to the place. However, what is less well known is whether and how community participation occurs in practice. This concerns the governance of the heritage transformation process from the multi-stakeholder perspective and engaging the community.

3.2 The governance of adaptive reuse of heritage sites: stakeholder inclusion and community participation

The adaptive reuse of heritage is a process that changes a disused or ineffective item into a new one that can be used for a different purpose or any work to a building over and above maintenance to change its capacity, function or performance (Douglas 2006:1). A successful adaptive reuse process is about negotiating the transition from the past to the future to secure the historical transfer of heritage assets while also meeting the needs of the contemporary world. Just like the debate on sustainable urban development, academic discussions concerning adaptive reuse consider various political, economic, social and environmental implications of heritage transformation and, consequently, how the balance between preservation, reuse, value capturing, sustainability, and social experiments is achieved and enforced (Li et al. 2021). Some challenges are identified in the studies on the adaptive reuse of heritage that hinder a smooth process of heritage transformation, like policy ambiguity on heritage buildings/sites or contradiction in the planning and heritage system towards heritages. But what influence may hinder the process significantly often arises from the different intentions, interests or imbalanced power and resources among the stakeholders.

In the process of heritage transformation, several stakeholders are critical to the success of a heritage transformation project. The stakeholders appreciate the cultural and historical value of heritages and see the potential economic value heritages buildings can contribute. In particular, the public sector includes the local authorities and their agencies using legal and policy instruments to address the historical, social and economic value in the process of heritage transformation, e.g. how the heritage projects fit into the principles of heritage preservation and planning vision, or achieve economic development and job creation or attract tourism. Property/land owners, real estate developers and financial investors belong to the private sector. They use their financial instruments or ownership as bargaining tools to create economic values via adaptive reuse of heritage projects (Ruijgrok 2006). Besides, architects, planning practices and construction companies play a part in addressing the architecture, authenticity and sustainability values.

In contrast, the discussion of involving the community is a more recent phenomenon. Local communities increasingly recognise that future generations may benefit from protecting specific places and areas but may suffer from inappropriate new functions in adaptive reuse and even get excluded. This initiative from the community also coincides with increasing attention to broader, non-expert perceptions of heritage and the communal values associated with these focuses. Besides place-based bottom-up initiatives, researchers and policymakers are convinced that involving communities may create opportunities to achieve social sustainability goals such as equity, well-being, social cohesion and inclusion.

While the belief that individuals should be given a voice appeals to democratic thinking, there is little agreement regarding the best way to achieve meaningful involvement (Callahan, 2007). Social sustainability requires an organisational commitment toward the stakeholders that should be brought together in new forms

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

of transparent and participative management, communication and decision-making (Hemmati, 2002). While participation emphasises how "stakeholders influence and share control over development initiatives, decisions and resources (World Bank 1996, xi), there are different levels of how participation can be organised and integrated into the decision-making process. The levels of participation described in the ladder of citizen participation by Arnstein (1969) varies in the participant's power in the end-product and relation to the public authorities. Whether the key stakeholders choose to inform the public, listen to the public, engage the public in problem-solving or co-develop agreement depends on the legal framework and institutional setting and the wills of the administrators (Creighton 2005). Galuppo et al. (2014) suggest two steps to set up a more socially sustainable multi-stakeholder process: a) "engaging multiple stakeholders in collaborate settings" to identify and activate stakeholders; b) "activating cycles of inquiry and action" to exchange views and promote the circulation of different values.

In the adaptive reuse of heritage buildings and sites, the communities often have neither the advantage of owning the heritage nor contributing to the financial mechanism. This adds extra barriers for local communities to get involved and voice their concerns at an early stage. Successful adaptive reuse projects require both good design for the building and planning that carefully considers the surrounding environment and the community's concerns about the future of the heritage sites (Macmillan 2006). Therefore, it is crucial to understand each stakeholder's diverse needs and concerns through surveys and interviews and later address these needs and possible solutions that address these needs and concerns through collaborative workshops (Galuppo et al. 2014).

4 METHOD AND TWO CASES ON THE ADAPTIVE USE OF HERITAGE SITES

4.1 Methodology and the case selection

Following the literature review, this paper examines two private-led adaptive reuse projects in the Netherlands - the adaptive reuse of the industrial heritage Soda Factory in the middle of a residential neighbourhood and the transformation of the UNESCO heritage Fort Kudelstaart at the edge of a city. The two selected projects have been used in various education programs that aim to help students investigate the complexity of the regeneration of the existing urban environment, with a focus on understanding the stakeholder's involvement and the role of the community in the process of the adaptive reuse of heritage buildings and sites. They help understand why the local community should play a role in the adaptive reuse of private-owned heritage sites about results and process. Face-to-face interviews and document analysis have been used to collect information for stakeholder analysis and the wishes and interests of stakeholders related to the community's role. The interviewed stakeholders include various public authorities (e.g., planning department, tourism department, monument preservation agencies), private sector (e.g., real estate developer, property owner) and local community representatives (neighbourhood community organisations, inhabitants, visitors, local business communities and passengers). Interview protocols have been prepared beforehand to address specific interviewees and ethical considerations. In the case of Fort Kudelstaart, workshops were organised to better understand the stakeholders' wishes, including the inhabitants and (mis)communication.

4.2 Two cases: the adaptive reuse of the Soda Factory and the Fort Kudelstaart

The Dutch cases - the Soda Factory and the Fort Kudelstaart are both ongoing heritage projects for adaptive reuse. The Soda Factory is a two-warehouse building (Lijfland and Coerlandt with a total floor area of 2188 m2) located in a residential neighbourhood at the Buitenhaven in the centre of Schiedam, a city adjacent to the famous Dutch port city Rotterdam. It is a former industrial property used to produce soda in the 19th century. It has been vacant since 1975 and was in a dire state. A local initiative prevented this building from demolition before the municipality sold the warehouses for the symbolic sum of one euro.

The current owner – a retired architect Peter van Velzen acquired the building in 2012 and started restoration. The intention was to give the building a new social function in the city of Schiedam and become a breeding space for various entrepreneurs and initiatives. In December 2015, the Soda Factory was included in the municipal monument list. With the help of the new fund-raising mechanism like crowdfunding, the transformation of the Soda Factory started. The owner wanted to follow an organic development strategy. Some temporary functions like a café, escape room and photo shooting space have been added, but that has so far resulted in inadequate development and has not been financially sufficient on an annual basis. The

City vision 2030 of the Municipality of Schiedam has adopted new functions such as the leisure economy. Specific government organisations support the reuse of the Soda Factory, but in comparison with similar heritage projects, governmental support is lacking. Besides, little information has been communicated with stakeholders and the inhabitants. Despite the social intention of the owner, no direct community involvement and participation have been incorporated into the project development process. On the other hand, concerns and opposition were expressed from the neighbourhood inhabitants and organisations on the noise and chaos caused by the visitors.

Fig. 1: Image of the Soda Factory (Above) and Fort Kudelstaart (Below)

In the second project, the Kudelstaart - an old military defence fort constructed in 1906 as part of the "Defence Line of Amsterdam" - became a UNESCO World Heritage in 1996. As a result of budget cuts, the Dutch government asked the municipality of Aalsmeer to buy Fort Kudelstaart. After researching the feasibility of the purchase of the defence fort, the city of Aalsmeer purchased the fort in 2014 and decided "to make the fort an icon for the water sports in Aalsmeer" (Municipality of Aalsmeer, 2020). In the same period, the village council and immediate residents proposed to make the fort more accessible to the public. Aalsmeer town council approved a change of its local zoning plan, paving the way for the transformation of 'Fort bij Kudelstaart' into a vibrant and pioneering venue for water sports. The municipality selected a property developer Martijn de Liefde via a European tendering process to collaborate on the Fort Kudelstaart project based on a ground lease contract. The proposal by developer Martijn de Liefde envisages the transformation of the 60,000 m2 site into a high-quality nautical centre. The definite master plan drawn up by Serge Schoemaker Architects for Kudelstaart Sailing Fort foresees the change of the 60,000 m2 site into a

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

high-quality maritime centre with additional mooring spots and harbour amenities, hotel rooms, spa/wellness facilities and meeting spaces. The design vision includes a restaurant, café, small museum and viewing platform. In early 2021, the redevelopment started with soil and roof preparation.

The redevelopment plan and the preparation activities received opposition from the local inhabitants and community organisations. The worries include the possible negative impact of the commercial function on the cultural-historical value of the fort and the surrounding environment. To voice these concerns, the residents established an organisation called Sticht Werkgroep Fort Kudelstaart (SWFK). They defined their task as preserving and improving the living environment of residents in the vicinity of Fort Kudelstaart. They filed an appeal to the state against the newly established zoning plan to stop the redevelopment. The council ruled to suspend the zoning plan and put the redevelopment plan on hold until further decision.

4.3 Role of the local communities

The two investigated heritage projects are both private-led heritage projects. The Soda Factory case is an industrial heritage located in a dense residential neighbourhood in the city centre of Schiedam. In contrast, the Fort Kudelstaart case is situated in the peripheral of the city Aalsmeer along the lake Westeiderplassen. Both projects were initiated because of the historical and cultural value of the heritage. In the Soda Factory case, the whole development is privately owned. The owner describes the current development as an organic development that can maintain the roughness of the industrial characteristics of the Soda factory. Even though the current owner hoped to create a space for the community and crowdfunding was used to mobilise societal force for investment, little has been done to communicate the owner's idea to the neighbourhood or consult the inhabitants about their wishes. The municipality of Schiedam expects the Soda factory to play a role in the area within the boundaries of the master plan but remains ambiguous about the development trajection. From the interviews of key stakeholders, it is clear that the adjacent inhabitants and community organisations have an expectation that the Soda Factory can be a natural meeting place for the neighbourhood, but also want to avoid the disturbance from the public function which the Soda Factory may bring to the quiet neighbourhood as Plantagebuurt where the Soda Factory is located.

In the Fort Kudelstaart case, the property developer leased the fort from the Municipality of Aalsmeer for adaptive reuse, focusing on creating economic value with a new recreation function. The municipality of Aalsmeer addressed the historical and economic value of the heritage and the catalyst effect the redevelopment can bring to local tourism, the business sector and the job market. The monument-related organisation hoped to bring the fort to life; facilitating local tourism was their primary focus. Interestingly, it differs from what the local community focus of this redevelopment project. From the interview, it is clear that inhabitants and community organisations are worried about both traffic from outside visitors and the crime issues linked to the redevelopment (e.g. attraction of youth hanging out and causing damage to the neighbourhood). Local activist groups like MEERGroen opposed the parking garage and feared the damage to the marina.

In both cases, the developers considered their development a good deed of bringing transformation to the heritage projects and emphasised the positive economic impact they could get. However, (mis)communication appears to have caused conflicts that lead to stagnation. In the Soda Factory case, no actual participation process was organised. Because the ongoing development was organic and slow, the adjacent inhabitants complained directly to the owner. The neighbouring inhabitants mostly complained about the noise directly to the heritage owner when certain group activities were organised at the Soda Factory. The interviews also suggest the community expected the Soda Factory to become a city identity and provide social functions for the community. In the Fort Kuldestaart case, the fraction between the project initiators and the local communities was much more prolonged and deeper. The earliest feasibility study of the project in 2014 did not include any input from the inhabitants. The lack of communication and participation was mentioned in the consultation note of the zoning plan for 2020. Although information evenings and open days were organised at the forts, it seems that the inhabitants' concerns were lost in the process, not well understood by the parties, and consequently not addressed by the redevelopment plan. The uncertainty about whether the developers would address their concerns led to the more aggressive way opposition was chosen by the local communities. It resulted in the stagnancy situation of the project.

Involved key actors	Case Soda Factory		Case Kuldestaart	
Private sector	Owner/developer	Maintain rough characteristics, organic development, feasibility, profit	Property developer	Profit of the fort, regional icon
Public sector	City of Schiedam	Industrial monument cluster; city icon and tourism attraction	Municipality of Aalsmeer	Attract local tourism, facilitate the growth of the business sector and the job market; income
Community				
Community adjacent to the heritage	Neighbourhood Association Plantagebuurt	Avoid disturbance A real meeting place	Inhabitants, SWFK	Oppose to possible traffic and safety due to redevelopment Healthy living environment
Local citizen-initiated organisations & NGOs	Crowdfunding		MEERGroen Place holders marina, visitors	Oppose the current plan of parking garage Attractive Leisure activities
Local business community	Stichting Promotie Schiedam S'DAM	-Schiedam's branding is: authentic, lively and innovative, Soda factory is not yet innovative -Need for more unique and authentic overnight accommodation, but of high quality! -Let the history and story of the soda factory return, without it becoming a museum -S'dam sees opportunities for involving parties such as S'loep and WhaSup NL in water tourism	Local shops, restaurant, cafes, tourist related business	Benefit from the increasing visitors

Table 1: Wishes of key stakeholders in the two heritage projects, Soda Factory and Fort Kudelstaart.

5 CONCLUSION

In this research, the focus is to understand the role of local communities in the adaptive reuse of two heritage projects and to what extent the local communities got involved in the two heritage projects. Documents analysis and interviews were used to understand the wishes and concerns of all involved and potential stakeholders. Discussions with property owners, developers, financial investors, government officials, monument protection agencies, community organisations, inhabitants and visitors were explored to enable people to discuss their interests and wishes. On certain occasions, collaborative working groups were organised to understand the stagnation and where the miscommunications occur, as well as what possible solutions can address the need of the communities.

What is clear is that both heritage projects were initiated by the private sector and supported by the local government because of the historical, cultural, economic and social value of the heritage buildings and the possible impacts that can be created on the surrounding urban environment. However, since the projects were initiated by the private sector (property owner in the Soda Factory case and property developer who won the development right from the Municipality with a lease contract), how to develop an appropriate economic function to realise financial return has been a significant concern. The local governments wanted to support the two heritage projects because their successful adaptive reuse would create new tourism attractions,

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

improve the local business environment and create job opportunities, all of which align with their local development ambition. The role of the community has been mentioned (the aspiration of the property owner in the Soda Factory case) and in various planning documents. However, the local inhabitants and community organisations were hardly involved or consulted in the decision-making process. The development proposals and ideas initiated by the private sector focused on commercial success and financial gain. Even though some information exchange meetings were offered later to inform that certain social functions have been included in the zoning plan, these social thoughts remain window dressing and do not touch upon the real worries of the local communities about disturbance and damage to the environment. What also needs to be noticed is that the private developer in the Fort Kudelstaart case even had the unrealistic view that the task of communication with the community had been carried out. They did not realise that there was no actual candid exchange at the information meetings with the local inhabitants to address community-related problems.

From the interviews with the community representatives, the insights and wishes of the community in both cases are more explicit. For example, in the Sodafrabrik case the neighbourhood organisations see this building as an important location symbol and hope that the Sodafabriek provides space for a neighbourhood gathering. For the adaptive reuse of the heritage building, adjacent inhabitants are worried about the noise, and parking disturbance future visitors to the leisure functions in Sodafabriek may bring. Local artists were interested in the space of this property but did not wish visitors to become a distraction for their work. The same can be said about the Kudelstaart; adjacent communities hope to develop educational functions that benefit local youth but fear disturbances like noise, traffic and crime. Other community organisations hope the heritage can provide leisure functions that the area lacks but are worried about the environmental damage to the marina. Following the mapping of stakeholders and their wishes and concerns, it is apparent that the suggested solutions from the community in both projects are much more social-oriented. For example, the inhabitants in the Plantagebuurt consider the neighbourhood-related function of the Soda Factory more as a community centre, a small workshop for the neighbourhood, and space for local young artists. In the Fort Kudelstaart project, besides reducing noise and traffic, the local community hopes to address local youth's educational function through a museum, education centre and water sports centre.

After investigating the two heritage projects, it can be concluded that communication should be improved to reduce miscommunication between stakeholders, the developers and the communities. The collaborating workshop shared and discussed the visions of different stakeholders. It became the first step in bridging the difference between the private sector and the local communities. By engaging the communities, knowledge can be shared and exchanged. More social values appeared in the discussion, and more place-based, community-based suggestions were documented in the shared vision. Even with private-led adaptive reuse, different stakeholders have started to grow a shared and more social-oriented vision toward the future of the heritage buildings.

6 REFERENCES

AALBERS, M.B. and Gibb, K.: Housing and the right to the city: Introduction to the special issue. In: International Journal of Housing Policy, Vol. 14, Issue 3, pp. 207-213, 2014.

AALBERS, M.B. and Christophers, B.: Centering housing in political economy. In: Housing, Theory and Society, Vol 31, pp. 373-394, 2014.

ARNSTEIN, S.R.: Ladder of citizen participation. In: Journal of American Institute of Planners, Vol. 35, pp. 216-224, 1969.

AVELINO, F. & Wittmayer, J.: Shifting Power Relations in Sustainability Transitions: A Multi-actor Perspective. In: Journal of Environmental Policy & Planning, Vol. 18, Issue 5, pp. 628-649, 2016. DOI: 10.1080/1523908X.2015.1112259.

BRADSHAW, T.: The Post-Place Community: Contributions to the Debate about the Definition of Community, In: Journal of the Community Development, Vol. 39, No. I, pp. 5-16. 2009

BRAY, D. Building 'Community': new strategies of governance in urban China. In: Economy and Society, Vol. 35, issue 4, pp. 530-549, 2006.

BULLEN, P.A., & Love, P. E.D. Factors influencing the adaptive re-use of buildings. In: Journal of Engineering, Design and Technology, Vol. 9, Issue 1, pp. 32–46, 2011. doi:10.1108/17260531111121459.

CALLAHAN, K.: Citizen Participation: Models and Methods. In: International Journal of Public Administration, Vol. 30, issue 11, pp. 1179–1196, 2007.

CHAPMAN, A.: Technology as World Building. In: Ethics, Place and Environment, Vol. 7, Issue 1–2, pp. 59–72, 2004.

CHIU, R. L. H.: Social Sustainability, Sustainable Development and Housing Development: The Experience of Hong Kong. In: Forrest R. and Lee J. (Eds), Housing and Social Change: East-West perspectives, Routledge. London, 2003.

CONEJOS, S., Langston, C. Chan, E. and Chew, M. Building Research & Information, Governance of heritage buildings: Australian regulatory barriers to adaptive reuse, In: Building Research & Information, 2016. DOI: 10.1080/09613218.2016.1156951.

CREIGHTON, J. L.: The Public Participation Handbook: Making Better Decisions through Citizen Involvement. San Francisco: Jossey-Bass. Jossey-Bass: San Francisco, 2005.
DAVIES, M. Property: Meanings, Histories, Theories. Abingdon: Routledge-Cavendish, 2007. DOUGLAS, J.: Building Adaptation, Butterworth-Heinemann, London, 2006.
DEAKIN, M., and S. Allwinkle.: Urban regeneration and sustainable communities. The role of networks, innovation, and creativity in building successful partnerships. In: Journal of Urban Technology, Vol. 14, Issue 1, pp. 77–91, 2007.
DOI: 10.1080/10630730701260118.
FINCHER, R. & Iveson, K. Planning and diversity in the city: Redistribution, recognition and encounter. New York, NY: Palgrave Macmillan, 2008.
GALUPPO, L., Gorli, M., Scarratti, G. and Kaneklin, C.: Building social sustainability:
Multi-stakeholder processes and conflict management, in: Social Responsibility Journal, Vol. 10, Issue 4, pp. 685-701, 2014. DOI: 10.1108/SRJ-10-2012-0134.
HARVEY, D.: The right to the city, in New Left Review, Vol. 53, pp. 23–40, 2008.
HEMMATI, M.: Multi-stakeholder Processes for Governance and Sustainability: Beyond Deadlock and Conflict, Earthscan Publications Ltd, London, 2002.
JAMES, S. W.: Rights to the diverse city: Challenges to indigenous participation in urban planning and heritage preservation in Sydney, Australia. Space and Culture, Vol. 16, pp. 274–287. 2013. doi:10.1177/1206331213487052.
ICOMOS Burra Charter: The Australia ICOMOS Charter for Places of Cultural Significance, 2013.
JONES, S.: Wrestling with the Social Value of Heritage: Problems, Dilemmas and Opportunities. In: Journal of Community Archaeology & Heritage, Vol 4, Issue 1, pp. 21-37, 2017. doi:10.1080/20518196.2016.1193996.
LEFEBVRE, H. : Le droit a la Ville [The Right to the City]. Paris: Anthropos, 1968.
LEFEBVRE, H. : Writings on cities. Oxford: Blackwell, 1996.
LI, Y., Zhao, L., Huang, J. and Law, A. A review of research frameworks, methodologies, and assessment methods concerning the adaptive reuse of architectural heritage. In: Built Heritage, Vol. 5, issue 6, 2021. DOI.
LILLEVOLD, K.& Haarstad, H. The deep city: cultural heritage as a resource for sustainable local transformation. In: Local Environment, Vol. 24, Issue 4, pp. 329-341, 2019. DOI:10.1080/13549839.2019.1567481.
LIPE, William D.: Value and meaning in cultural resources. In: H.Cleere (ed.) Approaches to the archaeological heritage. A comparative study of world cultural resource management systems, pp. 1-11. Cambridge: Cambridge University Press, 1984.
LITTIG, B., and Griessler, E. Social sustainability: a catchword between political pragmatism and social theory. In: International Journal of Sustainable Development, Vol. 8, pp. 65–79. 2005.
MACMILLAN, S.: Added value of good design, Building Research & Information, Vol. 34, issue 3, pp. 257-271, 2006. DOI: 10.1080/09613210600590074
MAGIS, K.: Community Resilience: An Indicator of Social Sustainability, In Society and Natural Resources, Vol. 23, issue 5, pp. 401-416, 2010. DOI: 10.1080/08941920903305674
MITCHELL, D., and Villanueva, J.: Right to the city. In: R. Hutchinson, M.B. Aalbers, R.A. Beauregard, & M. Crang (Eds.), Encyclopedia of urban studies, pp. 667-671. Los Angeles, CA: Sage, 2010.
PARK, E., Choi, B. and Lee, T. The role and dimensions of authenticity in heritage tourism, 99-109, 2019. DOI: 10.1016/j.tourman.2019.03.001
POLESE, M. and Stren, R, (Eds.): Social Sustainability of Cities: Diversity and the. Management of Change, University of Toronto Press, Toronto, 2000.
RUIJGROK, E.: The three economic values of cultural heritage: a case study in the Netherlands. In: Journal of Cultural Heritage, Vol. 7, Issue 3, 206-213, 2006.
SWYNGEDOUW, E.: Governance innovation and the citizen: the Janus-face of governance- beyond-the-state, Urban Studies, 42(11), pp. 1991-2006, 2005.
TAYLOR, M.: Community participation in the real world: opportunities and pitfalls in new governance spaces, In Urban Studies, Vol. 44, pp. 297–317, 2007
WAITT, G.: Consuming heritage: perceived historical authenticity. In: Annual of Tourism Research, Vol. 27, Issue 4, pp. 835-862. 2000.
WORLD BANK. The World Bank Participation Sourcebook (First printing ed.). The International Bank. https://agris.fao.org/agrissearch/search.do?recordID=US2012420865, 1996.

🏆 *reviewed paper*

Pathways to Drive (Social, Economic and Physical) Transformation of Informal Settlements into Sustainable Urban Neighbourhoods: a Case of Johannesburg

Wandisa Ndevu, Trynos Gumbo

(Wandisa Ndevu, Urban and Regional Planning Department, University of Johannaeburg, wndevu@gmail.com)
(Professor Trynos Gumbo, Urban and Regional Planning Department, University of Johannesburg, tgumbo@uj.ac.za)

1 ABSTRACT

Globally, several studies have been commissied on informal settlements, particularly in cities such as Barcelona, Johannesburg, Cairo and Lagos. Much of the literature on urban informality from several disciplines maintain that informality occurs as a result of globalisation and population exclusions that occur due to development and urbanisation. Besides the prevalence of this phenomeon, there still lacks scholarly work that fully tackles the epistemology behind informal "otherness" of the urban form. Apparent gaps are notable in informal economies and communities which are detached from formal communities and thus, function to a greater or lesser extent without the intervention of formal economies. This paper focuses on investigating pathways to transforming informal settlements into sustainable urban neighbourhoods. The research adopted a case study research design wherein Johannesburg was used to investigate the socioeconomic political dimensions of informal settlements. This draws from various narratives that were employed to articulate the rationale behind informal settlement developments along with a contemporary understanding of the concept. This will further be contextualised under the spatial theme with reference to the urban form of the informal regions Therefore, the paper adopted a mixed method approach making reference to both a quantitative and qualitative research approach by means of a case study research design wherein various spatial planning tools are reviewed pertinent to the research objectives and offered a narrative perspective to the research aim and questions. We further conducted multiple interviews with various officials of the Johannesburg Department of Housing as a primary data collection method and a thematic analysis was respectively employed as tool of analysing the data The findings indicate that Johannesburg functions as a partial satellite city with sub-cities connecting to it and informal settlements in these areas have developed in a similar pattern. They form behind commercial spaces for the convenience of accessibility. A common trend across these settlements is their informal design typology and the lack of formal masterplans in conjunction to the city's spatial development initiatives. Proximity to existing economic nodes such as Midrand, Kempton Park, and Sandton, provides a vantage point to both informal, transitioning, and formal urban forms. Across Kaalfontein, the informal urban form comprises natural and formalised street layouts. The erven are densely divided and are often influenced by the spatial landscape and density of the population. These findings indicate that there exists a need to critically and intrinsically query the expectations and rationale that lies behind local government strategies and policies that purport to be directed towards the sustainable upgrading of informal settlements and slums. Set against a background of entrenched socio-cultural protocols, limiting institutional processes, and economic disparity as noted in other strategic documents of the city, there exists a difficulty in integrating informal settlements into sustainable urban forms. In an era of joint ventures and ascendancy of neo-liberal market policy, informal settlements are increasingly at risk of being subject to the "full force" of formal state law to enable the redevelopment process to proceed. Consequently, The paper concludes by generating new perspectivess on sustainable urban forms under the context of informal settlements and provides clarity on how the city can employ the proposed indicator matrix toolkit to gauge informal settlements urban form sustainability performance. Key to the application of this matrix tool is geographic information systems software and spatial processing tools that can effectively deduce the relationship performance of various elements in facilitating the desired growth.

Keywords: Informal Settlements; informal urban form; sustainable urban form; Informal settlement upgrading; spatial transformation.

2 INTRODUCTION

A variety of studies maintain that informality occurs as a result of globalisation and population exclusions that occur due to development and urbanisation (Romero et al., 2016). Drakakis-Smith (1981) however, provides an alternative argument in which the scholar maintains that the "urban growth of the 21st century is taking place in the developing world, but many of the theories of how cities function remain rooted in the

developed world". As such, contemporary urban sociology reveals new points and factors which lead to a contemporary understanding of urban informality, with factors such as social, economic, and political issues being some of the focus areas that urban sociological studies tackle. Jones (2016) elaborates that in contemporary city planning and urban renewal, there has been a development of new theories and approaches focused on the space division of the city, which debunk the myths encircling informality. The new city planning theories bring a new division and approach which states that informal economies and communities are detached from formal communities and thus, function to a greater or lesser extent without the intervention of formal economies. These new theories paved the way to a broader understanding of informal settlements - subsequently defining the existence of informal settlements as a result of socio-economic growth and spatial improvements made in cities.

The formation of informal settlements in a historical context, therefore, needs to be understood in-order to develop city planning methodologies that will satiate all needs of city planning. As such, this research assesses the socioeconomic political dimensions of informal settlements and aims to assess informal settlements within the national mandate of radical spatial transformation to provide for a just spatial economy that is equitable and sustainable from a socio-spatial economic perspective. The research aims to offer an outline on the role of spatial planning mechanisms and housing policies in achieving sustainable urban forms. In order to realise the research aim, the research is premised on the following 4 objectives:

- Conceptualising the notion of "sustainable urban form" from an informal settlement perspective
- Providing a status quo overview analysis of the current spatial planning mechanisms and directives in relation to informal settlements.
- Evaluating various socioeconomic spatial elements taken into cognisance in the incorporation of informal settlements within sustainable urban forms
- Proposing a performance-based monitoring matrix for assessing the sustainability of urban forms in informal settlements.

This draws from various narratives that were employed to articulate the rationale behind informal settlement developments along with a contemporary understanding of the concept. This was further contextualised under the spatial theme with reference to the urban form of the informal regions. This study was premised on the scholarly work of the likes of Escobar (1985); Sánchez (1985); Augustijn-Beckers et al. (2011) and Vaughan (1997) to mention a few, who have closely monitored and assessed the urban form of informal settlements in the context of the socioeconomic political themes to oversee the influence they have on the communities who reside in these spaces. The study starts with providing a conceptual synopsis of sustainable urban form relating to the physical, ecomonical, environmental and social challenges of informal settlements, it goes on to discuss applicable policy and regulation and it ends by proposing a conceptual performance-based monitoring matrix for assessing the sustainability of urban forms in informal settlements.

3 CONCEPTUAL SYNOPSIS

The development and growth of informal settlements has been an on-going challenge globally. Although city planning initiatives have been established to mitigate informal land occupation, these land occupation anomalies still continue to grow all over the world, more especially in low-income countries. As per the nature in which land is occupied, informal settlement inhabitants are susceptible to many dangers due to the lack of safety, a clean environment, lack of access to basic services and lack of access to health care. There are many reasons behind the development and mushrooming of informal settlements; with the rationales being interlinked. At the forefront of these reasons is population growth and rural-urban migration, which serve as the most influential push factors towards the development of informal settlements. Additionally, the role urban settlements play in the process of this facilitation is acting as temporary domiciles for migrants who come to occupy these spaces. Global political activity and unrest contribute greatly toward the issue of global migration, as a result, the observed trend in this is that contemporary demographics will be affected by the development of informal settlements (Winayanti, 2004). Thus, informal settlements as part of unsustainable development have to be understood in the context of rural-urban migration and population growth as subsets of socioeconomic political dimensions. With the existence of these issues, policy making and the implementation of it thereof becomes a strenuous and rather crippled process due to the fact that

rural-urban migration grows rapidly and the formation of informal settlements is in direct proportion to rural-urban migration globally (Weksea et al., 2011).

3.1 Sustainable Urban Form

Development motives in Gauteng reflect numerous global patterns. It is South Africa's smallest province, but its demographic growth is the quickest in the country (Condo, 2010). However, the inheritance of apartheid racial discrimination continues to have an impact on spatial imbalance, as a result of deliberate spatial division between racial groups as well as functions (separating commercial and residential areas). This has resulted not just in structural discrimination with disproportionately worse accessibility for the black population of resources and opportunities, as well as in cities with isolated housing and commercial areas.

The post-apartheid government placed substantial importance on building completely funded low-cost houses for underprivileged South Africans, through the 1994 Reconstruction and Development Programme (RDP) (Dovey, 2013). The dual purpose of this programme is to offer enhanced living conditions and the needed support to let these inhabitants rise out of poverty (Huchzemeyer, 2011). In South Africa, the delivery of low-income houses is realised as a opportunity for people to get on the housing ladder, with the main purpose of altering the tenure profile of property (Argo et al., 2013).

Government housing developments in the initial post-apartheid years, tending to be low-compactness and situated on the urban advantage, have been disparaged for aggravating spatial apartheid, inequality, barring and urban sprawl, and establishing incompetent land-use designs with high resource consumption trajectories (Gnatz et al., 2016). Dempsey et al. (2009) suggest that the government's housing policy has created "vast RDP archipelagos that sit in a kind of peri-urban limbo-like loosely-associated satellites".

Considering reviews of RDP, the government announced the 2004 Comprehensive Plan for Housing Delivery: Breaking New Ground (BNG) to address and realign low-income housing policy. The BNG policy redefined the housing delivery method as one that thoroughly tackled wider-ranging effects of apartheid – focusing on "sustainable human settlements". This emphasis moved in the direction of housing as a facilitator for enhancing the quality of life, decreasing inequality, and utilising housing development as an instrument in spatial reorganisation. A significant acknowledgment was the necessity for cohesive housing developments in well-located regions, where needs of more than just housing can be met – exclusively concentrated on urban areas (Dempsey et al., 2010). In compliance with these principles, the Gauteng government proposed public housing programmes as an important tool of constructing integration, by offering essential services and allowing access to economic possibilities.

3.2 Socio-Economic Spatial Elements

Urban planning in South Africa is happening within the framework of extraordinary social and political changes. The social problems have got to do with high levels of joblessness and poverty, the catastrophic HIV/AIDS outbreak, and the rise in crime and worry for both personal and property safety according to data from the Institute for Security Studies (ISS). Politically, the challenge has something to do with the fight to balance out the need for a devolved system of governance from national to municipal and ultimately to the local level of vicinity/ward, with even more unified and graded decision-making procedures. The latter tends to be more conducive to the requirements of government and conferred interests (Hamdi et al., 1997, cited in Handal, 2005:2). The economic challenges have to do with the consequences for the growth in the incorporation of South Africa into the international economic arena, which marked a shift in the macro-economic policy to the neo-liberalism of the Growth, Employment, and Redistribution (GEAR) strategy.

Ever Since 1994, the vocational challenge has had mostly to do with the (difficult to fault) great and passionate effort of reforming a broken society (Harrison, 2001:69). Ideas like the compact metropolises approach, comprehensive development planning, sustainable growth, and participatory design approaches have turned into common language in the post-apartheid urban planning dictionary. Nevertheless, the application of these ideas has resulted in utter inconsistencies that escort planning practice. For instance, walling-off and cordoning streets and neighbourhoods from each other and the growing phenomenon of gated communities are the reason behind Integrated Development Plans (IDP), which pursue to attain the exact opposite through big investment in public infrastructure to fight the same disintegration and spatial partitioning of past apartheid (See Landman, 2000).

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

The aspects of comprehensiveness and well-governance are far too controversial and tend to linger far behind the schedule and aspect of a valuable city. Meanwhile, this aspect of sustainable development disguises these inconsistencies and disputes, at least in the urban development process.

Notably, urban planning practices in South Africa transformed from "planned oppression" that depicted apartheid government urban planning to post-apartheid "planned emancipation" (Mabin, 1995). However, it is contended that existing standard-setting urban planning theories, which compete to replace contemporary sensible urban planning theory and practice, though helpful, are also not strong enough to address the complex and often-conflicting world that planning practice confronts.

3.3 Informal Settlements

Informal settlements can be regarded as areas where groups of housing units have been constructed on land that the occupants have no legal claim to (Satterthwaite et al., 2020). The growth of informal settlements, slums and poor residential neighbourhoods is a global phenomenon accompanying the growth of urban populations. An estimated 25% of the world's urban population live in informal settlements, with 213 million informal settlement residents added to the global population since 1990 (Rush et al., 2020). Various factors have driven the emergence of informal settlements: population growth; rural-urban migration; lack of affordable housing; weak governance economic vulnerability and low-paid work; segregation and displacement caused by conflict, natural disasters, and climate change.

Notwithstanding, these settlements continue to be geographically, economically, socially, and politically disengaged from wider urban systems and excluded from urban opportunities and decision-making (Sinharoy et al., 2018). Informal settlements are often found on the periphery of urban areas, lacking access to markets and resources. Poor quality housing, or eviction and homelessness, can also increase the risk of insecurity and sexual violence.

The regularisation of settlements may not overcome the stigma associated with living in certain areas (Habitat, 2013). National governments must provide enabling environments to develop and implement appropriate policies to bring about change.

Responsible authorities should adopt rights-based policies and integrated governance to create prosperous, sustainable, and inclusive cities. Initiatives work best when they capitalise on agglomeration economies; use innovative financing and taxes; ensure equitable land management; recognise multiple forms of employment; reintegrate informal settlements with infrastructure and services via planning and design; clarify administrative responsibility for peri-urban areas; and undertake sensitive planning to avoid exposure to environmental hazards (Habitat, 2013).Participation must be at the heart of this approach, ensuring an understanding of economic and social community dynamics (Smit et al., 2019). There is a need to provide affordable, adequate housing, including in situ upgrading and avoidance of forced evictions, security of tenure and livelihood and employment generation. All these play a role in urban prosperity. This includes pro-poor housing plans and financing support for all tiers of government. Increasing the potential of urban areas requires institutionalising mechanisms of coordination, planning and accountability among different stakeholders in a way that recognises the complexity of urban challenges. Urban governance is often neither inclusive nor participatory (Smit et al., 2019). Policies to address 'informality' need to involve partnerships among tiers of government, urban actors, and the private sector to expand rather than undermine opportunities and livelihoods. Urban authorities often fail to provide access to services for the poor (Habitat, 2013).

South Africa has a progressive legal and policy framework governing the right to housing. The country has established a comprehensive state-subsidised housing programme, which seeks to redress the legacy of apartheid and grant eligible beneficiaries a variety of state-subsidised housing options. State-subsidised housing, therefore, plays a critical role in addressing the acute shortage of affordable housing available to poor and low-income households in South Africa. However, the implementation of the right to adequate housing has been plagued by poor planning, lack of coordination, insufficient capacity, failure to adequately monitor the implementation of government policies, and lack of political will. These challenges are particularly acute in the context of informal settlements and inner-city 'slum' buildings (Dovey et a., 2020). As this paper indicates, those living in informal settlements experience inadequate housing, lack access to basic services and face the threat of evictions among other challenges.

3.4 Access to basic services in informal settlements

Informal settlements in South Africa are characterised by intrinsic inequalities in access to basic services such as water, sanitation, and electricity. This is particularly apparent in relation to informal settlements located in rural areas (Dovey et al., 2020). For instance, there is a serious divide in access to basic services and adequate standard of living in the country on the basis of race, geography, and economic status, with a disproportionate disadvantage for children living in rural areas and in urban informal settlements (Smit et al., 2019). The gap is further widened for people with disabilities. The government has reported that many persons with disabilities living in informal settlements are further disadvantaged by not having access to other basic amenities.

3.5 Informal settlement upgrading policies in South Africa

The current approach to informal settlement upgrading in South Africa is focused on incremental upgrading as a step-by-step process where the municipality provides communal services (Georgiadou et al., 2016). Networked services are provided in the case of a full upgrade which includes subsidised housing and services though often this approach has been proven to be financially unsustainable. Depending on the suitability of the land, informal settlement upgrading can include in-situ upgrading and interim services programmes. The prioritisation of infrastructure services is reflected in the shift in policies with the revision of housing policy in the early 2000s to spark more inclusive and holistic informal settlement upgrading with emphasised inclusion and participation through the Upgrading of Informal Settlements Programme (UISP) as provided in the National Housing Code, 2009. Overall, the government is moving away from housing delivery as the main upgrading response (given the financial and temporal unsustainability of the process) and shifting towards a more rapid, participative, and incremental approach based on the in-situ provision of basic services to informal settlements along with basic, functional tenure (Parikh et al., 2020).

3.6 Planning and regulation

Planning has the potential to play a transformational role in improving the quality of life of urban communities and tackling poverty (Blay-Palmer et al., 2018). It can enhance peoples' well-being and inclusion, facilitate access to services, amenities, and economic opportunities, and empower communities to have a say about their future. Further, globalisation, deregulation and free market policies often shift decision-making powers to the private sector. Where governance and oversight are weak, much urban development takes place outside formal frameworks (Brown, 2015). Several problems arise from unplanned development, including the expense of the retrospective provision of infrastructure and the increased cost of providing water, roads, and sewerage in low-density layouts (Porter et al., 2017).The poor are often excluded from planning and decision-making processes critical to ensuring that cities meet their specific needs. Effective urban governance requires planners to seek legitimacy for plans and for city dwellers to be able to hold them accountable throughout the planning process. While metropolitan plans may channel directions for urban growth, housing development and major infrastructure local plans can identify potential development sites and protected areas. Strategy should focus on key metropolitan functions such as transport infrastructure, solid waste disposal and trunk sewerage and water provision."

To strengthen planning coordination in contexts of weak governance, it is crucial to evaluate existing capacity and processes, noting the legal frameworks for planning, effectiveness of decision-making, development control, as well as appeals and enforcement. Where capacity is limited the focus should be on managing developments that have significant environmental or social impact. Effective urban planning depends on locally appropriate solutions and integrated approaches that combine physical interventions with strengthening governance capacity (Rangel-Buitrago et al., 2018). According to the World Bank (2015), both physical and socio-economic planning processes should be well-coordinated, legally enforceable, inclusive, and cross-sectoral. Action or problem-oriented planning is one approach recommended for increasing the capacity of understaffed and financed planning agencies. Wheras, planning tools such as master planning or zoning, which have proved inflexible in dealing with urban change, are being replaced by innovative strategies such as planning agreements between local stakeholders and tradable development rights. However, establishing transparency and resolving conflicts over new instruments remains a challenge (Afzalan et al., 2017)."

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

4 MATERIALS AND METHODS

The research adopted a case research design to start with then followed by a qualitative research approach based on a review of literature to allow to develop a theoretical framework based on a review of literature and other methods to attain the aim of the overall research. This assisted in generating a new perspective on sustainable urban forms in the context of informal settlements and provide clarity on how the city can employ the proposed matrix in facilitating the desired growth. Given the variety of designs available, this research employs a phenomenological and evaluative approach as a hybrid approach in addressing the research objectives successfully. The literature review design provided the platform for a theoretical assessment of what constitutes a sustainable urban form in informal settlements while the case study design assisted in assessing the findings premised on the City of Johannesburg, being the chosen locality. Therefore, previous publications and similar research papers and journal papers were reviewed as the study was desktop based. Discussions on, but not limited to the challenges and opportunities, along with existing government interventions are also discussed in this section. A cross-sectional analysis of the comprehensive literature review was applied to facilitate the data collection. The analysis involved a review of the literature pertinent to the research objectives and offered a narrative perspective to the research aim and questions. Thereafter, the theoretical inclinations on what constitutes a sustainable urban form in informal settlements was validated through site and personal experience of such spaces.

5 FINDINGS AND RESULTS

Sustainable urban form is the outcome of ecological division and distribution of the environment and built space. It consists of the relationship between the environment and how city residents experience it socially and economically; the relationship between the environment and the physical use of land; and the relationship between the environment and transportation or accessibility. In this sense, sustainability refers to optimal liveability within the city. Informal settelments are charecterised by informality meaning a lack of sevices, facilities, policy provision and regulation, thereby contending with the notion of sustainable urban form. Hence, the need to conceptualise these contending ideas and formulate a performance based matrix to assess the sustainability of urban form within informal settlements.

5.1 Conceptualising the notion of sustainable urban form

During the case study of Tembisa informal settlements, the majority of these spaces were established by the apartheid rule and underwent spatial reconfiguration throughout the years of democracy. Established far away from places of socioeconomic opportunities, these spaces have seen tremendous development, facilitating entrance of newer informal settlements (e.g., Kaalfontein; Rabie Ridge; and Winnie Mandela informal settlement). A common trend of the informal urban form of these settlements is their settlement design typology and the lack of formal masterplans in conjunction to the city's Spatial Development initiatives. Other additional factors are discussed below:

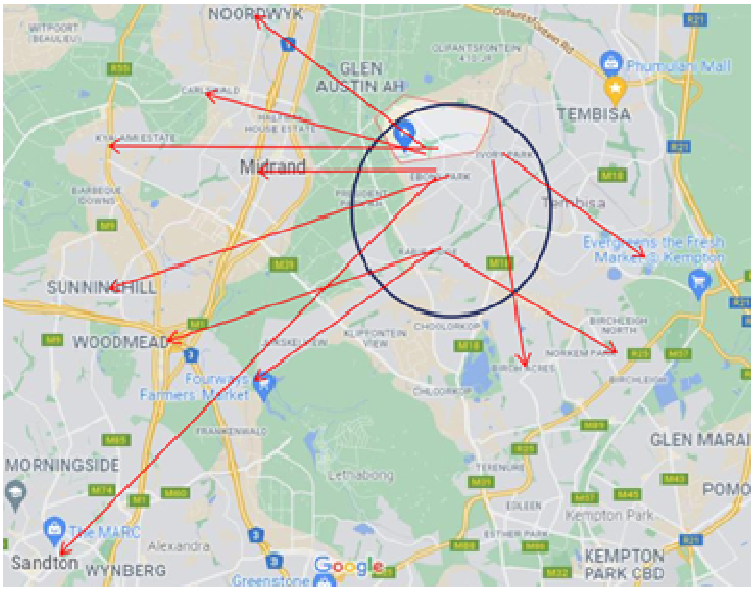


Figure 1: Informal settlements near major economic nodes. Source: Authors compilation.

5.1.1 Size and locality

Studies indicate that urban informality is often on perilous, underutilised, and hazardous land in proxximity of existing formalised settlements. While these areas mushroomed rapidly both internally and externally, their growth has put these spaces into socioeconomically strategic localities. Proximity to existing economic nodes such as Midrand, Kempton Park, and Sandton, provides a vantage point to both informal, transitioning, and formal urban forms as noted in Figure 1 below.

The informal urban form typologies (Pojani, 2021) across the city can generally be observed in the following instances as indicated in Table 1 below:

Urban Form Typologies	Description
Waterfronts	land prone to flooding or exposure along floodlines and wetlands
Easements	Land located along railways, freeways and power lines
Adherences	informal additions or protrusions to formal public façades onto public space
Backstages	urban zones that become more informal the deeper one penetrates behind a relatively formal street frontage

Table 1: Urban Form Typologies. Source: authors compilation.

5.1.2 Layout and density

The informal urban form observed indicates irregularity across elements of sustainability. The street designs are premised on the typology of the landscape and needs of the residents in conjunction to proximity to areas of economic nodes. Across Kaalfontein, the informal urban form comprises natural and formalised street layouts. The erven are densely divided and are often influenced by the spatial landscape and density of the population. As can be seen in Figure 1 and 2, the road systems are frequently curvy and characterised by dead ends and poor hierarchical transitions that depend on space availability.

Figure 2: dense informal form with linear street design, Figure 3: irregular street designs. Source: Authors compilation (2021)

5.1.3 Architecture and symbolism

The architectural dimension of the informal urban fabric in the City of Johannesburg interprets how the building form is often influenced by both market demand and housing models in alignment with the resident's aspirations. In particular, this is why the majority of these spaces undergo inner densification through backyard rooms and unlicensed shops. These backyards are prevalent in emerging (Winnie Mandela) and transitioning (Rabie Ridge) urban forms as compared to formally established (Allandale and Ebony) and/or renewed forms. Adjacent neighbours, particularly in informal forms, have a homogenous approach to development. Often enough, this stimulates internal social competition and status as "landlords" compete over house heights.

5.2 Unsustainable urban form

Figure 3 and 4 below represent the landscape in Swazi Inn, Tembisa, which is associated with unsustainable urban form. Some roads in the area are not upgraded, no storm water management, the use of outside toilets, stand pipes and lack of regulation. Moreover, their natural environment is susceptible to pollution due to the lack of upgrades within the area. Such conditions make the community prone to experiencing floods and blockages in drains, more especially in water drainage and irrigation systems that are full of litter.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Figure 4: poor toilet infrastructure. Figure 5: States of roads in the informal settlement.

The pictures further indicate that some communities lack sanitation services. The lack of these services poses health risks to the residents in the area.

5.3 Policy environment - Introduction and background

Housing in South Africa has long been racially profiled. Communities and households were built according to the provisions of the Group Areas Act of 1950 and the Promotion of Bantu Self-Government (1959). According to the acts, coexistence between different racial groups was prohibited, thus coercing them to inhabit separate designated areas. The spatial ramifications incurred due to apartheid spatial legislation and policy were still discernible in contemporary South Africa. To amend the detrimental effects of past spatial imbalances, the post-apartheid South African government adopted the South African Constitution (1996). The provision of the South African Constitution declares that every individual in the country has the right to access adequate housing. Defining "Adequate housing", however, has been an arduous task for diverse scholars and policymakers.

The South African housing challenges began during the apartheid dispensation where shacks were erected in formal residential areas. In response to the challenges, policy changes were made. The first post-apartheid policy to be developed was the Reconstruction and Development Programne (RDP). The RDP policy provided subsidised housing to those who were denigrated by the apartheid policy. This policy's main aim was to combat poverty, inequality, and unemployment. The RDP policy, however, was not the only policy that was developed to tackle housing issues. Other-core housing policies included the White Paper on Housing (1994) and Breaking New Ground (BNG): a Comprehensive Plan for the Development of Sustainable Human Settlements (2004). The RDP delivered housing without settlement land uses, which mobilised the development of policy that was holistic and inclusive, thus the introduction of BNG. The BNG made it possible for human settlements to grow into sustainable nodes for development.

Additionally ro the above policy is the Enhanced People's Housing Process (ePHP), (2008) which is a revised policy of the 1998 People's Housing Process (PHP). The Enhanced People's Housing Process was established to integrate beneficiaries into housing upgrading. According to Clark (2013), the ePHP model served as a step-by-step process of on-site, incremental upgrading in communities. The process mobilises community members, retains social capital, promotes local economic development, fosters empowerment, involves women and youth, and creates sustainable and inclusive human settlements according to the needs of their specific communities.

5.4 Informal settlement upgrading policies in South Africa.

The prioritisation of infrastructure in the housing policy was created to push the agenda of inclusive and holistic informal settlement upgrading programmes. Huchzermeyer (2006) explained how the emphasis was on insertion and contribution through the UISP. In this regard, the process of advancement entailed on-site upgrades. During the process, structures were kept in their original positions and the focus was on a broad range of infrastructure services. The structures were enhanced through provisional or permanent engineering solutions, the aim was to fiercely confront environmental vulnerability and further entrench social inclusion.

One of the policies that encourage participation in the process of upgrading is The National Housing Code (2009).

According to The South African Housing Development Agency, the main categories of developmental response in addressing basic infrastructure and housing needs include: (1) full upgrading which includes the top structures and formal tenure through upgrading; (2) yhe provision of interim basic services; (3) the basic emergency services for informal settlement; and (4) relocations.

As cities undergo incessant development, growth, and informal settlement growth, this develops various challenges such as an increase in environmental urgencies i.e. air pollution, water pollution, and waste management. "The lack of resilient and adequate infrastructure in informal settlements coupled with poor housing stock in high-density settings greatly increases the risk of illness and injury". Tackling urban informality requires a thorough comprehension of how various deprivations compound each other.

5.5 The Informal Settlement Upgrading Programme

The introduction of the Breaking New Ground Framework encouraged the introduction of the Informal Settlement Upgrading Programme. The programne acts as the platform to develop upgrading projects and has been used as an approach focused on eradicating urban informality through evictions and market-driven infrastructure development upgrading programmes. However, the approaches do not consider the growth of the settlements and their economic security. They do not address the existing economic inequities that accompany informal settlements (SERI, 2014). as well as the deficiency in the provision of infrastructure.

As a resultt, the revised housing programme (the Informal Settlement Upgrading Programme) was named Breaking New Grounds. Considering the factors that led to the upgrades of informal settlements, Huysteen, (2009) deliberated that for the successful integration of informal settlements into sustainable urban form, social and economic requirements must be fulfilled. The Inner-City Housing Implementation Plan (ICHIP 2014 -2021) recogniaes the importance of allowing the private sector to be involved in the ownership and management of the housing stock.

5.6 Physical elements of Sustainable Urban Form

The physical characteristic of a city is described through a term known as "urban form". Anderston et al. (1996) further elaborate that the term urban form is the determinant that configures spatial elements of urban areas at a regional and broad city scale. Scale plays a cardinal role in deducing the urban elements that formulate urban form, and scale has a direct bearing on the urban settlement type, such as towns, central business districts or suburbs. Williams et al. (2020) formalise the interrelation of urban scale as 'morphological attributes' of an urban area at all scales. The localisation of urban form scale is the spatial arrangement and configuration of elements housing type, street patterns, layout, land use, infrastructure, and accessibility. Bickford (2014) notes that urban form is not just physical nature but comprises non-physical elements such as density which can be arithmetically computed to the number of people in a given area or square kilometer. Urban form sustainability needs to be discussed in regard to urban economic and social sustainability, to effectively discuss the interrelation of the above referred to urban elements, together with the examination of these morphological attributes. Inter alia, each of these provides the bedrock in establishing an indicator framework that is capable of gauging the sustainability performance of informal settlements urban form.

5.7 Social Sustainability and The Spatial Dimension

Dekker's (2012) sentiments on tenants and principles of social sustainability loosely uncover the conversion of social sustainability into spatial representation by asserting that social sustainability is underpinned by accessibility to certain elements of the public environment that is central to fostering good livelihoods. From a different perspective, Sebastien and Bauler (2013) pragmatically obsetve the spatial manifestation of social sustainability from a theoretical perspective. The point of departure of Sebastien and Bauler begins by them describing the physical environment and development pattern required for social sustainability. The scholars affirm that land use diversity coupled with pedestrian friendly streets are cardinal for social interaction and citizenship-based cities where a sense of belonging is imperative.

The sense of belonging and citizenship based cites, as well as a diversity of land uses indicate an important aspect of what social sustainability is like in the spatial dimension. The elements of urban space should all be

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

stitched together to each other by a road network that structures walkability movement. Thus land use diversity, walkability accessibility to these land uses, and urban social amenities are key performance areas for an indicator framework to measure urban form sustainability in informal settlements. Several studies have indicated that urban form and pattern is the major key performance area for urban sustainability. Urban form is characterised by intensity, mixture, size, shape, and the spatial distribution of various land uses. (Lynch and Robinson, 2001). Therefore, social sustainability is directly linked to the behaviour of residents with respect to the characteristics of their neighbourhoods.

5.8 Economic Sustainability

The acceleration and installation of the new urban agenda in conjunction with attainment of the sustainable development goals has somewhat relegated the importance of economic sustainability (Tarzia, 2015). In cognisance of the urban agenda, states are rolling out urban infrastructure for urban service delivery at a financial loss. This inefficient course of action has been permitted due to states adopting an anti-ring-fence philosophy in the collection of municipal revenue. This principle on the distribution of funds is particularly prevalent in urban states that are battling with inequality.

Economic sustainability essentially refers to economic growth where the distribution of income amongst individuals is not characterised by stark inequalities. In recognition of theoretical aspects pertaining to economic sustainability Roderick (2009: 32) defines the critical goals behind economic sustainability:

- "Autonomous subsistence based on income from own work. All members of a society must be given the right to be able to secure their own livelihood by means of a freely chosen occupation."
- "Reducing high-income and wealth inequities."
- "Sustainable development of man-made, human, and knowledge capitals". such that economic performance can be maintained or improved.

When it comes to transcending the traditional statistical measures of economic sustainability. such as unemployment rates, income distribution gross value added and gross domestic product to be spatially interpreted, economic geography or the spatial economy have been the common measures of practices. It is noted that they do not consider the spatial variances between economic contribution from industries and business, they are often combined to govern an overall performance of the area. Secondly, they analyse how the distribution of urban services such as infrastructure, social and public amenities correlate to individual's and household's distribution income. The average income distribution statistic is one of the statistical measures aimed at nullifying the deficiencies of economic sustainability indicators. However they in themselve are susceptible to extreme outliers on income earned that mask the true performance of a state's economic sustainability.

5.9 A performance-based monitoring matrix for assessing the sustainability of urban forms in informal settlements

The above discussion on the urban morphological elements and their spatial interaction which constitutes sustainable urban form have been developed in a proposed indicator matrix toolkit to gauge ithe sustainability performanceof nformal settlements urban form. Key to the application of this matrix tool is geographic information systems software and spatial processing tools that can effectively deduce the relationship performance of various elements.

The above urban form matrix discusses how the physical characteristic of a city is described through a term known as "urban form". The examination of these morphological attributes, inter alia, shows that together each of them contribute to providing the bedrock in establishing a monitoring tool to assess the sustainability of informal settlements through the use of primary and secondary performance areas associated with the economy, the integration of infrastructure, service delivery and housing. However, the application of such tools and the success of such upgrading to longer term urban resilience ultimately depends on political will and more inclusive governance.

Primary KPAs	Secondary KPAs	Primary KPI (Singular)	GIS Spatial Mapping	Diagnostic Assessment – Secondary Spatial Indicator (Composite)	
Economy	Gross Value Added	GVA Per Capita	Spatial Mapping GVA Contribution		
	Average Household Income	Average Household Income Per Capita)	Mapping of Household Income distribution	Accessibility	To Commercial Land Uses
					To Industrial Land Uses
	Employment	Gini Coefficient	Mapping of Unemployment and Employment		To Public Transport
					To basic Services
					To Education Qualification
Integrated Urban infrastructure	Education	Higher Education	Mapping of Higher Education (Population)	In relation to	Household Income distribution
					Accessibility to public Transport
		Matric Education Level	Mapping of Matric Education (Population)	In relation to	Household Income distribution
					Accessibility to public Transport
		No Education	Mapping of No Education (population)	In relation to	Household Income distribution
					Accessibility to public Transport
	Health	Number of Clinics Per Capita	Mapping of health clinics	In relation to	Spatial life expectancy data
					Accessibility to public transport
	Public Transport	Rea Vaya BRT stops Per Capita	Mapping of Public Transportation stations and stops	In relation to	Percentage of population/households within 1km ,2km ,3km ,4 Km public transport stations
		Metrobus Stops Per Capita		In relation to	Average Household Income
		Metrorail Stations Per Capita			
		Gaut.rain Stations Per capita			Access to Job opportunities (Commercial and Industrial Land Uses)
		Taxi Ranks per Capita			
Service Delivery (Infrastructure	Water	Household percentage accessibility to	Mapping of Infrastructure coverage in relation to	Public transport	
	Energy			Life expectancy	
	Sewage			Household distribution income	
	Waste Removal			Education	
	Housing			Health Infrastructure	
Housing	Affordability	Affordability Ratio	Mapping of Household Income in relation to	Property Values	
	Location	Access to Job opportunities		Accessibility to Commercial Land uses	
				Accessibility to industrial Land Uses	

Table 2: Urban Form Matrix. Source: Authors compilation 2021.

6 CONCLUSION

It can be justified to consider informal settlements as areas that rampantly develop without a sustainable urban form, outlining a need for adequate housing, For instance, in the National Housing Needs Registry for the City of Johannesburg, there is an approximate figure of 457 thousand people within the database that are awaiting housing. This backlog is further exacerbated by government intervensions, political will, increased infrastructural and associated bulk service demands for these fast-developing informal areas. It is as such pivotal to understand the conception of sustainable urban form, particularly looking at it as the division and distribution of the environment and space.

To tackle the issue of growth and spatial development that caters to all its residents, the city of Johannesburg aims to make the city more compact as a means to achieve easy access to health care systems, easy accessibility to jobs, social integration, high economic development, functional diversity in neighborhoods, access to transport systems and full basic service to communities. In understanding the policy implications for sustainable forms of informal settlements, this chapter discussed how housing in South Africa has long been racially profiled. To amend the detrimental effects of past spatial imbalances, the post-apartheid South African government adopted the South African Constitution (1996). The provision of the South African Constitution declares that every individual in the country has the right to access adequate housing. The. preconceptual conclusions observe urban informality as a pre-existing form of development before formalization, particularly in the earlier centuries of planning. A common trend across these settlements' informal urban form is their settlement design typology and the lack of formal masterplans in conjunction to the city's Spatial Development initiatives.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

6.1 Socioeconomic spatial elements taken into cognizance in the incorporation of informal settlements within sustainable urban forms

The most problematic service issues for black residents in the study area are electricity, water, toilets, health services, and street lighting. Additionally, the scholar maintained that service delivery issues are related to electricity cuts, the sharing of taps, queuing for water, the lack of water supply in houses, insufficient public water supply points, and supply interruptions without warning. The infrastructure investment to deal with backlogs in deprivation areas initiative focuses on servicing backlogs and deficiencies in engineering, and social infrastructure in various points in the city that have experienced marginalization and service provision that is below the minimum standards. Under the Gauteng City-Region (GCR), the CoJ has set its priorities of addressing informal settlement developments within the jurisdiction. Faced with the SDG-11 obligation, the city's 2040 Growth and Development Strategy, the Integrated Development Plan (IDP), and the Spatial Development Framework 2040 (SDF) will be key in fostering the established aspirations. The SDF plays a key role as it facilitates the environment for successful Spatially Targeted Investment Areas (STIAs).

6.2 A performance-based monitoring matrix for assessing the sustainability of urban forms in informal settlements.

Scale plays cardinal factor in deducing the urban elements that formulate urban form, scale has a direct bearing on the urban settlement type, such as towns, central business districts or suburbs. The localisation of urban form scale is the spatial arrangement and configuration of elements housing type, street patterns, layout, land use, infrastructure, and accessibility. Urban form sustainability needs to be discussed in the themes of urban economic and social sustainability, which means effectively discussing the interrelation of these urban elements which provides that platform for the importance of the utilisation of spatial indicators to capture these relations.in gauging sustainability performance of informal settlements urban form.

Land use diversity coupled with pedestrian friendly streets are cardinal for social interaction and citizenship-based cities where a sense of belonging is imperative. The sense of belonging and citizenship based cities, as well as a diversity of land uses together with good governance indicates an important aspect of what social sustainability is like in the spatial dimension. Economic sustainability is the improving of the productivity of the public states finances through improving the productivity an individual’s finances. Key to the application of this matrix tool is geographic information systems software and spatial processing tools that can effectively deduce the relationship performance of various elements.

7 RECOMMENDATIONS AND POLICY IMPLICATIONS

Smith and Berlanda confirm several philosophies for refining informal settlements from the preceding study. John Lupala has seven recommendations for district plans in informal African cities: (1) manage city spread; (2) create tenancy systems through land merging and replotting; (3) impact participatory and gradual regularising of "informal urban types" and properties; (4) device localised planning and upgraded information management systems; (5) recognise suitable housing forms for the city’s future; (6) decrease plot sizes; and (7) legalise and advance external public spaces.

Moreover, Janice Perlman sets out eight recommendations for the development of informal settlements: (1) offer a diversity of housing selections in regards to tenancy and imbursement, for instance, short-term rental, long-term tenancy, cohousing, and financed acquisition; (2) capitalise in education, healthcare, and social services for people, not just in infrastructure and constructions; (3) include the community in the development and continuing decisions; (4) offer a sturdier government attendance in informal settlements; (5) continue refining and integrating preceding government-subsidised schemes and peripheral neighbourhoods; (6) avert scoundrel designers and landowners from conducting deceitful property transactions and housing rental practices; (7) secure land and housing in expectation of future relocation and population development; (8) political support inclusive of clearly directed governement development intervension at all sphere of government and (9) foster development and augmented density according to the long-term needs of the metropolitan region and the best welfares of the inhabitants.

8 REFERENCES

Argo, T., Hau, D., Winarso, H., Forbes, D. & Childs, I. (2013). Slum upgrading and urban governance: Case studies in three South East Asian cities. Habitat Int. Vol. 39: 162–169.

Bidandi, F. and Williams, J. J. (2020). Understanding urban land, politics, and planning: A critical appraisal of Kampala's urban sprawl. Cities, Vol. 106: 10-58.
Blay-Palmer, A., Santini, G., Dubbeling, M., Renting, H., Taguchi, M. & Giordano, T. (2018). Validating the city region food system approach: Enacting inclusive, transformational city region food systems. Sustainability, Vol. 10(5): 16-80.
Bickford, G. (2014). Transit Oriented Development: An appropriate tool to drive improved mobility and accessibility in South African cities? Spatial Transformation of Cities. Johannesburg: South African Cities Network.
COGTA. (2014). Integrated Urban Development Framework. Pretoria: Department of Cooperative Governance and Traditional Affairs.
Dempsey, N., Bramley, G. & Power, S. (2009). The social dimension of sustainable development: Defining urban social sustainability. Sustainable Development, Vol. 19(5): 289–300.
Drakakis-Smith, D. (1981). Urbanisation, Housing and the Development Process. Croom Helm: London, UK.
Eicher, C. l. & Brewer, C. A. (2001). Dasymetric mapping and areal interpolation: implementation and evaluation. Cartography and Geographic Information Science. Vol 28(2): 125-138.
Fox, S. (2014). The Political Economy of Slums: Theory and Evidence from Sub-Saharan Africa. World Dev. Vol. 54: 191–203.
Gnatz, D., Wilhelmi, O. & Hayden, M. (2016). Urban Sustainability and Resilience: From Theory to Practice. Sustainability. Vol. 8: 12-24.
Habitat, U. N. (2013). State of the world's cities 2012/2013: Prosperity of cities. Routledge.
Gülersoy, N.Z. & Gürler, E. 2011. Conceptual challenges on urban transformation. ITU Journal of the Faculty of Architecture. Vol. 8(1): 10-24
Harrison, P. & Todes, A. (2015). Spatial Transformation in a "loosening state": South Africa in a comparative perspective. Geoforum,. Vol61: 148-162.
Huggins, R. (2009). Regional competitive intelligence: Benchmarking and policy-making. Regional Studies. Vol 44(5): 639–658.
Huchzermeyer, M. (2011). Cities with 'Slums': From Informal Settlements Eradication to a Right to the City in Africa. UCT Press: Claremont, South Africa.
Jones, P. (2016). Unpacking Informal Urbanism: Urban Planning and Design Education in Practice. Penerbit Press: Bandung, Indonesia.
Kitchin, R., Lauriault, T.P. & Mcardle, G. (2016). Urban Indicators and dashboards: epistemology. Contradictions and power/knowledge. (Available From: https://doi.org/10.1080/21681376.2014.991485), [Accessed: 2019/03/26]
Marutlulle, N. K. (2017). Causes of informal settlements in Ekurhuleni Metropolitan Municipality: An exploration. Africa's Public Service Delivery and Performance Review, Vol. 5(1): 1-11.
Mogale, T. M. (2003). Developmental Local Government and Decentralised Service Delivery in the Democratic South Africa Mogale, T. Governance in the New South Africa: The challenges of globalisation.
National Planning Commission. (2012). National Development Plan 2030 Our Future – Make it Work:. Pretoria: The Presidency.
Oranje, M. (2014). Spatial Transformation and Urban Restructuring: Lessons for the 20-year old post-apartheid South African city? Spatial transformation of cities. Pretoria: South African Cities Network.
Parikh, P., Bisaga, I., Loggia, C., Georgiadou, M. C.& Ojo-Aromokudu, J. (2020). Barriers and opportunities for participatory environmental upgrading: Case study of Havelock informal settlement, Durban. City and Environment Interactions, Vol. 5, 10-41.
Rangel-Buitrago, N., de Jonge, V. N. & Neal, W. (2018). How to make integrated coastal erosion management a reality. Ocean and Coastal Management, Vol. 156, 290-299.
Republic of South Africa, (2013). Spatial Planning and Land Use Management Act, Act 16 of 2013. Cape Town: The Presidency.
Republic of South Africa. (2000). Local Government: Municipal Systems Act, Act 32 of 2000.Cape Town: The Presidency.
Satterthwaite, D., Archer, D., Colenbrander, S., Dodman, D., Hardoy, J. & Patel, S. (2018). Responding to climate change in cities and in their informal settlements and economies. International Institute for Environment and Development, Edmonton, Canada.
Satterthwaite, D., Archer, D., Colenbrander, S., Dodman, D., Hardoy, J., Mitlin, D. & Patel, S. (2020). Building resilience to climate change in informal settlements. One Earth, Vol. 2(2): 143-156.
Smit, S., Musango, J. K. & Brent, A. C. (2019). Understanding electricity legitimacy dynamics in an urban informal settlement in South Africa: A Community Based System Dynamics approach. Energy for Sustainable Development, Vol. 49: 39-52.
Sinharoy, S. S., Pittluck, R. & Clasen, T. (2019). Review of drivers and barriers of water and sanitation policies for urban informal settlements in low-income and middle-income countries. Utilities policy, Vol. 60: 100-957.
Ward, P. M., Huerta, E. R. J. & Di Virgilio, M. M. (2015). Housing policy in Latin American cities: A new generation of strategies and approaches for 2016 UN-Habitat III. Routledge.
Williams, J. J. (2000). Urban transformation. Cities, Vol.17(3): 167-183.
Sheng, Y. K. (2010). Good Urban Governance in Southeast Asia. Environ. Urban. ASIA. Vol. 1: 131–147.
Yang, Y. (2010). Sustainable Urban Transformation driving forces, indicators and processes. Zurich: Swiss Federal Institute of Technology (ETH).

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

🏆 *reviewed paper*

Pathways to Effective Public Participation for Sustainable Transport Infrastructure Development: Experiences of the Gauteng Freeway Improvement Project

Lerato Morojele-Zwane, Trynos Gumbo, Smart Dumba

(Lerato Morojele-Zwane, PhD Candidate Department of Urban and Regional Planning, Faculty of Engineering and the Built Environment, University of Johannesburg, leratozwane15@gmail.com)
(Trynos Gumbo, Associate Professor and Head; Department of Urban and Regional Planning, Faculty of Engineering and the Built Environment, University of Johannesburg; tgumbo@uj.ac.za)
(Smart Dumba, Senior Lecturer; Department of Marketing and Logistics, Faculty of Commerce, Human Sciences and Education, Namibia University of Science and Technology, sdumba@nust.na)

1 ABSTRACT

World cities, particularly in the global south, have been experiencing rapid urbanisation. Seemingly, rapid and high urbanisation levels that have been experienced are forcing governments at all levels to plan and implement transport infrastructure that meet the ever incerasing travel demand. Coincidentally, sustainability discourses have been gaining momentum in the past few decades. At the heart of the quest to develop and manage sustainable and inclusive transport infrastructure is the adherence and promotion of public participation throughout the project life cycle. If the effectiveness of public participation is not monitored, such processes are perceived to be limited to simply informing the public or manipulation of the public and controlling of planning outcomes by authorities. Consequently, this paper explores the different types of public participation experienced during the conceptualisation, planning, implementation and management of the Gauteng Freeway Improvement Project (GFIP). The work adopted a qualitative research approach wherein an exploratory reseach design was applied in the GIFP case study in South Africa. We sought to get insights into the extent and scope of engagement of stakeholders throughout the GFIP project lifecycle. Research findings reveal that the public outcry over the GFIP electronic payment tolling (e-tolling) resulted in defiance of the payments. The e-toll debate in Gauteng has caused widespread criticism and this strong response to the method of road levy rests on the perception that decision makers undertook insufficient public participation. Besides the statutory public participation requirements executed in terms of the applicable by-law, public engagements were perceived to have not been effective, yet the user-pay scheme makes the user or public an important component of the project. Future studies are necessary for assessing the public participation from conceptualisation, not after the implementation of plans. This study reviews a project already implemented and it might be necessary to analyse a project before implementation so that processes involved are analysed during the real-life cycle. The public participation process must be interrogated before project commencement and future research is necessary.

Keywords : Public, stakeholder, participation, urbanisation, sustainability, transportation, infrastructure

2 INTRODUCTION

The United Nations estimated that by 2050, approximately 66% of the population of the world will be living in cities (Bibri and Krogstie 2017:184) resulting in cities expanding the spatial footprint and surpassing the limits of transport infrastructure. Like any cities in developing countries, South African cities largely depend on road transport infrastructure for daily commuting (Gumbo et al 2022). Rapid urbanisation is resulting in a variety of technical and infrastructure-oriented problems (Risimati et. al 2021). This results in a self-organising process from regular to complex, causing increasing environmental pressure within the transport segment and thereby increasing air pollution through the high usage of global oil and energy (Gumbo and Moyo 2020; Wang et al 2022:2, Shi et al 2021:9). Critical to this research is the significance of urban sustainability, transportation planning and the just planning practices which recognise public participation as a critical planning and implementation component. Of importance is the notion of urban sustainability which requires sustainable transportation solutions to be part of an integrated solution. To achieve urban sustainability, public participation is central to achieving desirable outcomes. The public participation concept gained momentum in 1992 after principle 10 of the Rio Declaration was developed and further reiterated in Chapter 23 of Agenda 21 at the Earth Summit (Mauerhofer 2016:481). In South Africa, irrespective of the legislative framework for strengthening public participation in managing the environment, several challenges persist (Sabela-Rikhotso et al. 2021:6). The paper seeks to explore the role the public played during the planning and implementation of GFIP and to assess the government stance after the publicised public outcry and this requires careful planning to extract the necessary information. This paper

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

starts by briefly explaining the setting of the research topic and conceptual framework. It goes on to describe GFIP and the research methodology which outline the data collection and analysis procedures. It ends with recommendations for effective public participation to achieve sustainable transportation solutions and the conclusion.

3 CONCEPTUAL EXPOSITION

Urban sustainability has become important for mitigating the negative impact of rapid urbanisation. Provision of transport infrastructure is crucial for achieving urban sustainability and it cannot be reviewed in isolation. The overreaching objective of this research is to model for achieving sustainable transportation. The essence of this paper is public participation and how it can be incorporated during the planning of transport infrastructure.

3.1 Urban sustainability

Urban sustainability emanates from the overall sustainable development awareness. The transportation segment within urban areas has a direct impact on sustainable outcomes. According to Asadzadeh e t al. (2022:2), currently 55% of the global population is in urban areas and by 2050 it is projected that 67% of the population will be residing in urban areas. As a result, rapid urbanization result in challenges such as imbalanced supply of essential infrastructure. To achieve sustainable outcomes several social, economic, and environmental variables should be concurrently evaluated and considered (Mehlawat et al. 2019:2). Achieving urban sustainability requires a comprehensive approach to planning. Coordination of the sustainability attributes are relevant for realising liveable cities when dealing with the ever-increasing urban areas. Sustainability has been applied to cities in metropolitan areas to advance the working standards of the quality of life desired by the current generation without diminishing the future generation's options within urban boundaries and beyond (Zeng et al 2022:10). Addressing urban sustainability must entail a more comprehensive approach, and this paper seeks to model a comprehensive pathway to capture various attributes.

3.2 Rapid motorisation and transport planning

The boom of private cars within urban areas has resulted in undesirable consequences and the need to reduce car dependency requires a comprehensive approach by transportation advances, land use planning and other holistic solutions like environmental planning. From inception, the transportation concept was based on the importance of cars and accessibility, however, since the urban sustainability concept gained momentum there has been a paradigm shift to reducing the use of cars and increasing alternative mode of transportation (Hansson 2020:3). This gave a new meaning to transportation provisions and the necessity for alternative concepts that align with the sustainable development era. As a result of urban sustainability, a change in thinking, in planning was necessary, whereby transportation planning became an important agenda for governments. According to Holz-Rau and Scheiner (2019:128) the alignment of the transportation planning concept and land use entails aspects such the regulations of densities, the intensity of uses, travel demand management and the provision of transport infrastructure. In planning, density denotes the number of dwellings, individuals, and places of employment within a precinct (Litman and Steele 2019:13) and this is a vital component for supporting alternative transportation provisions, as higher densities can support public transport efficiently. The density measure within urban areas is crucial for setting development parameters and achieving the appropriate balance necessary to support alternative modes of transport. Integrating land use and transport planning within urban areas should emphasise the provision of improved quality of life, public participation and social inclusion, pollution reduction and safe transport infrastructure facilities (Holz-Rau and Scheiner 2019:134). Critical to this paper is the significance of urban sustainability, transportation planning and the just planning practices which recognise public participation as a critical planning and implementation component.

3.3 Public participation and stakeholder engagements

As indicated in preceding sections, urbanisation recognises that the urban population has been increasing rapidly and as such, the public has become crucial within urban settings. To achieve urban sustainability, the public participation concept is central to achieving desirable outcomes, necessitating the establishment of relevant pathways. Ideally, for public participation to be effective throughout the planning process, the public

must the allowed to influence decisions such that the ownership of such decisions is shared by all stakeholders (Arbab et al. 2020:2). Public participation is necessary as urban scenarios are complex and may require diverse inputs. Principle 10 of the UN Rio Declaration became a global commitment for the ordinary public to become part of responding to environmental challenges (Stec and Jendroska 2019:534). The fundamental goal of Principle 10 is to ensure that the sustainable development is achieved through suitable discussions with the citizens and by ensuring that the public contribute to decision making processes (Orellana 2016:52). Agenda 2030 adopted by the United Nations member states in 2015 also emphasised the importance of the concept of public participation for the successful implementation of the UN Sustainable Development Goals (SDG's) and, more importantly, the role played by normal people and community-based associations (Khan et al. 2018:68). Procedures must be in place to achieve comprehensive high-level inclusion, information sharing, extensive engagements, and the flexibility to change the plans to accommodate experts' and non-experts' contributions. The main advantages of public participation during planning are regarded as recognizing the public as part of the collaboration, enhancing transparency, all-encompassing and fair decision-making (Kim et al. 2022:2, Brown and Eckold 2019:85). Literature on policy that adopts scenario planning includes concepts such as participatory scenarios, stakeholder engagement and stakeholder integrated exploration outcomes (Andersen et al. 2021:4). To clearly understand the notion of stakeholder engagements, it is relevant to first define stakeholder. For transportation planning, stakeholders are defined as those who can affect or be affected by outcomes and in the context of transportation, all citizens within urban areas are directly affected by the policy outcomes or indirectly affected because of external traffic (Brůhová Foltýnová et al. 2020:4). The view that all citizens are directly or indirectly affected by transportation outcomes may render stakeholders as all the people within the area and this research explores how the transport planning leaders incorporate the citizens.

The efficient provision of transport infrastructure requires stakeholder inclusion of ordinary people, transport users, and users of diverse modes may be involved to address the various requirements (Keseru et al. 2021:3). Identifying stakeholders for the planning and implementation of transport infrastructure is relevant for the study, especially in the context of the institutions tasked with identifying the stakeholders and deciding who is relevant or not and how they conclude who is relevant. When it comes to reviewing transport infrastructure provisions within urban areas, Ariza-Álvarez et al. (2022:277) classifies stakeholders as policy makers, transport planners, environmentalists, business communities, property developers and the society. Stakeholder engagements is not limited to non-expert stakeholders but to all stakeholders to accommodate outsider perspectives and align it with scientific knowledge during engagements which can result in improved understanding and collective outcomes (Andersen et al. 2021:10). In this regard, Beck and Storopoli (2022:4), argue that urban managers could acknowledge stakeholders' insights to develop accepted urban policies. In some cases, the concept of stakeholder engagement outcomes maybe so diverse that it becomes challenging to reach consensus. This scenario may result in uncertainty and indecision which is dependent on the previous knowledge about the preferences of the stakeholders (Laurila-Pant et al. 2019:2). The uncertainty due to diverse opinions is relevant and can be explored to understand the effect on transport infrastructure. Relevant to this research is understanding the main ideologies behind transportation planning and to effectively comprehend the subsequent provisions of transport infrastructure.

4 THEORETICAL FRAMEWORK

Central to public participation and stakeholder engagements is the concept of democracy and justice. It is important to understand the interplay between public participation and the provision of transport infrastructure within democratic states. They are essential for understanding different preferences from non-experts, thereby rendering citizens as important components of policy formulation. There are many theories covering the evaluation of justice, but the study limits itself to the one giving the original background of the concept 'public participation' and the core principles that embed participation issues. On this basis, it is important to mention that the focus will be on the interplay between citizen participation and policy development.

4.1 Rawls' theory of justice

Even though for many decades governments have been viewed as legitimate, they were still characterised by the various injustices due to instabilities in addressing political problems, by theorists such as Rawls (Young 2009:2). During the early 1970s, John Rawls presented the "Theory of Justice". Over 50 years was spent

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

developing and refining Rawls' concept of justice, and his goal was to present the type of governance which Rawls believed could offer a governance framework needed to manage the dilemmas of political stability/instability properly, and in doing so, offer a just and stable liberal democracy (Young 2009:2). In the transport project, Rawls' theory emphasises access as the main advantage dispersed over transport projects (Martens et al 2012:685). Within current practices, Rawls' theory of justice is necessary for dealing with inequality due to current transport infrastructure (Verlinghier 2020:365). Participation without justice still results in social inequalities. Within the transportation fraternity, the term "justice" is what underpins participation, based on Rawls' theory (Grossardt and Bailey 2018:27). According to Sen (2009:24), the first crucial step is a notion of objectivity which must establish a public framework of thinking, necessary for appropriate conclusions to be agreed upon. To promote equality, Rawls recommended ideologies, by way of motivational influences, given that these results do not just achieve a large economic output, but must also result in improved income for the less fortunate group (Martens et al 2012: 687). The term justice can be regarded as controversial because it might have different meanings depending on the affected parties. An agreement of what is regarded as just can guide effective public participation for achieving sustainable outcomes.

5 METHODOLOGY

The paper is premised on the pragmatic view to explore public participation during the planning and implementation of GFIP. The study questions are regarded as crucial for this paradigm. Pragmatism emphasises the research method that is required to answer the research questions rather than methods limited to specific traditions (Ritchie et al. 2014:22). The paper employs a case study phenomenological research design. This design emanates from the philosophy of lived experiences regarding a phenomenon (Creswell and Creswell 2018:13). Therefore, the paper assesses the stakeholders and the role they played during the planning and implementation of GFIP. It further assesses the government stance after the publicised public outcry. In this case, the prepositions were already established to inform the boundaries of what the researcher questions about the phenomenon due to available information (Prosek and Gibson 2021:173). The strength of this case study is derived from the view that it is being implemented within the economic hub of South Africa as the first electronic tolling project within the country. Reviewing the GFIP public outcry and how it affected the implementation process requires thorough investigation. The methods of data collections for the qualitative component of the paper are mainly existing secondary data (Mukhopadhhyay and Gupta 2014:111). Secondary data is mainly used to review public participation processes that were employed during the planning and implementation of GFIP. In so doing this data collection technique enable the critical evaluation of documents to derive meaning and acquire insights into public participation in the provision of transport infrastructure within the South African national sphere. The data collected is examined through content analysis. We used methodical techniques to review and analyse data to identify themes. Using the themes and patterns, establishes the required information for the development of a model for effective public participation during the planning and implementation of transport infrastructure. Through journal articles from search engines such as Google Scholar and Elsevier secondary data is improved.

6 RESULTS AND DISCUSSIONS

The role of the citizens cannot be underestimated as the transportation solutions are meant to benefit the public. Robust public participation framework or legislation might be required within South Africa to administer step by step robust, transparent, comprehensive public participation during the planning and implementation of mega transport infrastructure projects. Provision of mega transport infrastructure can be regarded as a specialised field and as such, the applicable public participation framework cannot just focus on participation without addressing components of transportation planning that can assist the public to make informed decisions. To achieve sustainable outcomes, cities require more innovative approaches to ensure more sustainable solutions. In South Africa, the national sphere (the agency) of government is tasked with the construction and maintenance of national roads. According to Section 40 of the Constitution of the Republic of South Africa, 1996 (the Constitution), government is constituted as national, provincial, and local spheres of government which are distinctive, interdependent, and interrelated. The national government commenced with GFIP in 2007 in terms of the South African National Roads Act of 1998. Based on the publicised backlash between the public and agency, it can be assumed that during the planning of this

project, complying with statutory public participation requirements may not have translated into a public buy-in.

6.1 GFIP Inception

The South African National Roads Agency Limited (the agency) is governed by The South African National Roads Agency Limited, Act 7 of 1998 (hereafter SANRAL Act), and is part of national planning responsible for facilitating national roads throughout the Republic of South Africa (RSA). Various studies were undertaken as part of the preparatory phase 1 of GFIP. It is worth mentioning that in 2004, the 2010 soccer world cup was awarded to South Africa. It was in 2004 when elections were held in South Africa. A lot of planning was required from the new government in line with the anticipated soccer world cup. Although several provinces within South Africa embarked on infrastructure developments for the soccer world cup, GFIP was not part of the world Cup, yet the GFIP phase 1 upgrades benefited Gauteng during the world cup. In 2006, the proposal for the GFIP was developed as a joint initiative of Gauteng Department of Road and Transport and the National Department of Transport, and municipalities, for utilisation and sustainability of the Gauteng freeways. A user payment-based toll scheme, with electronic fare collection as a basis to ensure free traffic flow, was proposed as the most effective funding mechanism. The scheme included the existing road network capacity expansions and development of new freeways (Makhura 2014:40). The improvement of the Gauteng Freeways was a much-needed relief to the poor road infrastructure. It was a requirement that the benefit should outweigh the cost and that an acceptable rate of return on investment is achieved. It is commonly known that congestion impacts on economic growth potential, loss of business opportunity, and increased road user costs. Not addressing the congestion experienced on the freeway network was simply not an option (SANRAL, 2010). Improving the freeways was needed and after the implementation of Phase 1, SANRAL (2016:5) found that in 2015 the GFIP saved the road users an estimated 443 000 vehicle hours per day of which 155 000 are on freeways. It is evident that the freeway upgrades brought some much needed relieve and improved travelling conditions.

The agency, which is tasked with the construction and maintenance of national roads published the intention to commence with GFIP in 2007. In terms of Section 27 of the SANRAL Act, the intention to toll GFIP were published in the Government Gazette and other local newspapers from the 12 October 2007, inviting the public to comment within 30 days. This is regarded as the public participation phase for the planning of National Roads in South Africa. Simultaneously with the public participation phase, notices were sent to both the local and provincial spheres of government as a requirement in terms of the SANRAL Act of 1998. It appears no major objections were received as the project was thereafter approved and commenced. For the agency to comply with the requirements of the Act, the requirement is only to mention the location of the toll booth. Based on the notices, the public and other spheres of government can only comment on the physical location of the tolls.

6.2 GFIP Planning

The democratic government of South Africa was only elected in 1994, and the majority of South Africans at the time were marginalised. It was thus obvious that the GFIP funding through National Treasury was not feasible. The pronouncement to embark on the Gauteng freeway upgrade was not in question, as this was a burning requirement, but the interrogation on the method of funding the upgrade was one that resulted in an unpopular decision to toll freeways (OUTA, 2016:2). This initial phase of upgrading the 185 km involved upgrading the bottleneck areas and interchanges. The next phase of the project entails upgrading 376 km, as well as the construction of new freeways. According to Makhura (2014:40), the history of the GFIP can be traced back to 1995 as follows

In 1995 Gauteng established the Freeway Implementation Scheme established. It was decided that the freeways would be privatised and tolled due to lack of funding. Central government, however, refused to pass the provincial toll road bill.

In 1998 – Gauteng published its Toll Road Strategy premised on the establishment of a “network of toll roads”. It culminated in the publication of the Gauteng Toll Roads Bill, 2003 (notice 1880 of 2003 in the Provincial Gazette) providing for user charging on provincial toll roads, an agreement with the agency for implementation of the toll road network and proper consultations with municipalities regarding the declaration of toll roads. The bill was, however, not promulgated after the elections in 2004.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

In 2006 the Gauteng Transport Network Integration Process started. A proposal for the GFIP was developed as a joint initiative of the Gauteng Department of Road and Transport and the National Department of Transport, the agency, and municipalities, for utilisation and sustainability of the Gauteng freeways. A user payment-based toll scheme, with electronic fare collection as a basis to ensure free traffic flow, was proposed as the most effective funding mechanism. The scheme included the existing road network capacity expansions and the development of new freeways. The GFIP was to be implemented holistically to include the Gautrain, the upgrading of the commuter rail network, BRT systems, HOV lanes, intercity public transport, inter-modalism and park-and-ride facilities.

In 2007 the GFIP was approved by the national cabinet after the Soccer World Cup was awarded to South Africa. Approval was given for the upgrade and tolling of the N1, N3 and N12. The agency advertised the intention to toll at an estimated 50c/km and 82 representations were received from the public.

In 2008 a Memorandum of Agreement was signed by the Gauteng Provincial Government and the agency handed over the R21 to be funded through e-tolling. The agency advertised the intention to toll the R21 and two representations were received. Contracts were awarded and construction commenced in June.

In 2009 the construction of e-toll gantries commenced.

In 2010 the e-tolling launch was anticipated but had to await promulgation of the Transport Related Matters Act Amendment Bill.

In 2011 – toll tariffs were published, followed by the establishment of the GFIP steering committee chaired by the deputy general of the National Department of Transport and the deputy general of the Gauteng provincial government to revisit the proposed tariff, implement a broad consultative process and explore the possibilities of increasing the public transport offering. The agency commenced with e-toll registration and Phase 2 of the GFIP was put on hold by the National Department of Transport.

In 2012 the Inter-Ministerial Committee of the GFIP was established to coordinate all work of the implementation of the project, respond to the legal disputes, consult stakeholders, and propose short-term funding solutions for the agency.

In 2013 the bill was signed into law by President Zuma on 25 September 2013 and e-tolls commenced on 3 December.

6.3 GFIP Implementation

The project implementation was based on the user-pay system. The final planning of the GFIP started in 2005, merely eleven years after the election of the democratic government and the demands from government funding were immense. Democracy is important in transportation planning as indicated in preceding sections. The key factor of democracy is public participation during the formulation of policies (Holum 2022:1). The then premier of Gauteng, David Makhura established an advisory panel to review GFIP following the publicist backlash. The advisory panel investigated the socio-economic impacts of GFIP. Several advantages of GFIP were recognised and the panel concluded that the project responded to the overall needs of the Gauteng residents. According to Hwang et al (2020:437), megaprojects perform an important role in tackling the basic need of the people. Reviewing GFIP and the impacts on the public was necessary. The panel noted that in terms of the National Land Transport Act, 2009 of South Africa, it is important that infrastructure improvements facilitate financial, technical, and environmental sustainability. The point of contention is not the need for infrastructure, but the public involvement during the planning of GFIP. It is reasonable to assume that a state which promotes public aggressively would be regarded as open and responsive to the public views (Holum 2022:2).

The GFIP e-tolling system or user-pay has been affected by the road users defying the system. As much as the agency argued that appropriate processes were followed to this end the agency was struggling to recover e-tolling fees to repay the GFIP loan. According to the then chairperson of the agency, 2017/2018 was a defining moment as for the first time the roads agency had to transfer R1 667 000 from non-toll business to the road toll portfolio. This was decided in agreement with the Minister of Transport because of sustained non-payment of toll fees by the GFIP users. The amount allocated from the non-toll project was in addition to the R406 000 000 special grant from the Treasury and this amount meant to offset the reduced income on the GFIP (SANRAL, 2018:9). The lack of e-tolling success has resulted in debt accumulation and money

from other national roads projects being allocated to the GFIP. During the year 2017 and 2018, media companies reported that some freeway users with outstanding e-toll debts were blacklisted. On 19 March 2019, it was reported that the toll collection company indicated that the motorists who failed to pay their e-toll and who also ignored the court summonses, would be left with defaults orders against their names, which would lead to them being blacklisted by credit bureaus (BusinessTech, 2019). The following media reports contradicted the statement from the toll collection company. It was reported that the blacklisting was a mistake as the SANRAL Act excludes the levying and collecting of e-tolls from the provisions of the National Credit Act, 2005. This means that the freeway users not paying e-tolls could not be blacklisted, and the credit bureaus confirmed that the SANRAL debt cannot be held on credit. On 27 March 2019, it was reported that President Cyril Ramaphosa issued a statement that no new summons could be applied for, and it is still unclear how the agency intends to deal with the e-toll debt. The agency confirmed that it suspended the summons applied from 2015 (BusinessTech, 2019).

Poor toll collection has resulted in delays for the implementation of GFIP phase 2. Phase questionnaires were circulated to five representatives from the national agency involved in the planning and implementation of roads. All respondents strongly agree that the if GFIP Phase 2 and 3 cannot proceed, the Gauteng freeways will the congested. Phase 1 was anticipated to only relieve traffic congestion for approximately 3 to 5 years and thereafter Phases 2 and 3 will have to be implemented to improve linkages across the Gauteng City Region (Makhura 2014:35). The majority of the informants confirmed that the agency is not engaging with international funders or the Treasury for the implementation of the subsequent GFIP phases. Phases 2 and 3 are required and yet no other alternative funding is being sourced to finance the proposed improvements. This project is one where public acceptance has affected and may affect sustainability, as the agency has not been able to proceed with Phases 2 and 3. Without a successful funding model, it may be argued that although the implementation of Phase 1 was successful, the sustainability of GFIP can be questioned.

Several court actions resulted in the projects being halted temporarily. Moseneke (2012) pointed out that the parties were not arguing whether the upgrades were necessary. All parties agreed that the upgrades were necessary and needed within the Gauteng province. The contentious issue was the funding of the upgrades, and in this case, the court pointed out that only the government has the right to decide on the funding mechanism. In 2014, the then chief executive officer of the national roads department of the agency was experiencing financial problems. The ratings agency maintained a negative outlook due to the delay in commencing with the GFIP toll collection (SANRAL, 2014:7). According to Makhura (2014:137), Consultations can never be exhaustive, and nor will it result in 100% consensus. Whilst the underlying sentiments to the opposition to e-tolls, including the anger and frustration about perceived and real lack of consultation, the panel can see no justification for the campaign, which sets unsustainable precedents and threatens democracy and social cohesion. According to SANRAL (2017:1), “the e-toll project is not coming to an end. This means that all e-toll money owed to the state must be paid. No debt has been written off.”

6.4 GFIP public participation and stakeholder engagements

As indicated in preceding sections, the intention to toll the freeways were published in the Government Gazette and other local newspapers, inviting the public to comment within 30 days. At the same time notices were sent to both the local and provincial spheres of government as a requirement in terms of the Act. For the national department to comply with the requirements of the Act, the requirement has only to mention the location of the toll booths. Based on the notices, the public and other spheres of government can only comment on the physical location of the tolls. It was not until 2011 that the toll fees were gazetted. This was just after the 2010 soccer world cup, which might have confused the public as a lot of upgrades throughout the country were undertaken for the world cup. At no point prior to the 2011 notice, were the funding models disclosed and in terms of the Act, the national department is not compelled to disclose the funding model. It is worth mentioning that when the tariffs were gazetted in 2011, GFIP Phase 1 of the project was already complete. The agency made it clear that all statutory requirements were fulfilled, and they have been arguing from 2012 that the e-toll launch should proceed. Table 1 indicates agency’s stance on the GFIP.

The intention to toll specifically for e-tolling was halted after it was announced by the relevant department. The existing Act only incorporated standard toll booths, not electronic tolling. The department had to amend certain sections of the SANRAL Act to allow for the electronic toll collection. At their discretion, the ruling party which held majority seats in parliament, opted to pass the Bill in terms of Section 75 of the

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Constitution of the Republic of South Africa. The Section 75 Bills are regarded as ordinary, and they do not accommodate public participation. In 2013, when this Bill was passed. Section 75 Bills are regarded as those bills that do not affect provinces. The Transport Laws and Related Matters Amendment bill was regarded as not affecting provinces and it was introduced as such in the National Assembly. In this case, the Bill is passed in the National Assembly and then sent to the National Council of Provinces where most of the delegates must vote for the Bill. The participation of the National Council of Provinces is very limited as they cannot prevent the Bill from being passed. The Minister is only required to submit the Bill to parliament, requesting approval and not comments. The role of the National Council of Provinces was to simply rubber-stamp the Bill and not to participate in amending the contents of the Bill. The Transport Laws and Related Matters Bill were meant to amend both the SANRAL Act and the Cross-Border Road Transport Act, 1998. Although the Cross-Border Road Transport Act is not significant for this study, it is important to note that certain sections of this Act had to be amended for the agency to be able to recover e-tolling from motorists residing in other countries. Certain provisions, including day-passes would be facilitated and it would be possible for the agency to recover the e-toll fees after foreign motorists have used the Gauteng freeways. If the intention was to amend the Act through engagements with other spheres of government, the ruling party could have opted for a Section 76 bill. Section 76 are Ordinary Bills affecting provinces and procedures must be followed to ensure that provincial government (in the case Gauteng Province) are involved and not informed. Mediation is an important component of Section 76 which could have assisted in achieving robust debates. By 2013, it was already known that the e-toll debate in Gauteng has caused widespread criticism. Besides the statutory stakeholder and public participation requirements being executed in terms of the applicable by-law, public engagements are perceived to have not been effective. Since 2013, the agency has not been willing to back down.

The agency's Annual Report	Statements by the then CEO
2012	The uncertainty surrounding e-toll created confusion and negative sentiment in the market and among the public, and as a result, the agency's global and national ratings were downgraded. The agency remains steadfast in their conviction that the GFIP will deliver tangible and sustained benefits to Gauteng Road users and that it should be implemented in all its facets.
2013	The CEO expressed disappointment at the call being made for civil disobedience with respect to the judgements regarding the GFIP. Once the court's integrity is placed under doubt, doors to anarchy are opened. Ali appealed to all to respect the judiciary and that the misguided actions have delayed the toll collection at considerable cost to the agency.
2014	Although delays were experienced with the promulgation of the Transport and Related Matters Bill, toll collection commenced on 3 December 2013. This removed the negative sentiment in the market. The agency remained steadfast in their conviction that the selective application of the user-pay as endorsed in the National Development Plan of South Africa, with the appropriate protection of the poor would enable the agency to deliver a sustainable road network in support of socio-economic development.
2015	Six court judgements have affirmed the agency's use of the user-pay principle and confirmed that the agency has always acted lawfully. The new toll dispensation within Gauteng brought certainty to the use of user-pay principles as an instrument to fund roads in the future. SANRAL remained steadfast in their conviction that the selective application of the user-pay principle, with appropriate protection for the poor, will enable the agency to deliver a sustainable national road network that supports socio-economic development.
2016	The GFIP affects only 201 km of the agency's 21 490 km network but is has had the biggest reputation impact on the agency. The GFIP continued to offer qualitative benefits from overall improved travel conditions. The GFIP benefits are ignored by those seeking attention through unrelenting and unfolded attacks on the project. None have proven to be true, and the agency cautioned road uses to take care. Ali referred to Oliver Tambo when he said: "beware the wedge driver. Watch his poisonous tongue."

Table 1: Statements by the then, chief executive officer of the agency. Source: Own construction (2021) derived from SANRAL (2012, 2013, 2014, 2015, 2016)

6.5 Infrastructure sustainability within Gauteng

As mentioned, sustainability discourses have been gaining momentum to reduce the use of cars within urban areas. During the official launch of the GFIP, the then minister of transport, Jeff Radebe indicated that the design of the roads has considered the need to move from private vehicles to public transport, by concentrating on inter-modal transport options and high-occupancy vehicle (HOV) lanes to facilitate quick travelling by bus and taxi. The project was approved by cabinet in early 2007 (SANRAL, 2008:33). Although the public transport aspect was meant to form part of the integrated objectives of the GFIP, this has not been implemented. Integrated transportation planning has intensified the complexity as it includes various entities, participation, spatial and functional elements completely (Kotzebue 2022:2). Although the

integrated approach can be regarded as complex, the Gauteng 25-year Integrated Transport Master Plan (ITMP) (Gauteng Roads and Transport Department, 2013:7) confirmed as follows:

"with the planning of the GFIP, the agency took other transport modes into consideration (the Gautrain, Metrorail, and Bus Rapid Transport) and strived to create links with other transport modes to provide citizens with the choice of using public transportation or car-pooling and will alleviate congestion caused by single-passenger vehicles''

After the completion of the GFIP Phase 1 upgrades, SANRAL (2011:6) indicated that the network design includes space for a dedicated HOV lane. It therefore appears that the initial plan to provide the HOV lanes was omitted during the implementation. One of the initiatives that was tested within Gauteng in 2006 was the High Occupancy Vehicle lanes. In reviewing the social impact of the GFIP, Bew et al. (2007) also investigated the HOV lane option. According to Bew et al. (2007:19), an HOV survey compiled by Synovate during the trial period indicated that among 400 motorists surveyed, only 30% believed that the HOV lane option could be a solution to the traffic congestion along the Gauteng freeways. Even though the announcement of the GFIP alluded to the introduction of HOV lanes, it was never implemented. Like the HOV strategy above, the GFIP solution was meant to incorporate public transport strategies. The Makura (2014) panel considered the issue of lack of reliable public transport as important, and it was recommended that the intergovernmental forums should be ongoing. The panel made it clear that priority public transport should be identified and/or an HOV project so that they can serve as alternatives for freeway users who wish to switch from using cars. Balanced transport systems must/ be debated. The panel also received submissions relating to the lack of reliable public transport. The panel considered this issue as important, and it was recommended that the intergovernmental forums should be ongoing. The forums should include all three spheres of government, as well as SANRAL, and the forum should deal with e-toll issues that were submitted to the panel.

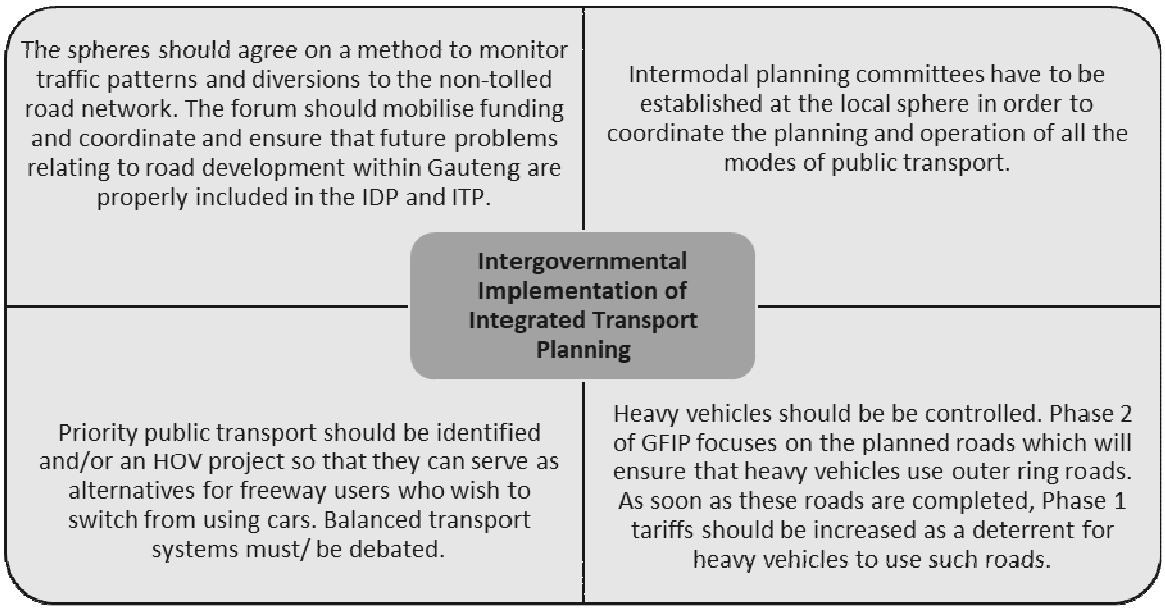


Figure 1: Recommendations on the implementation of integrated transport planning. Source: Own construction based on Makhura (2014)

The recommendations in figure 2 highlight the importance of integrated planning solutions and alignment across the three spheres of government. Complex planning is necessitated by megaprojects such as urban and infrastructure projects (Machiels et al. 2021: 538). The panel assessed the information provided, and the recommendations are based on the solutions to rectify the one-sided implementation of freeway improvements which was not implemented in conjunction with other alternatives. Besides the various funding methods, the panel recommended that whatever the agency's solution, it should not disadvantage the lower income groups. The panel acknowledged that the lower income groups use freeways and as such the agency must apply a different principle. Based on this recommendation, the agency then amended the e-tolling and excluded public transport from paying for e-tolls. The assumption was that the poor rely on public transport and if the buses and taxis pay for e-tolls, the cost will translate into the bus and taxi operators increasing the fees to cover the e-toll fees.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

7 PATHWAYS TO EFFECTIVE PUBLIC PARTICIPATION FOR SUSTAINABLE TRANSPORTATION OUTCOMES

Achieving sustainable development strategies in developing and the developed counctries, requires the promotion of an evironment that promotes successful democratic governance (Hue and. Yung-wen sun 2022:6).

While public participation for sustainable development gained momentum post the Rio Declaration, it is worth mentioning that public participation in planning started as far back in the 1960s. Sherry Arnestein proposed a basic public participation ladder which is now very well known as the Arnestein ladder of participation. Arnestein's approach is based on a ladder structure which indicates the magnitude of involvement between the public and citizens in planning (Wilker et al. 2016:232). The public outcry was discussed in preceeding sections and evaluated using exisiting public participation frameworks. Despite the public outcry, the then project manager of the GFIP, argued that critics of the programme confuse the cost of building a sophisticated freeway network in a densely populated area such as Gauteng with rural highways elsewhere in Africa (SANRAL, 2016:1). The project leaders seem to have been oblivious to the stance that public participation was indeed the issue, not the freeway improvements. Perić (2019:214) reviwed several government projects in various states and concluded that in most cases powerful entities violate the interests of public. The democratic processes are of interest when mega projects meant for the people do not incorporate ordinary citizens during the conceptualisation and planning of such projects where in the case of GFIP participation can be viewed as minimum. Democracy without justice cannot guarantee effective public participation in conceptualisation, planning and implementation of transport projects as explained by Rawls. To this end, it has been establised that megaprojects have to employ strict procedures and thorough transparency reporting because projects of such magnitude attract public attention (Wiewiora and Desouza 2022:237).

In compiling the ladder of public participation, Arnstein argued that the public participation ladder can range from Level 1 to 8, with level 8 being the most inclusive in decision making. The ladder is categorised by eight levels of public impact on decision making and the different categories demonstrate the public power in formulating plans (Wang and Chan 2020:1). The debate surrounding the GFIP has highlighted a lot of impediments that could be experienced during the planning and implementation of mega transport plans in South Africa. The highest level of participation according to Arnstein is when the public can extensively exercise power in decision making processes (Kwak 2019:259). Accordingly, authorities cannot ignore the fact that the pubic can exercise such power, especially when projects directly affect the citizems. Several frameworks have been emerging to enhance the Arnsein ladder. However, Arnstein's ladder intended to avoid nonparticipation whereby the leaders do not allow citizens to express their opinion and she wanted to avoid tokenism whereby the citizen's opinions do not change the decisions made by power holders (Rosen and Painter 2019:336)

The GFIP user-pay scheme makes the user/public an especially important component of the project and yet SANRAL Act does not compel the full disclosure of tolling costs, which could limit the public's perception of the project's costs and the overall implications. This can be regarded to be at Level 2 of the Arnestein ladder because the information provided during the public participation was limited and failed to disclose the toll prices. To this end, the agency has only been able to prove that it ticked all the boxes in terms of the tolling process. The question can be asked: was the public properly consulted before the implementation of e-tolls? Besides the statutory public participation requirements being executed in terms of the applicable by-law, public engagements are perceived to have not been effective. It is not clear how transportation agencies within South Afriaca are mandated to comprehensively engage with ordinary citizens at length throughout the planning and implementation stages of major government projects. The important component according to Arnstein's analysis is that the power holders and ordinary citizens must be on equal footing such that all the partners have suffucient knowledge to effectively negotiate (Gaber 2019:196). It is worth noting that beside private vehicle owners, the Gauteng residents who do not own motor vehicles might somehow be affected by the tolling of the freeways. According to the report prepared for the Road Freight Association and Afriforum, by Schussler (2011:21) "the commercial road freight will in all likelihood have no choice but to pass on the actual costs of the tolls to their clients, who themselves are likely to pass on these costs to their clients. At the end of the day all goods transported by road via the GFIP will have a level of cost increase

that the consumer will have to bear the brunt of." The highest leve of public participation according to the Arnstein would be partnership, delegated power and citizen control (Wang and Chan 2020:2).

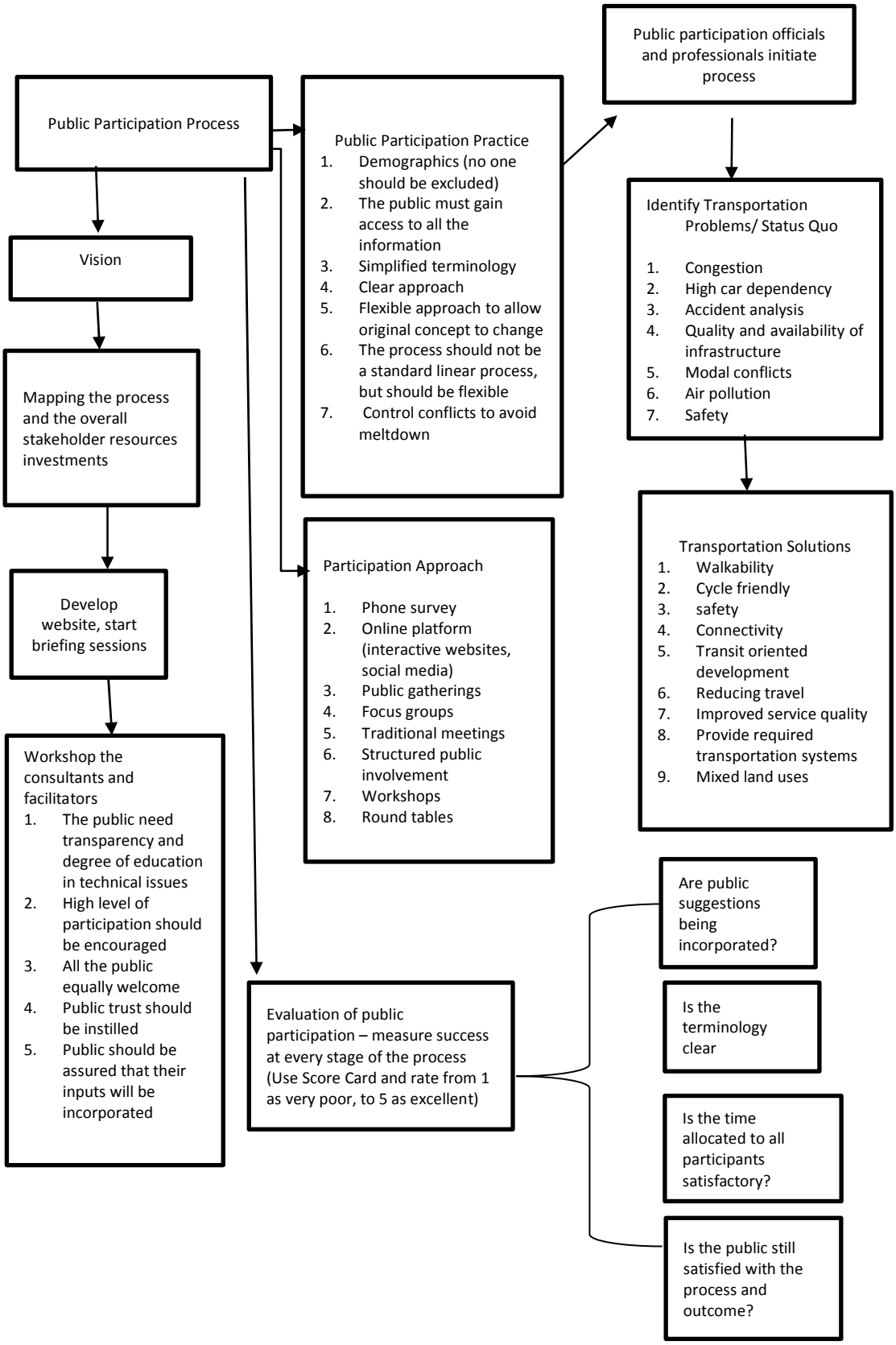


Figure 2: Guidelines for effective transport planning public participation. Source: Adapted from Macmillan et al. (2020:4-5); Bailey et al. (2015:47-50); Sagaris and Ortuzar (2015:21); Wang and Chan (2020:3); Grossardt and Bailey (2018:7-13)

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

The critical relevance of stakeholders to this study is whether the engagements acknowledge the contributions from diverse participants. For transportation planning, the High-Performance Public Involvement framework was formulated to bridge the Arnstein Gap, by introducing quality, inclusion, clarity, and efficiency as a system of measurement for public participation (Bailey et al. 2015:45). Public participation to achieve quality, inclusion, clarity, and efficiency can be a goal for ensuring successful transportation solutions. Stakeholders, public, and other professionals are obliged to investigate significant ambiguities to inform or develop policy recommendations (Andersen et al. 2021:1). Understanding the required resource investment is important and this should be done before the conceptualisation stage. This is because several authors (Akerman and Höjer, 2006; Banister et al., 2000; Lyons and Davidson, 2016) argue that scenario-building within transportation planning provides the participants with a framework to investigate potential ambiguities and integrate them into policymaking processes (Ariza-Álvarez et al. 2022:275). According to Makhura (2014:132), with implementation of GFIP a comprehensive approach should be formulated towards funding models and plans for integrated and transformative Gauteng public transport. This should incorporate all the metro's BRTs, the local municipality's bust services, the Passenger Rail Agency of South Africa, Gautrain and all other means of public transport. This is alined with what has already been established, namely that many authorities spend funds on highway expansions because of traffic congestion and yet the highways will only be able to reduce congestion for a couple of years (Speck, 2018:65).

For achieving sustainable transportation solutions, alternative modes of transport are important and should be provided in conjunction with road improvements as highlighted in preceding sections. Integrating the different sustainability factors is necessary for correcting the negative outcomes caused by motorisation. To realise urban sustainability, transportation solutions must correct unjust mobility which encompasses irregularly dispersed, harmful environmental and societal impacts and this requires institutional changes (Verlinghieri 2020: 364). The most significant input for developing a model is to clearly define the vision to translate the goals and objectives of public participation which in turn forms the basis for pathways to effective public participation for sustainable transport infrastructure development as indicated in Figure 2. The ground for developing a clear pathway is based on the importance of being able to execute public participation scientifically to facilitate the evaluation of process success based on clear objectives. Engagements amongst role players is a dynamic procedure and can be characterised by several reviews of the system (Pira et al. 2016:231). Due to the dynamic nature of stakeholder engagement, establishing an appropriate approach is central to the success of the process. This highlights the importance of a clear approach to the "how" to avoid conflicts over major transportation projects which in turn speeds up the attainment of sustainability while also acknowledging the importance of citizen participation (Sagaris and Ortuzar 2015:21).

8 CONCLUSION

The debate surrounding the GFIP has highlighted the impediments that can be experienced during the planning and implementation of mega transport projects in South Africa. What is of concern is that the GFIP agency is of the opinion that the project planning and implementation was done correctly and that the road users must pay for the e-toll roads. It remains to be seen whether the agency will eventually manage to recover the costs of the GFIP through the use–pay system as was initially proposed. Although alternative transportation modes were proposed as part of the integrated objectives of the GFIP, this has not been implemented. One can argue that the road users are not opposed to the project, but they are opposed to poor integrated planning and lack of sufficient public consultations prior to the implementation of this project. The paper concludes that high-level public participation is a key component of democracy for planning and implementation of transport infrastructure project. It highlights the pathways to effective public participation for the development and management of inclusive/sustainable transport infrastructure. Pursuant to that, the paper ends by recommending high-level engagements between all stakeholders, including ordinary citizens to enhance accountability, user acceptance and desirable socio-economic outcomes: inclusive transport infrastructure development, management and use. To this end, it is not clear how South African transportation departments facilitate comprehensive public participation during the planning and implementation of mega projects. Future studies are necessary for assessing public participation from conceptualisation, not after implementation of plans. This study reviews a project already implemented and it

might be necessary to analyse a project before implementation so that processes involved are analysed during the real-life cycle. The public participation process must be interrogated before project commencement and future research is necessary. The success of institution to mobilise the public and the stakeholders must be evaluated, including the level of involvement throughout the project planning and implementation.

9 REFERENCES

Andersen PD, Hansen M and Selin C. 2021 Stakeholder inclusion in scenario planning—A review of European projects. Technological Forecasting & Social Change, 169. Elsevier Inc. https://doi.org/10.1016/j.techfore.2021.120802

Arbab P, Taghizadeh K and Nezhad SF. 2020. Toward Participation-Based Urban Planning and Development: Evaluating Participatory Revitalization in Middle Oudlajan Neighbourhood of Tehran. Journal of Urban Planning and Development, 146(4):05020022. https://doi.org/10.1061/(ASCE)UP.1943-5444.0000611 Asadzadeh A, Kotter T, Fekete A, Moghadas M, Alizadeh M, Zebardast E, Weiss D, Basirat M , and Hutter G. 2022. Urbanization, migration, and the challenges of resilience thinking in urban planning: Insights from two contrasting planning systems in Germany and Iran. Cities 125:103642. https://doi.org/10.1016/j.cities.2022.103642

Ariza-Álvareza A, Soria-Laraa JA and Aguilera-Benaventec F. Planning Adaptive Strategies for Urban Transport and Land Use using Scenario-Building. Transportation Research Procedia 60:274–281. https://doi.org/10.1016/j.trpro.2021.12.036 2022.

Bai X, Surveyer A, Elmqvist T, Gatzweiler FW, Guneralp B, Parnell S, Prieur-Richard A, Shrivastava P, Siri JG, Stafford-Smith M, Toussaint J and Webb R. 2016. Defining and advancing a systems approach for sustainable cities. Current Opinion in Environmental Sustainability, 23:69–78. http://dx.doi.org/10.1016/j.cosust.2016.11.010

Bailey, Grossardt T and Ripy J. 2015. High-Performance Public Involvement: Frameworks, Performance Measures, and Data. Journal of the Transportation Research Board, 2499: 45–53. https://doi.org/10.3141%2F2499-07

Bew N and Associates. 2007. Gauteng Freeway Improvement Project Social Impact Assessment. http://www.socialassessment.co.za/

Bibri ES and Krogstie J. 2017. Smart sustainable cities of the future: an extensive interdisciplinary literature review. Sustainable Cities and Society, 31:183-212.doi:10.1016/j.scs.2017.02.016

Browna,G and Eckold H. 2022. An evaluation of public participation information for land use decisions: public comment, surveys, and participatory mapping. Local environment, 25(2) 85–100. https://doi.org/10.1080/13549839.2019.1703660

Brůhová Foltýnováa, H, Vejchodskáa E , Rybováa K , and Květoňb V. 2020. Sustainable urban mobility: One definition, different stakeholders' opinions. Transportation Research Part D, 87:1-14. https://doi.org/10.1016/j.trd.2020.102465

BusinessTech. 2019. SANRAL will not pursue e-toll debts. https://businesstech.co.za/news/motoring/307430/sanral-will-not-pursue-e-toll-debts/

BusinessTech. 2019. E-toll debt decision could lead to a downgrade: finance minister. https://businesstech.co.za/news/motoring/307430/sanral-will-not-pursue-e-toll-debts/

BusinessTech. 2019. E-tolls gets a R5.7 billion bailout. https://businesstech.co.za/news/motoring/304662/e-tolls-gets-a-r5-7-billion-bailout/

Creswell JW and Creswell JD. 2018. Research design: Qualitative, quantitative, and mixed methods approaches. SAGE publication. London

City Press. 2013. Cosatu plans to 'occupy freeways' in renewed e-toll protests. City Press, 28 January. https://www.news24.com/Archives/City-Press/Cosatu-plans-to-occupy-freeways-in-renewed-e-toll-protests-20150430

Gauteng Roads and Transport Department. (2013). Gauteng 25-year Integrated Transport Master Plan. Gauteng Provincial Government.

Gaber J. 2019. Building "A Ladder of Citizen Participation". Journal of the American Planning Association, 85(3): 188-201. https://doi.org/10.1080/01944363.2019.1612267

Gumbo Trynos and Moyo Thembani (2020) Exploring the Interoperability of Public Transport Systems for Sustainable Mobility in Developing Cities: Lessons from Johannesburg Metropolitan City, South Africa, Sustainability, 12, 5875; 1-16; https://doi:10.3390/su12155875

Gumbo Trynos; Moyo Thembani; Ndwandwe Bongumusa; Risimati Brightnes; Mbatha Siphiwe (2022) Urban Public Transport Systems Innovations in the Era of the Fourth Industrial Revolution: Perspectives, Reflections and Conjectures, Springer Nature Switzerland AG, https://link.springer.com/book/10.1007/9783030987176

Grossardt T and Bailey K. 2018. Transportation planning and public participation. Elsevier Inc. United States of America.

Hansson L. 2020. Visual representation in urban transport planning: Where have all the cars gone? Transportation Research Part A, 133: 1–11. https://doi.org/10.1016/j.tra.2019.11.027

Hwanga BG, Shanb M, Zhuc L and Lim WC. 2020. Cost control in megaprojects: efficacy, tools and techniques, key knowledge areas and project comparisons. International journal of construction management, 20(5), 437–449. https://doi.org/10.1080/15623599.2018.1484976

Holum M. 2022. Citizen Participation: Linking Government Efforts, Actual Participation, and Trust in Local Politicians. International journal of public administration, https://doi.org/10.1080/01900692.2022.2048667

Holz-Rau C and Scheiner J. 2019. Land-use and transport planning – A field of complex cause-impact relationships. Thoughts on transport growth, greenhouse gas emissions and the built environment. Transport Policy 74: 127–137. https://doi.org/10.1016/j.tranpol.2018.12.004

Khan R, Thwaites N, Williams H, O'Connor MMD, Roberts A, Browne K, Daniels D, Francis C, Hall K, Sparkes K and Bailey A. 2018. Community-based Approaches and Measuring the SDGs. Social and economic studies, 67:4(67-93). https://www.jstor.org/stable/45204454

Keseru I, Coosemans T and Macharis C. 2021. Stakeholders' preferences for the future of transport in Europe: Participatory evaluation of scenarios combining scenario planning and the multi-actor multi-criteria analysis. Futures 127:1-22. https://doi.org/10.1016/j.futures.2020.102690

Kim NY , Kim HJ and Kim SH. 2022. Are satisfied citizens willing to participate more? An analysis of citizens' life satisfaction in the public service domain and public participation. International Review of Public Administration. ,https://doi.org/10.1080/12294659.2022.2119650

Kotzebue JR. 2022. Integrated urban transport infrastructure development: The role of digital social geo-communication in Hamburg's TEN-T improvement. Journal of Transport Geography, 99 (103280). https://doi.org/10.1016/j.jtrangeo.2022.103280

Kwak S. 2019. Deconstructing the multi-layered nature of citizen participation in Vietnam: conceptual connotations, discourses of international development, and the country's institutional context. Asian journal of political science. 27(3): 257–271. https://doi.org/10.1080/02185377.2019.1631866

Laurila-Pant M, Mäntyniemi S, Venesjärvi R and Lehikoinen A. 2019. Incorporating stakeholders' values into environmental decision support: A Bayesian Belief Network approach. Science of the Total Environment 697:1-11. https://doi.org/10.1016/j.scitotenv.2019.134026

Litman T. and Steele R. 2019. Land use impacts on transport: How land use factors affect travel behavior. https://www.vtpi.org/landtravel.pdf

Macmillan A, Smith M, Witten K, Woodward A, Hosking J, Wild K and Field A. Suburb-level changes for active transport to meet the SDGs: Causal theory and a New Zealand case study. Science of the Total Environment,714:136678. https://doi.org/10.1016/j.scitotenv.2020.136678

Machiels T, Compernolle T and Coppens T. 2021 Explaining Uncertainty Avoidance in Megaprojects: Resource Constraints, Strategic Behaviour, or Institutions? Planning theory and practice, 22(4)537–555. https://doi.org/10.1080/14649357.2021.1944659 Makhura D. 2014. Socio-economic Impact of the Gauteng Freeway Improvement Project and E-tolls Report: Report of the Advisory Panel. http://www.gautengonline.gov.za/

Martens K, Golub A and Robinson G. 2012. A justice-theoretic approach to the distribution of transportation benefits: Implications for transportation planning practice in the United States. Transportation Research Part A 46:684–695. http://dx.doi.org/10.1016/j.tra.2012.01.004

Mauerhofer V. 2016. Public participation in environmental matters: Compendium, challenges and chances globally. Land use policy, 52: 481- 491. http://dx.doi.org/10.1016/j.landusepol.2014.12.012

Mehlawat MK, Kannan D, Gupta P and Aggarwal U. 2019. Sustainable transportation planning for a three-stage fixed charge multi-objective transportation problem. Annals of Operations Research. Springer. https://doi.org/10.1007/s10479-019-03451-4

Moseneke DCJ. 2012. Constitutional court of South Africa: National Treasury and Others v Opposition to Urban Tolling Alliance and Others. https://www.lexisnexis.co.za/

Mukhopadhyay S and Gupta R. 2014. Survey of qualitative research methodology in strategy research and implication for Indian researchers. SAGE Publication, 18(2): 109 – 123. http://DOI10.1177/0972262914528437

Orellana M. 2016. Governance and sustainable development goals: The increasing relevance of access rights in

Perić A. 2020. Public engagement under authoritarian entrepreneurialism: the Belgrade Waterfront project. Urban research and practice., 13(2) 213–227. https://doi.org/10.1080/17535069.2019.1670469

Pira M, Ignaccolo M, Inturri G and Pluchino A. 2016. Modelling stakeholder participation in transport planning. Case studies on transport policy, 4: 230-238. http://dx.doi.org/10.1016/j.cstp.2016.06.002

Prosek EA and Gibson DM. 2021. Promoting Rigorous Research by Examining Lived Experiences: A Review of Four Qualitative Traditions. Journal of Counseling & Development, Volume 99. https://doi.org/10.1002/jcad.12364

Puppim de Oliveira JA and Fra.Paelo U. 2016. Lost in participation: How local knowledge was overlooked in land use planning and risk governance in Tōhoku, Japan. Journal of Land Use Policy, 52:543-551. doi:10.1016/j.landusepol.2014.09.023

Risimati Brightnes, Gumbo Trynos and Chakwizira James (2021) Spatial Integration of Non-Motorised Transport and Urban Public Transport Infrastructure: A Case of Johannesburg, Sustainability, 13, 11461; 1-17, https://www.mdpi.com/2071-1050/13/20/11461

Ritchie J, Lewis J, Nicholss CM, and Ormston R. 2014. Qualitative research practice: a guide for social science students and researchers. SAGE publication. London.

Rodrigue JP. 2013. The geography of transport systems. https://books.google.co.za

Rosen J and Painter G. 2019. From citizen control to co-production. Journal of the American Planning Association, 85(3): 335-347. https://doi.org/10.1080/01944363.2019.1618727

Sabela-Rikhotso P, Van Niekerk D and Nemakonde L. 2022. A conceptual model for marine oil spills management in South Africa. Disaster Prevention and Management: an international journal. https://doi.org/10.1108/dpm-08-2021-0241

Sen A. 2009. The idea of justice. The Belknap Press of Havard University Press. United States of America

SANRAL. 2008. Annual Report. www.nra.co.za

SANRAL. 2011. Annual Report. www.nra.co.za

SANRAL. 2012. Annual Report. www.nra.co.za

SANRAL. 2014. Annual Report. www.nra.co.za

SANRAL. 2015. Annual Report. www.nra.co.za

SANRAL. 2013. Annual Report. www.nra.co.za

SANRAL. 2016. Annual Report. www.nra.co.za

SANRAL. 2017. Annual Report. www.nra.co.za

SANRAL. 2010. What you need to know – Freeway Improvement Project (GFIP). http://www.nra.co.za/content/Gauteng_GFIP_final_economic_report.pdf

Schussler, M. 2011. Consumer impact of the Gauteng Freeway Improvement Program: Prepared for the Road Freight Association and Afriforum. https://www.politicsweb.co.za/comment/gauteng-tolls-mike-schusslers-analysis

Sagaris L and Ortuzar J. 2015. Reflection of citizen-technical dialogue as part of cycling-inclusive planning in Santiago, Chile. Research in transportation economics 53(20 – 30). http://dx.doi.org/10.1016/j.retrec.2015.10.016

Speck J. 2018. Walkable city rules: 101 steps to making better spaces. Island Press. United States of America

Stec S and Jendroska J. 2019. The Escaz'u agreement and regional approach to Rio Principle 10: Process, innovation and shortcomings. Journal of environmental law, 31(533-545). http://doi:10.1093/jel/eqz027

Statistics South Africa. (Stats SA). 2014. National Household Travel Survey: Gauteng profile. http://www.statssa.gov.za
Statistics South Africa. 2018. Mid-year population estimates. http://www.statssa.gov.za
Verlinghieri E. 2020. Learning from the grassroots: A resourcefulness-based worldview for transport planning. Transportation Research Part A 133: 364–37. https://doi.org/10.1016/j.tra.2019.07.001
The Constitution of the Republic of South Africa (the Constitution) 1996. https://www.justice.gov.za/legislation/constitution/saconstitution-web-eng.pdf
The South African National Roads Agency Limited and National Roads Act, Act 7 of 1998. www.nra.co.za
Transport laws and related matters amendment bill. 2012. Government Gazette No. 35597. https://www.gov.za/sites/default/files/gcis_document/201409/b30-2012121005a.pdf
United Nations, 2019. The sustainable development goals report 2019. United Nations publication
Wang S, Xie Z, Wu R, and Feng K.2022. How does urbanization affect the carbon intensity of human well-being? A global assessment. Applied Energy. https://doi.org/10.1016/j.apenergy.2022.118798
Wang A and Chan EHW. 2020. The impact of power-geometry in participatory planning on urban greening. Urban Forestry & Urban Greening 48:126571. https://doi.org/10.1016/j.ufug.2019.126571
Wilker J, Rusche K and Rymsa-Fitschen C. 2016. Improving Participation in Green Infrastructure Planning. Planning practcice and research. 31(3):229–249. http://dx.doi.org/10.1080/02697459.2016.1158065
Wiewiora A and Desouza KC. 2022. Surfacing and responding paradoxes in megascale projects. International Journal of Project Management, 40:235–250. https://doi.org/10.1016/j.ijproman.2022.01.009
Young SP. 2009. Reflections of Rawls: an assessment and legacy. Routledge. United States of America
Zeng X , Yu Y, Yang S, Lv Y and Sarker NZ. 2022. Urban Resilience for Urban Sustainability: Concepts, Dimensions, and Perspectives. Sustainability, 14:1-27. https://doi.org/10.3390/su14052481

🏆 *reviewed paper*

Pathways to Sustainable Public Transport: Analysing Modal Choice in Johannesburg

Retsepile Charity Kalaoane, Trynos Gumbo, Alain Kibangou, Walter Musakwa, Innocent Musonda

(Retsepile Charity Kalaoane, Department of Town and Regional Planning, Faculty of Engineering and the Built Environment, University of Johannesburg, tshepytoya20@gmail.com)
(Trynos Gumbo, Professor, Department of Town and Regional Planning, Faculty of Engineering and the Built Environment, University of Johannesburg (tgumbo@uj.ac.za)
(Alain Kibangou, Professor, Department of Electrical Engineering and Industrial Informatics, University of Grenoble, France (alain.kibangou@univ-grenoble-alpes.fr)
(Walter Musakwa, Professor, Department of geography, environmental and energy studies, Faculty of science, University of Johannesburg (wmusakwa@uj.ac.za)
(Innocent Musonda, Professor, Department of construction management and quantity surveying, Faculty of Engineering and the Built Environment, University of Johannesburg (imusonda@uj.ac.za)

1 ABSTRACT

The incessant high rate of urbanisation in cities of the developing world continues to threaten mobility and access resulting in cities grappling to achieve sustainability. At the centre of this quagmire are concerns about the efficient functioning of public transport systems, particularly in African cities. Ostensibly, the quality of public transport services is deteriorating, more so in South African cities, resulting in constrained accessibility particularly for the urban poor and increased motor vehicle usage by the middle and high class households. This paper is based on a case study research design and a quantitative research approach to examine modal choice in public transport. Questionnaires were administered among the private vehicle owners and the public transport users to determine the factors affecting modal choice in the city. Preliminary findings reveal that the majority of commuters use public transport within the precinct but still quite a large number of people resort to private vehicle. The results highlight concerns within safety, convenience and stations that are highly polluted. Consequently, the challenges associated with conventional public transport, force those without their own vehicles to use paratransit modes of public transport which are often unregulated, major contributors of traffic congestion, reckless driving and hotspots for criminal activities. It is apparent that for people using public transport once they start affording to buy own vehicle, they would make a shift and this will increase environment consequences making our fight for sustainability far from over. The study concludes that public transport in a developing world needs to be understood from a holistic perspective to identify the leverage points which are critical points of intervention that may assist in planning for sustainable public transport.

Keywords: sustainability, public transport, modal choice, sustainable development goals, urban planning

2 INTRODUCTION

Cities are concentrated with a variety of economic activities and spatial structures that are supported by transportation. Nonetheless, increased urbanisation has perpetuated transportation challenges and deteriorated cities in the Global South, manifested through ineffecient public transport systems (Andreasen and Moller-Jensen, 2017; Chakwizira, et al. 2019; Moyo, et al. 2021). As a result, most African cities have been working towards sustainable development since the turn of the 21st century (Taghvaee, et al. 2020). One of the most important aspect in the sustainable development discourse is sustainable public transport. The need to achieve sustainable public transport has found its way into strategies and policies in many African cities. Ochoa-Covarrubias, Grindlay, and Lizarraga (2021) state that sustainable transport development and provision makes reference to “access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations”.

However, despite the existence of Urban Agendas, Sustainable Development Goals (SDGs), African Agendas making their way into national policies in African cities, (Sam, Hamidu and Daniels, 2018), there is a continued reliance on private motor vehicle mode of transport (Risimati and Gumbo, 2019; Gumbo and Moyo, 2020). The increase in car ownership and informal public transport in South Africa have been identified as the main contributors of traffic congestion in Johannesburg (Gumbo et al, 2022; Moyo, et al. 2022). The existing mobility challenges patent by increase in traffic congestion has affected people’s travel mode of choice . Therefore, this demands a shift in the mind-set to better understand reasons behind people’s modal choices and their experiences with public transport.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Considering that public transportation is the main tool for socio-economic, physical, political and environmental development, this paper aims at analysing commuter's modal choice for an improved public transportation. This paper makes three key contributions to the practise and field of public transport studies. First, it extends the understanding of analysing complex issues in public transport for sustainable public transport. Secondly, the article gives rear mirror in the experiences of different demographics with public transport. Finally, the paper makes contribution to a small untapped research focus on public transport. This will be done by using Johannesburg commuters lived experiences of both private and public transport users while noting the different dynamics in different African cities. The paper commences with a brief background of the research topic and conceptual framework. Followed by description of Braamfontein, Johannesburg, the study area. The research methodology section outlines data collection procedure undertaken. The results section analyses findings from data collected. The policy recommendations and lessons learned section narrates lived experiences of people in Braamfontein and provides direction for policy making. Lastly is the conclusion.

3 CONCEPTUAL FRAMEWORK

Sustinable public transport as explained in the introductory section is mostly aimed in satisfying the user. The lived experiences provide insights on the envisioned transportation modes from people's lense.

3.1 Modal Choice

Modal choice is an area of research that has taken interest in various disciplines. The usage of different mobility options depends on the user 's needs. Indeed, transportation users are the ones making decision on the type of transport mode to choose depending on their needs and requirements. In fact, research shows that the decision on the choice of mode depends on variety of factors (Tyrinopoulos and Antoniou, 2013; Cheng, et al. 2019; Samimi, et al. 2020). The determining factors are dependent on the user and the structure of the city. The factors affecting users of transportation differs from socio-economic attributes, transportation attributes, trip related and environmental attributes (Suaa, et al. 2022). The way the city is designed is dependent on the inability of existing policy and legislation framework to encourage public transport by initiating different strategies in a city and investment in public transport infrastructure (Gao, et al. 2022; Lee, et al. 2022). In an effort to understand modal choice, Mayo and Taboada, (2020) conducted a study on attributes affecting modal choice. Factors such as safety in public transport, lenient and unrelevant policies and legislative framework on private vehicle increased motor vehicle ownership making public transport less preffered modal choice. Jia et al. (2018) analysed users awareness of the impact caused by their modal choice on the environment, factors such as speed, comfort and safety were the determining factors for modal choice despite the harmful impact they cause to the environment. Moreover, socio-demographics contributed towards modal choice. Mehdizadeh, Nordfjaern and Mamdoohi (2020) enthisised that it is vital to analyse demographics and other related attributes affecting modal choice in policy and practice. Improved quality of services determined by factors affecting modal choice in transport significantly influences a shift to more sustainable mobility options. Consequently, analyzing modal choice is allows understanding people travel patterns in order to improve future public transport while making them sustainable.

3.2 Sustainable public transport in Johannesburg, South Africa

particularly in South Africa. The city of Johannesburg Integrated Master Plan aims for efficient integrated transport system to achieve sustainable transport. At the centre of this system is public transport with special focus on rail as the backbone for sustainable public transport (Department of Roads and Transport report, 2022/23). The Integrated transport systems goals gave birth to BRT (Bus Rapid Transit), High speed train and smart mobility (Department of Roads and Transport report, 2022/23). Conversely, there has been an increase in travelling time by public transport from 46 minutes in 2014 to 57 minutes in 2020 in the city of Johannesburg, this increase is estimated at 17% (Gauteng Household Travel Survey, 2020). In addition, walking to first public transport takes even longer, from 9 minutes to 14 minutes by the year 2020 (Gauteng Household Travel Survey, 2020). The estimated delay in trip duration has declined the economy of Johannesburg (Moyo, et al. 2022). Indeed Olvera, et al (2020) acknowledge that the existing mass transit is to some extend unable to give full user satisfaction.

The existing conventional public transport has not been able to meet the needs of the people and this is evident from increased usage of paratransit modes of transport (Dzisi, et al, 2022). Paratransit is a primary

mode of public transport in African cities often subsidizing conventional public transport (Cirella, et al. 2019). This informal mode of public transport is said to be used by more than 70% daily commuters (Tchanche, 2018). Examples are minibus taxis, tuk-tuk, motorcycles and bicycle taxis. However, these paratransit modes are often contributors of major pollution in cities and are usually referred to as unsustainable, unsafe, unlicensed informal, chaotic mode of transport (Tchanche, 2018; Abraham, et al. 2021).

4 STUDY AREA

Johannesburg is the economic hub of Gauteng, and number one destination for most Africans (Risimati, Gumbo and Chakwizira, 2021: 2). The paper focuses on Braamfontein, a suburb in the centre of Johannesburg (figure 1) and has gained popularity as the safer node for middle and creative class (Hoogendoorn and Gregory, 2016).

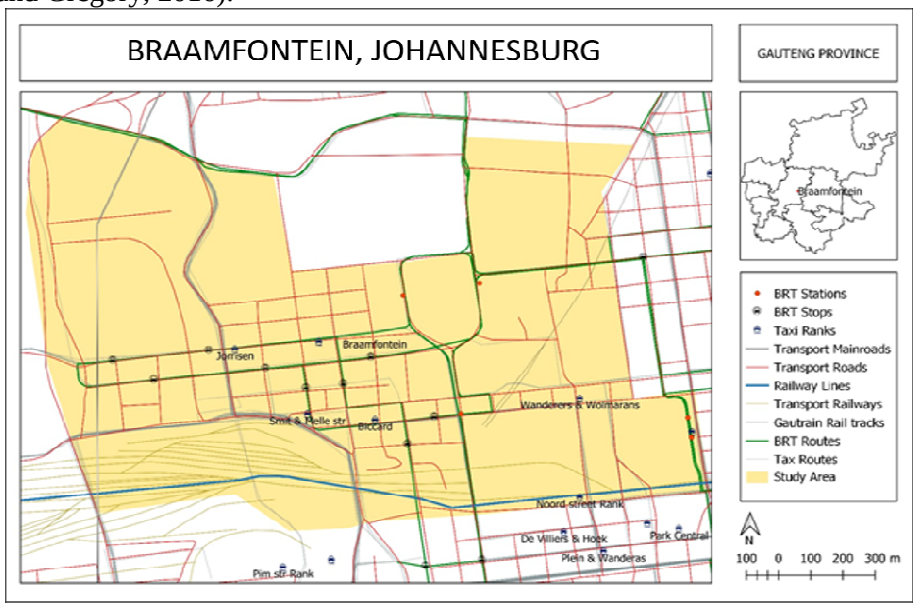


Figure 1: Location map of Braamfontein

Braamfontein has been one of the oldest suburbs in the city of Johannesburg dating back to 1886. As the city of Johannesburg developed, so did Braamfontein. Braamfontein reconstruction in the early 1950s, the regeneration projects and development of BRT, that later followed, attracted many investors in Braamfontein and made it one of the busiest places in Johannesburg (Gregory and Rogerson, 2019). Currently, what was once a small town has turned into the busiest, firm high density precinct that has attracted students, young professionals and low to high income households to the city. Approximately 3000 people visit Braamfontein on a weekly basis (Bank, Cloete and van Schalkwyk, 2018). The tourists and existing population makes it an interesting study area for public transport since public transport is an essential component for socio-economic growth for a city.

5 MATERIALS AND METHODS

The case study research design and quantitative data in a form of questionnaires were used to determine the commuters modal choice. It was noted that the travelling patterns for transport users varies throughout the day. Therefore, data was collected during morning rush, during the day and afternoon peak hours to rule out bias that may be caused by sampling time. This ensured that commuters using different modes of transport were interviewed. This paper used a cluster sampling technique to identify respondents to be interviewed for this research. Cluster sampling technique divides the population of interest in groups and randomly select from each cluster to represent the sample of the study (Ebeto, 2017). Following cluster sampling technique, questionnaire based survey were administered to 300 respondents.

The survey questions were divided into different sections to critically understand the topic in this paper. The first section of the questionnaire focused more on the socio economic aspects of the commuting population. The second section investigated both public and private car users to understand factors affecting modal

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

choice. Lastly, the respondents were probed on their travelling patterns. The data collection was done in three stages to avoid bias and increase variability for research results (figure 2):

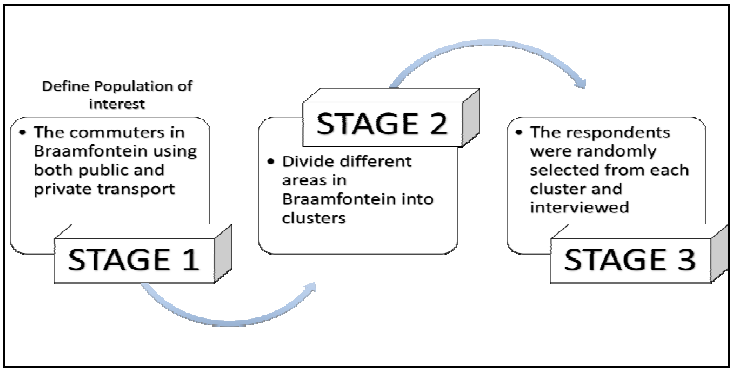


Figure 2: Framework followed for data collection

The data collected was analyzed through google forms. In google forms, the questionnaires were created and data from the 300 respondents was entered by storing all the responses in the created questionnaires. Furthermore, the analyzed data in google forms was then imported in both microsoft excel and matlab for more graphic analyzation of the results. Secondary data was used to complement the collected data.

6 FINDINGS

The findings presented in this paper are conveyed through the socio-economic profile, population ditsribution, preferences on transportation modes, factors determining mode of transport and travelling patterns of the respondents.

6.1 Socio economic aspects

The results in figure 3 revealed that the age group with the highest secondary education beackgound is the Under 20 leading with 82%, followed by 21-30 age group with 43% and lastly, over 30 age group at 16%. The first entry category is made up of Certificate and Diploma holders. In this category, the leading age group with 40% is respondents between the age of 21-30. The over 30 age group takes the lead with 29% degree holders and 8% postgraduates.

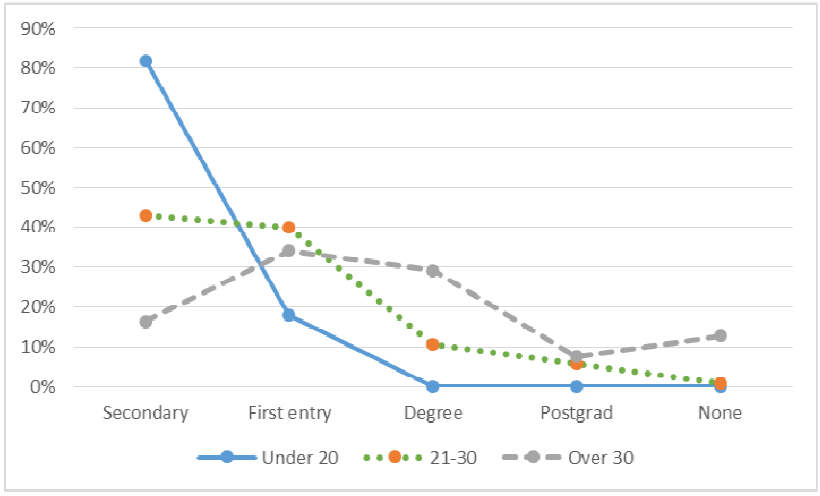


Figure 3: Education level of commuters from sampled population in Braamfontein by age

Therefore, it is eminent from the results in figure 3 that the sampled commuters in Braamfontein is composed of fairly educated population, with only 10% over 30 year old respondents with no educational background.

The respondents were further proped on their occupation status (Figure 4). The data shows that from the sample, most commuters (79%) are students between the age of 21-30 years. Although 45% aged over 30 are employed, a fair number of the respondents between age 21-30 are also employed with no record of the retired. In addition, the results also shows the diversity of the sample from the data collected.

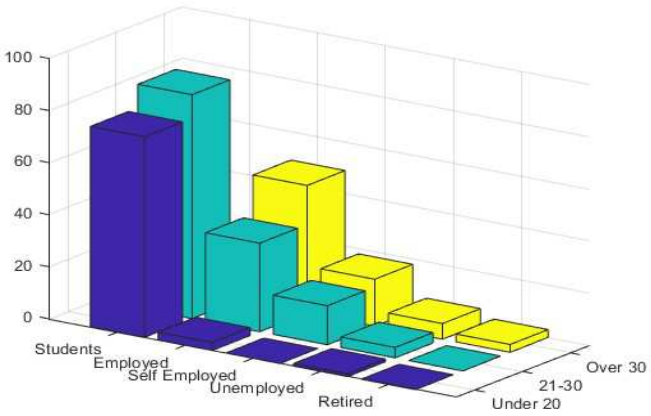


Figure 4: Occupation status of commuters from sampled population in Braamfontein by age

The sample as depicted in figure 4 is highly mixed with students, young professionals, the unemployed, self employed and retired. The results are in correlation with Bank, et al (2018) whose finding were that Braamfontein consists of different population dynamics. These makes Braamfontein an interesting place for this study.

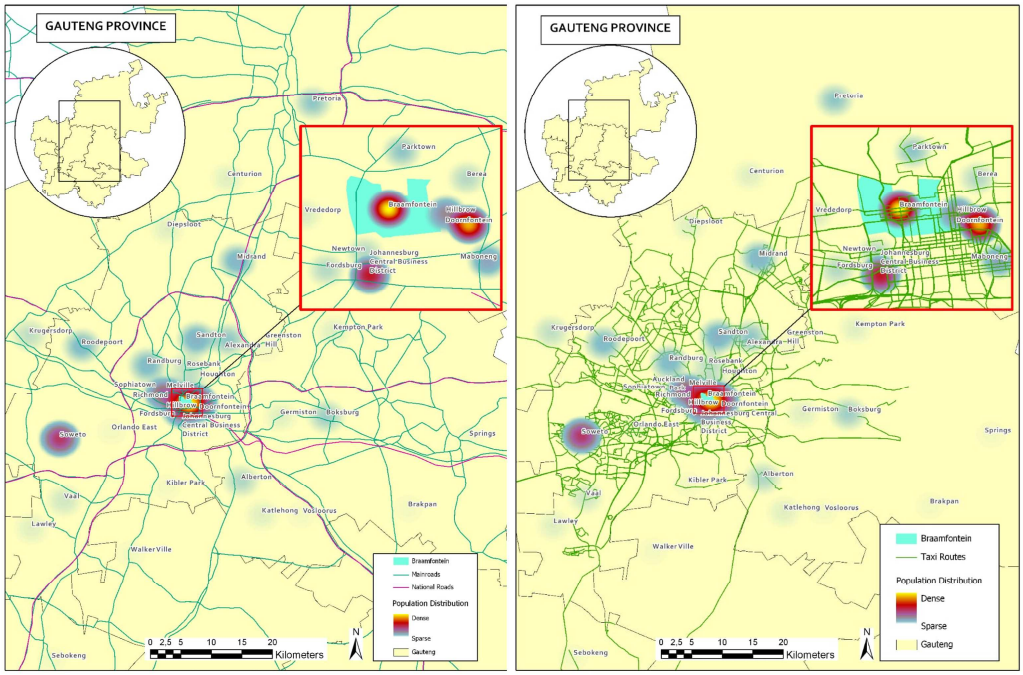


Figure 5: Analysis of population distribution using mini bus and ride hailing routes

6.2 Population distribution on respondents

The maps in figure 5 and 6 shows the respondents place of residence. Majority of the respondent resides from the west and in the centre of Braamfontein. Additionally, the maps represents the existing routes used by different public transport mode available in the city of Johannesburg.

In figure 5, the depicted routes are used by ride hailing services and mini bus taxis. The two modes based on figure 5 are the most accessible modes of public transport in and outside of the city. While the BRT is not far behind (Figure 6) interms of accessibility, most of the respondents have to take either a mini bus taxi or a ride hailing mode to drop them off at a Gautrain station to be able to access a train. Unlike a mini bus taxi and ride hailing, Gautrain does not have convenient routes based on reponses from respondents.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

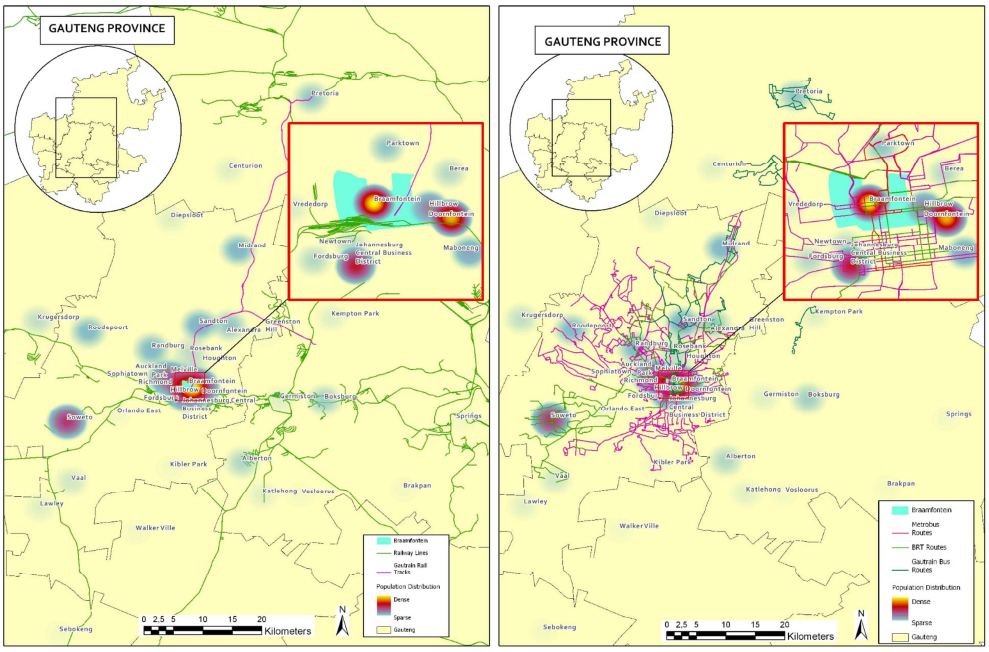


Figure 6: Analysis of population distribution showing railway and BRT routes

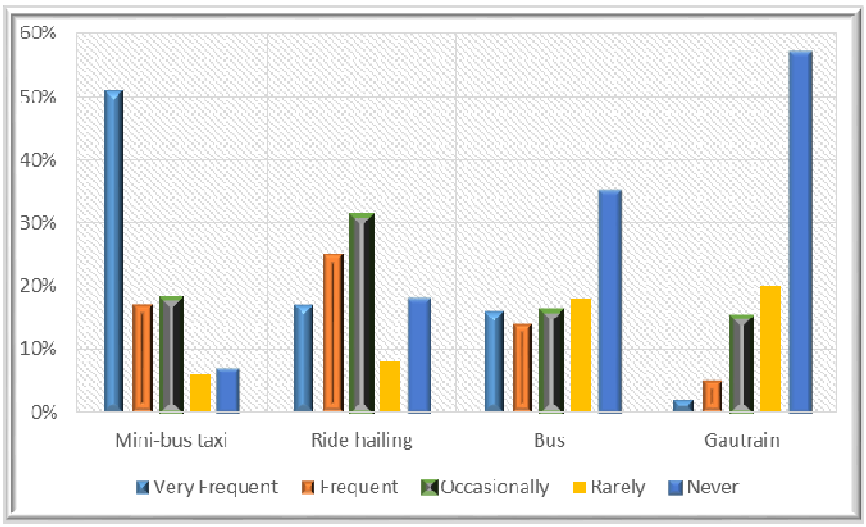


Figure 7: The highly used mode of public transport

In addition, the level of accessibility also depends on the availability of public transport at the time they are needed since they are not always available. Figure 7 depicts the mostly used mode of transport by respondents to travel in and out of Braamfontein.

The highly used mode of public transport (figure 7) is mini bus taxis with 52%. Ride hailing was the common used mode of public transport with 28% of the respondents used it very frequent. The majority of the respondents (58%) have never used a Gautrain and 35% have never used Bus to commute to Braamfontein. It was important to understand reasons for frequent use or lack of a mode of public transport. The frequent use of mini bus taxis was based more on affordability for mini bus taxis despite their criticism on attitudes of drivers for the mode. Ride hailing is occasionally used because of the unsafety associated with the mode and the cost people inquire. One respondent said:

"Ride hailing services are unpredictable, yesterday I requested, and on the mid way to the destination, the driver told me the amount will increase based on traffic on the road and these is common among ride hailing drivers".

Indeed the issue of safety in public transport is one of the factors determining mode choice as depicted in figure 8. Figure 8(a) represents the occurence of the determinging factors in mode choice. It is evident from the results that convenience (13%), safety (13%) and reliable (13%/) are not the determining factors of why

people choose public transport. In private transport, affordability (8%) does not contribute to the modal choice.

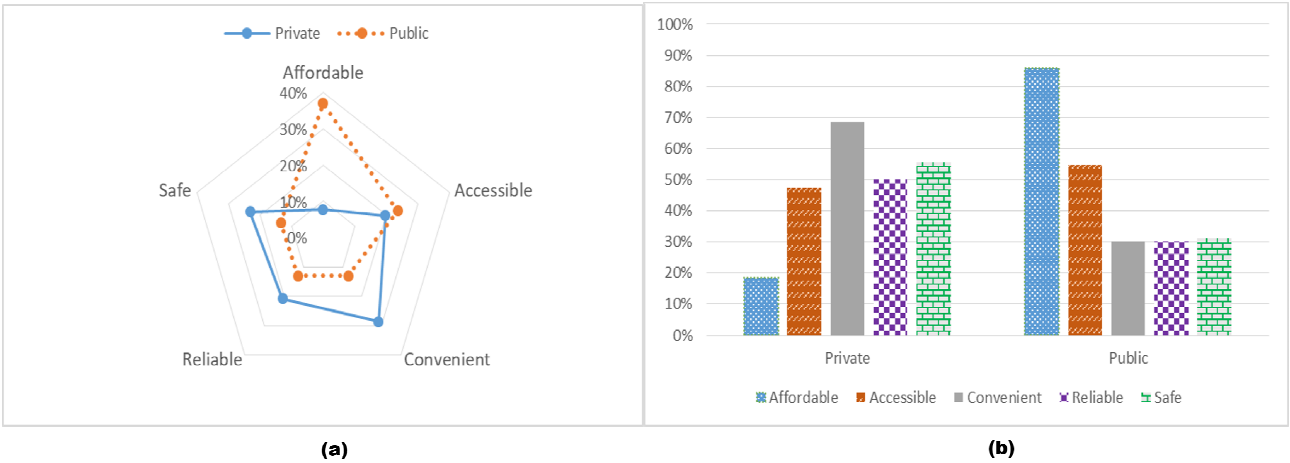


Figure 8: Factors determining mode choice

Additionally, in figure 8(b), In private transport, convenience was rated at 69% as the most important attribute and in public transport, affordability at (86%) is the most important factors to respondents.

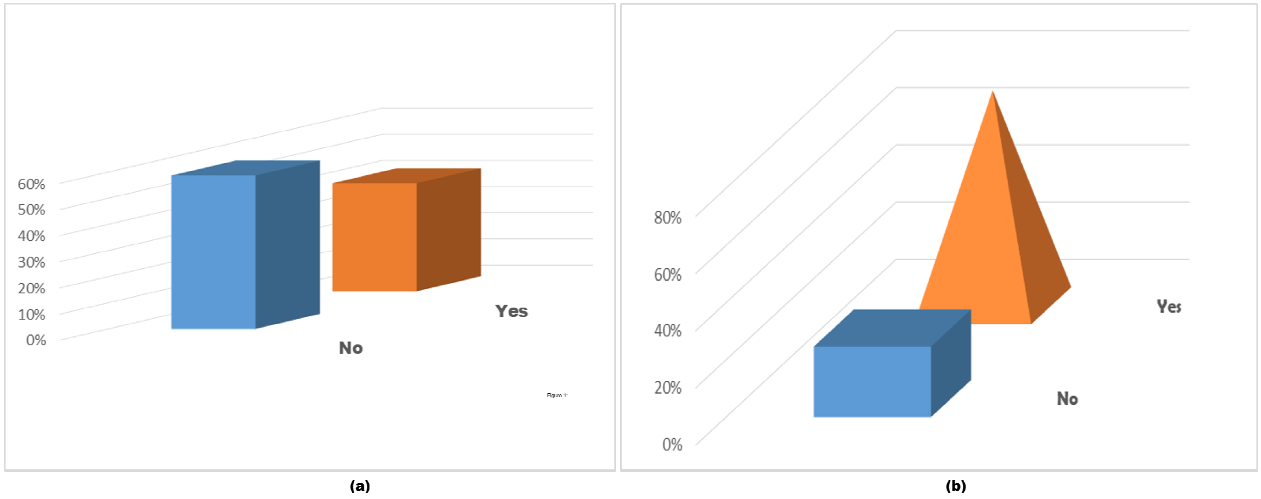


Figure 9: (a) Respondents responses to car ownership, (b) respondents preference on using own motor vehicle to commute

6.3 Motor vehicle ownership

The majority of the respondents (59%) have no access to own motor vehicle while only 41% have motor vehicles in figure 9(a). Furthermore, out of the respondents that have motor vehicle, 75% prefer using their own motor vehicle to commute to Braamfontein while 25% prefer to use public transport (figure 9b).

The respondents in figure 9(b) who prefer to use public transport stated that because of the unsafe environment in Braamfontein, they are afraid of their motor vehicle being stolen while some respondents complained of the lack of parking spaces due to congestion in the city.

6.4 Travelling patterns

In a city faced with increasingly usage of private motor vehicle, it was important to analyse travel patterns of users of both transportation modes. It is is evident from figure 10 that the respondents find it extremely difficult travelling around the city using public transport at night, with 50% of the respondents ranking it below 10, and 75% ranking it at 10.

It is equally difficult to travel using private transport in the moring with 50% of the respondents ranking the difficulty at 8 or less than 8.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

7 DISCUSSIONS

The analysis of the results was delivered as a road map into understanding respondents experiences with different transportation modes. The daily commuters from the sampled population are educated, young adults who commutes for educational activities and work related activities. Most of these respondents are young adults between the ages of 21-30 years old from all works of life, mostly living in the city centre and outskirts of Johannesburg city. Those living in the city centre were also part of the respondents using public transport and private transport to travel to work and school. This is because according to the repondents, the city is deemed an unsafe environment for people walking with valuable things like electronics and money. The population distribution reveals Braamfontein as a meet point for most of the respondents.

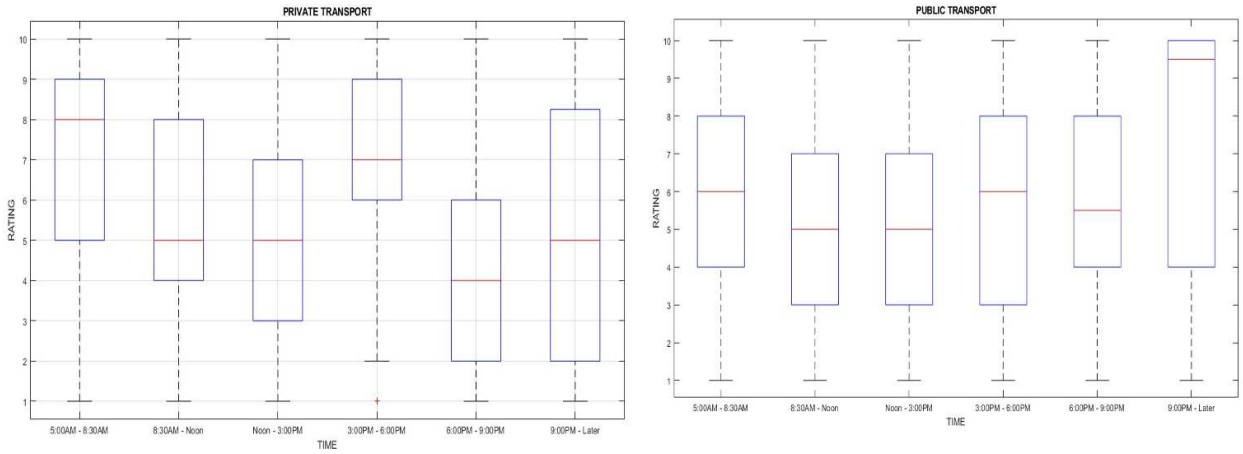


Figure 10: Difficulties in travelling using private and public transport by time travelled

The frequent use of public transport by respondents is in line with findings by Moyo et al. (2022) pointing that mini bus taxis and buses are used by the majority of population in the city of Johannesburg. Although praised by most respondents as the most comfortable and convenient mode of public transport, ride hailing is unsafe and very costly. Most of the respondents experienced a life threatening moment, encountered abuse or had their friends and family experience such traumatic experience using ride hailing services. The stories of respondents are also evident with their experiences in mini bus taxi ranks, where difference in language is asking for threats and humuliations from the mini bus taxi drivers. One lady was quoted saying

“One day I was in MTN taxi rank when two guys came from nowhere and took all my belonging, while the taxi drivers and people watched, pretending they are not seeing what is happening in their presence. Instead of getting help after I screamed for help, one man passed by me and told me to stop showing off, this is Gauteng, the city of lions”.

There were so many stories told of respondents experiences with public transport. Most of the respondents using private transport understand the effects of increased car ownership but they are determined to pay the price for their own convenience and safety. The factors determining usage of both private and public transport paints a picture of what public transport lacks that explains the increasing usage of private transport. The unavailability of public transport after 6pm makes it difficult for frontline workers to travel to and from work for their night shift. The results are clear indication that for this study, socio-demographics does not have a direct influence on modal choice, however, occupational status does. Most of the respondent choice to use public transport relies more on affordability, availability and majority of those living in the outskirts of town rely heavily on mini bus taxis. The conventional mode of transport to the respeondents are often expensive, not convenient to an extend where once the repondents afford to buy own motor vehicle, they will make a shift of modal choice to private vehicle.

8 POLICY IMPLICATIONS AND LESSONS LEARNED

Sustainable public transport is a vision that can be achieved. However, questions remain:. Are our strategies in line of our realities? Are we being fully inclusive? The questions bears answers in this study. Public transport is used by different demographics, and policy needs to understand the reasons for modal choices by contextualising the strategies locally. The existing policy aimed in promoting sustainable public transport continues to put rail as the backbone of this initiative but according to the respondents, it is few people ,s

mode of choice. The master plan for integrated transportation is therefore not inclusive to the majority of the respondents. The development of our policies based on the respondents is continually ignoring the lived realities on the ground. The involvement of private transport users in this study was set to give an example of what aspects of private transport are people drawn to that could possibly be inherited by public transport. There was concensus during data collection where respondent had the same idea that as soon as they get employed into better paying jobs, they will make a shift to private cars. These provide lessons for the future of sustainable public transport.

Moreover,as technology advances, it becomes very hard to control different dynamics in our society.This is evident from horrific experiences of ride hailing users. Thus, it is important to formulate policies that are futuristic so that as our cities develops, technology advances, people are not threatened rather eager to take part in the economic life using different public transport mode of choice that are sustainable.

9 CONCLUSIONS

The paper pursued to understand user's modal choice of different transportation modes and the factors determining modal choice. The highly used mode and travelling patterns were also analysed. Although it is clear from the article that there is no size fits all solution to sustainable public transport. However, studying demographics of the place, investigating people's experiences in a city is a step in a right direction in improving public transport that does not only include the vulnerable groups but also attract private motor vehicle users to use as well for the future of sustainable African cities. Moreover, the findings focused more on the descriptive analysis, however, there is a potential to explore different machine learning techniques to uncover key insights for an improved public transport. It will be interesting to explore gender dynamics in public transport as well, to be able to map the gender differences and experiences with different public transport modes.

10 ACKNOWLEDGEMENT

This work is partly supported by the National Research Foundation South Africa, Grant Number 129925, South Africa/France (Protea) Joint Research Programme-PercepTrans project.

11 REFERENCES

Abraham, C.J., Rix, A.J., Ndibatya, I. and Booysen, M.J., 2021. Ray of hope for sub-Saharan Africa's paratransit: Solar charging of urban electric minibus taxis in South Africa. Energy for Sustainable Development, 64, pp.118-127, https://doi.org/10.1016/j.esd.2021.08.003.

Acar, C. and Dincer, I. 2020. The potential role of hydrogen as a sustainable transportation fuel to combat global warming. International Journal of Hydrogen Energy, 45(5), pp.3396-3406.

Bank, L., Cloete, N. and Van Schalkwyk, F. 2018. Anchored in Place: Rethinking the university and development in South Africa. Cape Town: African Minds.

Cheng, L., Chen, X., De Vos, J., Lai, X. and Witlox, F. 2019. Applying a random forest method approach to model travel mode choice behavior. Travel behaviour and society, 14, pp.1-10, https://doi.org/10.1016/j.tbs.2018.09.002.

Cirella, G. T., Bąk, M., Kozlak, A., Pawłowska, B. and Borkowski, P. 2019. Transport innovations for elderly people. Research in Transportation Business & Management, 30, pp. 1-17, https://doi.org/10.1016/j.rtbm.2019.100381.

de la Torre, R., Corlu, C.G., Faulin, J., Onggo, B.S. and Juan, A.A., 2021. Simulation, optimization, and machine learning in sustainable transportation systems: models and applications. Sustainability, 13(3), pp. 1-21, https://doi.org/10.3390/su13031551.

De Ona, J., Est´evez, E. and de Ona, R. 2021. Public transport users versus private vehicle users: Differences about quality of service, satisfaction and attitudes toward public transport in Madrid (Spain). Travel Behaviour and Society, 23, pp. 76-85, https://doi.org/10.1016/j.tbs.2020.11.003.

Dzisi, E.K.J., Obeng, D.A., Ackaah, W. and Tuffour, Y.A., 2022. MaaS for paratransit minibus taxis in developing countries: A review. Travel Behaviour and Society, 26, pp.18-27, https://doi.org/10.1016/j.tbs.2021.09.001.

Gao, K., Shao, M., Axhausen, K. W., Sun, L., Tu, H. and Wang, Y. 2022. Inertia efects of past behavior in commuting modal shift behavior: interactions, variations and implications for demand estimation. Transportation, 49, pp. 1063–1097, https://doi.org/10.1007/s11116-021-10203-6.

Gregory, J.J. and Rogerson, J.M., 2019. Studentification and commodification of student lifestyle in Braamfontein, Johannesburg. Urbani izziv, 30, pp. 178-193, https://doi.org/10.1016/j.rtbm.2019.100381.

Gumbo, T., Moyo, T., Ndwandwe, B., Brightnes., R. and Mbatha, S .2022. Urban Public Transport Systems Innovations in the Era of the Fourth Industrial Revolution: Perspectives, Reflections and Conjectures. Springer Nature Switzerland: AG, https://link.springer.com/book/10.1007/9783030987176.

Gumbo, T., and Thembani, M. 2020. Exploring the Interoperability of Public Transport Systems for Sustainable Mobility in Developing Cities: Lessons from Johannesburg Metropolitan City, South Africa. Sustainability, 12(5875), pp. 1-16, https://doi:10.3390/su12155875.

Hoogendoorn, G. and Gregory, J. 2016, Instagrammers, urban renewal and the Johannesburg inner city. In Urban Forum, 27(4), pp. 399-414. Springer Netherlands.

Jennings, G. and Arogundade, E., 2021. Women were put on the back-end: covid-19 mobility constraints and their lessons and implications for gender-equity in Sub-Saharan Africa. 39th International Southern African Transport Conference, 05 - 07 July Pretoria: South Africa.

Jia, N., Li, L., Ling, S., Ma, S. and Yao, W. 2018. Influence of attitudinal and low-carbon factors on behavioral intention of commuting mode choice–A cross-city study in China. Transportation research part A: policy and practice, 111, pp. 108-118, https://doi.org/10.1016/j.tra.2018.03.010.

Lee, S., Lee, J., Mastrigt, S. H. and Kim, E. 2022. What cities have is how people travel: Conceptualizing a data-mining-driven modal split framework. Cities, 131, pp. 1-12, https://doi.org/10.1016/j.cities.2022.103902.

Ma, L., Kent, J. L. and Mulley, C. 2018. Transport disadvantage, social exclusion, and subjective well-being. Journal of transport and land use, 11(1), pp.31-47, http://dx.doi.org/10.5198/jtlu.2018.1008.

Machado-León, J. L., de Oña, R., Baouni, T. and de Oña, J. 2017. Railway transit services in Algiers: priority improvement actions based on users perceptions. Transport Policy, 53, pp.175-185, https://doi.org/10.1016/j.tranpol.2016.10.004.

Mayo, F. L. and Taboada, E .B. 2020. Ranking factors affecting public transport mode choice of commuters in an urban city of a developing country using analytic hierarchy process: The case of Metro Cebu, Philippines. Transportation Research Interdisciplinary Perspectives, 4, pp. 1-12, http://dx.doi.org/10.1016/j.trip.2019.100078.

Mehdizadeh, M., Nordfjaern, T. and Mamdoohi, A. 2020. Environmental norms and sustainable transport mode choice on children's school travels: The norm-activation theory. International Journal of Sustainable Transportation, 14(2), pp. 137-149, https://doi.10.1080/15568318.2018.1532542.

Moyo, T., Kibangou, A. and Musakwa, W., 2020. Exploring the Potential of Traffic Index Data to Analyze Essential Traffic Impact in Developing Cities. In ISPRS 2020-XXIV ISPRS Congress International Society for Photogrammetry and Remote Sensing, Vol. 43, pp. 137-141.

Moyo, T., Kibangou, A.Y. and Musakwa, W., 2021. Societal context-dependent multi-modal transportation network augmentation in Johannesburg, South Africa. Plos one, 16(4), p.e0249014.

Moyo, T., Mbatha, S., Aderibigbe, O. O., Gumbo, T., and Musonda, I. 2022. Assessing Spatial Variations of Traffic Congestion Using Traffic Index Data in a Developing City: Lessons from Johannesburg, South Africa. Sustainability, 14(8809), pp. 1-16, https://doi.org/10.3390/ su14148809.

Mugion, R. G., Toni, M., Raharjo, H., Di Pietro, L. and Sebathu, S. P. 2018. Does the service quality of urban public transport enhance sustainable mobility? Journal of Cleaner Production, 174, pp. 1566-1587, https://doi.org/10.1016/j.jclepro.2017.11.052.

Ochoa-Covarrubias, G., Grindlay, A.L. and Lizarraga, C. 2021. Does the Mass Public Transport System Cover the Social Transport Needs? Targeting SDG 11.2 in Guadalajara, Mexico. Applied Sciences, 11(16), pp. 1-18, https://doi.org/10.3390/app11167709 .

Olvera, L. D., Plat, D. and Pochet, P. 2020. Looking for the obvious: Motorcycle taxi services in Sub-Saharan African cities. Journal of Transport Geography, 88, pp. 1-14, https://doi.org/10.1016/j.jtrangeo.2019.102476.

Reis, V. and Macario, R. 2019. Understanding the freight transport sector. Intermodal Freight Transportation, pp. 13-14, https://doi.org/10.1016/B978-0-12-814464-0.00002-5.

Risimati, B. and Gumbo, T. 2019. Mapping the Spatial Integration of Motorised and Non-Motorised Transport Infrastructures: a Case Study of the City of Johannesburg. IN: M. Schrenk, V. V. Popovich, P. Zeile, P. Elisei, C. Beyer, J. Ryser, G. Stöglehner (Eds.). REAL CORP 2019: Is this the real world? Perfect Smart Cities vs. Real Emotional Cities, Germany 2-4 April 2019. Germany: REAL Corp.

Risimati, B., Gumbo, T. and Chakwizira, J. 2021. Spatial Integration of Non-Motorized Transport and Urban Public Transport Infrastructure: A Case of Johannesburg. Sustainability, 13(20), pp. 1-17, https://doi.org/10.3390/su132011461.

Sam, E. F., Hamidu, O. and Daniels, S. 2018. SERVQUAL analysis of public bus transport services in Kumasi metropolis, Ghana: Core user perspectives. Case Studies on Transport Policy, 6(1), pp.25-31, https://doi.org/10.1016/j.cstp.2017.12.004.

Samimi, A., Rahimi, E., Amini, H. and Jamshidi, H. 2020. Freight modal policies toward a sustainable society. Scientia Iranica, 27(6), pp. 2690-2703, https://dx.doi.org/10.24200/sci.2019.21386.

Schalekamp, H. and Klopp, J.M., 2018. Beyond BRT: Innovation in minibus-taxi reform in South African cities. 37th Southern African Transport Conference, 9-12 July Pretoria, South Africa.

Sharma, G. 2017. Pros and cons of different sampling techniques. International Journal of Applied Research, 3(7), pp. 749-752.

Smith, O. 2017. Commute well-being differences by mode: evidence from Portland, Oregon, USA. Journal of Transport Health, 4, pp. 246–254.

South Africa. Department of roads and Transport. 2022/23. Annual performance plan for 2022/23. Gauteng: Government Printer.

Suaa, A.J.Q., Chuaa, H.N., Khoob, H.L., Lowa, Y.C., Leea, A.S.H. and Ismailc, M.A., 2022. User Mode Choice Behavior in Public Transportation: A Systematic Literature Review. Jurnal Kejuruteraan, 34(1), pp.11-28, https://doi.org/10.17576/jkukm-2022-34(1)-02.

Taghvaee, V.M., Arani, A.A., Nodehi, M., Shirazi, J.K., Agheli, L., Ghojogh, H.M.N., Salehnia, N., Mirzaee, A., Taheri, S., Saber, R.M. and Faramarzi, H. 2021. Sustainable development goals: transportation, health and public policy. Review of Economics and Political Science, pp. 1-28.

Tchanche, B. F. 2018. Road transport in Africa: Analysis and appeal for innovation. CasamanSun.Proceedings, VIth Edition, Senegal 3-5 May 2018. Ziguinchor: Asamansun.

Tembe, A., Nakamura, F., Tanaka, S., Ariyoshi, R. and Miura, S. 2019. The demand for public buses in sub-Saharan African cities: case studies from Maputo and Nairobi. IATSS research, 43(2), pp.122-130, https://doi.org/10.1016/j.iatssr.2018.10.003.

Tyrinopoulos, Y. and Antoniou, C., 2013. Factors affecting modal choice in urban mobility. European Transport Research Review, 5(1), pp.27-39.

Wong, R. C. P., Szeto, W. Y., Yang, L., Li, Y. C. and Wong, S. C. 2017. Elderly users' level of satisfaction with public transport services in a high-density and transit-oriented city. Journal of Transport and Health, 7, pp. 209-217, http://dx.doi.org/10.1016/j.jth.2017.10.004/.

Ye, R. and Titheridge, H. 2017. Satisfaction with the commute: the role of travel mode choice, built environment and attitudes. Transport. Res. Transport Environment, 52, pp. 535–547.

🏆 *reviewed paper*

Possibilities of Integrating Motorized Transportation and Non-Motorized Transportation in the City of Johannesburg

Siphiwe Mbatha, Trynos Gumbo

(Siphiwe Given Mbatha, University of Johannesburg, Department of Urban and Regional Planning, Doornfontein Campus, Sixth Floor, John Orr Building, Beit and Siemert Street, 2028. Johannesburg, South Africa, gmbatha@uj.ac.za)
(Prof Trynos Gumbo, University of Johannesburg, Department of Town and Regional planning, Office 6062, Sixth Floor, John Orr Building, Beit and Siemert Street, 2028. Johannesburg, South Africa, tgumbo@uj.ac.za)

1 ABSTRACT

Developed countries around the world has great functioning public transportation systems, that include integration of innovative public transportation and non-motorized transportation creating smooth and seamless travelling in their cities for commuting. City of Johannesburg has numerous modes of public transportation to create convenient travelling across the city, and more innovative public transport systems are being implemented to ensure that the city has the world class transportation including the development of non-motorized transportation infrastructure such as cycling lanes and pedestrian sidewalks. However, there is a challenge of integration between motorized transportation, specifically, innovative public transport (Bus Rapid Transit system (Rea Vaya) and High-speed Rail (Gautrain system)) and non-motorized transportation. This paper aims to assess the possibility of integrating non-motorized transportation and Innovative public transportation, and the level of cycling to switch from bicycle to innovative public transportation by commuters to complete a journey in the City of Johannesburg. The study adopted qualitative research design that facilitated the gathering and analysis of spatial and qualitative data from the innovative urban public transport officials, commuters and the cyclists. The results revealed that there is a possibility of spatial integration between non-motorized transportation and innovative public transportation in different parts of the city. Cycling lanes and pedestrian sidewalks have a direct access to Rea Vaya stations and Gautrain stations, however, there is no development of bicycle parking next to Gautrain stations and Rea Vaya stations. Spatial access of a commuter from Gautrain station to Rea Vaya station is 74,5 metres in Johannesburg Park station were there is visible spatial integration in the city. The paper concludes that there is insufficient cycling across the city, no bicycle parking spots next to innovative public transportation station, no recognised integration between innovative public transportation and non-motorized transportation, commuters either walk or drive private vehicles to Rea Vaya or Gautrain stations. The study recommends the development of bicycle parking stations next to innovative public transportation stations to encourage the usage of cycling, and institutional integration of innovative public transportation to create swift transportation for commuters. Further, development of more non-motorized transportation policies and legislative frameworks that will support and encourage non-motorized transportation and integration of non-motorized transportation and motorized transportation.

Keywords: Non-motorized transport; Innovative public transportation; spatial integration; commuters.

2 INTRODUCTION

South Africa is a developing country on the right path to world class public transportation. Initiatives such as implementation of innovative public transport such as Bus Rapid Transit and High Speed Rail have been developed in the republic. Consequently, implementation of non-motorised transportation (NMT) have been visible as there are various cities across the country that have developed cycling lanes and pedestrian side-walks as some connect people from home to public transport stations and from public transport stations to areas of interest such as areas affording economic opportunities. The above mentioned pespective of implemented strategies are developed to move the republic's public transportation to world class transporation system. Many developed countries globally have well tailored intergrated non-motorized transportation and public transportation that the two concepts of transportation connects swiftly from non-motorized transportation to public transportation, and these strategies are used to encounter many challenges that arise from transportation hence world class cities have such transportation techniques and have been working well. The City of Johannesburg (COJ) is moving towards a world class city, hence, adoption of world class strategies in its transportation planning. Evidence to this, Bus Rapid Transit known as Rea Vaya system, high speed rail has been developed known as Gautrain system operating across three metropolitan municipalities in the Gauteng province which both these public transportation systems are innovative. Consequently, the city has development of cycling lanes in many locations in the City of Johannesburg

municipality together with pedestrian side walks. There is a high need to move from daily use of private motorized vehicles in the City of Johannesburg to combat traffic congestion, air pollution, high rate of car accidents and the use of public transportation have certain benefits such as less stress with driving and free from car accidents, less worrying of finding parking spot, bypass traffic through special lane such of Rea Vaya system, very cheap than owning a private vehicle and operating one. The paper aims to assess the possibility of integrating non-motorized transportation and innovative public transportation (innovative PT) , and the level of cycling to switch from bicycle to innovative public transportation by commuters to complete a journey in the City of Johannesburg. Further, develop a model that will inform NMT and innovatve PT.

3 LITERATURE REVIEW

3.1 Public transportation

Public transportation is a very important factor for the movement of people from origin to destination. It makes the movement of people simple and saves time. However, there are various factors that influence people to switch from urban public transport to private vehicles. These factors are caused by the dynamics of a trip such as travel time, trip motive, and frequent commuting. Further, demographic characteristics has an importance influence such as the level of income, gender and age. As the level of income and age increase, there is a switch that happens from urban public transport to private motor vehicles. Consequently, the most common factors leading to switch from urban public transport to private vehicle use and that makes owners of private vehicle users not to switch to urban public transport are; lack and easy connection for both long and short travelling from origin to destination, switching from one mode to the other mode that are not integrated which have high price costs, access from home or place of interest to the urban public transport station and the quality of service by service providers. Lack of well-tailored systems and network of urban public transportation it's a global challenge hence researchers, policy makers, Transport planners have been developing strategies to produce an effective integrated multimodal system (Maxwell, 1999, Ibrahim, 2003, Vassallo et al., 2012).

3.2 Non-motorized transportation

Non-Motorized Transportation (NMT) includes all forms of travel that do not rely on an engine or motor for movement. This include walking and bicycle, and using small-wheeled transport (skates, skateboards, push scooters and hand carts) and wheelchair (Mat Yazid et al., 2011). The importance of NMT is the provision of door-to-door transport; Non-motorized infrastructure usually has a very high spatial penetration; Non motorized do not lead to waiting times compared with waiting at public transport stops; Non-motorized have a favorable environmental performance; they are cheap transport modes; Non-motorized are essential elements in multimodal transport chains; Non-motorized provide healthy activities (Rietveld, 2001).

In Cape Town, Nairobi and Dar es Salaam, the cities that are relative to the City of Johannesburg, broader transport policies and strategies do include some attention to NMT; both Cape Town and Nairobi have, in addition, developed stand-alone NMT policies. Among the vision statements of the case cities are the following intentions:

- To create a safe, cohesive and comfortable network of footpaths and cycling lanes/tracks that include shade to develop laws and regulations to ensure prioritization of NMT facilities
- To promote investment in walking and cycling infrastructure
- To connect public transport with walking and cycling facilities
- To influence land-use planning and resettlement patterns to achieve easy access to amenities
- To promote a changed culture that accepts the use of cycling and walking as a means to move around in the city (Iacono et al., 2010).

Increasing the modal share of NMT is possible in any country; however the successfulness depends on many country-specific factors, including climate, geography, culture, political commitment, public awareness, policy effort and consistency, long-term vision and the attractiveness of the alternatives. Several of these are interdependent, and as shown by the example of Bogotá, strong NMT policies, awareness campaigns and political commitment can bring about a shift in public attitudes towards NMT and a 4-fold increase in cycle

trips (Witting et al., 2006; IPCC, 2007). Further, the use of NMT has greater benefit environmentally, economically and socially which this is one of the critically reasons to promote and implement it.

Environmental	Social	Economic
Air quality improvement	Congestion reduction	NMT, particylarly cycling, is easy, flexible, cheap and fast.
GHG emission reduction	Health benefits due to exercise. For example, cycling for 30 minutes a day reduces the chance of cardiovascular disease and diabetes by 50% (Witting et al., 2006)	More attractive cities for tourists and residents, particularly if car-free zones are included
	Gender benefits: cycling can be particularly suitable for the many short trips women in developing countries take	Reduced travel times due to improved traffic flow
	Social equality and poverty reduction: cheap, fast and reliable transport opportunities, and public space development directed towards all segments of society (ICE, 2000)	Energy security due to lower vehicle energy use
	Noise reduction	Safety: increase in bicycle use is often accompanied by a reduction in cycling accidents and an increase in safety in public areas (Vanderbulcke et al., 2009; Witting et al., 2006)

Table 1: NMT Benefits [Source: IPCC, 2007]

3.3 Integrated public transportation and non-motorized transportation

Integration of non-motorized transportation makes commuting easier for commuters and allow easy accessibilty to places of interest. The below figure illustrates integration of motorized transportation and non-motorized transportation. Commuting is convinient when there is accessibilty to public transportation. Consequently, public transportation commuting involves non-motorised transportation allowing movement from home to public transportation and from public transportation to destination.

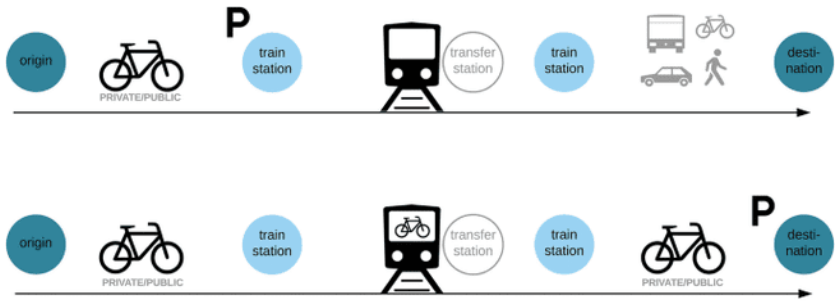


Figure 1: NMT and MT integration [Source: van Mil et.al., 2021]

According to Hall (2006) Integration between different services with fixed routes is not anything new. For example, busses arriving at train stations, even with coordinated timetables between the two transportation modes have been around for quite some time. The problem of scheduling an integrated service consisting of two fixed route services, train and bus, operated by two different operators are for example studied in Li & Lam (2004). Also in Martins & Pato (1998) a combination of train and bus services is studied. The problem is to design a feeder bus network given a rail network, with the objective to minimize a cost function considering both the operator's and the customers' interests. A well integrated public transportation system both rail and road makes easier for more tailored transportation system that include non-motorized transportation. Movement from origin by cycling and switching to public transportation makes commuting easier and attract more users to public transportation, and further, if there are less delays within the public transportation services.

3.4 South Africa NMT and public transportation policy and legislative frameworks

The Republic of South Africa has various policies and legislative frameworks that facilitate and regulate public transportation, and few policies and legislative frameworks that focuses more on non-motorized transportation. However, some of the public transportation policies and legislative frameworks also include non-motorized transportation but a little is mentioned. Below, it is the policies and legislative frameworks that addresses both national public transportation and non-motorized transportation.

3.4.1 White Paper on National Transport Policy, 1996

One of the policy principles of the White Paper is "to encourage, promote and etc.plan for the use of non-motorised transport where appropriate" (Land Passenger Transport Chapter, Strategic Objectives). The White Paper also states that "the use of more energy-efficient and less pollutant modes of transport will be

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

promoted. Greater energy awareness will be fostered in both planners and users of land passenger transport through public awareness programmes, differential fuel prices, etc."

3.4.2 National Land Transport Strategic Framework, 2006 (NLTSF)

The framework provides a sound basis for the promotion of NMT, and strategies and actions are provided in order to achieve this. The NLTSF suggests that planning authorities need to build, expand and maintain continuous networks of formal walkways (sidewalks, off-road paths, safe crossings, and the like.) and dedicated bicycle lanes along lines of high demand. To achieve this, transport plans should assess the status quo and the needs for NMT infrastructure and plan for its design, implementation and maintenance.

- Planning for NMT needs will consider NMT both as a main mode and as a feeder mode linking communities to public transport facilities.
- In rural areas, off-road footpaths, trails and tracks need to be included in the scope of planned rural transport infrastructure.
- In rural areas, animal-drawn carts and other intermediate means of transport will also be supported in transport plans where appropriate. The NLTSF also indicates that walking and cycling should be promoted as the preferred modes in South Africa for appropriate distances and this can be realised through the following:
- Government actively promotes walking and cycling with the expanded provision of NMT infrastructure as the preferred modes of transport over the appropriate distance ranges for these modes.
- Where people are walking excessively long distances on their routine journeys, transport plans should assess the scope for measures to support cycling, particularly for scholars. Both infrastructural measures and supporting services such as bicycle repair services should be considered.
- Successful demonstration projects promoting NMT are initiated and rolled out to other areas.

3.4.3 Public Transport Strategy and Action Plan, 2007

This is a central policy document on public transport, highlighting the creation of integrated rapid public transport networks (IRPTNs), wherein NMT is the key aspect of the 'first mile' and 'last mile' of a trip. The intention is to introduce public transport that would reduce unacceptable walking distances and improve NMT links to public transport. The Public Transport Strategy discusses "high quality non-motorised transport networks". It provides that NMT, particularly walking and cycling, will serve as an important mode of transport in the proposed IRPTNs. It provides that actions to improve NMT linkages fall into typical infrastructure development categories of planning, design, implementation and maintenance.

3.4.4 Department of Transport (DoT) Draft Policy Document on NMT

This policy states that the DoT will cooperate with relevant government departments and stakeholders in developing an institutional and legal framework that responds positively to the needs and implementation of the NMT system. This policy states that the primary objectives are, amongst others, to:

- Increase the role of NMT as one of the key transport modes,
- Integrate NMT as an essential element of public transport and provide a safe NMT infrastructure, and
- Allocate adequate and sustainable funding for the development and promotion of NMT. The document also states that non-motorised transport will be provided on the basis of a number of principles including the need to improve the quality of life, energy conservation and safety. The policy also recognises the main components of non-motorised transport as animal-drawn transport, cycling and walking.

3.4.5 National Land Transport Act 5 of 2009 (NLTA)

The NLTA provides that the Minister of Transport must facilitate the increased use of public transport and, in taking measures relating to public transport, must promote the safety of passengers, promote a strategic

and integrated approach to the provision of public transport and promote the efficient use of energy resources and limit adverse environmental impacts in relation to land transport3 . Section 36 provides that every municipality must produce an Integrated Transport Plan (ITP). In doing so they must comply with the Minimum Requirements for Integrated Transport Plans for which require the larger municipalities to produce a Comprehensive Integrated Transport Plan (CITP) including a Transport Needs Assessment that must give due attention to NMT. These policies and legislative framework are all aligned as they have goal of having non-motorised transportation integrated with public transportation, also, having non-motorized transportation taken as a mode of transport that can be used daily.

4 STUDY AREA

City of Johannesburg is the heart of the economy in the Republic of South Africa affording many different kinds of opportunities such as education, jobs, businesses etc., to many South Africans and international citizens. The city is made up of 7 regions and consists of 130 wards. Johannesburg is a divided city: the poor mostly live in the southern suburbs or on the peripheries of the far north, and the middle- and upper class live largely in the suburbs of the central and north (Smith, 2012). Around 20% of the city lives in abject poverty in informal settlements that lack proper roads, electricity, or any other kind of direct municipal service. Another 40% live in inadequate housing with insufficient municipal housing.

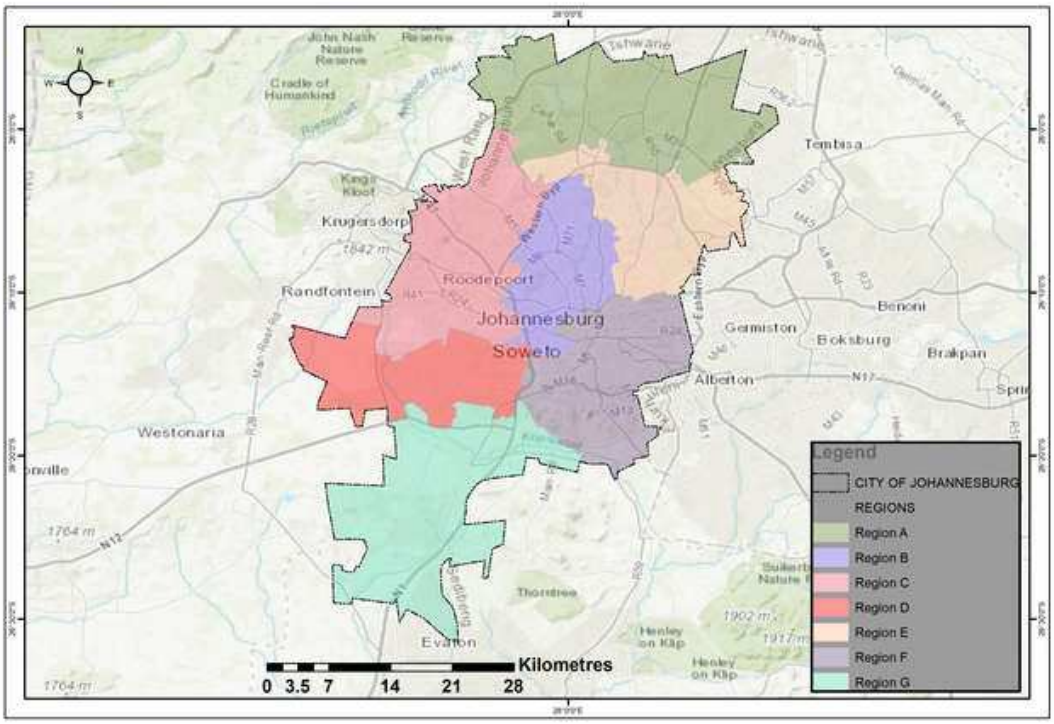


Figure 2: City of Johannesburg Map [Source: Authors, 2022]

Region A, B, C, D, E, F have the development of non-motorized transportation infrastracture such as cycling lanes with pedestrian side walks. Regions A, B, E, F, have the provision of innovative public transport, specifically, Gautrain and Gaubus system services and all regions across the city have the provision of Rea Vaya system, howerever, it does not sevice all locations and there is need for extensions. The City of Johannesburg innovative public transportation system is spread well across as in the northern areas there is dominance of Gaubus system and in the southern areas there is availability of Rea Vaya system, which however in time, there will be equivalent spread of both systems. Further, in the centre, there is availability of both system.

5 METHODOLOGY

A mixed method research design was adopted where qualitative data and spatial data analysis was used. Various research instruments were employed in the study. Ten interviews were carried out with officials from different departments, including the Johannesburg Road Agency, Department of Transport, Gautrain and BRT officials and Metropolitan Municipalities transport planners/ They assisted in providing insights for

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

the study about the possibility of integrating non-motorised transportation and innovative public transportation as well as the different public transport modes (bus and train) in general. Accordingly, commuters were also interviewed to understand the commuter patterns and if there are any commuters who cycle to connect to innovative public transportation. 40 different daily commuters were interviewed who may have different experiences taking place daily. Purposive sampling was adopted as it was necessary to conduct interviews with informed officials and commuters. ArcGIS assisted with creating Gautrain rail tracks and Gaubus routes and stations; BRT route maps were showing locations serviced; Cycling lanes network patterns, together with physical integration of the innovative public transportation modes. BRT data (shapefiles), Gautrain data (shapefiles), Cycling lanes data (shapefiles), interviews, observations and documented studies relating to this study were the sources of data. Experimental analysis was conducted to understand the network patterns of NMT and innovatve PT to identify possible areas of spatial integration. Further, content analysis was employed to review previous documented studies. Secondary data used was obtained from larger data base such as Scopus, Science direct, Sage and Google scholar.

6 FINDINGS

The development of non-motorized public transportation and innovative public transportation in the City of Johanneburg Metropolitan Municipality exist and the spatial integration between NMT and innovative PT in some locations is evident to indicate that the transport planners, urban planners and other stakeholders have been working on implementing integrating all transportation systems and modes to create effecient commuting across the city. However, not all aspects of cycling were addressed correctly to promote the use of cycling as a mode of transportation. The designed cycling lanes that currently exists, most individuals perceive them to be created for recreational purpose but not promoting a holistical transportation system. The lack of awareness campaign is one of the critical factors in regards to this matter. Consequently, most commuters indicated that the designed cycling lanes some of them do lead to public transportation modes stations/ hubs, however, there are no cycling parking lots next to the stations, this psychologically indicate that you can not use a bicycle to connect to public transportation. Further, it was indicated that cycling around the CBD its akward and dangerous as there is too much traffic of motor vehicles on the roads.

Cycling across the City of Johannesburg is not commonly used as a mode of transportation and only 2% use it as transportation and not for trips more than 15km. It has be noted that most of the cycling that takes place across the city (i) it is for entertainment purposes such as events, (ii) cycling clubs, (iii) keeping fit as mode of excercise, which this mostly happen on weekends and after working hours. Officials indicated that the development of cycling lanes is part of a strategy to integrate public transportation and non-motorised transportation, however, city residents are not used to cycling or encouaraged to cycle.

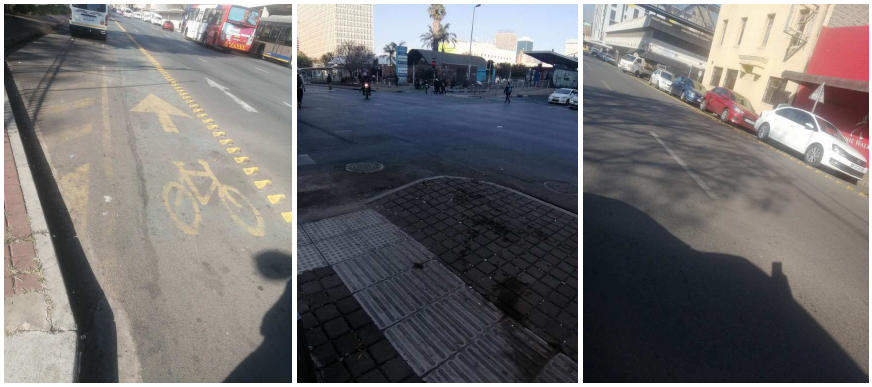


Figure 3: NMT and MT spatial integration around the CBD [Source: Authors, 2022]

The above figure 3 indicates Park station in the City of Johannesburg were there is feasible spatial integration of NMT and innovative public transportation and other areas within the CBD. The first image indicate the cycling lanes that are developed around the CBD for cycling. The second image indicates the BRT Rea Vaya station that is next to Gautrain and Gaubus station, with also development of cycling lanes just next to the innovative public transportation stations. Further, the third image shows the cycling lanes in the other areas around the CBD, howerever, the image indicate the current situation of the developed cycling lanes that are found around the CBD which indicate that the lack of usage in cycling lanes motorists turn

these cycling lanes into side parking for motor vehicles and this has occured for a number of years after immediate developement of the cycling lanes.

Figure 4: COJ south townships NMT and MT spatial integration [Source: Authors, 2022]

The above figure 4 indicates the development of non-motorised transportation infrastructure and innovative public transportation system in the southern township areas of the City of Johannesburg. The first image indicate the cycling lanes that are currently developed and there are more developments of cycling lanes taking place. The second image indicate the spatial integration of non-motorized transportation infrastructure with Rea Vaya system. The third image, indicates the pedestrian side-walks that have been developed together with cycling lanes. Rea Vaya system is the only innovative public transportation developed in the sourthern areas of the city. Therefore, the spatial integration that currently exists in some areas are between non-motorized transportation and Rea Vaya system. The development of cycling lanes in these areas are mostly found in the main roads and mostly they do not feed inside some areas from the neighbourhood to the Rea Vaya station. Further, there is still lack of cycling parking next to Rea Vaya stations

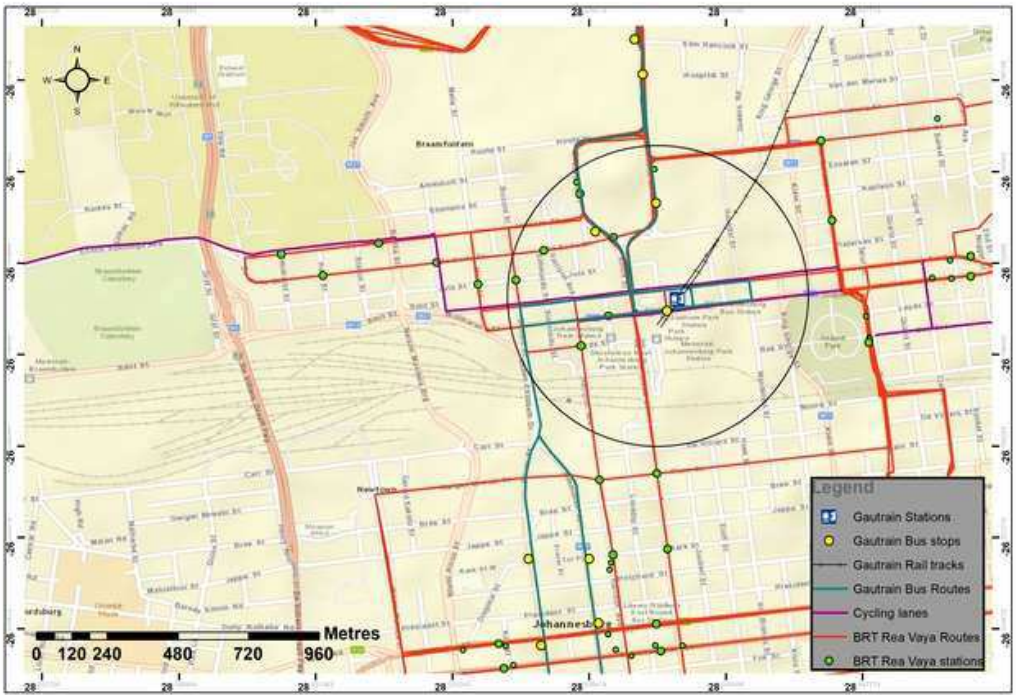


Figure 5: COJ central NMT and MT spatial integration map [Source: Authors, 2022]

Park station and the nearby areas have the visibility of being highly seviced by Gautrain/Gaubus system, Rea Vaya system and provision of cycling lanes as well as the pedestrian sidewalks. Park station according to figure 5 in the above map serve as a spine of non-motorized transportation and innovative public transportation as pedestrian side-walk, cycling lanes, gautrain/gaubus station and Rea Vaya are less than 100 metres apart from each other. This area is well serviced, and can allow for integrated transportation network system. Since southern areas of the City of Johannesburg are only serviced by Rea Vaya system and northern areas of the City of Johannesburg are serviced by Gaubus, if there is institutional integration between Gautrain system and Rea Vaya system, this can allow seameless travelling across the city through switch

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

inbetween in Park station and near stations that are highlighted on the map. Further, with improvements in the development of cycling, there could be smooth travelling created feeding innovative public transportation systems. Commuters will not be forced to walk far or travel far around the CBD to board a certain mode of innovative public transportation but can have an alternative and later switch in-between.

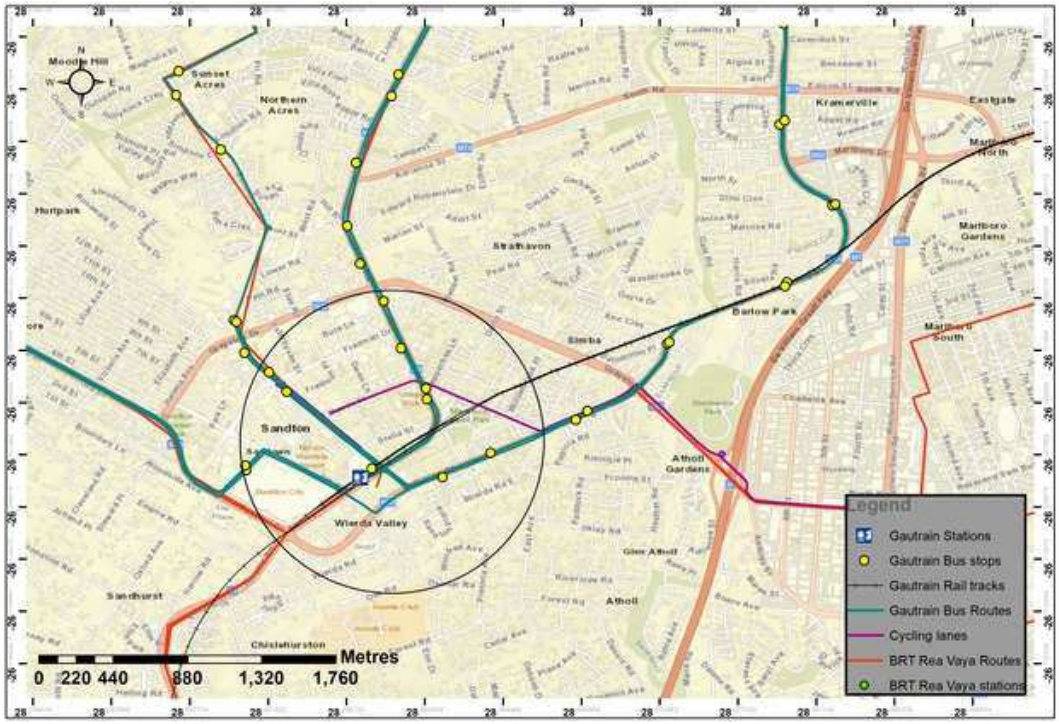


Figure 6: COJ north NMT and MT spatial integration map [Source: Authors, 2022]

The above figure 6 indicates NMT and innovative public transportation in the northern areas of the City of Johannesburg. Northern areas of the city are dominated by the use of Gaubus services, with the visibility of Rea Vaya system also servicing the area. Consequently, There is visibility of the development of cycling lanes in the northern areas of the city with assurity of the development of pedestrian sidewalks. In different areas, there is spatial integration of NMT and innovative public transportation as there are cycling lanes that lead to innovative public transportation stations as there cycling lanes passing through Sandton Gautrain stations and Gaubus stations from different neighbourhoods with Rea Vaya routes joining Gaubus route network. Further, increasing of cycling lanes to other neighbourhoods can assist commuters to cycle to the nearest locations of Gaubus station and Rea Vaya stations. Consequently, the highlighted areas indicate a good spatial integration of non-motorized transportation and innovative public transportation which could be a starting point to focus on development of recognized points of integrated network for commuting.

7 DISCUSSIONS

The development infrastucture of cycling lanes have not fullfilled the prime objective across the City of Johannesburg. In areas were the development of cycling lanes are developed together with pedestian side walks, they are perceived as sidewalks and are not used much for cycling. In areas that the cycling lanes are developed next to the roads, they are percieved as side parking. Currently, there are more developemnt of cycling lanes that are taking place especially the cycling lanes next to pedestrian sidewalks. This raises questions of why more cycling lanes are developed if they are not used, is it maybe hope or is it maybe for rolling out projects because this does not improve transporation at all. Most of these cycling lanes that are developed, they are strategically developed to feed public transportation stations and most of them are found in the main roads. The challenge is the lack of awareness campaign of the usage of these cycling lanes, they are just developed and assumable that the public will use them and there are no promotions done to attract people to start using them and create a stigma of cycling to everywhere especially trips that are not very long.

A possibility of integration for NMT and innovative public transportation is visible and is possible. (i) If the city can teach people and make them aware of the need to cycle and why cycling lanes are developed, (ii)

development of bicycle parking next to innovative public transportation stations with good security system, as there are many public open spaces and public institutions close to innovative public transportation that can be used for bicycle parking lots, (iii) for a desired outcome for these cycling lanes to be used effeciently and promote cycling, the city needs to financially support the innovative public transportation with bicycles provision that can be used by daily commuters in a sense of cheap rentals and free provision to old users. On some instances more money should be used for a certain goal to be achieved, already development of NMT and innovative public transporation infrastucture has be made and developed. This could encourage and attrack more usage of both innovative public transportation and NMT, and if there is more usage of cycling more people buy into the tradition of cycling and the entire city could be transformed in this aspect as accessibility to travelling becomes more convinient, and this could reduce some of the challenges that the city is facing in-regards to traffic congestions and other related challenges associated with private motor vehicles.

The national policies and legislative frameworks are aligned with supporting the spatial integration of the NMT and innovative public transporation, and the developments of both innovative public transportation and NMT across the city has shown practical existence from the point of having different innovative public transportation strategically developed close to one another, to cycling lanes developed next to pedestrian walks connecting to innovative public transportation. However, all this positive development and initiatives of cycling lanes are currently not working for a daily usage, as this infrastructure knows cycling when people are cycling for fitness and entertainment purposes other than that they do not serve their full potential. Therefore, a need for policies and legislative frameworks that align to the current situation on the ground with the under used cycling lanes and which are deteriorating from being used by motor vehicles, consequently, how best can the city promote the usage of cycling and the linkage of cycling with public transport. A knowledge gap exists in how does the cities residents effectively use cycling as a form of transportation, and consequently use bicycles to connect to innovative public transportation. Further, how can non-motorized transportation be integrated with innovative public transportation.

8 NMT AND INNOVATIVE PT MODEL

Bicycles are eco-friendly and are very cheap together with their maintanance. For this model to work in the City of Johannesburg, there is a need for usage of bicycles and for this to be a possibility, there should be rented bicycles by services providers, and service providers could join with the city management to ensure the possibility of bicycles availability.

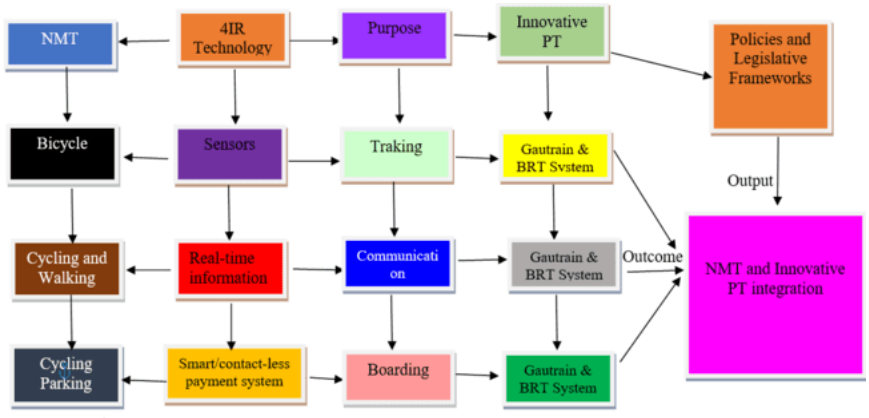


Figure 7: Passenger cyclist model (PCM) [Source: Authors, 2022]

City of Johannesburg has proper functioning innovative public transportation and developed NMT infrastructure which however needs to be fully developed, specifically, creating bicycle parking within the innovative PT stations. The above figure is a proposed model to integrate NMT and innovative public transportation across the city. Development of bicycle parking in or next to innovative public transport need to fuction consequently with innovative PT. 4IR Technologies acts as the central point to integrate NMT and Innovative PT. There is still a gap in identifying ways on how the 4IR technologies could be levaraged in NMT, and this model could be one of the first models to provide an idea that can work for both NMT and Innovative PT. Technological equippment could be installed in the service providers bicycles to be able to track bicycles for monitoring and management. This tech used in the bicycles can be linked in the smart

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

phone app to detect movement speed of bicycle and the mode that is to be boarded by a commuter. The function of the model is as follow:

(i) Sensors are critical for tracking bicycles, train and bus. A mobile smart phone could be developed that will include BRT system, Gautrain system and Bicycles for commuters who will be cycling to connect to innovative PT stations. A commuter who cycles to the station can be able to be informed in real-time how long will it take to get to the station and board a bus or train that a commuter is interested in taking. The sensors installed in the bicycles can have indicators (a) green indicator which will show that the cyclist is still on track to get in time to the station to board the intended bus or train, (b) yellow indicator which will indicate that the cyclist is behind and need to cycle faster to be able to reach the station on time, (c) red indicator which will indicate that the cyclist is very behind and will not be able to reach to the station to be able to take the intended bus unless the cyclist cycle quick and the indicator turns green.

(ii) Real-time information can be distributed through the mobile app which will be beneficial for commuters walking and cycling to notify commuters to know how far the bus or train is and the time it will take to reach the station of interest and other stations by bus or train with the current conditions at that particular moment e.g if there is traffic congestion or a particular certain mode is travelling fast and can reach the station than expected. The information in real-time can also assist commuters who switch inbetween modes (Rea Vaya system to Gautrain system or from Gautrain system to Rea Vaya system) to complete a certain trip to be able to plan their journeys properly.

(iii) Smart cards/contact less payment can be integrated for a Gautrain system and a Rea Vaya system which will allow seamless travelling with a certain agreement of profit sharing between the two systems if there were switch in-betweens made by commuters. Accordingly, the use of the integrated smart card/ contactless for Gautrain system and Rea Vaya system for fare payment could be used to pay or gain access for bicycle parking in the relevant stations. Benefits provided by service providers such as free parking to monthly innovative public transport users could be provided at a more cheaper rate or free to attract more ridership and promote cycling in the city. Further, service providers could have bicycles that are rented to commuters and commuters to gain first preference of access to such benefits are registered commuters with integrated smart card of Gautrain system and Rea Vaya system. Further, contactless payment through smart phones are an advantage as they provide alternative for payment if an individual is not carrying a smart card and they bring services into one platform for example information dissemination and payment method could be all setup in one app for Gautrain system, Rea Vaya system and NMT.

(iv) Policies and legislative frameworks need to stress the importatnce of integrated public transportation system in the city and the country as a whole. These documents should be strengthened and support the use of NMT to create sustainable transportation. There current developed policies and legislative frameworks are not positively impacting NMT on the ground as the city is currently struggling to provide both a working system for NMT and a working system for integrating different public transportation systems. There is a need for policies and legislative frameworks to adress the connection of NMT, Rea Vaya system and NMT to be integrated as they promote sustainable development and are eco-friendly as the Rea Vaya system and Gautrain system ensure that carbon emissions are low as possible, and they reduce city's CO2 emmision. With the introduction of 4IR technologies, policies and legislative frameworks need to indicate the gap that could be solve which have existed for years and for the first time in the city's transportaion system integration could be possible.

Passenger cyclist model is intended to connect Innovative PT and NMT through technological innovations that are afforded in the 21st century to ensure that mobility in cities and urban areas is sustainable. This is the first model of its kind that include technology to integrate NMT and MT, it is feasible and could be implemented in many cities working towards affording sustainable public transportation. Providing a sustainable transportation systems require different strategies from city regulators and service providers. Having subsidize bicycles by the service providers which are rented cheap at a rate that is less and even lesser when having a smart card would attract more coummuters to cycle, and such alternative of having availability of bicycles could attract motorists as well as most people do not like to walk to station as it is time consuming. Using technological innovations that could improve effeciency in innovative public transport by ensuring effecient movement of buses and trains being frequent in all stations as per demand improves ridership. In general, people are attracted to systems that are well tailored and everything is set to

one platform. Hence, integrating Gautrain system, Rea Vaya system and bicycles as well as walking can provide a sense of convinience, and ideal way of daily travelling for commuters and even better with technology involved as people enjoy the use of technological innovations.

9 CONCLUSION

The paper has revealed the existence of availability of infrastructure for non-motorised transportation and the development of innovative public transportation in the City of Johannesburg, and further assess the points of areas that are serviced by both non-motorised transportation and innovative public transportation were there could be possible integration. Most noticeable in this paper, there is insufficient cycling, no bicycle parking stations, no recognised integration between innovative public transportation and non-motorized transportation, commuters either walk or drive private vehicles to Rea Vaya or Gautrain stations but do not cycle. Further, only few people make trips by bicycles as a form of transportation and trips made are not over 15 km or 10 km. However, there is a possibilty of having integrated transport network system of non-motorised transportation and innovative public transportation as the network patterns of pedestrian side-walks and cycling lanes across some areas in the city connect with Gautrain/ Gaubus stations and Rea Vaya stations.

The study recommends the development of bicycle parking stations next to innovative public transportation stations to encourage the usage of cycling, and institutional integration of innovative public transportation to create swift transportation for commuters. Consequently, implementation of passenger cyclist model that will enhance the mobility across the City of Johannesburg and the country as a whole. Further, development of more non-motorized transportation policies and legislative frameworks that will support and encourage non-motorized transportation and integration of non-motorized transportation and innovative transportation. Further, financial aid support by the government to provide bicycles to commuters through innovative public transpotation to encourage cycling and more usage of innovative public transportation could be an advantage.

10 REFERENCES

Häll, C.H. (2006). A framework for evaluation and design of an integrated public transport system (Doctoral dissertation, Institutionen för teknik och naturvetenskap).

Iacono, M., Krizek, K.J. and El-Geneidy, A. (2010). Measuring non-motorized accessibility: issues, alternatives, and execution. Journal of Transport Geography, 18(1), pp.133-140.

Ibrahim, M.F., 2003. Improvements and integration of a public transport system: The case of Singapore. Cities 20 (3), 205 – 216.

IPCC (2007). Transport and its infrastructure. In Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [B. Metz, O.R. Davidson, P.R. Bosch, R. Dave, L.A. Meyer (eds)], Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Martins, C.L. and Pato, M.V. (1998). Search strategies for the feeder bus network design problem. European journal of operational research, 106(2-3), pp.425-440.

Maxwell, R.R. (1999). Intercity rail fixed-interval, timed-transfer, multihub system: Applicability of the Integraler Taktfahrplan Strategy to North America. Transportation Research Record, 1691(1), pp.1-11.

Rietveld, P. (2001). Biking and Walking: The Position of Non-Motorized Transport Modes in
Transport Systems, Tinbergen Institute Discussion Papers 01-111/3, Tinbergen Institute.

Vandenbulcke, G. I., Thomas, B., de Geus, B., Degraeuwe, R., Torfs, R. and Meeusen, L. P. (2009) Mapping bicycle use and the risk of accidents for commuters who cycle to work in Belgium. Transport Policy 16 (2), 77-87.

Vassallo, J.M., Di Ciommo, F. and García, Á. (2012). Intermodal exchange stations in the city of Madrid. Transportation, 39(5), pp.975-995.

Witting, R. J., Rijnsburger, D. and Wijnen, A. P. (2006). Cycling, a smart way of moving. Second edition. (2006).

Yazid, M.M., Ismail, R. and Atiq, R. (2011). The use of non-motorized for sustainable transportation in Malaysia. Procedia Engineering, 20, pp.125-134.

van Mil, J.F., Leferink, T.S., Annema, J.A. and van Oort, N., 2021. Insights into factors affecting the combined bicycle-transit mode. Public Transport, 13(3), pp.649-673.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

🏆 *reviewed paper*

Proposing an Indicator System for Measuring City Sustainability

Parsa Arbab

(Parsa Arbab, Assistant Professor, School of Urban Planning, University of Tehran, Tehran, Iran, parsaarbab@ut.ac.ir)

1 ABSTRACT

An increasingly rapidly urbanising world highlights sustainable urban development as an inevitable crucial issue that has recently been at the forefront of numerous scientific inquiries. Measuring city sustainability contributing to the quality of urbanisation is a substantial research field in this area. Meanwhile, a comprehensive functional indicator system, including accurate indicators, is the first point of measuring city sustainability. Hence, this paper aims to propose an indicator system for measuring city sustainability by analysing current research and experiences, including existing frameworks, indicator systems, and case studies. Through a systematic literature review of articles published by Elsevierand MDPI from 2019 onwards, an indicator system has been developed that could be applied for measuring city sustainability according to available and accessible data. It includes the 21 most frequent indicators based on the three main subsystems of economy, society, and environment. Concerning their effects on city sustainability, they were categorised into two properties of benefit and cost regarding the sustainable development of a city. Thus, seven indicators measure the economic dimension, sevenconsider the social dimension, and seven address the environmental dimension. Conducting empirical case studies following the proposed indicator system accompanied by weighting approaches and aggregating methods as another significant issue concerning measuring city sustainability will complement the current path to future further research.

Keywords: Indicator System; Sustainability; Sustainable City; Sustainable Development; Urban Sustainability

2 INTRODUCTION

City sustainability is extremely important because it directly contributes to the quality of urbanisation (Li and Yi, 2020). In an increasingly rapid urbanising world, city sustainability has been the focus of numerous academic studies (Liu et al., 2020). The interest in research on city sustainability as an emergent concept has grown exponentially, and it has been at the front of scientific inquiries in recent years (Xie et al., 2022). We need to understand where we are and where we are going. Thus, searching for sustainable development at the urban level and how cities can approach sustainability is of interest (Tomatis et al., 2022).

The cities require more and more to be transformedto become more sustainable through pursuing a sustainability agenda (Antolín et al., 2020; Hassan and Kotval-K, 2019). Measuring city sustainability by providing the possibility to know cities' status and preparing baselines for decision makers has a notable role in this regard (Zhou et al., 2021).It could provide an important reference for sustainable urban development. However, sustainability is a multi-dimensional system that requires a comprehensive, accurate, and rational index system for evaluation (Gong et al., 2019).Incorporating sustainability into local urban planning depends on measuring city sustainability and developing indicators for it (Hassan and Kotval-K, 2019). Therefore, indicator selection is the first point of measuring city sustainability, and accordingly, the accuracy of the indicator system has a significant effect on the results (Zhou et al., 2021).

While measuring city sustainability performance has become an attractive and popular broad research field, a comprehensive functional indicator system has not been well developed (Yi et al., 2019b).Current studies on sustainable urban systems lack complete analytical frameworks for indicator selection and focus mainly on ecological aspects that depend on the selections of indicators, often challenged by the limitation of available and accessible data (Xie et al., 2022). Despite numerous pieces of literature on city sustainability, it is still a complicated area where multiple indicators and measures already exist regarding different purposes and agendas (Liu et al., 2020).

Hence, this paper aims to propose an indicator system for measuring city sustainability. For this purpose, a systematic literature review has been considered, which is explained in the methodology section. It resulted in identifying and screening the articles published by Elsevier and MDPI from 2019 onwards, following four search keywords for the titles: sustainable city, urban sustainability, sustainable urban development, and city sustainability. Among the identified articles, nine articles were finally selected, and the results section analyses them, focusing on the indicator system for measuring city sustainability.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

3 METHODOLOGY

The systematic literature review was used to focus on recent studies published by Elsevier and MDPI from 2019 onwards. Accordingly, the ScienceDirect and MDPI databases were explored following the title search strategy in the middle of July 2022. Consequently, 84 and 108, 82 and 106, 28 and 35, and 14 and 35 articles were found in Elsevier and MDPI, respectively, by considering four keywords of sustainable city, urban sustainability, sustainable urban development, and city sustainability. Tables 1 and 2 show the details of these articles based on their types and years of publishing.

Search Keyword	Article Type		Year	
sustainable city	research article	74	2019	21
			2020	11
	review article	10	2021	27
			2022	25
	Total		84	
urban sustainability	research article	69	2019	22
			2020	25
	review article	13	2021	23
			2022	12
	Total		82	
sustainable urban development	research article	22	2019	6
			2020	5
	review article	6	2021	5
			2022	12
	Total		28	
city sustainability	research article	13	2019	3
			2020	5
	review article	1	2021	4
			2022	2
	Total		14	

Table 1: Details of the identified recent articles on city sustainability published by Elsevier

Search Keyword	Article Type		Year	
sustainable city	article	102	2019	20
			2020	26
	review	6	2021	39
			2022	23
	Total		108	
urban sustainability	article	95	2019	27
			2020	27
	review	11	2021	36
			2022	16
	Total		106	
sustainable urban development	article	30	2019	7
			2020	9
	review	5	2021	11
			2022	8
	Total		35	
city sustainability	article	34	2019	10
			2020	8
	review	1	2021	11
			2022	6
	Total		35	

Table 2: Details of the identifiedrecent articles on city sustainability published by MDPI

Figure 1 presents the distribution of the city sustainability articles published by Elsevier and MDPI based on years of publishing. Figure 2 also shows them based on the title's search keywords and years of publishing. First, 40 articles were included by reviewing the title and the abstract. Subsequently, in the second-level screening, by reviewing the full content, fifteen and then nine articles were selected for further analysis regarding proposing an indicator system for measuring city sustainability. Fifteen mentioned articles have been presented in the references section.

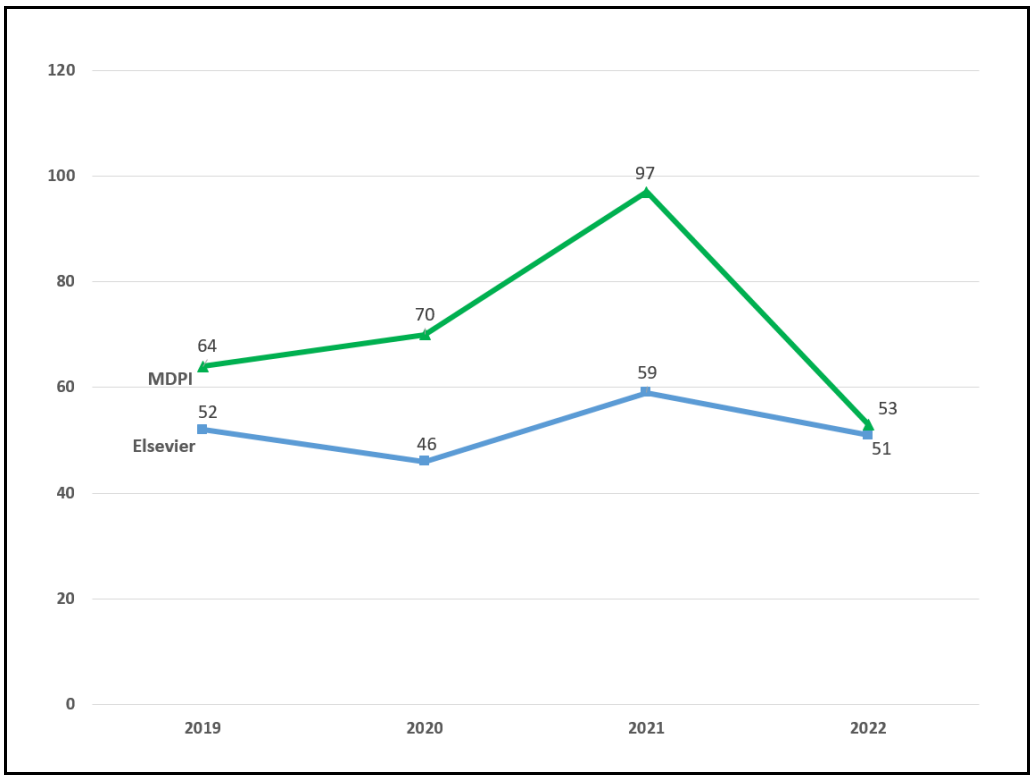


Fig. 1: Distribution of the identified recent articles on city sustainabilitypublished by Elsevier and MDPI based on years of publishing

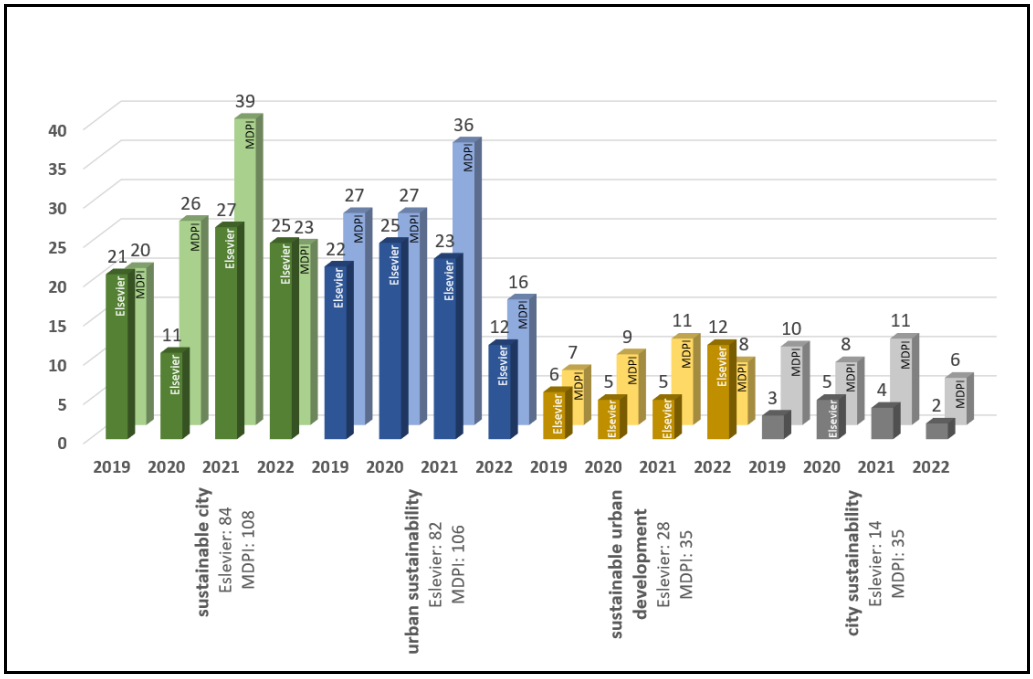


Fig. 2: Distribution of the identified recent articles on city sustainability published by Elsevier and MDPI based on the title's search keywords and years of publishing

4 RESULTS

As explained in the methodology section, nine articles were finally selected for further analysis concerning proposing an indicator system for measuring city sustainability. Chen and Zhang (2020) have measured the sustainability performance of 14 Chinese cities in the province of Liaoning by considering the linkage among multiple criteria. Based on the data availability within the complexity of urban systems, they have selected 21 indicators to include all subsystems with a suitable balance. Having a direct/indirect relationship to city sustainability, denoting the various facets of economy, society, and environment, and data accessibility and measurability were theirkeyconsiderationsindeveloping this indicator system (Chen and Zhang, 2020). In

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

another researchanalysing the sustainability performancesof the 34 shrinking cities in Northeast China, they used the same criteria system (Chen and Zhang, 2021).

Li and Yi (2020) have measured the sustainability of 9 national central cities of China by an indicator system including 24 indicators from three interacting pillars of the sustainability concept. City sustainability supports the quantity and the quality of economic growth, aims at overall social and human progress, and indicates the sustainable use of natural resources and the ecological environment. However, they say that this set of indicators could represent only part of all aspects of urban sustainability because of the limitation of accessibility to the statistical data.

Tang et al.(2019) believe that city sustainability needs to be measured by an all-directional and multi-angled approach that can assess, monitor, and promote the sustainable development of cities. Hence, a complete, simple, and accurate city sustainability measuring index system should consider all effective factors of economy, society, and ecology. They have objectively evaluated the sustainability of 16 cities in the Anhui province of China through an index system that includes 39 indicators in three economic, social, and ecological development categories.

Yang et al.(2020) have suggesteda scientific base for decision-makers to measure and compare urban development directions by analysing the sustainability of 13 prefecture-level cities in the Beijing-Tianjin-Hebei region under various policy intervention scenarios. To that effect, a city sustainability evaluation model has been proposed following the principle of system dynamics and future policy scenarios, including sustainable development, business-as-usual development, partial sustainable development, extremely imbalanced development, and economic-growth-oriented development. Among numerous indicators characterising city sustainability, 20 accessible ones were selected in the Chinese urban management context, considering six subsystems of economy, livelihood, risk, environment, pollution governance, and resource.

Yi et al.(2019a), who have measured the sustainability of 17 Chinese cities in Shandong province with a set of 21 indicators, consider two main factors influencing city sustainability. Internal factors are the innate configuration of the city itself, including geographical location, climate, and natural resources. External factors are activities and states derived from the city, such as city size, population density, urban transportation, and social welfare.For measuring city sustainability, they have selected indicators by focusing on external factors fettered by the data availability. They were divided into economy addressing the quantity and quality of economic growth and development, society considering the basic demands of current and future generations, and environment fulfilling the basis of city sustainability.

In other studies, theyhave measured the sustainability level of 13 Chinese cities in the Capital Economic Circle and 15 sub-provincial cities in China from the Multi-Criteria Decision Making perspective. For the indicator system, they have considered comprehensiveness as a reflection of city sustainability by the economy, society, and environment, measurability as data accessibility to allow practical measurement, objectiveness as focusing on the actual objective performances, and stability as being relatively constant in responding to a long-term process. Accordingly, the indicator system includes 18 economic, social, and environmental indicators(Yi et al., 2019b and 2021).

Zhou et al.(2021) believe that the indicator system for measuring city sustainability should consider three social, economic, and environmental systems to achievesustainability. Accordingly, they've developed an indicator system for measuring the profit of the economic system, the benefits of the social system, and the rationality of the environmental system. It includes 24 indicators used to analyse the sustainability performances of 14 cities in the province of Liaoning. However, this set cannot entirely represent all aspects of city sustainability due to the data accessibility limitation and cannot be completely independent because of the partial overlap.

Followingthe analysis of existing research and case studies (Chen and Zhang, 2020 and 2021; Li and Yi, 2020; Tang et al., 2019; Yang et al., 2020; Yi et al., 2019a, 2019b, and 2021; Zhou et al., 2021), an indicator system was developed and proposed for measuring city sustainability. Those indicators were selected in the proposed indicator system for measuring city sustainability, which were atleast repeated and used four times or more in these studies. Consequently, as Fig. 3 and Table 3 show, it includes the 21 most frequent indicators for measuring city sustainability based on the three main dimensions/subsystems of economy, society, and environment. Concerning their effects on city sustainability, they were categorised into two attributes/properties of benefit: the greater criterion value is better for city sustainability and cost: the lesser

criterion value is better for city sustainability. As stated in the analysed studies, this indicator system cannot measure all aspects of city sustainability and will also be affected by the limitation of available and accessible data.

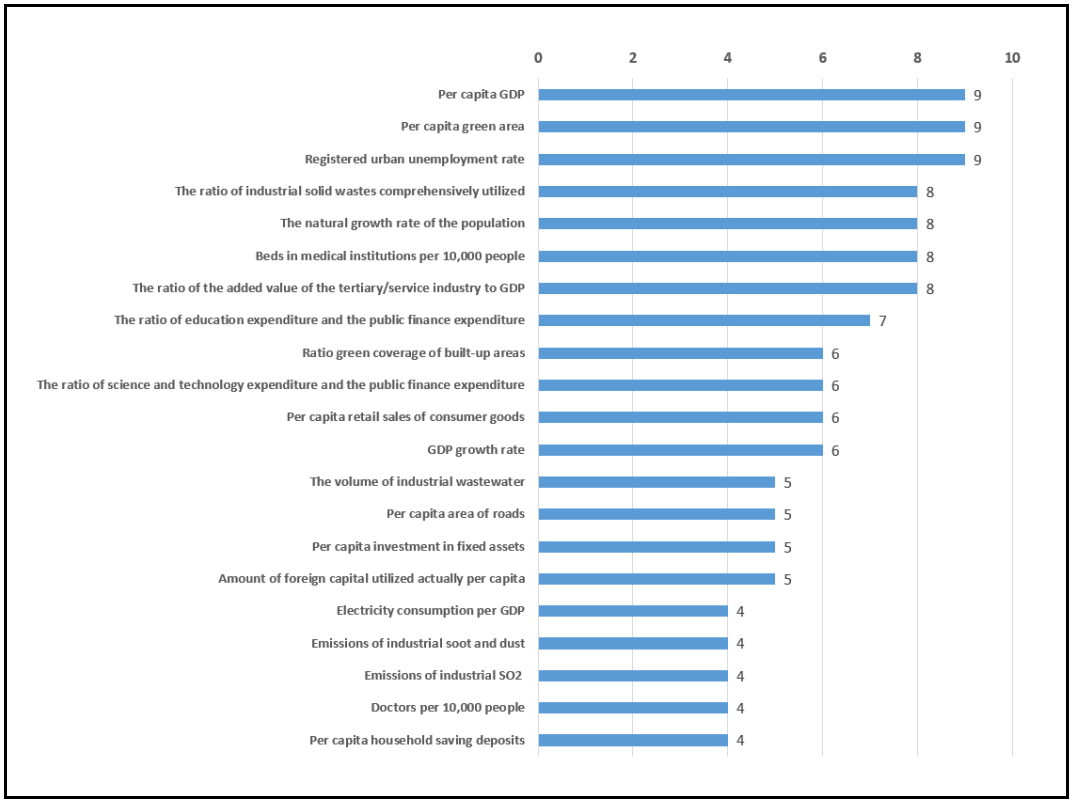


Fig. 3: Most frequent indicators for measuring city sustainability ranked by the number of the studied indicator sets in which have appeared (Chen and Zhang, 2020 and 2021; Li and Yi, 2020; Tang et al., 2019; Yang et al., 2020; Yi et al., 2019a, 2019b, and 2021; Zhou et al., 2021)

Economy		
Indicator	Unit	Property
Per capita GDP	Currency	Benefit
The ratio of the added value of the tertiary/service industry to GDP	%	Benefit
GDP growth rate	%	Benefit
Per capita retail sales of consumer goods	Currency	Benefit
Amount of foreign capital utilized actually per capita	Currency	Benefit
Per capita investment in fixed assets	Currency	Benefit
Per capita household saving deposits	Currency	Benefit
Society		
Indicator	Unit	Property
Registered urban unemployment rate	%	Cost
Beds in medical institutions per 10,000 people	Bed/104people	Benefit
The natural growth rate of the population	%	Benefit
The ratio of education expenditure and the public finance expenditure	%	Benefit
The ratio of science and technology expenditure and the public finance expenditure	%	Benefit
Per capita area of roads	m2	Benefit
Doctors per 10,000 people	Person/104people	Benefit
Environment		
Indicator	Unit	Property
Per capita green area	m2	Benefit
The ratio of industrial solid wastes comprehensively utilized	%	Benefit
Ratio green coverage of built-up areas	%	Benefit
The volume of industrial wastewater	Ton	Cost
Emissions of industrial SO2	Ton	Cost
Emissions of industrial soot and dust	Ton	Cost
Electricity consumption per GDP	kWh/Currency	Cost

Table 3: Proposed indicator system for measuring city sustainability (Chen and Zhang, 2020 and 2021; Li and Yi, 2020; Tang et al., 2019; Yang et al., 2020; Yi et al., 2019a, 2019b, and 2021; Zhou et al., 2021)

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

5 CONCLUSION

City sustainability as an emergent concept directly contributing to the quality of increasing urbanisation is an attractive and popular research field in a broad range and at the front of numerous scientific inquiries recently. Measuring city sustainability could provide the possibility to know the status of cities as an important reference for sustainable urban development. Meanwhile, a comprehensive functional indicator system, including accurate indicators often challenged by available and accessible data, is the first point of measuring city sustainability. This study brings a theoretical and conceptual approach to this significant area through a systematic literature review of current research and experiences measuring city sustainability, including existing frameworks, indicator systems, and case studies.

Accordingly, an indicator system was developed and proposed to measure city sustainability. It includes the 21 most frequent indicators based on the three main dimensions/subsystems of economy, society, and environment. Concerning their effects on city sustainability, they were categorised into two attributes/properties of benefit: the greater the criterion value is better for city sustainability and cost: the lesser the criterion value is better for city sustainability. Thus, seven indicators measure the economic dimension, sevenconsider the social dimension, and seven address the environmental dimension. Conducting empirical case studies in future further research following the proposed indicator system will complement the path of this research. At the same time, it will be accompanied by weighting approaches and aggregating methods as another significant issue concerning measuring city sustainability.

6 REFERENCES

Antolín, J., de Torre, C., García-Fuentes, M. Á., Pérez, A., Tomé, I., Mirantes, M. L., &Hoyos, E. (2020). Development of an evaluation framework for smartness and sustainability in cities. Sustainability, 12(12), 5193.

Chen, Y., & Zhang, D. (2020). Evaluation of city sustainability using multi-criteria decision-making considering interaction among criteria in Liaoning province China. Sustainable Cities and Society, 59, 102211.

Chen, Y., & Zhang, D. (2021). Evaluation and driving factors of city sustainability in Northeast China: An analysis based on interaction among multiple indicators. Sustainable Cities and Society, 67, 102721.

Gong, Q., Chen, M., Zhao, X., & Ji, Z. (2019). Sustainable urban development system measurement based on dissipative structure theory, the grey entropy method and coupling theory: a case study in Chengdu, China. Sustainability, 11(1), 293.

Hassan, A., &Kotval-K, Z. (2019). A Framework for measuring urban sustainability in an emerging region: the City of Duhok as a case study. Sustainability, 11(19), 5402.

Li, W., & Yi, P. (2020). Assessment of city sustainability—Coupling coordinated development among economy, society and environment. Journal of Cleaner Production, 256, 120453.

Liu, S., Ding, P., Xue, B., Zhu, H., &Gao, J. (2020). Urban sustainability evaluation based on the DPSIR dynamic model: a case study in Shaanxi province, China. Sustainability, 12(18), 7460.

Tang, J., Zhu, H. L., Liu, Z., Jia, F., & Zheng, X. X. (2019). Urban sustainability evaluation under the modified TOPSIS based on grey relational analysis. International Journal of Environmental Research and Public Health, 16(2): 256.

Tomatis, F., Lozano-Castellanos, L. F., García-Navarrete, O. L., Correa-Guimaraes, A., Wilhelm, M. S., Boukharta, O. F., ...& Méndez-Vanegas, J. E. (2022). Evaluation of Urban Sustainability in Cities of The French Way of Saint James (Camino de Santiago Francés) in Castilla y León according to The Spanish Urban Agenda. Sustainability, 14(15), 9164.

Xie, Y., Liu, C., Chang, S., & Jiang, B. (2022). Urban Sustainability: Integrating Socioeconomic and Environmental Data for Multi-Objective Assessment. Sustainability, 14(15), 9142.

Yang, Z., Yang, H., & Wang, H. (2020). Evaluating urban sustainability under different development pathways: A case study of the Beijing-Tianjin-Hebei region. Sustainable Cities and Society, 61, 102226.

Yi, P., Dong, Q., & Li, W. (2019a). Evaluation of city sustainability using the deviation maximization method. Sustainable Cities and Society, 50, 101529.

Yi, P., Dong, Q., Li, W., & Wang, L. (2021). Measurement of city sustainability based on the grey relational analysis: The case of 15 sub-provincial cities in China. Sustainable Cities and Society, 73, 103143.

Yi, P., Li, W., & Zhang, D. (2019b). Assessment of city sustainability using MCDM with interdependent criteria weight. Sustainability, 11(6), 1632.

Zhou, Y., Yi, P., Li, W., & Gong, C. (2021). Assessment of city sustainability from the perspective of multi-source data-driven. Sustainable Cities and Society, 70, 102918.

🏆 *reviewed paper*

Regeneration of Routes in Cities to Meet Pedestrian and Two-Wheeler Demands by Utilizing Space Syntax Theory

Ingy El-Darwish

(Associate Professor Ingy El-Darwish, Faculty of Engineering, Tanta Universiy, Sabarbay, Tanta, Gharbia Governorate 6646210, eldarwishi@yahoo.com)

1 ABSTRACT

The rapid growth in cities has led to new city patterns specially in third world countries. With the development and progress in technology, new demands have appeared. The future of technology and the digital transformation have led to the request for faster and cheaper means of transport that need to fulfill new demands. One of these challenges is the usage of two wheelers to quickly support delivery demands in crowded cities. In addition no pedestrian routes are considered. Modification in the infrastructure needed to be done to meet these demands. In this study the coastal city of Alexandria in Egypt is studied as an example of a quick expanding city. First, investigation of the direct impact of currect routes on the built environment whether main or secondary routes two-wheelers movement is done. Followed an analysis of integration and choice of current routes in order to help in suggesting safe pedestrian and two-wheeler paths and roads. The research aims at providing regeneration of roads in cities and for guiding the design of new ones in existing projects based on simulation results. Green and energy saving is what is needed to collaborate with the digital era. The significance, magnitude, and consistency of integration and choice measures justify their relevance in built infrastructure interventions to promote pedestrian and two wheelers. The main aim of this study is to optimize decision making by using the space syntax theory. The research aims at providing a pilot sample of responsive routes in existing cities and for guiding the design of new ones in the future.

Keywords: space syntax, Pedestrian, bicycle, regeneration, city planning

2 INTRODUCTION

2.1 Routes in Cities for Pedestrian and Two-Wheelers

Currently, vehicular; two-wheelers; and pedestrian flow are inevitably overlapped in old cities. To solve the problem of their overlap, interface and match a study must be made to study optimal location of their interaction in order to suggest parking areas for vehicles and two-wheelers. Considering in mind that two-wheelers can be bicycles whch is a green mode of transport or motor cycles which are treated as vehicles. Followed is to provide a suggested suitable walkable pedestrian flow, considering other transport modes as well as. This will also lead to preserving some urban old historic cities from traffic; thus, increasing and diversifying transport modes, so as to offer suitable alternatives to easier transport modes such as two-wheelers and suggest safe pedestrian routes. In urban areas pedestrian routes are typically provided by a combination of sidewalks, carriageways and crossing points. “One specific example is the designation of pedestrian routes to schools” (Institute for Transport Studies, 2005). However, it is relatively uncommon for pedestrian routes to be planned and signed as a network. Pedestrian routes can also be shared with other users, most commonly with cyclists (Institute for Transport Studies, 2005). Cycling is considered “an extremely flexible transport mode, which makes it easy to combine with other transport modes” (Institute for Transport Studies, 2005). Therefore, it is fundamental to include cycling “infrastructure in mobility planning” considering that choice of transport depends on several factors (Institute for Transport Studies, 2005). These factors include time; reliability; flexibility; comfort; security; finances; and the environment which fall into the choice of bicycles and the two-wheelers ((Institute for Transport Studies, 2005).

2.2 Strategies for Pedestrian and Two-Wheelers

A city’s parking strategy can help support pedestrian and two-wheeler traffic. If there is a distance between the parking space and the destination more people will consider pedestrianization and two-wheelers an attractive transport mode. Pedestrianisation is known as a traffic policy that is intended to reduce the opposing environmental and safety effects of vehicles, to reclaim space for both pedestrians and non-traffic activities, and, to improve the urban environment (Institute for Transport Studies, 2022). In urban areas pedestrians are provided by a combination of sidewalks, carriageways and crossing points. An example is the designation of pedestrian routes to schools and educational facilities. Yet, it is relatively uncommon for

these routes to be planned and signed as a network. Nevertheless, the majority of pedestrian routes comprise road corridors which are footpaths along major highways; routes over land available for public use such as parks and river banks; and other public places. Pedestrian routes can also be shared with cyclists as has been previously mentioned. An image of a bike route and footpath with symbols along a bridge at a park in Poznan, Poland can be shown in Figure 1.

Fig. 1: An Image of a Bike Route and Footpath with Symbols Along a Bridge at a Park in Poznan, Poland (Source: Dreamstime, 2019)

On the other hnd two-wheelers presented by bicycles have taken a faster turning point. Several countries have already invested in improving its bicycle infrastructure. The expanding bicycle network and parking areas has been found to be a green sustainable economic mean of transportation. “In larger cities where rush hour congestion is an issue the bicycle will be perceived as a good alternative to the car in relation to travel time (Cycling Embassy of Denmark, 2018). To promote two-wheelers local authorities are to work with structure plans, as well as master plans. Here the focus is on the local area and how different local planning fields should work together to provide good land use and organize infrastructure, including the cycle track network. The mobility plan should help ensure good two-wheeler parking facilities at traffic hubs when transferring to another transport mode. There should be a focus on destinations such as schools, commercial areas, and all central areas. A focus area is the link to the primary cycle track and pedestrian network, in order to reach more outlying destinations such as traffic hubs and commercial areas with many workplaces.

The local authority’s various plans for the physical design of cities and local areas are crucial for the function of cities and local communities, including how to get from one place to another. Successful land use planning makes it easy and natural to move by two-wheelers or on foot. “However, there is a fine balance here since many functions in a small area may also mean traffic chaos if the area isn’t geared to traffic or if the design isn’t optimal” (Cycling Embassy of Denmark, 2018). This could have a negative impact on people who wish to use two-wheelers or walk in the area. As a result, there will be a need for many parking spaces since people will drive into the center shop, or to pick up children from schools. Architecture and mainly planning can play an important role in encouraging the use of two-wheelers. Cities equipped with safe two-wheeler lanes, parking lots, and pedestrian routes and facilties. This can encourage citizens ˝to refrain from using their cars and opt for a much more sustainable means of transportation” (Tommorrow City, 2021).

3 SPACE SYNTAX APPROACH

Space syntax, originated in the seventies of the last century by Bill Hillier and his colleagues at the Bartlett School of Architecture, University of London. Space syntax is ˝a theory and method for analysing spatial relationships“ (Akkelies van Nes et al., 2021). Hillier‘s contribution to understanding the built environment ˝through an operational method to analyze spatial relationships between built objects allowed for a new refined knowledge about the relationship between space and society“ (Yamu C. et als., 2021). It combines tangible factors with intangible factors.

For urban planning and design, space syntax can test the spatial effects of various urban design proposals and potentials. If the land use is affected by the volume and density of people in the streets, then space syntax ˝assesses the effects on the future potentials of street life that are connected to land use“ (Yamu C. et als., 2021). Thus, urban design proposals can be tested to give an indication of the potentials of vital urban street life. Space syntax can support decision-making for urban designs, allowing the creation of sustainable cities and communities.

In this study the axial analysis which reduces the grid into a system of lines is used (Hillier B. et Hanson J., 2009). In the space syntax theory, "spaces and routes could be ranked from most integrated to most segregated based on the integration analysis" (El-Darwish I., 2022). The more "integrated space or a route is the more likely it is to be a destination location for it is easier to reach" (Hillier B., 1996). It is important to distinguish between local and global integration first. Axial integration estimates the degree of accessibility that a street has to all other streets in the urban system, taking into consideration the total number of directions (Yamu C. et als., 2021). Axial integration is strongly related to connectivity. The fewer the direction changes of a certain street to all other streets in the system, the higher its integration, hence its inter-accessibility (Yamu C. et als., 2021). Figure 2 illustrates an axial map (b) and a global axial integration analysis (c) of the settlement (a) and the justification graph (d), with the root node A representing the main street.

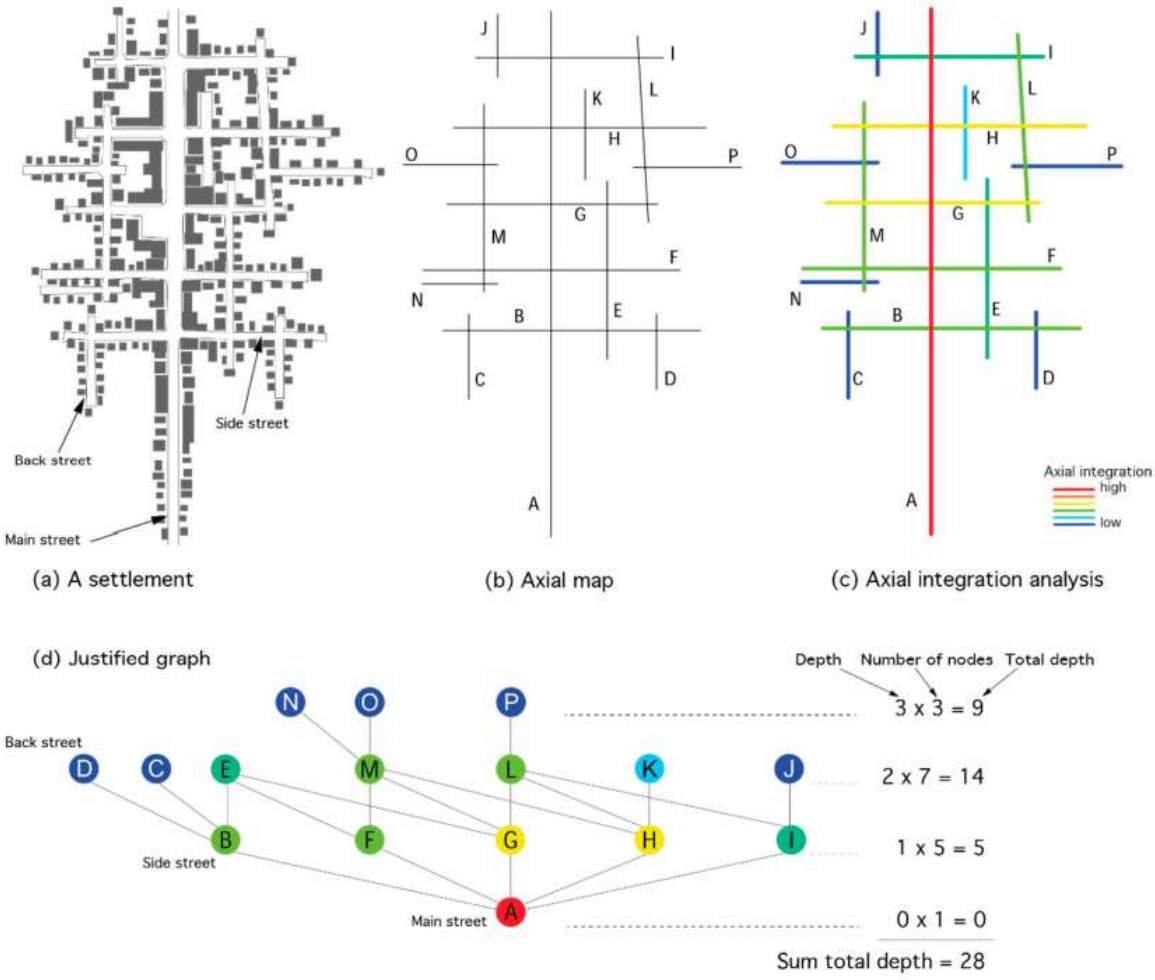


Fig. 2: An axial map (b) and a global axial integration analysis (c) of the settlement (a) and the justification graph (d), with the root node A representing the main street. (Source: Yamu C. et als., 2021)

Another analysis is the Choice analysis that shows how much a route could be used as being the shortest path from and to all other routes (Al-Sayed K., 2018). Choice is the potential of through movement, a route is chosen for movement from all routes to all others. Choice measures how likely ˝an axial line or a street segment is to be passed through on all shortest routes from all spaces to all other spaces in the entire system or within a predetermined distance (radius) from each segment" (Hillier B. et als., 1987). Figure 3 demonstrates the depth analysis in two differrent roots, which is the base idea of integration analysis and shows how choice is calculated (Source: Mohareb N., 2019).

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

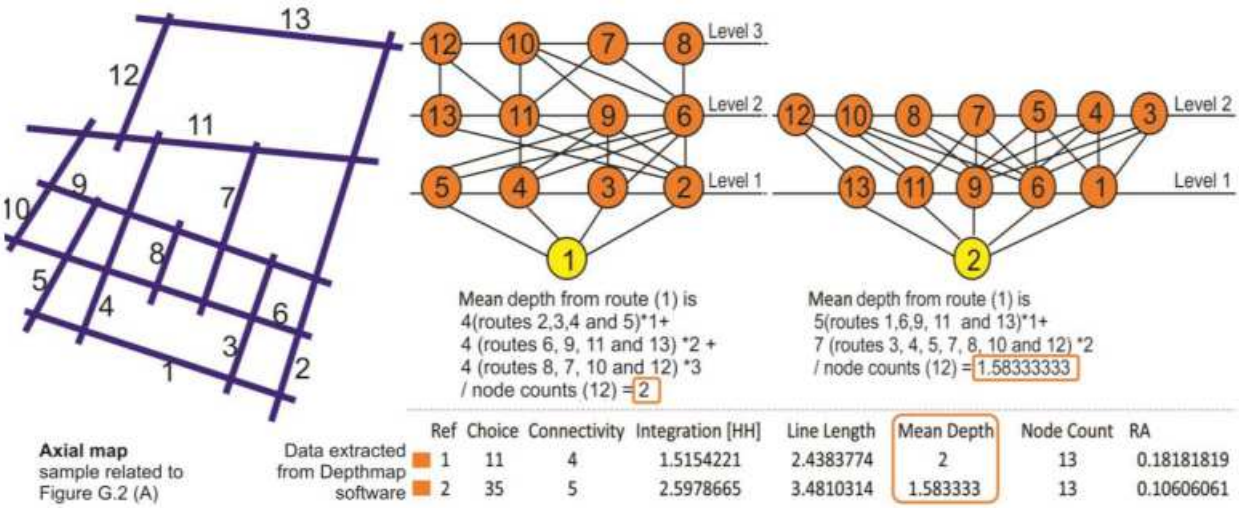


Fig. 3: The Depth Analysis in Two Differrent Roots (Source: Mohareb N., 2019)

4 CASE STUDY

This study focuses on the historical city of Alexandria, Egypt. By using Depthmap for applying the space syntax theory routes are suggested based on intersections and many other analysis for both pedestrians and two-wheelers due to their importance. Mixed pedestrian, two-wheelers and vehicles are shown in the eight different views of various routes located in the sample area of the study showing mixed modes (Figure 4).

Fig. 4: Views of Eight Different Streets Showing Mixed Modes (Source: Author)

This experimental research using an inductive approach starts by studying a sample of a residential area in Alexandria, Egypt. An ariel view of Stanely bridge a main feature of the study area in Alexandria, Egypt can be seen in (Figure 5). By testing the study area's routes utilizing the space syntax theory parking areas are suggested in order to be able to choose and provide two-wheelers and pedestrian routes. Followed the Space Syntax theory is again applied to check differences to help in decision making in the choice of pedestrian and two-wheelers routes.

Fig. 5: View of Stanley Bridge, Alexandria, Egypt (Source: (The Arab Contractors, 2019)).

5 METHODOLOGY

A configurational approach is faced with suggesting parking locations, taking space into action. First, the urban grid provides the required information about its uses, and therefore could help in proposing the location of parking areas, considering the movement behavior along its paths for the transfer from vehicle to the pedestrian/two-wheeler tracks. The first step of the work is to create two different plans of three neighborhoods in the East district of Alexandria, Egypt. A terrain view of Alexandria, Egypt showing the study area is shown in (Figure 6). (Figure 7) shows the study area consisting of three neighborhoods in the East district of Alexandria, Egypt. The plan is then reduced into sets of straight paths, named axial maps. Such axial maps are further transformed into segment maps, “suitable for allowing the adoption of a metric length for the radius and a more intuitive understanding of the results” (Turner A., 2007). (Figure 8) shows the defined cores in the grid of the study area: vehicular (a) Choice core, (b) Integration core. The normalization step is then acted, in order to be able to graphically overlap the results coming out of the analysis, in view of the fact that the analysis for the pedestrians (R= 1000 m) and for the vehicles (R= 8000 m).

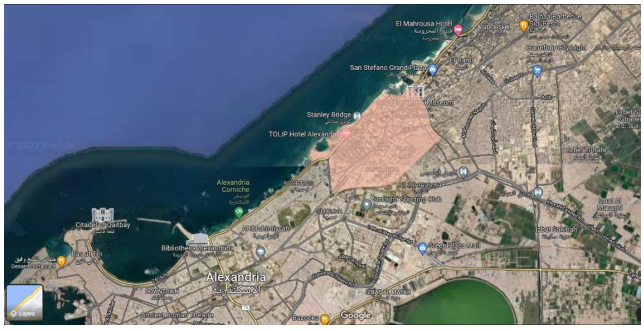


Fig. 6: A Terrain View of Alexandria, Egypt Showing the Study Area (Source: Adapted from Google Earth).

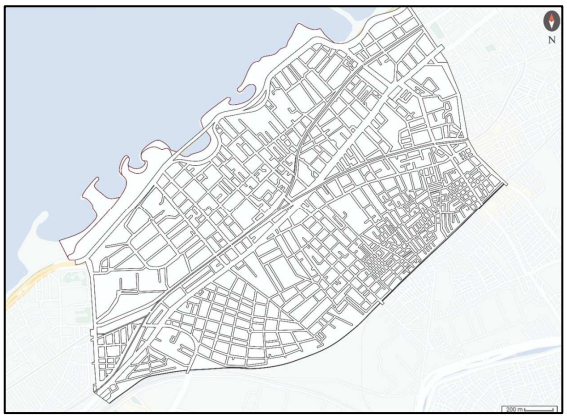


Fig. 7: The Study Area Consisting of Three Neighborhoods in the East District of Alexandria, Egypt (Source: Author).

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Fig. 8: The Defined Cores in the Grid of the Study Area East Alexandria, Egypt: Vehicular (a) Choice Core, (b) Integration Core (Source: Author).

Areas, highly affected by different traffic modes, are hence suggested to be suitable for the location of parking. In order to verify the level of proximity of those locations to schools, commercial areas and main public facilities of the selected residential study area located in the East district of Alexandria, Egypt, the pedestrian and vehicles Choice cores are overlapped to the Integration core, computed according to a local (R= 3) radius of Integration. (Figure 9) shows the different landuse of the study area.

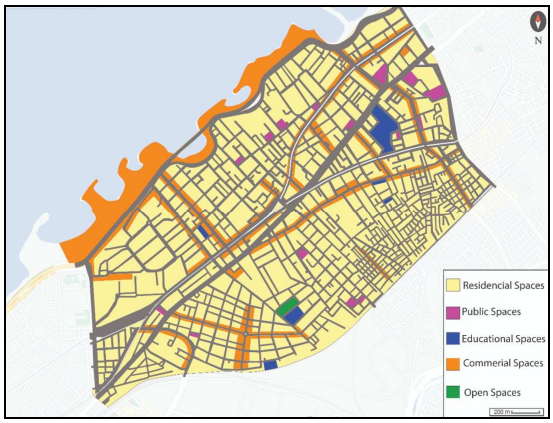


Fig. 9: The Different Landuse of the Study Area (Source: Author)

6 RESULTS

The main results are summarized in (Figure 10) where most of the suitable location for parking sites appear based on the map in (Figure 8) (a) and (b) which represent the actual result of the interception between the pedestrian Choice core (R= 1000 m), the vehicular Choice core (R=8000 m) and the Integration core. The most suitable location for parking sites appears according to the pivoting areas around different movement flows, as a point of conjunction of several important streets and the land use. And from subjective observation of mixed uses found everywhere as shown in (Figure 9). In this study only significant uses are considered and merged with the Choice and Integration core results. Based on the suggested pedestrian/two-wheelers routes and parking locations of the study area another analysis is done for vehicular (a) Choice Core, (b) Integration Core as shown in Figure 11. From Figure 11 it can be seen that choice results did not differ a lot but some routes became more integrated. If highly integrated could cause traffic congestion in peak hours which was not considered in the study. More designs could be tested in further studies to reach ultimate proposals based on configuration analysis applyin space syntax theory which is considered a powerful tool. One of the drawbacks is that traffic can differ at different hours and different seasons which cannot be measured by the space syntax theory but surely it could comapre between different design proposals.It is also important to highlight on the waterfront sidewalks, where people stroll along the seaside overlooking the sea and where various points of interest like restaurants, entertainment centres, sports facilities, and beach properties are located and adjacent to it. For this cause sidewalks and traffic lights are enough for two-wheelers and pedestrians considering that the waterfront of linear Alexandria is one of its main features.

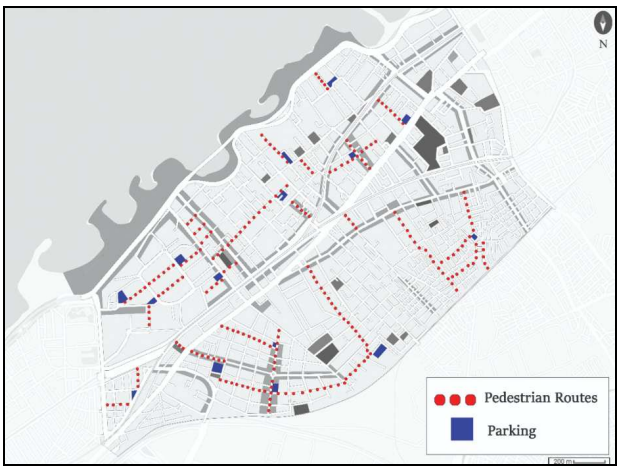


Fig. 10: Suggested Location for Parking and Pedestrian/Two-wheeler Routes (Source: Author)

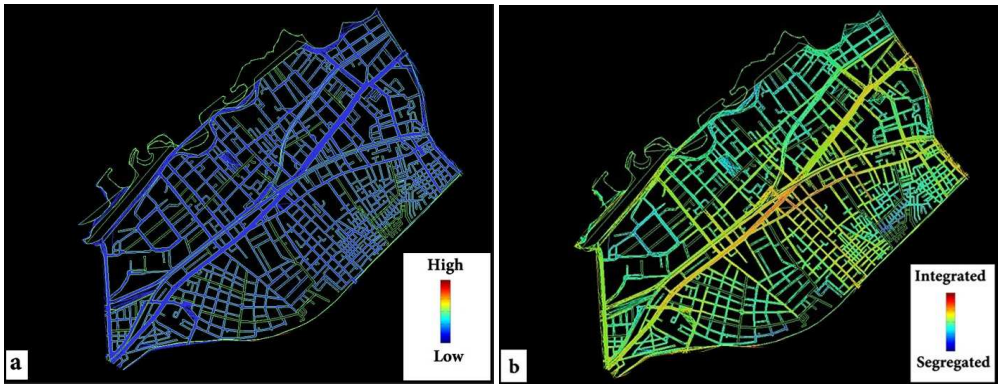


Fig. 11: Based on the suggested parking and pedestrian/two-wheelers routes of the Study Area East Alexandria, Egypt: Vehicular (a) Choice Core, (b) Integration Core (Source: Author).

7 CONCLUSION

This research shows how space syntax can powerfully be used to help select the location for pedestrian/two wheeler routes and parking sites, providing results that appear to narrowly correspond to the actual situation. It is worth underlining that this research is merely a theoretical study that aims at testing a method for identifying possible for pedestrian/two wheeler locations, which could sometimes not be applicable for actual old cities design but some uses can be modified,and because of the presence of buildings that could not be removed or demolished. However, this study can help in suggesting pedestrian and two-wheelers routes based on the results, when accompanied and sustained by the outputs of traffic models and their details. The suggested location for pedestrian/two wheelers and the parking zones, using Space Syntax theory in the case of part of East Alexandria is a reliable tool for concretely supporting planning and decision-making. Furthermore, a similar approach can be easily extended to suggesting routes and the location of other urban activities, differently related to the distribution and influence of other vehicles and transportation movement.

8 REFERENCES

Institute for Transport Studies. https://www.its.leeds.ac.uk/projects/konsult/private/level2/instruments/instrument049/l2_049a.htm (accessed 12 9, 2022)

Dreamstime. https://www.dreamstime.com/bike-pedestrian-route-poznan-poland-march-footpath-symbols-along-bridge-park-image141957938. (accessed 5 5, 2019)

Cycling Embassy of Denmark. Urban Planning and Local Planning. 2018

Tommorrow City. https://tomorrow.city/a/10-cities-embracing-bicycles-in-their-urban-planning. (accessed 24 6, 2021).

Akkelies van Nes et Claudia Yamu: Introduction to Space Syntax in Urban Studies, Springer, 2021

Yamu et als.: Bill Hillier's Legacy: Space Syntax—A Synopsis of Basic Concepts, Measures, and Empirical Application, March 2021Sustainability 13(6):1-25

Hillier B. et Hanson J. The Social Logic of Space. Cambridge: Cambridge University Press, 2009.

El-Darwish I.: Enhancing Outdoor Campus Design by Utilizing Space Syntax Theory for Social Interaction Locations. Ain Shams Engineering Journal (REAL CORP: Shaping Urban Change), 2022: 101524.

Hillier B.: Space is the Machine: A Configurational Theory of Architecture. London: Space Syntax, 1996.

Al-Sayed K. Space Syntax Methodology. London: Bartlett School of Architecture UCL, 2018.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Hillier, B., Burdett, R., Peponis, J., Penn, A. (1987), Creating Life: or, Does Architecture Determine Anything? ,Architecture et Comportement/Architecture and Behaviour , 3 (3) 233 - 250. pp.237
Mohareb, N.: Urban Design – Building Analysis, Workshop at Housing & Building National Research Center- HBRC, Cairo 2019
The Arab Contractors. Stanley Bridge, Alexandria. 2019.
Turner A. "From Axial to Road-Centre Lines." Environment and Planning B, Planning and Design 34, 2007: 539-555.
Google Earth. https://earth.google.com/web/@31.23349454,29.95739507,9.17961101a,15142.11034085d,35y,323.88614065h,0t,0r. 2022. (accessed 7 29, 2022).

🏆 *reviewed paper*

Reviewing the Evolving Categorisation of Metropolitan Municipalities: A South African Perspective

Zaakirah Jeeva, Trynos Gumbo, Juanee Cilliers

(Dr. Zaakirah Jeeva, University of Johannesburg, Zakirah.jeeva@gmail.com)
(Professor Trynos Gumbo, University of Johannesburg, tgumbo@uj.ac.za)
(Prof. Juanee Cilliers, Sydney University of Technology, Sydney, jua.cilliers@uts.edu.au)

1 ABSTRACT

From a theoretical perspective there is limited understanding of how settlements develop, from villages to metropolitan regions. Research reveals that this limitation is due to settlements developing differently, ascribable to the variation in cultural, politics and topography amongst others, globally. As a result, the United Nations found that countries have categorised and delimited their settlements according to their own definitions. Consequently, there is limited comparable knowledge on how settlements develop or how they are categorised, from an empirical perspective. This paper seeks to unpack how administrative regions were delineated in South Africa (a member of the United Nations) and provides empirical insight into the criteria used in South Africa to categorised metropolitan region (post 1994). The research utilised both qualitative and quantitative data to unpack the Section 2 criteria as prescribed in the Municipal Structures Act, as employed by the Municipal Demarcation Act (MDB). The study found that although the Act has many theoretical sound concepts, the application of these concepts is not easy and this has resulted in many different forms of metropolitan regions in South Africa. This questions the ease with which the criteria could be manipulated and unmasks the challenges the country has experiences in the delimitation of administrative regions. Lessons learnt contribute to the broader understanding of how administrative regions can be re-categoris ed and policy mishaps be avoided.

Keywords: Settlements, administrative regions, categorisation, classification criteria, metropolitan region

2 INTRODUCTION

During the early 1930's, Walter Christaller introduced the central place model, which classified settlements hierarchically, according to population concentration, distance between settlements and the economic functions that each housed. Little did he foresee the huge impact that rapid urbanisation and modern socio-economic realities, such as technological improvements, migration, economic advancements, urban competitiveness and the resultant functional linkages between settlements, could have on the morphological settlement structure. According to Antrop (2004) these developments have seen many settlements morphologically, economically and politically sprawl beyond their traditional boundaries to capture physically separate yet functionally networked cities and towns from their surrounding hinterland. This expansion has blurred the division on where urbanity disappears and rurality begins. Subsequently, the UN Habitat I (UN, 1976), recognised the need to create more sustainable human settlements. As a result, many governments have opted to artificially amalgamate, two or more settlements, with complementary functions, to allow for its efficient development and effective management through economics of scale and functional cooperation (Taubenböck, Ferstl & Dech, and 2017:2).

Jessop (2002) found, that these administrative "regions" are not fixed but fuzzy soft entities whose boundaries are malleable. The purpose for their construction differs between economic, spatial, political, social, functional or institutional rationales that are favoured by government. As a result, the criteria for categorisation and delimitation differ in terms of method, indicators, features, definitions and purpose. In their studies, Ch, Martin and Vargas (2018:5) observed that many developing countries categorised and delimited their settlements and administrative regions in an ad hoc manner, based on availability of statistical data, spatial perspective and the political preferences of the country. However, the regions delimited were labelled according to the traditional typology (Villages, towns, cities, metropolitan regions). This meant that many settlements were labelled the same but implied many different structures across the world (World cities report, 2020: 2-6; Dijkstra & Poelman, 2014:2).

The inconsistent definition and understanding of regions, has in turn sparked a scientific debate on what is the best form to contain a "region" for efficient and effective development and what sort of indicators should be used? In light of this, some countries have either opted for more intensive smaller regions, where the growth of their settlements is managed through high density, compact development (Bibri, Krogstie & Kärrholm, and 2020:2). While others have encouraged more extensive forms of development, which support

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

more dispersed, functionally related, lower density developments (Gomes, 2020:2). Ironically, both these approaches motivate their stance as the best suited method to address the issues of sprawl while promoting smart growth (Pack, 2016:5). A direct spin off, from the above debate is how then each modified settlement structure can be categorised; since, data collected would differ according to territorial approach i.e. intensively or extensively (Roberts, Bosker & Park, 2018: 8).

In reply to this shortcoming, international organisations such as the United Nations Habitat (UN-Habitat, 2019: 5), The European Commission (EC), the Organisation for Economic Co-operation and Development (OECD), and Eurostat are all actively trying to find a settlement typology that can be consistently applied globally in order to understand the level of development in countries (Dadashpoor & Malekzadeh, 2020: 288; Dijkstra & Poelman, 2014:2-6).

Research into the South African context, reveals that there is a lack of consistent understanding of what is an urban area, what a rural area is or how a metropolitan regions are categorised? Furthermore, there are limited studies conducted in the country on how administrative regions are categorised in South Africa. Consequently, this paper contributes to this discussion by providing insight into how settlements are theoretically defined and how contemporary administrative regions are defined by the United Nations. It further unpacks how the administrative regions were categorized in post-apartheid South Africa. From an empirical perspective, the paper analyses the application of the section 2 criteria of the Municipal Structures Act (117 of 1998) which is employed by the Municipal Demarcation Board to categorize 8 metropolitan administrative regions or municipalities in South Africa (2000- 2016). The paper concludes with lessons learnt and recommendations.

3 LITERATURE REVIEW

3.1 Spatial formation and transformation

To date, there is no global consensus on what exactly a village or a town or a city entails (UN, 2020:5; Dijkstra & Poelman, 2014:2). From a theoretically stance, rural settlement with a limited population and economic base are known as a village. Theorist claim that with population growth and the concentration of economic activities, these villages grew into towns. Scott (2019:1-2) explains that towns evolve into cities due to centripetal process such as industrialisation, rapid urbanisation, social cohesion and innovation. As a result, cities are essentially towns with higher population densities, more diverse economies and modern infrastructure (Taubenböck, Ferstl & Dech, and 2017:3). However, due to the congestion, increase in housing cost, higher municipal rates and the subsequent increase in crime, grime and social ills, many socio-economic activities dispersed out of cities into smaller rural settlements on the outskirts (Taubenböck, Ferstl & Dech, 2017:4). Eventually these settlements spatially converged to form what is known as a conurbation (Geddes, 1915) or a primate city (Jefferson, 1939) or a formless city (Mumford, 1961) or a higher-order city (Christaller, 1966) or a Metropolitan region. Although this convergence is seen as the natural evolution of urbanisation, the formation of a single administrative region with a mono-centric core was encouraged during the early 1900s, as it was believed larger settlements offered higher economics of scale and more efficient development (Scott, 2019: 2-3)(See Figure 1).

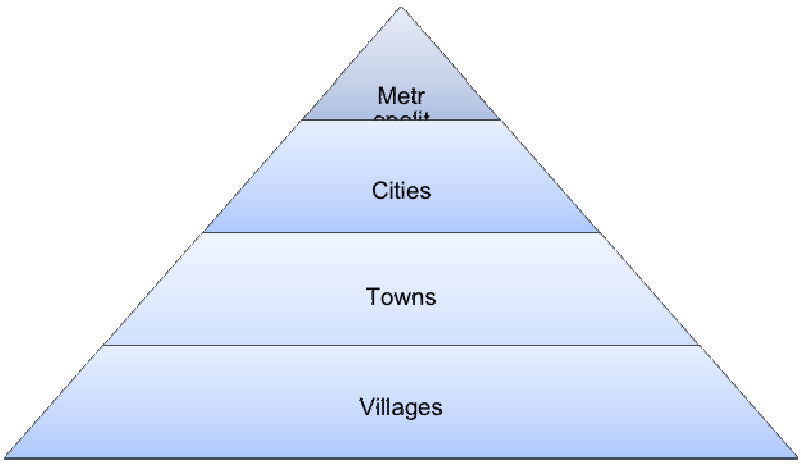


Fig. 1: Traditional Settlement hierarchy (Authors Own)

The model demonstrates that countries have many small villages, fewer towns, limited cities and only a few metropolitan regions. One of the biggest limitations of this model is lack of objective information on the urban size or population density or economic activity allocated to any of these settlement categories and the explanation of how settlements could move across the hierarchy. Furthermore, a common misconception of settlement typology is the separation and independence of the entities.

As a result of these shortcomings, academics, urban planners and international organisations from around the world, have challenged this approach and sought for alternative methods of categorising settlements. One of the alternate views is the categorisation of settlements as 'networked city-regions' or 'multicore city-regions' (Boudeville, 1968) or the 'polynucleated regions' (Meijers, 2007:3). This form of categorisation, acknowledges the inter-dependence of settlements and there is no size-function hierarchy (Sat Aydan, 2018:2-3). For example, the higher-order (city) that offers the most economic activity would have functional linkages with surrounding middle-order settlements (towns) which offer residential and secondary economic activities (Moreno-Monroy, Schiavia & Veneri, 2020:1). Furthermore, villages between these centres could specialise in tertiary services (Yousefi & Dadashpoor, 2020: 49) (See Figure 2).

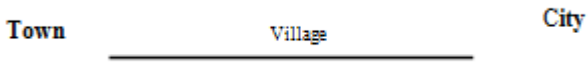


Fig. 2: Spatial Relationships in reality (Authors Own)

Subsequently, the United Nations proposed that functionally linked settlements should be administratively merged to form more efficient settlement regions. Internationally, this was reinforced in the New Urban Agenda, who was committed to 'support the implementation of integrated, polycentric and balanced territorial development policies and plans, which encouraged cooperation and mutual support among different scales of cities and human settlements' (UN-Habitat, 2016, p. 24). In this form of spatial organisation, settlements do not necessarily converge to form powerful hierarchal structures but are dispersed and interrelated by means of functional linkages (Sat Aydan, 2018:2-3). In light of this the United Nations (2018) recommended the following model (refer to Figure 3).

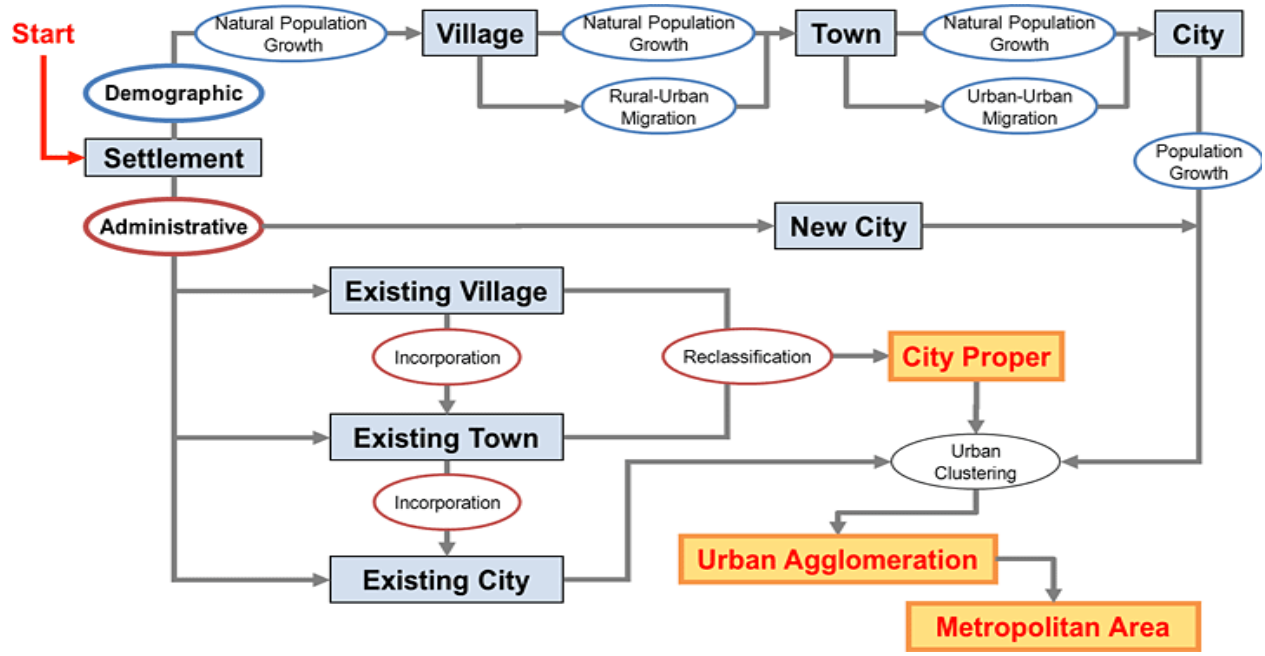


Fig. 3: United Nations classification of settelments (UN, 2018: online)

In this suggested form of settlement typology data is based on the degree of urbanisation index. According to this index, villages which are settlements with less than 300 people/ km2and towns which have a population of over 5000 people or more than 300 people / km2 and which are functionally related could be legally amalgamated and reclassified as a "city-proper" region. Furthermore, these city proper regions (villages + towns) could be further amalgamated with a functionally related city, which has a population of over 50 000 people and 1500 people/ km2be classified as an agglomeration. However, Fang and Yu (2017) revealing that

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

the simple clustering of settlements does not automatically form an urban agglomeration and it is unknown if large agglomerations (conurbation) generate more benefits or whether networks of smaller settlements (polycentric urban region) generate more impulses. As a result, how and when an urban agglomeration evolves into a metropolitan administrative area remains uncertain (UN, 2018; Soja, 2015: 379; Jeeva, 2019: 21-27). The application of the above typology requires population density per km2 and the strength of commuting data between local units to categorise settlements. This data is not always available in developing countries such as South Africa making the classification close to impossible to implement. Furthermore, the model is vague in terms of the required strength of functional linkages or physical distance between settlements for them to qualify for incorporation/]

In synthesis, spatial formation and settlement categorisation has transformed over the past three decades from a mono-centric settlement approach to a more poly-centric approach (see Table 1 below).

	Mono-Centric Spatial Structure	Poly-Centric Spatial Structure
Commuting patters	High- Commuting routes to the main centre	More dispersed commuting flows within the administrative region
Development approach	Intensive, compact, high density development	Extensive dispersed and lower density development.
Spatial structure	Has one main centre or settlement	No dominant settlement or centre
Travel times	Longer commuting times	Shorter commuting times.
Development approach	Intensive development	Extensive development

Table 1: Mono-Centric vs Polycentric Form (Authors Own)

The polycentric model was believed to address all the shortcomings of the traditional mono-centric spatial model, such as high-factor costs, congestion, pollution, long travel times and crime (Eurostat, 2021). However, the dispersed urban population, long travelling distances, small-scale infrastructure facilities, the lack of high-order business services, and the uncertain division of power and function between incorporated centres in a polycentric model, have added new challenges to the development of regions (OECD, 2018:5; Sat Aydan, 2018:2; You, 2018:1-4; Champion & Hugo, 2017: 10-24). As a result, the application of settlement typology models depends on the preferences of the country, since each approach has strength and weakness. The following section will unpack the motivation and classification of administrative regions in South Africa.

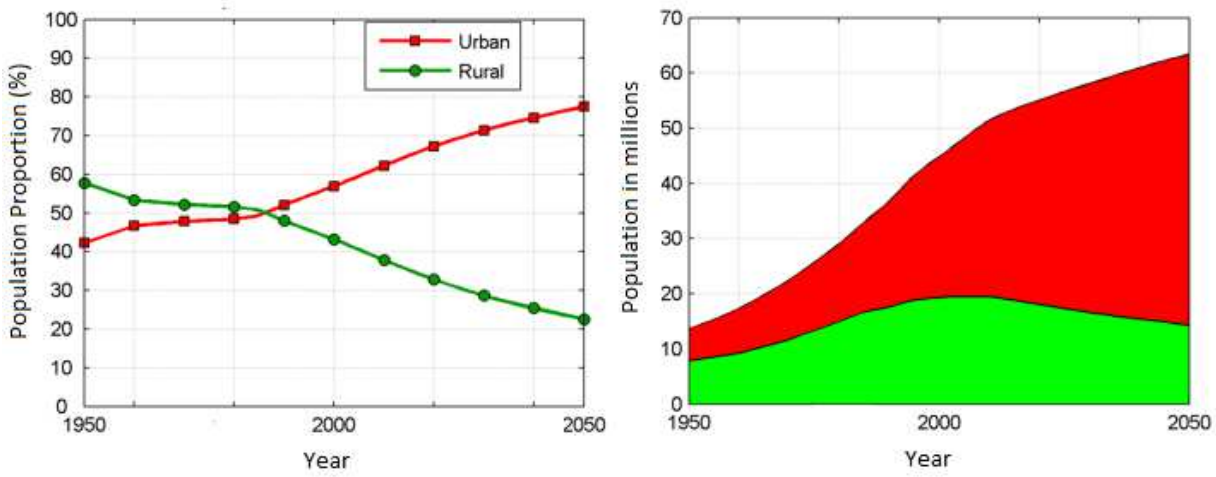


Fig. 4: Population Migration in South Africa 1950-2050 (adapted from Business Tech, 2014: online)

3.2 Administrative Evolution in South Africa

Prior to democracy, South Africa's spatial-demographic and economic arrangement was based on racial segregation and mono-centric morphology, regardless of settlement typology. Furthermore, even though the United Nations (1980) classification of: metropolitans, cities, towns and villages was applied in the country. The official classification was only based on the population density of the white racial group (Jeeva and Cilliers, 2020: 3). Subsequently, there was little information on the actual population density in settlements

and the actual settlement typology of South Africa, right up to the early 1990s. The uplifting of influx control measures, in the late 1980s, further complicated settlement categorisation, as the country experienced large scale demographic transformation and rapid urbanisation (See figure 5 below).

This speedy migration of non-whites out of rural areas and outlying suburbs, into urban areas resulted in haphazard and sprawling urban development increasing the financial and administrative pressure on local municipalities, which were already fragmented and unequally developed (Jeeva & Cilliers, 2020:2). As a first step to correct the spatial-administrative challenge, the Local Government Transition Act (209 of 1993) encouraged the amalgamation of then 1262 racially based local administrations through the 'nearest neighbour principal' with the aim of creating a 'wall-to-wall' integrated administrative system with a 'one city-one tax base' principle, to ensure that the financial revenue collected was spent equally within the integrated administrative area (Giraut & Maharaj, 2002: 40). This administrative change resulted in the revision of settlement categorisation and administrative classification, in 1994. However, in terms of morphological structure, these administrative regions were still mono-centric, just larger.

In light of this, the interim constitution made provisions for administrative areas to be categorised as either: a) Metropolitan, b) Urban or c) Rural Transitional Local Councils (TLC) (RSA, 1993). With, a Metropolitan TLC comprising of an urban core (cities and town) (former white areas) along with the peripheral non-white suburbs, while the surrounding rural areas formed a separate rural TLC (Cameron, 2005:330). This resulted in the 1262 racially defined apartheid government structures being reduced to 843 racially integrated TLC's (SALGA, 2017:17). Although this form of categorisation did display a shift from the traditional categorisation of mono-centric and intensively developed settlements, to a more extensive, polycentric administrative model, the categorisation was found to be inconsistent, inefficient and suspected to be a product of gerrymeandering (Cameron, 2005: 329-330). This was largely due to the lack of objective classification of what an urban area comprised of, or what a rural area was, or what a city or town should encompass, and the rapid rate of migration added to the complexity.

In response, the South African government passed and implemented spatial planning policies that were based on compact, integrated and intensive development objectives with the hope of improving service delivery, housing, health and education, Subsequently, section 155 (1) of the final constitution called the revision of the administrative settlement classification to allow for the mergers of functionally linked urban and rural settlements to form either: Metropolitan Municipality (Category A), Local Municipality (Category B) or District Municipality (Category C) (RSA, 1996). This approach aligned to that of the United Nations polycentric settlement typology with Category A- being aligned to metropolitan regions, Category B aligning to city proper and category C aligning to agglomeration (refer to section 2).

To reduce the effects of gerrymandering, the constitution further called for the election of an independent Municipal Demarcation Board (MDB) to oversee the demarcation and categorisation of administrative regions for the entire country. Later that same year, the Municipal Structures Act (117 of 1998) provided legal criteria on how the aforementioned municipalities should be categorised. According to this Act, Category a Metropolitan municipalities should be (SALGA, 2017: 14):

(a) A conurbation featuring

(i) Areas of high population density;

(ii) An intense movement of people, goods, and services;

(iii) Extensive development;

(iv) Multiple business districts and industrial areas;

(b) A centre of economic activity with a complex and diverse economy;

(c) A single area for which integrated development planning is desirable;

(d) Having strong interdependent social and economic linkages between its constituent units

The sections of the above act are not compiled in an ad hoc basis, but linked to a science of locational theory and urbanism (see section 2 of this paper). Theoretically, a conurbation or metropolitan region is a large urban area which is polycentric in morphology. The area is delimited based on the strength of internal functional linkages, its financial viability (complex and diverse economy) and the integration between the different areas (Geddes, 1915), a global requirement for the formation of metropolitan regions. However, the

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

legislation does not stipulate what is meant by "high density" or how many business districts are encompassed, it just says "multiple", or on what basis integrated planning should be desirable – economic, social, political or whether the region should comprise only urban areas (Functional Urban Area (FUA) or only rural areas (Functional Rural Area (FRA), or a combination of Urban and Rural areas (Functional Urban Region (FUR). On, but wonders, if the criteria are left vague to adapt to context and interpretation. However, a coherently planned approach to create an efficient and equitable administrative region is desirable (see SPLUMA and the National Development Plan 2030 (NDP)).

To add to this complexity, Section 3, adds that if a settlement or region does not have the above mentioned features it would have to be categorised as either a category B (local municipality) or a Category C (district municipality). With Category B municipalities are comprising a combination of urban and rural areas which were functionally related [similar to the UN city proper in section 2 of this paper] and the Category C municipality is an umbrella body over two or more local municipalities and the outlying rural areas [similar to the UN agglomeration in section 2 of this paper]. The method of classification and boundary demarcation was left to the MDB, in consultation with the local communities.

As a result, in February of 1999 the Municipal Demarcation Board (MDB) was established and it began the delimitation and categorisation process together with the assistance of professional consultants and the public. Consequently, by the end of 1999, the 843 TLC were reduced to form 284 Municipalities. Of the 284 established Municipalities - 6 were categorised as Category A (metropolitan municipalities), 47 Category C (District municipalities) and 231 Category B (local municipalities) (SALGA, 2017:18).

However, over the next two years the categorisation of these municipalities was hotly debated since many Category B (Local Municipality) were cross- boundary municipalities and this affected their service delivery. As a result in 2005 the national government passed an Abolishment of Cross Boundary `Municipalities Act with the hope that it would reduce the duplication in service provision. According to the MDB (2008:8), by late 2006 many Category B (local Municipality) started to express their frustration in being dominated by Category C (District municipalities) and stated that they could function better on their own. However, according to legislation they could only function on their own, if they could prove that they adhered to the section 2 criteria of the Municipal Structures Act. However, if this was to occur the Category C (district municipality) in which they were located, would lose a substantial portion of their RSC levies. As a result, many district municipalities opposed the applications (Cameron, 2005: 332). Nevertheless, in late 2006 the RSC levies were abolished and replaced by a government's municipal grant and this brought about a renewed interest in how Category B (local municipalities) could become Category A (metropolitan Municipalities) (SALGA, 2017:17-19).

Consequently, between 2006 and 2008 many larger Category B local municipalities lobbied the MDB to categories them as Category A metropolitan municipalities, stating that larger areas would offer economies of scale. In light of this, in 2008 the National government and the local MEC's requested the MDB to assess the aspiring Buffalo City, Manguang and Msunduzi Category B (local municipalities) on their readiness to become Category A (metropolitan municipalities) based on their existing Category C (district municipality) boundaries and the "financial viability" of the region (SALGA, 2017:17-20). Subsequently, in 2011, both the Manguang and Buffalo city Category B municipalities were provided with Category A municipal status, while Msunduzi was not. This resulted in the increase from 6 to 8 metropolitan municipalities.

The motivation behind the formation and categorisation of these metropolitan regions differs over the 20 year period. Initially, regions with high density were categorised as such because it would promote coherence and integration. However, since 2008 the formation of metropolitans regions was motivated to promote economies of scale and promote financial viability and political administrative independence. Nonetheless, the municipality still needed to prove that it adhered to the Section 2 criteria. The question that came forth is how did these eight municipalities adhere to the Section 2 criteria to become metropolitan municipalities? And to what would other aspiring municipalities have to adhere to qualify as metropolitan municipal status? The next section will evaluate how the Section 2 of the act criterion is empirically applied or interpreted to categorise metropolitan municipalities in South Africa, with the hope of taking lessons and providing a degree of objectivity when categorising aspiring metropolitan municipalities.

4 METHODS AND REVIEW APPROACH

The study utilised a combination of qualitative and quantitative methodology. The qualitative methodology comprised of literature review to understand how metropolitan regions are categorised globally as well as in South Africa. The literature review entailed reading academic literature sourced directly from the Municipal Demarcation Board (MDB) and Google scholar on the dynamics, anomalies, institutions, challenges and controversies of municipal demarcation and categorisation between 1994 -2020. Thereafter, an MDB report written in 2008 was analysed to define the criteria as it is applied by the MBD to categorise metropolitan municipalities. Subsequently, secondary quantitative data was obtained from Quatec and Global insight data on the 8 metropolitan municipalities in South Africa to compare and contrast the application of Section 2 criteria between 2000 and 2016. Lastly, one-on-one interviews were conducted with a former MDB chairperson, as well as with three MDB officials who were randomly chosen from the delimitation and determination department to provide further insight and to verify findings.

5 EMPIRICAL FINDINGS

Although, the prescribed legislative criteria, as found in the Municipal Structures Act (117 of 1998) are based on sound theoretical principles, the study found that the application is challenging due to the lack of definitions and data to support its implementation (See Table 2 below). The table below provides a comparison on how the criterion can be interpreted from a theoretical perspective and its actual application as found in the 2008 MDB report.

Section 2 Criteria	Theoretical perspective	Review findings
High-density areas	No standard theoretical definition. However, the World Bank prescribes that cities and high density areas should have 1,500 inhabitants/km² (World Bank, 2020).	Not objectively defined. MDB applies this criterion ad hoc. Five metropolitan municipalities demarcated in 2000 have density over 1000 inhabitants/km². One has over 500 inhabitants/km² and two municipalities demarcated in 2011 have population below 500 inhabitants/km² (MDB, 2008:20-22).
Intensive movement of goods and services	Functional linkages have not yet been empirically defined and there is limitation on how it can be measured theoretically and empirically.	The required functional intensity between settlements for the settlement to be amalgamated is unknown . There is no data to date to support the criterion and it is motivated in various manners (MDB, 2008:21).
Extensive development	Development that extends over a large area.	MDB measures the percentage of "urban areas" in the administrative regions. No objective threshold is specified on how many urban areas are required in an area to be category A or what an urban area should be (MDB, 2008:24).
Multiple business districts	Higher-order centre with many business districts (i.e. Central Business District, Residential shopping centres, Regional Centres, Neighbourhood centres)	Ir is unspecified what businesses are required or how many business districts are required in a Category An administrative region. MDB implements this criterion by settlement type, which is also subjective as settlement type is not consistently applied in S.A (MDB, 2008:24- 25).
Centre of economic activity with complex and diverse economy	Higher-order centre with many economic activities.	MDB states that tertiary sector employment needs to be higher than secondary sector employment to qualify as a diverse economy. In addition, GVA contribution should be higher than two per cent (MDB, 2008:26-27).
Integrated development	To allow for effective planning and equitable development. The settlements should be continually developed, have similar spatial features and be economically integrated.	Integration is subjective in the empirical context. It is uncertain how to measure it (MDB, 2008:28).
Strong linkages between units	Functional linkages	No data on this criterion (MDB, 2008:30)

Table 2: Analysis of the Section 2 criteria theoretical perspective vs. review findings (Authors Own)

The Section 2 criteria require the settlement region to prove that it has high density for it to qualify for metropolitan status. However, high density by definition differs between countries and in the South African case density is not defined either. As a result it is applied according to context and interpretation of the MDB (MDB, 2008:20-22). As a result, this has led to the categorisation of metropolitan municipalities with 1974 people/Km2 (Johannesburg) and metropolitan municipalities with less than 114 people/ Km2 (Manguang). Arguably, the same legislative criteria was applied in their categorisation. Such differences could be understandable if they were in different countries, but differences such as these, raise eyebrows when found in the same country.

Furthermore, the criterion requires the region to demonstrate that it has 'strong functional linkages'. The term functional linkages are not clearly defined theoretically and there are numerous ways to measurey thist, including night-time lights and travel intensities. Statistics SA does not collect travel data between settlements and data would have to be collected per project. In engagements with the MDB regarding the distance to which functional linkages should extend, no clear definition was forthcoming, with comments

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

inferring the dependence on the municipalities or potential and not the current level of development. In light of the uncertainty MDB personnel revealed that "settlements should have connections" in terms of road and travel. However the intensity is "difficult to measure because people come from all directions to the city and there is no data". Hence, how this point is implemented in South Africa is unknown.

Business districts come in many forms i.e. neighbourhood centre, regional centre, central Business District etc. Each of these business districts house different ecoThe MDB report (2008:24-25) uses the number of 'urban areas' in the municipality to measure this criterion. This would be correct based on the previously demarcated CBD's being part of the white urban areas. However, in terms of mixed-zoning legislation, the interviews with MDB personnel suggested that the municipality "should at least demonstrate that there are many economic activities and many places to shop". However, the question of how many business districts should be in the municipality or what shops they should house was left open. Likewise, comparing the number of nodes or settlements within these municipalities, reveals inconsistency, with the City of Johannesburg having 11 11 settlements, while Buffalo City and Mangaung only had four settlements each, within their regions. The variation could be motivated according to the difference in context and spatial location. Similarly Manguang and Buffalo city have a more rural composition while the city of Johannesburg has a more urban composition. The dissimilarity does open up questions of premature classification in light struggling municipalities (Parliament, 2021:7).

The MDB (2008:24-25) report measures extensive development as "the percentage of urban areas in the administrative regions". In terms of theory this refers to a large area that is developed socially and economically. If one was to combine the two criteria 'extensive development' and 'integrated development', from a theoretical perspective it could imply a poly-centric region that has many settlements that are functionally related. In terms of development, the MDB analyses the GVA contribution of the region as a whole to determine if it is financially viable. By analysing the GVA of the 8 metropolitan mmunicipalties, the study found that the City of Johannesburg contributed 12.64 % of the national GVA in 2000, while Buffalo City only contributed 1.5% of the national GVA in 2011. This is a 10% difference and questions the viability and adherence of the latter. With regards to how regions are integrated, the MBD indicated that they "are currently looking at ways to measure the criterion more transparently, however, currently it is based on the motivation of the MEC's and their interpretation of the term "integration". It was further added that the MDB does not have a standard operating procedure on how category A municipalities are categorised "since each context is different".

In essence, even though the criterion is theoretically sound, the application is vague and appears to be implemented very differently within the country. This is a concern since the dangers of misclassification or premature classification of settlements (through forced mergers) is that these settlements must adhere to policies, legislation and governance according to their status, which they are not ready for. Subsequently, many settlements do not cope administratively, socially, economically or financially and this could result in the misappropriation of funds, misallocation of funds, corruption and poor service delivery making municipalities more of an economic burden then a contributor to the national fiscus. However, on the other hand there is no promise that if a region is delimited in a consistent manner, the outcome would be successful, since there are many independent factors that influence the development and sustainability of a municipality.

In this regard it is interesting to note that not even a year after gaining metropolitan status, Moody's withdrew its A1.za investment rating of the Buffalo City municipality (Moody's, 2012). The Auditor General of South Africa also reported that Manguang municipality who was struggling financially before gaining metropolitan status, continued to struggle more so to maintain its infrastructure and service delivery after becoming a metropolitan municipality (News24, 2019). Furthermore, in 2019, Ratings Afrika found that 231 of South African municipalities were facing collapse and Samkange et al., (2018:10) found that between 2010 and 2017, there were 28,215 service delivery protest in metropolitan municipalities alone. This equates to 4030 protest a year and an average of 11 protests a day! As a result, it is only befitting to ask, if the pre-mature categorisation might have compounded the issues of the municipalit.

6 SYNTHESIS

The following main points are drawn from this paper in an attempt to contribute to providing insight into how settlement regions are categorised in post -apartheid South Africa and the lessons learnt.

6.1 Unit of Measurement

The criteria used to classify a metropolitan region in South Africa are rather complex and difficult to apply, especially since it is close to impossible to meet all the criteria in a set manner at a given time. Hence, the paper recommends that the criteria be simplified to have fewer key criteria i.e. density and GVA contribution each having a set threshold. This would allow for a positive evaluation of similar settlements and make the process more transparent and credible.

The study also found that the Section 2 criteria have duplication in their requirements. The researcher found that point A. (ii) and Point D– both measure functional linkages, for which there is no data and theoretically they are not possible to measure. Thus, it is recommended that these points be excluded from the criteria. Furthermore, point A. (iii) and C both measure integrated development and it is suggested that one be deleted.

6.2 Collection of relevant data

There is a lack of data to support the implementation of the criterion. Thus it is recommended that the MDB collaborates further with Statistics South Africa to collect and disseminate relevant data at a grid cell scale. The benefit is that grid cells have the same shape and size and their borders are stable over time, even though the density or economic composition might change. This would allow for easier categorsation and policy implementation in the long run.

Although the CSIR had created a settlement typology in 2012, the application of this typology across various polices such as the NDP and NSDF remains inconsistent. There is a further call to have a consistent application of settlement typology based on objective criteria within the country.

6.3 Introducing contemporary measures in policy

The measurement of different factors to categorise municipalities or administrative regions would result in a different outcome and it is important to clearly state which factors would be relevant to determine categorisation. Where previously population density, functional linkages, geographical area and travel time were used, these seem less relevant in contemporary times, with people dispersing into rural areas and working over the internet. As a result, contemporary factors such as access to internet, mobile phones, level of access to basic services, virtual transactions, level of education, health and quality of life of inhabitants seems more relevant to categorising settlement and are more aligned to the Sustainable Development Goals for 2030. Thus, a way forward would be the revision of policy to adapt to contemporary factors in categorising administrative settlement regions.

7 CONCLUSION

The world has evolved and the structure of human settlements had to adapt. However, the human need for structure, definition and planning still remains. As a result, the manner in which settlements have been delimited and categorised had to advance. Previously, urban planners found it easy to define human settlements in terms of population composition and economic activities. However, as early as 1976, the UN Habitat I conference found that the mono-centric settlement structure and its related categorisation was becoming unsustainable. This was largely due to rapid urbanisation into cities and town that resulted in many expanding beyond their boundaries. Subsequently, studies into the core-periphery relationship proposed that settlements that are functionally related be amalgamated to form unified regions. It was believed that integrated, polycentric and balanced territorial development would encourage cooperation and efficient development.

However, the term “region” is elusive. Geddes referred to the conurbation as a compact, high density, large urban area that is made up of many settlements that are interrelated. However, the polycentric model states that it could be made up of a set of smaller settlements that have vibrant connection with each other, which are legally incorporated. The vagueness resulted in many different poly-centric settlement regions or metropolitan regions being formed globally, all based on different indicators, context, methods and motivations. In light of this in 2018, the UN Habitat proposed a model that was based on the degree of urbanisation on how these regions could be formed. However, the data that this was based on was not always available.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

South Africa followed the suggestion of the new urban agenda, when it restructured its administrative regions. This was largely due to the governments drive to create racially integrated and cohesive settlements. In light of this, the country opted to firstly distinguish between metropolitan regions, urban and rural areas. However, the initial stages revealed that urban and rural areas could not be separated in an effort of efficient and effective development. As a result, the Constitution called for three major categorisation A- metropolitan regions [similar to the UN], Category B which comprises of urban and rural areas in different combination, this is similar to the UN city proper, and Category C district municipality or what the UN refers to as an Amalgamation. The latter is basically an umbrella body over local municipalities within their jurisdiction. The interesting part is that legislation proposed criteria with an exclusion clause, They defined Metropolitan municipality in a theoretical sense in the Municipal Structures Act, but stated that settlements that do not adhere should be categorised as Category B or C municipalities.

The study investigated the definition and application of the criteria to categorise metropolitan municipalities, in order to determine, how municipalities adhere or are excluded from them. The study found that although the criteria are theoretically sound it is not easy to implement them, since, each context is different. Furthermore, the process is open to public participation and political approval. Subsequently, categorisation is not just a product of the application of the criteria but is subordinate to non-controllable forces of power and public opinion. Current theories fail to address issues of power and this is why the gap between theory and practice often seems unbridgeable and outcomes are inconsistent.

The question is, if the requirements are lowered (as shown above) and if more municipalities apply to become metropolitan municipalities, can they be denied metropolitan status? And if not, what is the implication of having lots of metropolitan municipalities? Subsequently, the paper recommends that legislation be more aligned to the requirements of the United Nations Sustainable Development Goals and Quality of Life index, rather than just the spatial and economic indicators. This would make the process more transparent and objective.

8 ACKNOWLEDGEMENTS

This work is based on the research supported by the National Institute for The Humanities and Social Sciences.

9 REFERENCES

BIBRI, S.E. KROGSTIE, J., and KARRHOLM, M. 2020. Compact city planning and development: Emerging practices and strategies for achieving the goals of sustainability. Developments in the Built Environment. Doi.org/10.1016/j.dibe.2020.100021.

BOUDEVILLE, J. R. 1968. Problems of Regional Economic Planning. Edinburgh: Edinburgh University press.

BUSINESS TECH. 2014. SA POPULATION FLOCKING TO CITIES. AVAILABLE FROM: HTTPS://BUSINESSTECH.CO.ZA/NEWS/TRENDING/62749/SA-POPULATION-FLOCKING-TO-CITIES/ [8 FEB 2022].

CAMERON, R. 2005. Metropolitan restructuring (and more restructuring) in South Africa. Public Administration and Development: The International Journal of Management Research and Practice. 25(4): 329-339.

CHAMPION, T. and HUGO, G. 2017. Introduction: Moving Beyond the Urban–Rural Dichotomy. In Hugo, G., New Forms of Urbanization, Routledge, New York, pp. 3–24.

CH, R., MARTIN, D., and VARGAS, J. 2018. Measuring the size and growth of cities using night time light. Working paper series. 2018/14. Development Bank of Latin America. Available from: https://scioteca.caf.com/bitstream/handle/123456789/1279/measuring-the-size-and-growth-of-cities-using-nighttime-light.pdf?sequence=1 [3 Nov 2021].

CHRISTALLER, W. 1933. Die Zentralen orte in Suddeutscland. In Fischer, J. 1966. Translated from the German by L.W. Baskin. Englewood Cliffs: Prentice Hall.)

DADASHPOOR, H. and MALEKZADEH, N.2020. Driving Factors of Formation, development and Change of spatial structure in metropolitan areas: A systematic review. Journal Of Urban Management. 9(3):286-297.

DIJKSTRA, L and POELMAN, H. 2014. A harmonised definition of cities and rural areas: the new degree of urbanisation. European Commission. WPS01/2014.

DU PLESSIS, C., IRURAH , D., and SCHOLES, R. 2010. The built environment and climate change in South Africa. Building Research & Information. pp. 240-256. DOI 10.1080/0961321032000097665.

FANG, C. and YU, D. 2017. Urban agglomeration: an evolving concept of an emerging phenomenon. Landscape and urban planning, 162:126–136.

EUROSTAT. 2021. Applying the Degree of Urbanisation — A new international manual for defining cities, towns and rural areas. DOI: 10.2785/485951

GEDDES, P. 1915. Cities in evolution. London: Williams & Norgate.

GIRAUT, F. and MAHARAJ, B. 2002. Contested terrains: cities and hinterlands in post-apartheid boundary delimitations. GeoJournal, 57: 39-51

GOMES, E. 2020. Sustainable Population Growth in Low-Density Areas in a New Technological Era: Prospective Thinking on How to Support Planning Policies Using Complex Spatial Models. Land 9-, 221. DOI:10.3390/land9070221
JEFFERSON, M. 1939 The law of primate city. Geographical review, 29(2):226–232.
JESSOP, B. 2002. The Political Economy of Scale. In M. Perkmann and N.L. Sum (eds) Globalization, Regionalization and Cross-Boarder Regions. Palgrave: 25-49.
JEEVA, Z.I. 2019. Reflecting the formation of Metropolitan regions in South Africa. PhD Thesis. NWU.
JEEVA, Z.I. and CILLERS, J.E. 2020. Exploring settlement typologies in Post-Apartheid South Africa. International Journal of Public Affairs. doi.org/10.1002/pa.2510
MEIJERS, E. 2007. 'FROM CENTRAL PLACE TO NETWORK MODEL: THEORY AND EVIDENCE OF A PARADIGM CHANGE. JOURNAL OF ECONOMIC AND HUMAN GEOGRAPHY. 98 (2): 245-259. DOI.ORG/10.1111/J.1467-9663.2007.00394.X
MUNICIPAL DEMARACTION BOARD (MDB). 2008. Investigating into possible demarcation of more metropolitan authorities and the extension of the municipal areas of existing metropolitan areas. Pretoria. May
MOODY'S. 2012. Credit opinion. Available from: https://www.yumpu.com/en/document/read/33988437/credit-opinion-buffalo-city-municipality-south-africa-rating - [15 May 2020].
MORENO-MONROY, A.I.,SCHIAVA, ,M. and VENERI, P. 2020 Metropolitan areas in the world. Delineation and population trends. Journal of Urban Economics. doi.org/10.1016/j.jue.2020.103242
MUMFORD,L. 1937. What is a City? Architectural records. https://deensharp.files.wordpress.com/2014/08/mumford-what-is-a-city_.pdf
NEWS24. 2019. Municipalities struggle to deliver services. Available from: https://www.news24.com/news24/SouthAfrica/Local/Express-News/municipalities-struggle-to-deliver-services-20191001 [20 June 2020].
ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT (OECD). 2018. Cities in the world: A new perspective on Urbanization. Doi.org/10.1787/B261814F-EN
PACK, J.R. 2016 Chapter 1: Metropolitan Development: Patterns, Problems, Causes, Policy Proposals. Available from: https://www.brookings.edu/wp-content/uploads/2016/07/sunbeltfrostbelt_chapter.pdf [28 July 2021].
PARLIAMENT. 2021.2019/20 Local Government Audit Outcomes. Available from: https://static.pmg.org.za/210908roup_Proactive_-_201920_Local_Government_Audit_Outcomes___July_2021.pdf [2 January 2022].
QUANTEC DATA. 2018. Data. https://www.quantec.co.za/easydata/
ROBERTS, M., BOSKER, M and PARK, J. 2018. How to define a metropolitan area? Sustainable cities. https://blogs.worldbank.org/sustainablecities/how-define-metro-area [26 Dec 2021].
SALGA. 2017 15 years of developmental and democratic local government 2000- 2015. Available: https://www.salga.org.za/Documents/Knowledge%20Hub/Local%20Government%20Briefs/15-YEARS-OF-DEVELOPMENTAL-AND-DEMOCRATIC-LOCAL-GOVERNMENT.pdf [9 Jan 2022].
SAT AYDAN, A. 2018. Monocentric or polycentric? Defining morphological structure of Nuts-2 regions of Turkey from 2000 to 2016. Geographica Pannonica, 22(1):1–13.
SAMKANGE, C., MASOLA, K. KUTELA, D.G., MAHABIR, J and DIKGANG, J. 2018. Counting the cost of community protest in public infrastructure. SALGA. Available from: https://www.salga.org.za/SALGA-Dullah%20Omar%20Institute/Documents/Dlulisa.pdf [20 Aug 2020]
SCOTT, A.J 2017. The Constitution of the City: Economy, Society, and Urbanization in the Capitalist Era. New York: Palgrave Macmillan
SCOTT, A.J. 2019. City Regions Reconsidered. Environment and Planning A.51(3). DOI: 10.1177/0308518X19831591
SOJA, E. 2015. Accentuate the regional. International Journal of urban and regional research, 39:372–381.
SOUTH AFRICA. 1993. Interim Constitution of the Republic of South Africa. Available from: http://www.justice.gov.za/legislation/acts/1993-200.pdf [6 Feb 2016].
SOUTH AFRICA. 1996. The Constitution of the Republic of South Africa, Act 108 of 1996. Cape Town: Government Printer.
SOUTH AFRICA. 1998. Local Government: Municipal Structures Act 117 of 1998. Cape Town: Government Printer.
TAUBENBOCK, H., FERSTL, J and DECH, S. 2017. Regions Set in Stone—Delimiting and Categorizing Regions in Europe by Settlement Patterns Derived from EO-Data. International Journal of Geo-Information. 6 (55) doi:10.3390/ijgi6020055
TUROK, I. 2014. South Africa's tortured urbanisation and the complications of reconstruction. In Martine, G. & McGranahan, G., (eds). Urban Growth in emerging economies: lessons from the BRICS. London: Routledge pp. 143–190.
UNITED NATIONS (UN). 2018. Methodology: Definition Issues. Available from: https://population.un.org/wup/General/DefinitionIssues.aspx [5 June 2018].
UNITED NATIONS. 2020. A recommendation on the method to delineate cities, urban and rural areas for international statistical comparisons. Available from: https://unstats.un.org/unsd/statcom/51st-session/documents/BG-Item3j-Recommendation-E.pdf [5 June 2018].
UNITED NATIONS HABITAT. 2019 Addressing Urban and Human Settlement Issues in NationalAdaptation Plans. Available from: https://unhabitat.org/nap-human-settlement [2 Sep 2020].
WORLD BANK. 2020. Urban Population (% of total population). Available from: https://data.worldbank.org/indicator/SP.URB.TOTL.IN.ZS [18 Oct 2020].
WORLD CITIES REPORT. (2020). The Value of Sustainable Urbanisation. Available from: https://unhabitat.org/sites/default/files/2020/10/wcr_2020_report.pdf [5 May 2020].
YOU, Y. (2017). The classification of urban systems: a review from
monocentric to polycentric. Advances in Economics, Business and Management Research, 42:1-4.
YOUSEFI, Z and DADASHPOOR, H. 2020. How do ICTs affect urban spatial structure? A systematic literature review. Journal of Urban Technology, 27 (1):47-65

🏆 *reviewed paper*

Shared Design Framework for Autonomous Vehicles and Land Use Interface

Swee Yong Ku, Sheila Conejos

(Swee Yong Ku, Singapore University of Social Sciences, 463 Clementi Road Singapore 599494, syku001@suss.edu.sg)
(Dr Sheila Conejos, Singapore University of Social Sciences, 463 Clementi Road Singapore 599494, sheilaconejos@suss.edu.sg)

1 ABSTRACT

Technologies around Autonomous Vehicles (AVs) have improved enormously in the last decade. Autonomous vehicles are increasingly being tested on roads around the world. While the commercialisation of AVs seems imminent and researchers have explored various scenarios on the impact of driverless cars, trucks and buses on urban planning, the research around how AVs interface with land use and buildings remains scarce. This means that AVs may not be ready for full end-to-end transportation of passengers in high-density cities where drop off points are built within the buildings. This research study aims to fill the gap by examining the issues around the AV interface with land use and buildings, before these vehicles can become a viable option for commuters. Further research is required to investigate how these vehicles can navigate away from the roads into buildings, navigate within buildings, and then navigate out of buildings back onto the roads. This paper reviews current literature on the subject of autonomous vehicles and how they interact with and impact on the built environment. The findings identified a knowledge gap on how autonomous vehicles interface with buildings. The scant research in this area could slow the adoption of autonomous vehicles in a city like Singapore. Thus, this paper proposes a novel shared design framework plan for stakeholders, such as commuters, car manufacturers, building owners and design consultants, etc., to adopt so that building owners may enhance their assets for smoother access by autonomous vehicles. The inputs from a range of stakeholders could steer the formulation of guidelines for upgrading existing buildings to be AV-friendly and introduce relevant design considerations for new buildings to be AV-ready.

Keywords: Autonomous vehicles, Built environment, Land use, Shared design framework, Singapore

2 BACKGROUND

The USA leads the world in the Autonomous Vehicle (AV) industry. One of the most advanced developers of AVs, Waymo, has road-tested their driverless cars in over 25 cities and covered more than 20 million miles (Holt, 2021) in the last decade. AVs have also been put on road-trials as robo-taxis in a multitude of countries such as China (Toh, 2022), Australia (Cole, 2021), South Korea (Shim, 2021) and more than 10 European countries (European Commission, 2019). Since 2014, Singapore has trialled AVs in low traffic environments, for example a driverless taxi with MIT spin-off NuTonomy in the One North district and a driverless bus with Volvo in Nanyang Technological University (Kelleher, 2017; Tan, 2020; Toh, 2019). During the July 2021 Tokyo Olympics, Toyota showcased their leadership in the AV industry by deploying a fleet of driverless electric cars to ferry athletes between venues in the Olympic Village (Davis, 2021).

With so many trials going on around the world, it might seem that society is on the cusp of having AVs ply our roads. However, before AVs may be added as mobility options as personal cars, fleets of shared vehicles or for the transportation of goods, appropriate policies and laws will have to be enacted. Government policies and laws are still playing catch up in order to enable the adoption and smooth rollout of AVs and any supporting infrastructure (Freemark et al., 2019). While the results of these road trials on city streets and highways were deemed positive, there is little evidence for AVs manoeuvring into and out of buildings.

Based on the report of the European Commission (2019), tests on automated driving were conducted across 10 countries examining four functions: 1) Motorway Chauffeur – including driving up to 130 km per hour and lane changing; 2) Traffic Jam Chauffeur – a driver activated function in congested streets; 3) Urban Chauffeur – city driving which can respond to traffic lights and other road users; 4) Parking Chauffeur – the car manoeuvres itself into a parking lot. Notably, these tests did not explore how AVs could navigate the interface between the roads into the multi-storey carpark of a retail mall or, to the loading and unloading bay of a warehouse.

Many research studies have discussed the potential benefits and downsides of AVs. The range of anticipated benefits include: coupling AVs with ride sharing will result in lower car ownership and a smaller vehicle population (Townsend, 2020); fewer traffic accidents as a result of errant or drunk drivers (Anderson et al, 2014); lower demand for parking lots allows the repurposing of parking lots for urban farming or

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

recreational uses (Bagloee et al, 2016); reduced pollution due to more efficient traffic management (Bahamonde-Birke et al, 2018); and big reduction in cost-per-trip due to shared vehicle cost and savings on drivers' salaries (Andersson & Ivehammar, 2019).

Some researchers highlighted the possible negative impacts of AVs such as: the massive loss of jobs for drivers of trucks, taxis and buses (Strömberg et al., 2021); as personal car ownership declines, businesses such as car insurance, car repair and maintenance, may become irrelevant (Anderson et al, 2014); the reduced costs of shared AVs may incentivise commuters to switch from mass public transit and buses to shared AVs, thereby increasing the number of trips and energy consumption (Kellett et al, 2019); eliminating the drive in and out of town as well as the need to park their cars, AVs may induce office workers in the CBD to live farther away in the suburbs, and leading to urban sprawl (Freemark et al., 2019; Duarte & Ratti, 2018).

Until AVs are widely adopted in various cities, whether the benefits will exceed the downsides remains uncertain.

As a small country of 728 square kilometres, Singapore has limited resources. The small land mass supports a 5.45 million population. The majority of Singapore's population work in, and live in, high density urban districts. The Land Transport Authority (LTA) recognised the value that AVs would bring to Singapore such as, increased mobility options for commuters and transportation of goods, improved sustainability of the transportation system for the city state, reduction in road accidents, optimised use of road space and the creation of higher value jobs related to AVs. The aim of this paper is to identify the issues and challenges of integrating AVs into Singapore's land use with a particular focus on how AVs navigate away from the roads into buildings, within the buildings and then out of the buildings back onto the roads.

3 LITERATURE REVIEW

While researchers are exploring various scenarios around the pace of adoption and penetration of AVs to ease mobility, policy makers and urban planners remain unprepared to deal with the disruptions that AV technology could bring (Faisal et al., 2019; Freemark et al., 2019; Milano, 2019; Mondschein, 2014). Legislation needs to be introduced to allow the AV technologies and commuter adoption to grow, while ensuring the safety of passengers and road users (Townsend, 2020).

At present, expected benefits and negative repercussions of introducing AVs into the transportation mix are forward looking and speculative (Townsend, 2014). For instance, the Rudin Centre for Transportation Policy & Management applied the four alternative future scenarios, ("Growth", "Collapse", "Constraint" and "Transformation") for mobility and transportation systems in the USA by 2030 (Townsend, 2014). Growth refers to a future where present trends are extended. Collapse refers to a future where negative events lead to critical systems failing. Constraint refers to a future where growth is slowed due to resource limitations. Transformation refers to a future disrupted by innovation resulting in steep growth conditions.

Milakis et al. (2017a) considered the future of transportation in the Netherlands using a 2 by 2 matrix to develop 4 scenarios based on an "intuitive logics method." The 4 scenarios were labelled "AV in standby," "AV in doubt," "AV in bloom" and "AV in demand" to imagine what the transportation landscape could look like in the years 2030 and 2050. They estimated the penetration rates of AVs and the possible implications on road usage. Similarly, Fagnant and Kockelman (2015) examined the impact of 10%, 50% and 90% AV market penetration on quantifiable parameters such as traffic accidents, congestion, cost savings and policy needs. The data from these quantitative simulations were used to substantiate the recommendations to policy makers. Some studies also looked at future scenarios based on the first order, second order and tertiary order effects of AV presence in the transportation mix (Milakis et al., 2017b; Bahamonde-Birke et al., 2018).

3.1 Positive Outcomes On The Use Of AVs

Most of the research conducted on AVs highlighted positive outcomes of their inclusion in a mobility system according to economic, environmental and social benefits as shown in Table 1.

Benefits	Areas	Description	Underpinning Literature
Economic	Lower operating costs and reduced total costs of ownership	The salaries of truck drivers, including overtime pay or additional allowances for night shifts, will be saved. For passenger car drivers, the time saved from driving may be allocated to productive work. Parking costs will be reduced. Lower risks of driver-induced accidents will imply lower insurance fees and reduced maintenance expenses for individual-owned AVs. Shared ownership of AVs will reduce idle time.	Andersson & Ivehammar (2019), Anderson et al. (2014), Bagloee et al. (2016), Bahamonde-Birke et al. (2018), Bösch et al. (2018), Fagnant & Kockelman (2013), Litman (2022), Pettigrew et al. (2018), Solon (2016), Strömberg et al. (2021), Townsend (2014)
	More high skilled jobs will be created	New jobs will be added for fleet operations and management of AVs. Skillsets for maintenance and repairs of AVs will require workers who are able to program software of the AVs and calibrate on-board instruments such as LIDAR, RADAR and visual cameras.	Anderson et al. (2014), Pettigrew et al. (2018), Townsend (2014)
Environmental	Less emissions from cars and trucks	Reduced fuel consumption as fleet owners optimise routes. AVs are assumed to be almost 100% electric vehicles.	Anderson et al. (2014), Mondschein (2014), Fagnant & Kockelman (2013), Milakis et al. (2017b), Townsend (2020)
	Less congestion	Overall car population will be reduced as the convenience of car sharing and ride sharing grows on commuters. Route optimisation for fleet-owned AVs will balance out traffic flow.	Kellett et al. (2019), Milakis et al. (2017a), Townsend (2020)
Social	Accessible to more people	Shared AVs with their lower cost per trip can increase accessibility to low-income households and improve travel for persons with mobility issues such as the elderly or young children.	Bagloee et al. (2016), Fagnant & Kockelman (2013), McCormick (2019), Strömberg et al. (2021), Townsend (2020)

Table 1: Some key benefits Autonomous Vehicles are expected to bring.

3.2 Negative Outcomes On The Use Of AVs

Researchers have also expressed concerns about various negatives that could arise from the use of AVs, based on economic, environmental and security perspectives as shown in Table 2.

Downsides	Areas	Description	Underpinning Literature
Economic	Government budgets	Convenience of AVs for door-to-door transport may reduce the usage of mass public transit (e.g. buses and trains), leading to an increased need for subsidies. Parking revenue, parking fines and traffic fines are expected to drop.	Anderson et al. (2014), Andersson & Ivehammar (2019), Driverless Seattle (2017), Kellett et al. (2019), McCormick (2019), Siddiq et al. (2021), Townsend (2020)
	Millions of jobs lost	The jobs and income of truck drivers, taxi drivers and bus drivers will be affected. The need for traffic police officers could be reduced. Education system needs to consider training them for AV related vocations.	Bagloee et al. (2016), Pettigrew et al. (2018), Solon (2016), Strömberg et al. (2021), Driverless Seattle (2017)
	Financial losses	City governments and building owners who have invested in new AV infrastructure and technologies risk rapid technology obsolescence and system failures.	Driverless Seattle (2017), Litman (2022), Townsend (2020)
Environmental	More congestion	AVs increase accessibility to a wider range of users and the increased demand for car trips which replaced buses, cycling or walking will lead to more traffic jams.	Anderson et al. (2014), Fagnant & Kockelman (2013), Kellett et al. (2019)
	Redundant carparks	Demand for carparks will be reduced significantly. A majority of carparks such as the multi-storey and basement carparks in buildings may be too costly to repurpose.	Anderson et al. (2014), Duarte & Ratti (2018), González-González et al. (2020), Autonomous Vehicles and Their Impact on Real Estate (2018)
Security	Hackers and bad actors	The system controls of AV fleets could be hacked by terrorists to create accidents or bring a city's traffic to a standstill.	Fagnant & Kockelman (2013), Litman (2022), Townsend (2020)
	Privacy and surveillance	Individuals' locations and travel data could be monitored. Hackers with malicious intent could spy on the activities of individuals to cause harm to them, their companies or society. Governments may track citizens' through the movement of AVs.	Fagnant & Kockelman (2013), Townsend (2020)

Table 2: Some of the potential downsides arising from the widespread adoption of Autonomous Vehicles.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

4 METHODOLOGY

This research uses a qualitative method combining a systematic literature review and selected case studies to examine the potential issues and challenges associated with AVs and the built environment. Case study data was collected from multiple sources to ensure data credibility (Patton, 1990; Yin, 2014). This research has reviewed publications written in English while reports published in Chinese on AV trials (for example by companies such as BYD, DiDi, AutoX, Pony.ai, etc) and articles published in Japanese, Korean and other European languages were not considered.

The case studies reviewed in detail are studies that considered the introduction of AVs into the mobility systems in the cities of Zug in Switzerland (Bösch et al., 2018), Seattle in USA (Driverless Seattle, 2017) and Adelaide in Australia (Kellett et al., 2019). Based on the literature review and undertaken case studies, the positive (Table 1) and negative (Table 2) outcomes were identified among global cases. These issues and challenges are then compared to Singapore's context so that the integration of AVs into Singapore's built environment can be considered. Given the high density urban typology of Singapore's built environment, we examine how AVs navigate away from the roads into buildings, within the buildings and then out of the buildings back onto the roads.

5 SINGAPORE CONTEXT

Singapore supports the 2030 Agenda for Sustainable Development guided by the Sustainable Development Goals (SDGs). Singapore's commitment to cut down on carbon emissions is evident, as outlined in the Green Plan 2030. Significantly, to encourage the use of electric vehicles (EV), Singapore introduced a policy to invest in 60,000 charging stations and make all towns EV-ready by 2030 (LTA, 2021). Another affirmative action concerned a reduction in the number of parking spaces and designated new residential neighbourhoods and business precincts as "car-lite" areas. In the past decade, such car-lite areas with reduced parking availability were gazetted in 10 areas around Singapore. According to the government, there are more than 12,000 carparks in Singapore, providing about 1.4 million parking lots spread across public housing estates, private residential areas, open air and curb-side carparks, retail malls, offices and industrial buildings (Lin, 2021). The adoption of AVs could allow a large number of carparks to be repurposed for greater social and economic value.

The evident potential of such reforms has resulted in Singapore's growing interest in adopting AV technology. Efforts to support AVs began with road trials in 2014 (Kelleher, 2017). This was followed by the opening of the Centre of Excellence for Testing & Research of Autonomous Vehicles (CETRAN) in 2017 and the building of a 1.8 hectares trial AV test circuit. The Land Transport Authority (LTA) has also published its roadmap for the deployment of AVs (albeit without any target dates) (LTA, n.d.).

As part of public engagement under the Long-Term Planning Review, the Urban Redevelopment Authority (URA) held a public exhibition entitled "Reimagining Urban Mobility with Autonomous Vehicles" in January 2022. The public engagements are intended to increase stakeholder awareness and adoption, particularly among commuters. At this exhibition, the URA highlighted that urban regeneration brought about by the efficiency of AVs would allow road lanes to be reclaimed as cycling paths and walkways, maximising links between residents and nature. Through these engagements, property developers and building owners are reminded of the government's commitment to introduce AVs as part of the transportation mix.

6 DISCUSSIONS OF FINDINGS

This research aims to identify issues and challenges of integrating AVs into Singapore's land use and built environment. We reviewed literature on the subject of autonomous vehicles and how they interact with and impact the built environment. There is sufficient engineering literature and data from road tests to confirm that AVs are able to navigate the streets using maps, street markings and road signs. However, the findings identified a knowledge gap on how autonomous vehicles interface with buildings: how AVs navigate away from the roads into buildings, within the buildings and then out of the buildings back onto the roads. Given the high built-up density of Singapore, AVs would be required to manoeuvre into and out of buildings (e.g. shopping malls, office buildings, schools, factories, condominiums, hotels, etc.) to pick up and drop off commuters and goods. Any issues around the interface of AVs with land use and buildings need to be resolved completely before AVs can be deployed into high-density urban settings.

The majority of literature on AVs in Singapore has been engineering-focused, such as in the areas of computer vision and mobility trials, etc. (Toh, 2019; Smart Nation Singapore, n.d.). A handful of recent papers surveyed commuters' perceptions and concerns around AVs (Chng & Cheah, 2020; Wang & Zhao, 2019) There is a lack of published research on issues and challenges concerning the deployment of AVs in Singapore such as social impact, financial benefits and traffic optimisation.

The case studies reviewed, namely Zug in Switzerland (Bösch et al., 2018), Seattle in USA (Driverless Seattle, 2017) and Adelaide in Australia (Kellett et al., 2019), were relevant to the Singapore context on various fronts. However, a key difference is that these papers studied the specific context of the cities whose built environment and population densities are much lower than Singapore's. At about 8,300 population per square kilometre, Singapore has one of the highest population densities in the world. Therefore the majority of the building typology is high-rise, and we are concerned that the movement of AVs into such high density, high-rise built environments has not been adequately considered. In contrast, Zug, Adelaide and Seattle have population densities of between 1,400 and 3,400 persons per square kilometre.

As shown in Table 3, literature and case study reviews tended to focus on economic, technology, social, legal and stakeholder aspects of AV usage. Where there is mention of the built environment and land use, they are mainly related to the reduced demand for parking lots and whether commuters will choose to live further from business districts, causing urban sprawl to be worsened (e.g. Duarte & Ratti, 2018). Studies in relation to the AV interface with land use and buildings are not available.

Case Study	Economic	Social	Technology	Legal	Stakeholders	Built Environment
Seattle	✓	✓	✓	✓	✓	✗
Zug	✓	✗	✓	✓	✗	✗
Adelaide	✓	✓	✓	✓	✓	✓
Singapore	✗	✗	✓	✗	✓	✗

Table 3: Comparison of Economic, Social, Technology, Legal, Stakeholder and Built Environment parameters covered by 3 case studies versus the AV literature in Singapore.

6.1 Economic factors

Simulations by Bösch et al. (2018) for the city of Zug revealed that when commuters switch to shared AV transport, it would result in reductions in the costs of automated public transport, vehicle population and reduced travel time for commuters. However, depending on the policies enacted, there are risks of increased costs due to additional Vehicle Kilometre Travelled (VKT) for vacant trips to pick up passengers.

When consumer sentiment around car ownership or resistance to technology adoption were excluded, Kellet et al. (2019) found that around 18% of the current vehicle fleet would be sufficient to service commuters during peak demand hours. This full adoption scenario would be of considerable financial and time savings to consumers in the long term. With ride sharing, a full AV fleet could further decrease this percentage. Considering the survey results indicated that two-thirds of drivers would prefer not to share rides, the remaining one-third would use a communal service fleet. In this modified version of the full adoption scenario, 73% of the current fleet could service peak-hour demand. During the transition, assuming a maximum AV occupancy of two-thirds, they determined that 82% of the current vehicle fleet could meet peak demand. The survey results also revealed that lower AV costs would encourage consumer uptake, consistent with results provided by other researchers (e.g. Kyriakidis et al., 2015).

Driverless Seattle (2017) highlighted several other economic factors to consider. The report recommended the city government to invest in AV infrastructure through collaboration with strategic industry partners and stakeholders such as researchers and standards groups. In addition, they cautioned about the significant financial impact on municipal revenues. Given that AVs are expected to reduce the numbers of road accidents, the number of traffic infringements and parking tickets, a large part of Seattle's $29.2million traffic fines could be removed from the city's annual budget. Alternative sources of revenues would need to be developed, such as AV registration fees and taxing commuters for VKT.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

6.2 Social

In Adelaide, Australia, commuter surveys by Kellet et al. (2019) revealed that the major factors affecting adoption are commuter attitudes to driving and AVs, the costs of owning and operating AVs and consumer attitudes to ride sharing. Survey respondents were willing to accept AV technology, but the pleasure of driving cars, along with the social status of car ownership may inhibit mass-adoption of ride sharing. Such factors would affect adoption models for e.g. 10, 50, 75% AV presence in the vehicle fleet. As riders of public transport shift to AVs, this could lead to an increase in "peak period vehicle flows," which would be likely to increase congestion, particularly at choke points.

Driverless Seattle (2017) highlighted that the introduction of AVs have implications for social justice and equity. AVs are expected to bring "tremendous mobility benefits" to groups that are restricted in mobility options due to age or disability. They recommended that policy makers in Seattle consider disadvantaged groups when developing new transport policies to incorporate AVs into the transportation mix.

6.3 Technology

Townsend (2020) stated that safety of lives inside and outside the AVs cannot be compromised. If the transportation industry wanted to see consumers' support for and use of AVs grow in the near future, the safety record of AVs on public roads with respect to lives would have to be impeccable. To quote the author, "we either perfect self-driving, or there won't be an industry to speak of."

One of the key benefits touted for AVs is the reduction of traffic accidents and the expected drop in traffic fatalities due to the elimination of driver error. The National Highway Traffic Safety Administration (NHTSA) of the U.S. Department of Transportation stated that "the major factor in 94 percent of all fatal crashes is human error" (NHTSA, 2017). According to NHTSA's statistics, there were more than 38,000 deaths arising from traffic accidents across USA in 2020 (NHTSA, 2022). This implies that tens of thousands of lives may be saved every year in the USA once AVs were widely adopted.

Paradoxically, the assumption that safety is treated with the highest priority may be one reason why many researchers focus on other aspects of technology: such as data security, privacy, stability of IT systems and communications systems. The research teams of Bösch et al. (2018) and Kellet et al. (2019) modelled traffic flow with AVs assuming that the technology for shared fleets of AVs will be rolled out smoothly.

The AV interface with the built environment will be facilitated by Vehicle-to-Infrastructure (V2I) communication, prompting further experiments such as data sharing between nearby cities to enable smooth transition of AVs between locations and cooperation in vehicle testing (Driverless Seattle, 2017). AV communication with the built environment is a broad area that requires regulations to be enacted to support technology standards to be set. For example, the standards and bandwidth for Wifi, Bluetooth or Dedicated Short-Range Communications (DSRC) that enable Vehicle-to-Vehicle (V2V) and V2I communications so that AVs can navigate the roads and prevent collisions need to be determined (Kenney, 2011).

Apart from the regulations around info-comm technology, automotive standards need to be set. For example, the roadworthiness of AVs, maintenance requirements, licensing or pre-qualification of car manufacturers, setting performance measures such as emissions, noise limits and their ability to operate under inclement weather.

6.4 Legal

In all three cases reviewed, the researchers have recommended policymakers catch up with technology improvements in AVs and urban mobility (Bösch et al., 2018; Driverless Seattle, 2017; Kellett et al., 2019). Existing policies and laws are specific to the current configuration of automotive technology. Policy makers will first have to understand the breadth of the AV spectrum, either developing laws to cover all iterations of the technology or to promote deployment of specific variations and delivering more focused regulation. For example German transport officials dislike Tesla's "Autopilot" terminology, as the name suggests the drivers need not pay attention when this mode is engaged (Driverless Seattle, 2017).

Researchers from Rand Corporation (Anderson et al., 2014) summarised legislations already enacted in 15 states across USA. The common denominator amongst policy makers in the 15 states was defining AVs as "vehicles with the capability to self-drive without being actively controlled or monitored by a human operator." Surprisingly, the research concluded that it was not clear that laws were required to permit testing

or actual road use of driverless cars. Perhaps this was because existing laws around transportation and vehicles did not explicitly account for scenarios where cars could operate by themselves.

Bösch et al. (2018) detailed the ways in which policy makers can influence the transport system: directly managing existing infrastructure or introducing new services or infrastructure to optimise movement; taxes and subsidies to promote the use of certain modes of transport or reduce the cost of public transport altogether; legislation to regulate the way the current systems are utilised and organised (e.g. speed limits, priority lanes); finally the use of advertising to change attitudes towards various modes of transport. They highlight that an optimal transport system needs to transfer goods and people rapidly yet safely and sustainably, while minimising costs on the consumer end. They suggest policy be used to improve current systems, such as implementing AVs in areas where public transport services are poor or low frequency and assessing how to use excess land in a more optimised road system. Policymakers need to consider the form in which the AVs will enter the market, i.e. as a private or public service, and acknowledge that automated services will be an attractive alternative for commuters. Ignoring or prolonging intentional organisation of these services will result in "the market organising itself", likely resulting in suboptimal function, and delaying further adoption.

Models produced by Kellett et al. (2019) estimated potential reduction in the vehicle fleet that would be made possible by the adoption of AVs, adapting their models for consumer preferences. They discussed issues likely to occur during the transition such as increased CBD congestion as the vehicle fleet expands, as well as issues related to parking. Government policies such as, grants for shared public transport, parking restrictions and taxation of non-AVs could be introduced to accelerate consumer adoption of AVs.

AVs are anticipated to "communicate" with buildings, sharing data to allow smooth transition between the roads and the built environment. Cities will also have to communicate to coordinate smooth transition of AVs across multiple jurisdictions. Policy standardisation of communication methods and data standards may help to alleviate some of these invisible borders (Driverless Seattle, 2017).

Note that policy recommendations from any research paper need to be viewed against the unique context of their cities and states. Any governments at the city, state or national levels would need to work on a wide range of policy areas if they were serious about rolling out AVs on their roads.

6.5 Stakeholders

The stakeholder groups considered in current literature are focused on commuters (or AV users), policymakers and transport operators, as exemplified by the studies of Bösch et al. (2018) and Kellett et al. (2019).

Driverless Seattle (2017) went a step further by calling on policymakers to consider stakeholders "traditionally under represented" during policymaking, e.g. those in "socio-economically disadvantaged communities." They recommend more diverse stakeholder considerations to assess the impacts of AVs and the responses to the policies developed to accommodate their adoption.

Strömberg et al. (2021) highlighted the need for inclusive regulations and encouraged more dialogue between stakeholders such as urban planners, AV car makers and future AV users or commuters. The opinions of urban planners has occasionally been included in the literature, for example by Legacy et al. (2019) and Smolnicki & Sołtys (2016), but these tend towards city-wide, municipal and transport planning. Stakeholders in the built environment, such as facility managers and building owners, are rarely surveyed for their views about AVs.

6.6 Built Environment

The introduction of AVs, coupled with the post-Covid Work-From-Home arrangements, could lead to the dispersion of cities, i.e., city boundaries expand as residents seek wider spaces and more affordable homes in the suburban areas. Post-Covid, many large companies have relaxed the need for staff to work from offices in the CBD. The reduced daily commute means that living in a lower-cost and larger home further from the city is now a more attractive proposition. Furthermore, even if the travel time exceeds an hour, commuters in AVs do not lose productive time as they may work from the AVs and at arrival, they are dropped off at their destinations without having to walk from a station or bus-stop to the destination (Townsend, 2020). Exposure

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

to the weather and other inconveniences will also be minimised. Workers have more incentives to shift their abodes to the suburbs and this could lead to urban sprawl.

Traffic studies by Kellett et al. (2019) also suggest that mass AV adoption could lead to an increase in urban sprawl. Their survey results suggest that a substantial reduction in city centre parking would allow more diverse land use in the CBD, however parking may become more concentrated around amenities. Urban policy would need to be prepared to counter such negative effects.

Another part of real estate that will be impacted by the adoption of AVs is carparks. Carparks located in the CBD, where land value is high, will be most impacted (Fagnant & Kockelman, 2013). Personal AVs may drop their owners off and cruise out to the city-fringe's parking lots that are less expensive. Shared AVs will simply drop off passengers and move to the next pick-up or drop-off point. Parking lots will increasingly be under-utilised and lawmakers should consider allowing their conversion to other uses rather than to let them remain as vacant unproductive space (which could cost landlords in terms of cleaning and periodic maintenance).

It is clear that AVs will impact land use, the built environment and privately-owned or government-owned real estate. Current literature regarding the impact of AVs on the built environment are largely focused on inner city carparks and urban sprawl (Townsend, 2020; Sagástegui, 2020). For AVs to cover the last mile in delivering commuters and goods to their destinations, the views of stakeholders in the built environment need to be sought.

7 TOWARDS A SHARED DESIGN FRAMEWORK FOR AV-LAND USE INTERFACE

Strömberg et al. (2021) reported that urban planners who participated in their research study "struggled with how to handle AVs, asking themselves how they could integrate future mobility into planning." This is supported by Faisal et al. (2019) who stated that presently, "urban planning as a profession is largely unprepared for AVs."

In addition to urban planners, we see a need to conduct deeper research with other stakeholders in the real estate industry (i.e. property developers, building owners, architects, facility managers) on how AVs might disrupt real estate assets and when they are progressively deployed in high density cities such as Singapore.

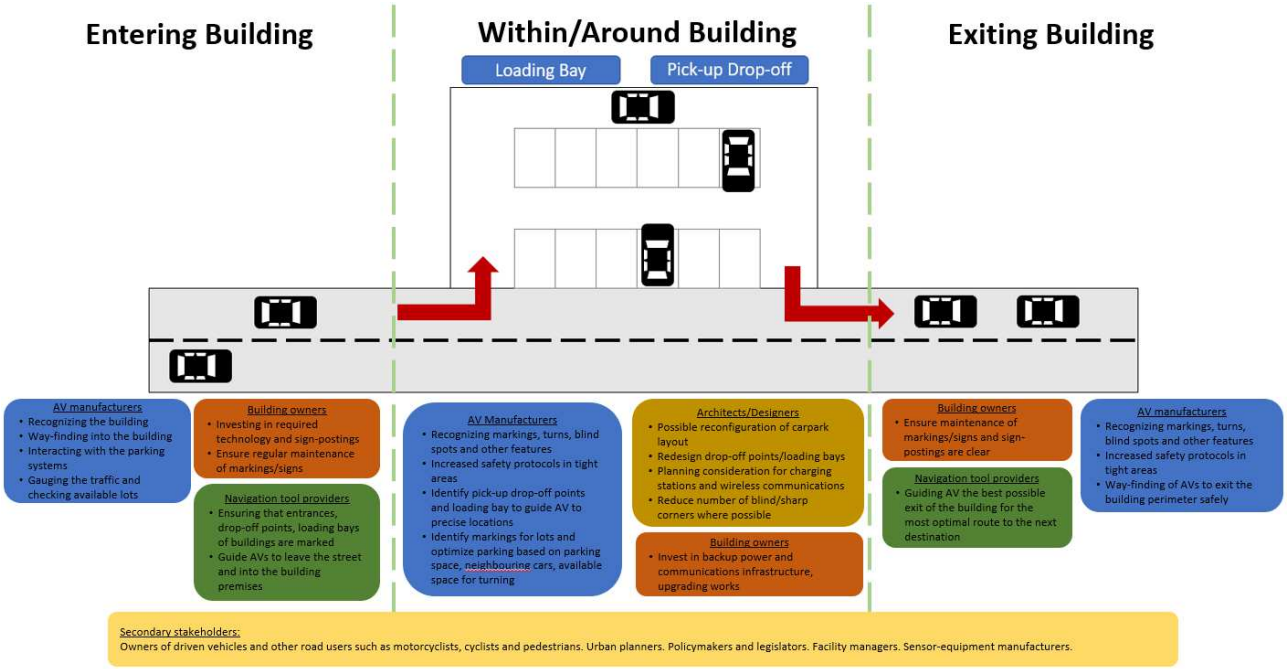


Fig. 1: Shared design framework plan for the AV-built environment interface.

Given the dearth of academic research linking AVs to land use and buildings, a proposed shared design framework and guidelines will be developed which will consider the concerns and ideas of stakeholders. Examples of primary stakeholders include, but are not limited to: 1) AV manufacturers, 2) building owners, 3) architects/designers and 4) navigation tool providers; secondary stakeholders would include 1) owners of

driven vehicles and commuters (e.g. motorcyclists, cyclists and pedestrians), 2) urban planners, 3) policy makers, 4) facility managers, 5) sensor-equipment manufacturers and 6) insurance companies.

A novel shared design framework with a list of parameters is proposed for stakeholders to consider when designing new buildings, or when planning the retrofitting of existing buildings, to be AV-friendly. For a city to realise optimum benefits from the deployment of AVs, existing buildings need to be retrofitted and enhanced to allow the smooth navigation of AVs into, within and out of buildings. New buildings submitted for development approvals should be AV-ready when the construction works are completed.

Bringing stakeholders together to identify potential impediments of AV adoption in the existing built environment will help Singapore to realise the benefits of AVs sooner. The main objective of this shared design process is also to allow stakeholders to come to an agreement during the pre-deployment stage of AVs in a dense urban setting like Singapore. The shared design framework plan as shown in Figure 1 will be the guiding tool in furthering this recent research study.

8 CONCLUSION AND FURTHER RESEARCH

While recognising the negatives that AVs might bring to the transportation system, we are in agreement with the optimistic views of most of the AV researchers about the potential benefits that AVs could bring. However, we are concerned that the "last mile" gap for AVs has not been addressed, especially for high density built environments such as Singapore. There is a need to conduct studies on how AVs will interact with the built environment, i.e. going into, within and out of buildings. The absence of literature on how AVs would transition between roads and private properties such as office buildings, malls, condominiums and carparks is not surprising given the lack of research participation from stakeholders in the real estate industry such as property developers, building owners and facility managers. This indicates that cities, and in the case of our study, Singapore, are a considerable number of years from deploying AVs to pick up or drop off goods and passengers within the loading bays, carparks or driveways of buildings.

The research on the interface between AVs and land use is nascent and there are many areas in need of deeper consideration. From a real estate perspective, this "last mile" issue has to be addressed, especially in Singapore, where the hot and rainy weather necessitates passengers to be picked up and dropped off under shelter, including in basement lift lobbies where telecommunication signals may be weak or non-existent. Moreover, given the expected shift from self-driven cars to AVs, building owners would need to expand the capacity of pick-up and drop-off points and loading/unloading bays, perhaps by redesigning sections of carparks or by altering the ingress and egress connecting the buildings to the roads. Policymakers need to provide the guidelines to facilitate such renovations.

Indeed, "a future involving widespread use of AVs presents both land-use opportunities and challenges" (Faisal et al., 2019). Such potential provides ample motivation for the development of a shared design framework and guidelines to ensure smooth deployment of AVs in Singapore. Leveraging the Singapore government's progressive stance on technology adoption and ambitions in making Singapore a smart city, this study will allow Singapore to gain an early advantage in deploying AVs.

9 REFERENCES

Autonomous Vehicles and Their Impact on Real Estate.. In: www.gensler.com. https://www.gensler.com/gri/autonomous-vehicles-and-their-impact-on-real-estate. 2018.

ANDERSON, J. M., Kalra, N. et al: Autonomous vehicle technology: A guide for policymakers. Rand Corporation. 2014.

ANDERSSON, P., Ivehammar, P.: Benefits and Costs of Autonomous Trucks and Cars. In: Journal of Transportation Technologies, Vol. 09, Issue 02, pp. 121–145. 2019.

BAGLOEE, S. A., Tavana, M., et al.: Autonomous vehicles: Challenges, opportunities, and future implications for transportation policies. In: Journal of Modern Transportation, Vol. 24, Issue 4, pp. 284–303. 2016.

BAHAMONDE-BIRKE, F. J., Kickhöfer, B. et al.: A Systemic View on Autonomous Vehicles: Policy Aspects for a Sustainable Transportation Planning. In: DisP - The Planning Review, Vol. 54, Issue 3, pp. 12–25. 2018.

BÖSCH, P. M., Ciari, F. et al.: Transport Policy Optimization with Autonomous Vehicles. In: Transportation Research Record: Journal of the Transportation Research Board, Vol. 2672, Issue 8, pp. 698–707. 2018.

CHNG, S., & Cheah, L. (2020). Understanding Autonomous Road Public Transport Acceptance: A Study of Singapore. Sustainability, 12(12), 4974. https://doi.org/10.3390/su12124974

COLE, H.: Autonomous vehicle on-road trial to begin early next year in Dubbo NSW. In: ABC News, 2022.

DAVIS, R.: Hyperdrive Daily: The Driverless Shuttle Helping Toyota Win Gold. In: Bloomberg, 2021.

DUARTE, F., Ratti, C.: The Impact of Autonomous Vehicles on Cities: A Review. In: Journal of Urban Technology, Vol. 25, Issue 4, pp. 3–18. 2018.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

DRIVERLESS SEATTLE: How Cities Can Prepare For Automated Vehicles: Key Findings and Recommendations. In: Tech Policy Lab. 2017.
EUROPEAN COMMISSION: Extensive tests to steer the future of self-driving cars. European Commission. 2019.
FAGNANT, D.J., Kockelman, K.: Preparing a nation for autonomous vehicles: Opportunities, barriers and policy recommendations. In: Transportation Research Part A: Policy and Practice, Vol. 77, pp. 167–181. 2013.
FAISAL, A., Yigitcanlar, T. et al.: Understanding autonomous vehicles: A systematic literature review on capability, impact, planning and policy. In: Journal of Transport and Land Use, Vol. 12, Issue 1. 2019.
FREEMARK, Y., Hudson, A.: Are Cities Prepared for Autonomous Vehicles?: Planning for Technological Change by U.S. Local Governments. In: Journal of the American Planning Association, Vol. 85, Issue 2, pp. 133–151. 2019.
GONZÁLEZ-GONZÁLEZ, E., Nogués, S.: Parking futures: Preparing European cities for the advent of automated vehicles. In: Land Use Policy, Vol. 91, pp. 104010. 2020.
HOLT, K.: Waymo's autonomous vehicles have clocked 20 million miles on public roads. In: Engadget. https://www.engadget.com/waymo-autonomous-vehicles-update-san-francisco-193934150.html . 2021.
KELLETT, J., Barreto, R., et al.: How Might Autonomous Vehicles Impact the City? The Case of Commuting to Central Adelaide. In: Urban Policy and Research, Vol. 37, Issue 4, pp. 442–457. 2019.
KENNEY, J. B.: Dedicated Short-Range Communications (DSRC) Standards in the United States. In: Proceedings of the IEEE, Vol. 99, Issue 7, pp. 1162–1182. 2011.
KELLEHER, J.: A SMART Driverless Future in Singapore. In: OpenGov Asia. 2017.
KYRIAKIDIS, M., Happee, R., & de Winter, J. C. F.: Public opinion on automated driving: Results of an international questionnaire among 5000 respondents. In: Transportation Research Part F: Traffic Psychology and Behaviour, 32, 127–140. 2015.
LEGACY, C., Ashmore, D., et al.: Planning the driverless city. In: Transport Reviews, 39(1), 84–102. https://doi.org/10.1080/01441647.2018.1466835 . 2019.
LIN, C.: "A huge opportunity for space": What going car-lite means for Singapore's 1.4 million parking lots—CNA. In: Channel NewsAsia. 2022.
LITMAN, T.: Autonomous Vehicle Implementation Predictions - Implications for Transport Planning. 2022.
LTA. Factsheet: Accelerating Nationwide Deployment of Electric Vehicle Charging Points. Land Transport Authority of Singapore. In: https://www.lta.gov.sg/content/ltagov/en/newsroom/2021/3/news-release/Accelerating_nationwide_deployment_of_electric_vehicle_charging_points.html. 2021.
LTA. Autonomous Vehicles. Land Transport Authority of Singapore. In: https://www.lta.gov.sg/content/ltagov/en/industry_innovations/technologies/autonomous_vehicles.html. n.d.
McCORMICK, K.: Urban Planners Shift Gears as Autonomous Vehicles Hit the Streets. In: Lincoln Institute of Land Policy. https://www.lincolninst.edu/publications/articles/driverless-ed . (2019)
MILAKIS, D., Snelder, M., et al.: Development and transport implications of automated vehicles in the Netherlands: Scenarios for 2030 and 2050. In: European Journal of Transport and Infrastructure Research, Vol. 17, Issue 1. 2017a.
MILAKIS, D., van Arem, B. et al.: Policy and society related implications of automated driving: A review of literature and directions for future research. In: Journal of Intelligent Transportation Systems, Vol. 21, Issue 4, pp. 324–348. 2017b.
MILANO, B.: Government can't keep up with technology's growth. In: Harvard Gazette. 2022.
MONDSCHEIN, A.: Re-Programming Mobility Literature Review. In: NYU Wagner Rudin Center for Transportation Policy & Management. 2014.
NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION (NHTSA). Automated Driving Systems 2.0: A Vision for Safety. U.S. Department of Transportation (DOT). 2017.
NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION (NHTSA). In: https://cdan.nhtsa.gov/ . 2022.
PATTON, M.: Qualitative Evaluation and Research Methods, 2nd ed., Sage, Newbury Park, CA. 1990.
PETTIGREW, S., Fritschi, L., et al.: The Potential Implications of Autonomous Vehicles in and around the Workplace. In: International Journal of Environmental Research and Public Health, Vol. 15, Issue 9, pp. 1876. 2018.
SAGASTEGUI, S. D. L.. The Driverless City: How will AVs shape cities in the future? In: Master thesis in OCAD University. http://rgdoi.net/10.13140/RG.2.2.10602.95689 . 2020.
SIDDIQ, A., Tang, C. S., et al.: Partnerships in Urban Mobility: Incentive Mechanisms for Improving Public Transit Adoption. In: Manufacturing & Service Operations Management. 2021.
SHIM, W.: Homegrown driverless car to get first trial run. In: The Korea Herald. 2021.
SMART NATION SINGAPORE. Autonomous Vehicles. Smart Nation Singapore. In: https://www.smartnation.gov.sg//initiatives/transport/autonomous-vehicles . n.d.
SMOLNICKI, P. M., & Sołtys, J.: Driverless Mobility: The Impact on Metropolitan Spatial Structures. In: Procedia Engineering, 161, 2184–2190. https://doi.org/10.1016/j.proeng.2016.08.813. 2016.
SOLON, O.: Self-driving trucks: What's the future for America's 3.5 million truckers? In: The Guardian. 2016.
STRÖMBERG, H., Ramos, É. M. S., et al.: A future without drivers? Comparing users', urban planners' and developers' assumptions, hopes, and concerns about autonomous vehicles. In: European Transport Research Review, Vol. 13, Issue 1, pp. 44. 2021.
TAN, C.: Human-like autonomous driving beyond today's tech, says newly-formed Motional. In: The Straits Times. 2020.
TOH, M.: Here's what it looks like to ride a Chinese robotaxi with no steering wheel. In: CNN Business https://www.cnn.com/2022/07/21/tech/baidu-self-driving-car-intl-hnk/index.html . 2022
TOH, T. W.: NTU and Volvo launch world's first full-sized driverless electric bus for trial. In: The Straits Times. 2019.
TOWNSEND, A. M.: Re-Programming Mobility: The Digital Transformation of Transportation in the United States. In: NYU Wagner Rudin Center for Transportation Policy & Management. 2014.
TOWNSEND, A. M.: Ghost road: Beyond the driverless car (First edition). W. W. Norton & Company, Inc. 2020.
URA. Equipping the City for Autonomous Vehicles. Urban Redevelopment Authority of Singapore. https://www.ura.gov.sg/Corporate/Event/AV-Exhibition . 2022.
WANG, S., Zhao, J.: Risk preference and adoption of autonomous vehicles. In: Transportation Research Part A: Policy and Practice, 126, 215–229. https://doi.org/10.1016/j.tra.2019.06.007 . 2019.
YIN, R. K.: Case Study Research Design and Methods (5th ed.). Sage. Thousand Oaks, CA. 2014.

🏆 *reviewed paper*

Smart Cities – wie kleine Städte dem Wandel begegnen

Mona Treude

(Dipl. Ök. Mona Treude, Wuppertal Institut, Döppersberg 19, 42103 Wuppertal, mona.treude@wupperinst.org)

1 ABSTRACT

Smart City meint per Definition Wandel, Veränderung und Transformation und das auf verschiedenen Ebenen: angesprochen wird dabei neben der technologischen Komponente zunehmend der Bereich der sozialen Interaktionen und der sozialen Innovationen in und für die Stadt.

Es werden Lösungen gesucht für das 21. Jahrhundert, welches geprägt ist von Anfordernungen an nachhaltige, wirtschaftliche und gesellschaftspolitische Konzepte und vermehrt tritt dabei das Konzept der Smart City in den Vordergrund. Um Einblicke in dieses komplexe System zu erhalten und ob die Smart City als Konzept dazu beitragen kann, eine Stadt im Rahmen der geforderten sozial-ökologischen Transformation zu gestalten, hängt von vielen Faktoren ab.

Mit der Methode der Innovationsbiografie werden der Entstehungsprozess von fünf deutschen Smart Cities rekonstruiert und insbesondere die sozialen Innovationen sowie ihre Treiber und Hemmnisse analysiert. Dabei wird die Smart City vor dem Hintergrund eines regionalen Innovationssystems (RIS) betrachet. In diesem stehen beteligte Akteure innerhalb des regioalen Kontextes und deren Verteilung von Wissen und die Interaktion und Kooperation im Vordergrund. Es kann gezeigt werden, dass interkommunale Interaktionen nicht nur für die beteiligten Kommunen gewinnbringend sind, sondern darüber hinaus Diffusionsprozesse anstoßen, die in die gesamte Region wirken. Außerdem soll die Bedeutung der Smart-City-Narrative in und für die Stadt während des Prozesses betrachetet werden.

Keywords: Smart Sustainable City, Narrative, Innovationsbiografie, Kooperation, Smart City

2 URBANE WENDE – EINLEITUNG

„Städte sind in vielerlei Hinsicht ein Schmelztiegel der Großen Transformation. Die meisten Nachhaltigkeitsherausforderungen zeigen sich hier in aller Intensität und Vielfalt.“ (Schneidewind, 2019: 621). Und damit ist die „ […] urbane Wende […] ein Knotenpunkt der großen Transformation.“ (ebd.: 621). Die Wissenschaft ist sich einig, dass sich die Welt bis 2030 grundlegend verändert haben wird (Guillén, 2021). Was braucht es, damit wir auf urbaner Ebene dem Wandel begegnen können und diesen gestalten? Welches Zielnarrativ bedarf es um die Menschen dafür zu gewinnen? Wie können wir der Digitalisierung und der mit ihr verbundenen Technolologie in diesem Rahmen Sinn und Richtung geben? Wie können die erforderlichen Impulse für die Veränderung gesetzt werden? Und kann das Konzept einer Smart City dazu beitragen?

2.1 Die Typen der Smart City

Die Ausgestaltung der Smart City und ihr genutzter digitaler und technologischer Umfang und Beitrag, unter anderem auf die (nachaltge) Stadtentwicklung, hängt von vielen Faktoren ab: der Größe der Stadt, Zugang zu Ressourcen, vorhandener (digitaler) Infrastruktren, Förderprogramme, der beteiligten Akteure und vieles mehr. So prägt auf europäischer internationaler Ebene insbesondere die Ausrufung des Förderprogramms Horizon 2020 den Smart City Diskurs (Späth & Knieling, 2018), (Lange & Knieling, 2020), (Lange, 2022). Auf deutscher Ebene orientieren sich die Städte außerdem an der Smart City Charta (aus 2017 und in Neuauflage 2021). Sie beschreibt die Ausgestaltung einer Smart City als nachhaltige digitale Transformation vor dem Hintergrund einer integrativen Stadtentwicklung (Günthner et al., 2017), (Bohle, 2021). Die Smart City Charta prägt in ihrer zugrundeliegenden Definition einer Smart City, die Ausgestaltung der Smart-City-Strategien der 73 Modellprojekte in Deutschland (BBSR, 2021).

Die zunächst dominierende technologisch gepäte Debatte zur Smart City hat sich lange schon zu einem umfassenderen und ganzheitlicheren Ansatz entwickelt (Bibri, 2018). Allerdings führt der Versuch der definitorischen Integration von Nachhaltigkeit, Ressourcenschonung und Lebensqualität verbunden mit der Digitalisierung eben auch zu Prioritäten in der eigenen, lokalen Definition und damit in der Ausgestaltung der Smart City (Treude et al., 2022). So kann die Formulierung oder das Narrativ einer Smart City lauten: Digitalisierung in der Stadt muss genutzt werden um die Stadt nachhaltiger und lebenswerter zu gestalten. Oder sie kann lauten: Die Digitalisierung wird genutzt, die wirtschaftliche Leisungsfähigkeit der Stadt zu

verbessern. Je nachdem in welchem Kontekt und vor welcher Priorität die Smart City (als Narrativ) verwendet wird, wird sie eine andere Ausrichtung bekommen (O'Neill et al., 2017).

Auch wie weitreichend eine Smart City in die bestehenden urbanen Strategien und Konzepte (z.B. Stadtentwicklungskonzept, Nachhaltigkeitsstrategie, Digitalstrategie, Mobilitätsstrategie), Abläufe und Zielsetzungen integriert wird, hängt von der jeweiligen Ausgestaltung ab. Nilssen (2019) beschreibt in ihrer Untersuchung anhand bestehender Smart City Untersuchungen ein Kontinuum an möglichen Smart City Initiativen, die von kleinen, inkrementellen Innovationen, die eher technologischer Natur sind, bis zu komplexen Veränderungsmöglichkeiten auf Stadtebene, wenn technologische, organisatorische und soziale (kollaborative) Innovationen zusammen kommen (Nilssen, 2019). Die rein technologischen Innovationen führen häufig zu kleinen Veränderungen und Verbesserungen auf Stadtebene, oder aber bieten Ansätze zu mehr Bürgerbeteiligungsmöglichkeiten. Sie sind eher inkrementeller Natur. Die zweite Dimension betrifft, so Nillsen (2019), die organisatorische Ebene der Stadtverwaltung. Inovationen in dieser können zu mehr Effizienz und besserem Output führen. Die nächste Dimension spricht die kollaborative Ebene an und meint einen offenen und interaktiven Governance Prozess innerhalb der Smart City unter Einbezug der relevanten Akteure. Diese Smart City Inititiaven sind in ihrer Wirklung und Entfaltung radikaler, da sie mit gesellschaftlicher Entwicklung, gesteigerter Motivation und Beteiligung einhergehen. Als letztes folgt die Dimension der Reallabore und städtischer Experimentierfelder, in der auch das Narrativ rund um die Smart City ein wichtiger Faktor ist. Hier kommen die zuvor genannten Dimensionen zusammen und entsprechen dem Ziel eines ganzheitlichen Ansatzes einer Smart City (Nilssen, 2019). Allerdings ist die Smart City kein geschützer Begriff, eine Stadt darf sich Smart City nennen, egal ob sie kleine technologische Schritte einführt, oder aber einen radikalen Stadtentwicklungs- oder Transformationsprozess unter diesem Titel beginnt.

2.2 Smart City zwischen Digitalisierung und Nachhaltigkeit

Neben dem Umfang und der Art eingesetzter Technologien bis hin zur Umgestaltung der Verwaltungsstrukturen und kollaborativen Ansätzen, interessiert uns in unserer Untersuchung, ob die Städte technologische Möglichkeiten nutzen, um den Problemstellungen in den Städten zu begegnen und zu einer nachhaltigen Stadtgestaltung im Sinne des Sustainable Development Goal (SDG) 11 beizutragen: resiliente, sichere, inklusive und nachhaltige Städte zu gestalten. Damit stellt sich die Frage, ob die Smart City genutzt wird, um nachhaltige Stadtentwicklung zu betreiben, oder um die Digitalisierung in der Stadt zu gestalten. Oder ob beides möglicherweise genutzt und miteinander verbunden wird.

Was in dieser Ausgestaltung nicht fehlen darf, an dieser Stelle aber nur kurz angerissen wird, ist der Aspekt des digitalen Fußabdrucks und ob der Nutzen, der durch die Digitalisierung im urbanen Raum entsteht, die (Umwelt)kosten übersteigt. Denn die Herstellung, der Stromverbrauch und die Entsorgung technologischer Geräte und Anwendungen müssen dazu in Relation gesetzt werden. Die Smart City rangiert also auf dem Kontinuum zwischen Digitalisierung im urbanen Raum als Experimentierfeld (Digital City) bis zur Ausgestaltung einer nachhaltigen Stadt im Sinne des SDG 11 unter Nutzung digitaler Anwendungen, sofern sie zu diesem Ziel beitragen (Sustainable Smart City) (Treude et al., 2022).

Um die Smart City vor dem Hintergrund der Art und Weise (rein digital und technologisch bis hin zu ganzheitlich und nachhaltig) besser zu verstehen, muss untersucht werden, welche Schwerpunkte im Prozess zur Smart City gelegt werden, welches das ihr zugrundeliegden Narrativ ist und ob ein holistischer Ansatz und der Umfang der drei oben genannten Dimensionen genutzt wird. Also welche Form der Governance liegt der Smart City zugrunde oder entwickelt sich in dieser. Welche Formen der Zusammenarbeit werden genutzt und wird die Bürgerschaft integriert. Und wie wird verhindert, dass es zu Lock-In Effekten kommt und ganze Einheiten in diesem Prozess die Entstehung einer Smart City blockieren oder gar verhindern.

2.3 Smart City als soziale Innovation im sozial-ökologischen Transformationsprozess

„Smart cities depend on creative and knowledge resources to maximize their innovation potential." (Kourtit et al., 2012: 229). Die wichtige Rolle von (Governance-)Netzwerken für die Entwicklung und Verbreitung von Innovationen sind insbesondere in den Sozialwissenschaften bereits seit langem bekannt (Rogers, 1983). Gleiches gilt für die Wirtschaftswissenschaften, welche in den Beziehungen im institutionellen Kontext einen wichtgen Treiber für Innovationen sehen: „This cumulative accumulation of knowledge and skills, i.e. the learning process, is crucial for innovation." (Røste, 2005: 3).

Innovationen werden traditionell vor dem Hintergrund ökonomischer Anwendungen beschrieben und finden viel Beachtung in der evolutorischen Ökonomik (Schumpeter, 1997), (Pyka, 2021). Vor dem Hintergrund der Transformationsforschung und den geforderten Nachhaltigkeitszielen, bedarf es jedoch einer umfassenderen Betrachtung als der rein technologisch- und oder marktorientierten Ergebnisse (Schneidewind, 2019: 261).

Soziale Innovationen haben einen stärkeren Fokus auf Aktuere und ihre Konstellationen, sprechen soziale Praktiken an und alternierende Befriedigung von Bedürfnissen und Problemlösungsansätzen (Howaldt et al., 2010: 174). Betrachtet man soziale Innovationen und die ihnen innewohnenden Akteursdynamiken vor dem Hintergrund der benötigten großen Transformation, bieten Chivers & Longhurst (2015) einen Analyserahmen in vier Dimensionen: Notwendige Lernprozesse, Formen des Handelns, Formen des Organisierens und der Governance und die Bedeutungen, das Framings oder eben die Narrative (Chilvers & Longhurst, 2015: 5). Entlang dieser Ebenen oder Dimensionen werden die Ergebnisse aus der vorliegenden Untersuchung hin ausgewertet. Zu beachten ist dabei, dass die Smart City ihre Transformationsprozesse auf räumlicher Ebene gestaltet. Gemeint sind hier sowohl der physisch-materielle Raum, wie Veränderungen in Infrastrukturen oder in Gebäuden und der sozio-kulturellem Raum, wenn es Akteure und Netzwerke betrifft oder aber Institutionen oder Governance-Prozesse verändert (Abassiharofteh et al., 2019).

Abbildung 1 zeigt die Smart Citiy Tyologien, den dadurch angesprochenen Anwendungsbereich, die Verwendung von Digitalisierung (unter Nachhaltigkeitsaspekten) und das damit verbundene Narrativ sowie die Ausgestaltung der Horizontalen Integration. Eine ganzheitlich ausgerichtete Smart City, die sich an den Zielen einer nachhaltigen Entwicklung orientiert und die radikale Veränderungsprozesse anstoßen kann, befände sich in der Abbildung 1 eher auf der rechten Seite. Diese hätten gemäß Chivers & Longhurst (2015) auch die besseren Transformationspotenziale in einem experimentierfreundlichem Raum mit einem ganzheitlichen Ansatz und einer horizontalen Ausgestaltung und Integration.

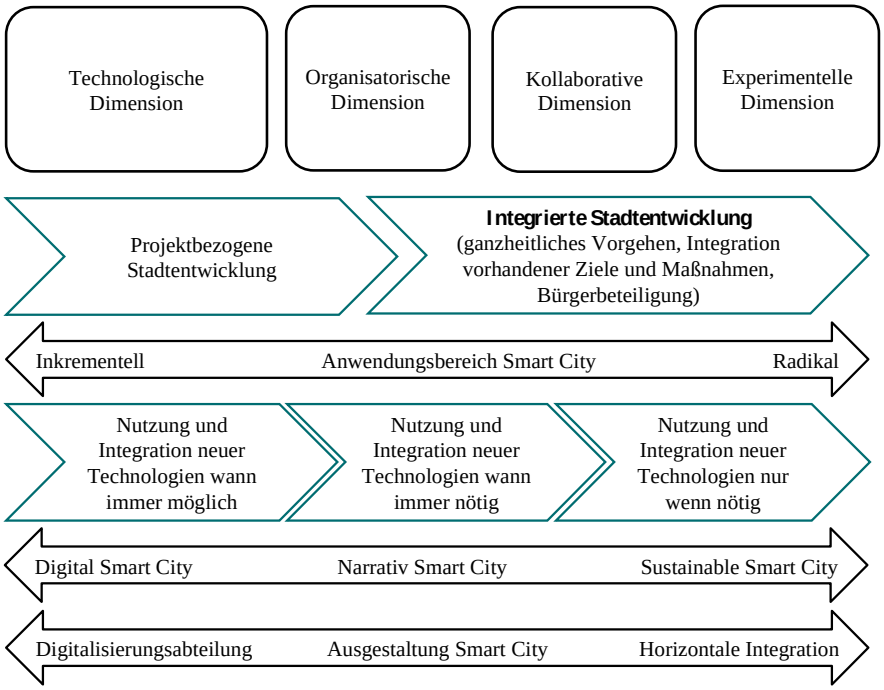


Abb. 1: Typologien und Ausgestaltung der Smart City in Anlehnung und Erweiterung an Nilssen (2019).

3 METHODISCHES VORGEHEN UND FALLSTUDIENAUSWAHL

Für die Untersuchung haben wir eine retrospektive Analysemethode gewählt, die den Prozess hin zu einer Smart City, von der ersten Idee bis hin zur Umsetzung offen legen soll. Diese prozessorientierte Methode soll Netzwerke identifizieren, Motivationen aufdecken und verdeutlichen, wie Wissen in diesen Strukturen geteilt und erweitert wird und Lerneffekte entstehen.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Die hier verwendete Methode der Innovationsbiografien hat erstmals in der Stadtforschung für die Fallstudie Smart City Wien interessante Einblicke sowohl in den Prozess der Smart City Wien, als auch in das entstandene und konstante Netzwerk und das zugrundeliegnde Narrativ und die Motivation zeigen können (Treude & Schüle, 2021).

Für vorliegende empirische Untersuchung wurden 22 narrative Interviews (in den Ergebnissen zitiert als IP 1- IP 22) mit beteiligten Akteuren geführt, transkribiert und entlang der oben beschriebenen Dimensionen (Notwendige Lernprozesse, Formen des Handelns, Formen des Organisierens und der Governance und die Bedeutungen, das Framings (Narrativ)) deduktiv ausgewertet. Durch die Verwendung narrativer Interviews wird sichergestellt, dass die Antworten nicht durch den Forschenden oder die Forschende vorstrukturiert wird, um so den befragten Personen (für sie) relevante Punkte auszuschließen (Schütze, 1983), (Baur & Blasius, 2014). In der Biografieerstellung des Smart City Prozesses trägt so jede:r Befragte mit seiner Erinnerung und seinen selbst gewählten Schwerpunkten bei. Die angesprochenen Schwerpunkte verraten nicht nur die zugrundeliegende Motivation (nachhaltig orientiert oder technologisch geprägt, projektbezogen oder ganzheitlich, kooperativ oder losgelöst von den anderen Abteilungen), sondern auch welche Meilensteine angestrebt worden sind oder im weiteren Vorgehen angestrebt werden. Zudem wurden zugängliche Unterlagen und Informationen gesichtet und ausgewertet und in einer Queranalyse gemeinsam ausgewertet. Das ergänzt die Erinnerungen der Befragten und hat den Vorteil, dass im Interview genannte Punkte hinsichtlich ihrer Validität geprüft werden können (Butzin et al., 2012). Das Vorgehen für die Innovationsbiografien lehnt an den von Butzin et. al. (2012) weiterentwickleten Schritten an (Treude, 2021), (Treude et al., 2022):

(1) Dokumentenanalyse frei zugänglicher Informationen zur Fallstudie

(2) Identifikation einer Schlüsselperson in dem Prozess und Durchführung eines ersten narrativen Interviews mit dieser

(3) Konstruktion eines Ego-zentrierten Netzwerkes zum Förderprojekt „5 für Südwestfalen“

(4) Ableitung weiterer Interviewpartnerinnen und Interviewpartner aus dem ersten narrativen Interview sowie der Netzwerknalyse aus Schritt 3

(5) Durchführung weiterer narrativer Interviews und gleichzeitige Dokumentenanalyse zur Validierung der Informationen

(6) Entwicklung der Innovationsbiografie(n) und Konstruktion eines Raum-Zeitpfades sowie eines Akteursnetzwerkes

(7) Weitere Interviews zur Bestätigung der vorherigen Interviews und Ausbau der Innovationsbiografien

(8) Qualitative Inhaltsanalyse der transkribierten Interviews, vorhandener Strategien und Projekt-Webseiten nach Mayring (Mayring & Fenzl, 2019) und Weiterentwicklung der Biografien nach Fischer-Rosenthal (Fischer-Rosenthal & Rosenthal, 1997)

Anschließend wurde das Vorgehen der Smart Cities hinsichtlich ihrer Prozesse, Strukturen und Akteure miteinander verglichen und Erfolgsfaktoren und Hemnisse abgeleitet und ein Raum-Zeit-Pfad sowie eine Akteuerskarte gezeichnet (Treude et al., 2022). Dabei wird die jeweilige Smart City in ihrem Untersuchungsrahmen als regionales Innovationssystem (RIS) verstanden und sowohl als soziale, raümliche und technologische Innovation untersucht. Von besonderer Bedeutung sind dabei beteiligte Akteure und deren Interaktionen und Kooperationen und die damit verbundenen Lerneffekte im Sinne von Peer Learning und Wissensverbreitung.

Um zu untersuchen, wie eine Smart City entsteht, wer beteiligt wird, welche Motivation zugrunde liegt und in welchem Umfang und in welcher der oben genannten Dimensionen Innovationen oder Veränderungen entstehen, werden fünf deutsche Klein- und Mittelstädte untersucht, die in einem Konsortium zusammen Fördermittel aus dem Förderprogramm „Smart Cities made in Germany“ akquiriert und 2019 begonnen haben, ihre Städte zu Smart Cities zu entwickeln (Laufzeit der Förderphase 2019-2026). Viele Studien fokussieren große Städte als Untersuchungsgegenstand der Smart City. Die hier ermittelten Erfahrungen können jedoch nicht ohne weiteres auf mittelgroße und kleine Städte übertragen werden (OECD, 2020). Allein in Deutschland leben 70% der Menschen in kleinen und mittelgroßen Städten (Milbert, 2021).

Die fünf untersuchten Städte liegen alle in Südwestfalen. Südwestfalen ist eine Region im Bundesland Nordrhein Westfalen in Deutschland, für die sich 5 Landkreise (Hochsauerlandkreis, Märkischer Kreis, Kreis Olpe, Kreis Siegen-Wittgenstein und Kreis Soest) im Jahr 2007 zusammengeschlossen haben. 1,4 Millionen Einwohnerinnen und Einwohner leben in den insgesamt 59 Städten und Gemeinden im südlichen Teil Westfalens (regionen.NRW, o. J.). Die fünf klein- und mittelgroße Städte stammen jeweils aus einem der o. g. Landkreise: Arnsberg, Bad Berleburg, Menden, Olpe und Soest. Zusammen mit der im Jahr 2012 gegründeten Regionalmarketing-Agentur „Südwestfalen-Agentur GmbH" bilden Sie das Konsortium „5 für Südwestfalen" im gemeinsamen Förderprojekt im Rahmen des Bundes-Förderprogramms Modellprojekte Smart Cities (MPSC), in dem die Bundesregierung seit 2019 73 Modellprojekte fördert, die sich zu einer Smart City entwickeln (Südwestfalen-Agentur, n.Y.). Das Konsortium „5 für Südwestfalen" wird in diesem Programm als ein Projekt mit 5 Städten und der Südwestfalen-Agentur gefördert. Die fünf Städte sind für die Erstellung von Innoavtionsbiografien interssant, da sie vor dem Hintergrund ihrer Größe zahlreiche deutsche Städte vertreten und hier gelernte Erfahrungen auf diese übertragen werden könnten. Zum anderen verfolgen die fünf Kommunen über die eigene Entwicklung zur Smart City das Ziel zur smartesten Region Deutschlands zu werden (Südwestfalen-Agentur GmbH, 2021). So können zu den eigenen innerstädtischen Prozessen, ihrer Typologie, dem Anwendungsbereich und der Ausgestaltung, mögliche Lerneffekte in der interkommunalen Zusamenarbeit abgeleitet werden, sowie deren Erfolgsfaktoren und mögliche Hemnisse.

4 ERGEBNISSE

4.1 Typologie

Die analysierten Prozesse der fünf Städte sowie der des Gesamtkonsortiums „5 für Südwestfalen" zeigen in ihrem Prozess eine Kombination aus allen vier Dimensionen (Abb. 1) mit starkem Schwerpunkt auf der kollaborativen und der experimentellen Ebene. Auch arbeiten die neu geschaffenen Smart City Abteilungen, Stabstellen oder Managerinnen und Manager in agilen, kleineren Teams nah an und eng mit der Stadtverwaltung und der Stadtspitze (Organisatorische Dimension, siehe Abb. 1). Die Intention dabei ist Vorbildfunktion und Experimentierfeld in einem zu sein (IP 3). Damit ist die für Prozessverläufe wichtige, horizontale Integration in allen fünf untersuchten Städten erkennbar. Hierbei wird „Kommunikation" häufig angesrochen und meint die anderen Abteilungen und Verwaltungseinheiten zu informieren und zu beteiligen, um Akzeptanz zu schaffen und so Lock-In Effekte zu verhindern.

Alle fünf untersuchten Städte entwickelten eine Smart-City-Strategie, was Vorgabe der Förderbedingungen war (BBSR, 2021). Die als Teil der Innovationsbiografie untersuchten Strategieprozesse zeigen je nach Vorerfahrungen kreative und umfassende Beteiligungsformate. Durch die im Jahr 2020 beginnende COVID-19 Pandemie sind viele dieser Formate online durchgeführt worden. Es wurden jedoch in jeder Stadt auch analoge Beteiligungsformate angeboten (postalisch oder als aufsuchende Beteiligung (IP 1)), was den inklusiven Charakter der Beteiligungsformate zeigt. Jede Stadt integriert die Smart-City-Strategie entweder in die vorhandene (Nachhaltigkeits-)Strategie oder übernimmt die Ziele und Maßnahmen der bestehenden in die Smart-City-Strategie (integrierte, ganzheitliche Stadtentwicklung, siehe Abb. 1). Die Bürgerinnen sollten und Bürger nicht nur die Adressaten der Smart-City-Maßnahmen sein, sondern aktive Gestalterinnen und Gestalter in dem Prozess. So wurden diese schon zu Beginn der Smart-City-Visionsentwicklung einbezogen ihre Ideen, Vorstellungen und Wünsche einzubringen.

Über die Ausgestaltung und die Umsetzung der Smart City und die Nutzung und Anwendung von Technologien, kann zum Untersuchungszeitpunkt (November 2021 – Februar 2022) noch keine Aussagen getroffen werden, da zunächst die zweijährige Strategiephase (2019-2021) im Vordergrund der kommunalen Prioritäten stand. Das erste gemeinsame digitale (Leit-)Projekt ist die Erstellung einer offenen regionalen Datenplattform, auf der Daten und Information gesammelt, aufbereitet und weiterverarbeitet werden und (bei nicht sensiblen) Daten öffentlich einsehbar sind. Diese können miteinander ausgewertet und vernetzt gesteuert werden. Umgesetzt wird dieses erste Leitprojekt mit und durch den regionalen IT-Dienstleister Südwestfalen IT.

Zu den individuellen Strategien, erarbeiteten die fünf Kommunen im ersten Schritt eine gemeinsame Rahmenstrategie, die das Narrativ einer gemeinsamen DNA „digital, nachhaltig, authentisch" aus dem REGIONALE Strukturförderprojekt aus dem Jahr 2016 mit den Kommunen und Gemeinden aus der Region entwicklet worden ist. So findet auch auf überregionaler Ebene eine Integration der vorhandenen in die neue

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Strategie statt. An die Rahenmenstratgie können und sollen sich bis 2030 möglichst viele Städte und Gemeinden der Region anschließen und von den in den fünf Kommunen gemachten Erfahrungen lernen. Bisher haben sich 14 Kommunen der Rahmenstrategie mit einem Ratsbeschluss, einem Letter of Intent oder einer Absichtserklärung des Bürgermeisters/der Bürgermeisterin angeschlossen. Insgesamt 21 Städte und Gemeinden sind Teil eines von der Südwestfalen-Agentur GmbH gepflegten Smart City Netzwerkes, in dem regelmäßig Austauschtreffen statt finden (Stand Juli 2022).

4.2 Transformationspotenzial nach (Chilvers & Longhurst, 2015)

Die aus den Innovationsbiografien der einzelnen Städte und des Gesamtprojekts „5 für Südwestfalen“ ermittelten Ergebnisse werden entlang der Ebenen „Formen des Handelns“, „Organisation und Governance“, „Framing und Narrationen“ und für die Diffusion in die Region notwendigen Lernprozesse dargestellt (siehe Abbildung 1). Diese sind teilweise eng miteinander verwoben oder wirken gemeinsam.

4.2.1 Formen des Handelns und sozialen Beziehungen

Das untersuchte Modellprojekt „5 für Südwetsfalen“ ist ein Konsortium aus fünf Kommunen gemeinsam mit der Südwestfalen-Agentur GmbH. Es gibt in jeder Stadt und in der Südwestfalen-Agentur eine neu geschaffene Stelle, die eng miteinander arbeiten und sich wöchentlich austauschen. Je nach Größe der Kommune gibt es dafür mindestens eine Personalstelle im Projektmanagement. Die Teams sind sehr eng an der Hausspitze und am Bürgermeister angesiedelt und haben insbesondere in den kleinen Städten engen Austausch (IP 6). In der interkommunalen Struktur existiert ein Steuerkreis, in der die Bürgermeister sowie die Projektverantwortliche aus der Südwestfalen-Agentur zusammen kommen und auf strategischer Ebene beraten. So gibt es eine operationale Arbeitsebene und eine strategische Ebene, die regelmäßig Erfahrungen austauschen. Ausserdem gibt es eine weitere beratende Ebene in Form eines Beirates, welcher mit den Chief Digital Officers (CDOs) oder Vorgesetzten der Smart City Manager bestezt ist. Für die Zusammenarbeit und Kooperationen haben sich die beteiligten Städte zusammen mit der Südwetstfalen Agentur eine gemeinsame Geschäftsordnung für die Laufzeit des Projektes (2019-2026) gegeben. Die Zusammenarbeit wird von allen Beteiligten als sehr positiv, wertschätzend und fruchtbar für die eigenen Prozesse empfunden. So berichten die interviewten Projektverantwortlichen voneinander zu lernen, wenn die anderen Städte im Prozess zur Smart-City-Strategie-Erstellung bereits weiter fortgeschritten waren (IP 1).

Zur Aktivierung der Bevölkerung nutzen zwei Städte unter anderem ein eigenes Stadtlabor, indem die Bürgerschaft informiert wird und mitagieren darf (IP 2), (IP 8). Auch sehr kreative Formate zur Beteiligung der Bürgerinnen und Bürger sind als aufsuchende Beteiligung oder in Form einer Bürgerinnen- und Bürger-Journey sind ausprobiert worden.

4.2.2 Organisation und Governance

Das Thema New Work ist von den Verantwortlichen immer wieder angesprochen worden und wird experimentell in einer der beteiligten Kommunen intensiv erprobt. Ziel ist dabei bestehende Strukturen zu erweitern, zu ergänzen und die gewonnenen Erfahrungen mit der Verwaltungsebene zu teilen. Neue verwaltungsinterne Strukturen (häufig in Form von Stabsstellen nah an der Stadtspitze) oder neue Kooperationen wurden in allen fünf Städten geschaffen (IP 2).

Auch das Thema Change Management wird mehrfach in den Interviews genannt, vor dem Verständis die Menschen aus der Stadtverwaltung für Veränderungen zu öffnen, damit sie den Prozess hin zur Smart City aktiv mitgestalten (IP 2). Damit verbunden wird das Thema Kommunikation angesprochen, welches Vertrauen schafft und die Menschen vor Ort und in der Verwaltung für die Themen begeistern soll. Damit sehen sich die befragten Smart-City-Mangerinnen und Smart-City-Manager als Change Agents in der Verwaltung und als Moderatorinnen und Moderatoren in dem gesamten Prozess innerhalb der Stadt. Die Umsetzung der gemeinsam erarbeiteten Maßnahmen erfolgt dann wieder durch die Abteilungen (IP 1). So wird der gemeinsam erarbeitete Rahmen für die Gestaltung der Smart City (die Smart-City-Strategie) durch den Stadtrat legitimiert und bietet in der Umsetzung Gesatltungsspielraum innerhalb der Abteilungen.

4.2.3 Framing und Narrationen: den Sinnsetzung und Deutungsmuster

Das Framing der Smart City geht in allen untersuchten Städten in Richtung Sustainable Smart City (siehe Abb. 1) (BBSR, 2021). In den Interviews werden auf Projektmanagementebene immer die Sustainable Development Goals (SDGs) angesprochen und die Relevanz einer nachhaltigen Stadtentwicklung. Alle

untersuchten Städte orientieren sich in ihrer Strategie an der Definition der Smart City Charta und alle Interviews bestätigten den Schwerpunkt „Der Mensch im Mittelpunkt“. Eine der untersuchten Kommunen nutzt die Smart City zur Umsetzung ihrer zuvor erarbeiteten Nachhaltigkeitsziele, die anderen implementieren die Ziele der vorhandenen Strategien (und Konzepte) in die Smart-City-Strategie. Jede der Strategien beginnt mit einer Vision, die sich an der 2016 entstandenen „Südwestfalen DNA – digital, nachhaltig und authentisch orientiert“ und diese in ein Narrativ der Stadt integriert. So lautet das Narrativ der Stadt Arnsberg „Gemeinsam den Wandel gestalten“, Menden nennt es „Das neue WIR“, oder Olpe „Olpe 2030: l(i)ebenswert, lernbegeistert, nachhaltig und digital“. Der genannte Zeithorizont ist dabei das Jahr 2030.

4.2.4 Notwendige Lernprozesse

Durch gezieltes und gesteuertes Wissensmanagement durch die Südwestfalen-Agentur entfalten sich vor allem räumliche Wirkungen. So erstellt die Südwestfalen-Agentur gemeinsam mit den fünf Modellkommunen Leitfäden zum Prozess, digitalen Anwendungen und der regionalen Datenplattform, die online zur Verfügung gestellt werden (Südwestfalen-Agentur GmbH, o. J.). Zudem organisiert die Südwestfalen-Agentur für die Region regelmäßig stattfindende Austauschformate und eine jährliche regionale Smart City Konferenz, die dem Austausch und der Weitergabe von Gelerntem dienen. Neue Lösungen und neues Wissen wird geschaffen, gebündelt und weitergetragen. Damit agiert die Südwestfalen-Agentur in diesem Prozess als sogennnater Wissens- oder Knowledgebroker, indem sie Wissen bündelt, aufarbeitet um im Netzwerk teilt.

5 ZUSAMMENFASSUNG

Das Konzept Smart City weist in allen fünf Städten auf Veränderungsprozesse in den von Chivers & Longhurst (2015) entwickelten Ebenen (Formen des Handelns, Organisation und Governnace, neues Framing und notwenige Lernprozesse) hin, die für soziale Innoavtionen und Veränderungsprozesse im Rahmen erfolderleicher Transformationsprozesse notwendig sind. Damit zeigt die Smart City in den fünf untersuchten Städten Ansätze und das Potenzial Veränderungen in bestehenden und dominanten Institutionen und Strukturen im urbanen Raum anzustoßen. Die Interpretationsfähigkeit des Konzeptes der Smart City macht es für die Stadtplanung nicht einfacher, dieses an- und aufzunehmen, aber in ihrem Facettenreichtum liegt möglicherweise auch der Reiz für die Ausgestaltung einer Smart City.

Die untersuchten Prozesse in den fünf Städten zeigen für die Entstehung zur Smart City gute Ansätze einer integrierten Stadtentwicklungspolitik. Sie integrieren auf horizontaler Ebene die anderen Abteilungen und Ressorts und auf vertikaler Ebene die Sustainable Development Goals. Horizonale Integration stellt sicher, dass die Fragen und Herausforderungen an den Schnittstellen nicht vergessen werden und so auch Wechselwirkungen Beachtung finden. Die Orientierung an den Sustainable Development Goals (SDGs) verdeutlicht außerdem die Richtung der Smart-City-Strategien in Sustainable Smart-City-Strategien (Abb. 1). Die Visionen und das Narrativ der untersuchten Städte bestätigen dies. Beteiligungsformate werden nicht nur im Förderauftrag gesehen, sondern aktiv gestaltet und trotz COVID-19-Pandemie erfolgreich und mitunter sehr kreativ umgesetzt. In der Ausgestaltung werden die Wüsnche der Bürgerinnen und Bürger einbezogen und (digitale) Projekte umgesetzt. Dabei zeigen die Interviews, dass diese an vorhandenen Problemstellungen und Herausforderungen der Stadt orientiert werden. Damit ist die Umsetzung der Smart City in den Maßnahmen projektbezogen, die Gesamtherangehensweise jedoch als radikal zu werten (vgl. Abb. 1).

Die angestrebte Ausweitung des Smart-City-Konzeptes in die Region (mit dem Ziel: „Smarteste Region Deutschlands“) zeigt bereits nach zweijähiger Projektphase Erfolge. Zu den fünf Förderkommunen, sind mehr als 20 Kommunen der ingesamt 59 bereits Teil des regionalen Netzwerkes (Stand Juli 2022). Diese stetig wachsende Netzwerkdichte verdeutlicht funktonierende positive Spill-Over-Effekte und Diffusionsmechanismen über die beteiligten Städte hinaus. Die in den fünf Städten gesammelten Erfahrungen werden durch die Südwestfalen-Agentur gebündelt und in das Netzwerk kommuniziert. Hier zeigt sich, dass ein gezieltes und gesteuertes Wissensmanagement gute Anstöße für die Diffusion des Smart-City-Konzeptes in die Region liefern kann. In Südwestfalen ist die interkommunale Zusammenarbeit in zwei REGIONALE Förderphasen bereits erprobt und gewachsen, so dass die Region auch in diesem Förderprogramm „Smart Cities made in Germnay“ davon profitiert. Insbesondere für kleine Städte mit wenig

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

personellen und finanziellen Ressourcen könnnen solche interkommunalen Kooperationen gewinnbringend sein, wenn Kompetenzen gebündelt werden und so „größere“ Projekte und Skalenvorteile entstehen, wie am Beispiel Südwestfalen, der Aufbau einer gemeinsamen regionalen offenen Datenplattform.

Förderprogramme sind auch in diesem Konsortium mit knappen Haushalten und wenig Ressourcen wichtiger Treiber für Veränderungsprozesse im urbanen Raum. Damit werden Experimentierfelder im urbanen Raum oft erst möglich. Geben die Förderprogramme die Richtung und die Rahmenbedingungen vor, wie die Orientierung an der Smart-City-Charta oder die Nutzung von Open-Source-Lösungen, ist dies mit Blick auf die nachhaltige Entwicklung durchaus positiv zu sehen. Auf der anderen Seite ist damit nicht viel Spielraum für wirklich individuelle Lösungen gegeben. Auch müssen die Städte in der Lage sein, aus diesem Projekt dauerhafte Strukturen zu schaffen, damit die während der Laufzeit erarbeiteten Lösungen, Kompetenzen und die Kooperationsbeziehungen nicht enden. Für die Ausgestaltung von Förderprogrammen zwischen den richtigen wegweisenden Rahemenbedigungen auf der einen und der Offenheit für individuelle Lösungen auf der anderen Seite ist sicherlich noch weitere Forschung notwendig. Auch müssen sich die Städte irgendwann an ihren Ergebnissen messen (lasssen), inwiefern sie ihre in den Visionen erarbeiteten Ziele erreicht haben und warum möglicherweise Prozesse oder Maßnahmen gescheitert sind. Dafür bedarf es einer offenen und lernendnen Fehlerkultur auf der einen und einem sinnvollen Key-Performance-Indikatoren (KPI)-System auf der anderen Seite.

6 REFERENCES

Abassiharofteh, M., Baier, J., Göb, A., Thimm, I., Eberth, A., Knaps, F., Larjosto, V., Zebner, F., Akademie für Raumforschung und Landesplanung, & TRUST-/ARL-Promotionskolleg (Hrsg.). (2019). Räumliche Transformation: Prozesse, Konzepte, Forschungsdesigns. Akademie für Raumforschung und Landesplanung, Leibniz-Forum für Raumwissenschaften.

Anthopoulos, L. (2017). Smart utopia VS smart reality: Learning by experience from 10 smart city cases. Cities, 63, 128–148. https://doi.org/10.1016/j.cities.2016.10.005

Baur, N., & Blasius, J. (Hrsg.). (2014). Handbuch Methoden der empirischen Sozialforschung. Springer VS.

BBSR, B. für B.-, Stadt-und Raumforschung (BBSR) im Bundesamt für Bauwesen und Raumordnung (BBR) (Hrsg.). (2021). „Im Zentrum steht die Nachhaltigkeit“ – Modellprojekte Smart Cities 2020 (Nr. 12/2021; S. 1–58). BBSR. https://www.smart-city-dialog.de/wp-content/uploads/2021/12/bbsr-bericht-12-2021-modellprojekte-smart-cities-2021-1.pdf

Bibri, S. E. (2018). Smart Sustainable Cities of the Future. Springer International Publishing. https://doi.org/10.1007/978-3-319-73981-6

Bohle, A. K. (2021). Smart City Charta (S. 32). Bundesinstitut für Bau-, Stadt- und Raumforschung (BBSR) im Bundesamt für Bauwesen und Raumordnung (BBR). https://www.smart-city-dialog.de/wp-content/uploads/2021/04/2021_Smart-City-Charta.pdf

Butzin, A., Rehfeld, D., & Widmaier, B. (Hrsg.). (2012). Innovationsbiographien: Räumliche und sektorale Dynamik (1. Auflage). Nomos.

Chilvers, J., & Longhurst, N. (2015). A Relational Co-productionist Approach to Sociotechnical Transitions. 3S Working Paper 2015-27 (Working Paper 3S Working Paper 2015-27; S. 59). Science, Society and Sustainability (3S) Research Group. https://uea3s.files.wordpress.com/2015/12/chilvers-and-longhurst-3swp-2015-27.pdf

Fischer-Rosenthal, W., & Rosenthal, G. (1997). Narrationsanalyse biographischer Selbstpräsentation. In R. Hitzler & A. Honer (Hrsg.), Sozialwissenschaftliche Hermeneutik (S. 133–164). VS Verlag für Sozialwissenschaften. https://doi.org/10.1007/978-3-663-11431-4_6

Guillén, M. F. (2021). 2030: Die Welt von morgen (S. Pauli, Übers.; 1. Auflage). Hoffmann und Campe.

Günthner, S., Bundesinstitut für Bau-, Stadt- und Raumforschung, & Deutschland (Hrsg.). (2017). Smart City Charta: Digitale Transformation in den Kommunen nachhaltig gestalten (Stand: Mai 2017). Bundesinstitut für Bau-, Stadt- und Raumforschung (BBSR) im Bundesamt für Bauwesen und Raumordnung (BBR).

Howaldt, J., Jacobsen, H., & Technische Universität Dortmund (Hrsg.). (2010). Soziale Innovation: Auf dem Weg zu einem postindustriellen Innovationsparadigma (1. Aufl). VS Verlag für Sozialwissenschaften.

Kourtit, K., Nijkamp, P., & Arribas, D. (2012). Smart cities in perspective – a comparative European study by means of self-organizing maps. Innovation: The European Journal of Social Science Research, 25(2), 229–246. https://doi.org/10.1080/13511610.2012.660330

Lange, K. (2022). Wirkungsanalysen von Smart-City-Projekten (S. 37). Bundesinstitut für Bau-, Stadt- und Raumforschung. https://www.bbsr.bund.de/BBSR/DE/veroeffentlichungen/bbsr-online/2022/bbsr-online-14-2022-dl.pdf;jsessionid=B119899179F4857ACD28EB7DCEB79C57.live21302?__blob=publicationFile&v=3

Lange, K., & Knieling, J. (2020). EU Smart City Lighthouse Projects between Top-Down Strategies and Local Legitimation: The Case of Hamburg. Urban Planning, 5(1), 107–115. https://doi.org/10.17645/up.v5i1.2531

Lee, J. H., Hancock, M. G., & Hu, M.-C. (2014). Towards an effective framework for building smart cities: Lessons from Seoul and San Francisco. Technological Forecasting and Social Change, 89, 80–99. https://doi.org/10.1016/j.techfore.2013.08.033

Mayring, P., & Fenzl, T. (2019). Qualitative Inhaltsanalyse. In N. Baur & J. Blasius (Hrsg.), Handbuch Methoden der empirischen Sozialforschung (S. 633–648). Springer Fachmedien Wiesbaden. https://doi.org/10.1007/978-3-658-21308-4_42

Milbert, A. (2021). Kleinstädte in Deutschland. Bundesinstitut für Bau-, Stadt- und Raumforschung (BBSR) im Bundesamt für Bauwesen und Raumordnung (BBR).

Nilssen, M. (2019). To the smart city and beyond? Developing a typology of smart urban innovation. Technological Forecasting and Social Change, 142, 98–104. https://doi.org/10.1016/j.techfore.2018.07.060

OECD. (2020). Smart Cities and Inclusive Growth. 59.
O`Neill, B. C., Kriegler, E., Ebi, K. L., Kemp-Benedict, E., Riahi, K., Rothman, D. S., van Ruijven, B. J., van Vuuren, D. P., Birkmann, J., Kok, K., Levy, M., & Solecki, W. (2017). The roads ahead: Narratives for shared socioeconomic pathways describing world futures in the 21st century. Global Environmental Change, 42, 169–180. https://doi.org/10.1016/j.gloenvcha.2015.01.004
Pyka, A. (2021). Evolutorische Innovationsökonomik. In B. Blättel-Mink, I. Schulz-Schaeffer, & A. Windeler (Hrsg.), Handbuch Innovationsforschung (S. 83–101). Springer Fachmedien Wiesbaden. https://doi.org/10.1007/978-3-658-17668-6_6
regionen.NRW. (o. J.). Südwestfalen—Regionen.NRW. Regionen NRW. Abgerufen 26. Juli 2022, von https://regionen.nrw/regionen-nrw/suedwestfalen/
Rogers, E. M. (1983). Diffusion of innovations (3rd ed). Free Press ; Collier Macmillan.
Røste, R. (2005). Studies of innovation in the public sector, a literature review. 43.
Schneidewind, U. (2019). Die große Transformation: Eine Einführung in die Kunst gesellschaftlichen Wandels (4. Auflage). Fischer Taschenbuch.
Schumpeter, J. A. (1997). Theorie der wirtschaftlichen Entwicklung: Eine Untersuchung über Unternehmergewinn, Kapital, Kredit, Zins und den Konjunkturzyklus (9. Auflage, unveränderter Nachdruck der 1934 erschienenen 4. Auflage). Duncker & Humblot.
Schütze, F. (1983). Biographieforschung und narratives Interview. Neue Praxis, 13(3), 283–293.
Späth, P., & Knieling, J. (2018). Endlich Smart-City-Leuchtturm: Auswirkungen des EU-Projektes mySMARTLife auf die Planungspraxis in Hamburg. In S. Bauriedl & A. Strüver (Hrsg.), Urban Studies (1. Aufl., S. 345–356). transcript Verlag. https://doi.org/10.14361/9783839443361-026
Südwestfalen-Agentur. (n.Y.). Wer wir sind—Südwestfalen-Agentur. Wer wir sind. https://www.suedwestfalen-agentur.com/suedwestfalen-agentur/wer-wir-sind/
Südwestfalen-Agentur GmbH. (o. J.). Leitfäden | Smart Cities: 5 für Südwestfalen. Abgerufen 24. März 2022, von https://smartcities-suedwestfalen.com/alle-leitfaeden/
Südwestfalen-Agentur GmbH. (2021). Smart Cities Rahmenstrategie für Südwestfalen (2.Auflage; S. 1–24). https://smartcities-suedwestfalen.com/wp-content/uploads/2021/12/Smart-Cities-Rahmenstrategie-fuer-Suedwestfalen-2.pdf
Treude, M. (2021). Sustainable Smart City—Opening a Black Box. Sustainability, 13(2), 769. https://doi.org/10.3390/su13020769
Treude, M., & Schüle, R. (2021). Sustainable Smart City – the Path of Vienna. Cities 20.50. Creating Habitats for the 3rd Millennium: Smart – Sustainable – Climate Neutral, 789–804.
Treude, M., Schüle, R., & Haake, H. (2022). Smart Sustainable Cities—Case Study Südwestfalen Germany. Sustainability, 14(10), 5957. https://doi.org/10.3390/su14105957

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

🏆 *reviewed paper*

Smart City and Digital Humanities

Vasily V. Popovich, Pietro Elisei, Manfred Schrenk, Oksana Smirnova, Tatiana Popovich

(Dr. Vasily V. Popovich, popovich@oogis.ru)
(Dr. Pietro Elisei, President – ExCom member, ISOCARP, Netherlands, elisei@isocarp.org)
(DI Manfred Schrenk, CORP – Consulting Research Projects, 2320 Mannswörth, Austria, schrenk@corp.at)
(Dr. Oksana Smirnova, sov@oogis.ru)
(Dr. Tatiana Popovich, t.popovich@oogis.ru)

1 ABSTRACT

This project presents an extension of a discussion of ideas related to the upcoming global digitization and the role and place of a person in the digital world. The digital environment of a human being and society was discussed in a number of papers and reports at scientific conferences, magazines and books. This work makes an attempt to determine possible forms of our future society based on an example of historical development of human society and taking into account growing digitization of all aspects of life.

CRISALIDE project (City Replicable and Integrated Smart Actions Leading Innovation to Develop Urban Economies) started in October 2018 and was one of the very few projects co-funded by EU and Russian Federation through the Horizon2020 programme and the ERA-NET RUS PLUS (ENRP) program. Participants of the CRISALIDE project were the following companies: SUPC Ltd. (Russian Federation), URBASOFIA (Romania), EMaTTech (Greece), SPIIRAS-HTR&DO Ltd. (Russian Federation) and CORP (Austria).

In the CRISALIDE project an Innovative Decision-Making Tool has been developed for Contributions on:

- Urban Information Systems and Decision Making
- Urban Decision Support Systems
- Geo-Information-Infrastructures, Data availability (Basemap, INSPIRE, Open Governmental Data et al.)
- Urban Planning context, participation

From our point of view a Digital City (DC) is a special terrain or a limited digital world from the one hand but from the other is unlimited as a part of a global information system of the Earth (WWW). This world (DC) contains a number of humans and many of them (not everybody) have their own HDS.

At the recent conference, CORP 2016, the idea about free space around a human has been discussed. In this paper we will provide some ideas to next generation of CRISALIDE with tide to humanity.

Keywords: Corporative Information Systems, Digital World, Human's Digital Space, Digital City, Digital Humanities

2 INTRODUCTION

In this paper, we would like to continue our research regarding human's digital space (HDS), smart city and CRISALIDE project, as a case study of our theoretical research. In previous research papers we have discussed different points of digitization such as: digital space, metrics of space and a metric for HDS properties. Metric plays important role for real work applications and an idea of Hausdorff measure (a special mathematical measure used to calculate length, area and volume of non-specific figures) discovers new opportunities for realisation of different kinds of business logics in complex multidimensional and implicitly specified spaces. For HDS, investigation the Hausdorff measure could be used as an approach for numerical interpretation of HDS properties.

Also a Corporative Information Systems idea has been selected as a main technological background for CRISALIDE project that can be used for decision making process tool for smart city investigation. As a rule the Corporative Information Systems (CIS) idea and tools are using for decision making support for rather big business companies. Such systems were introduced approximately twenty years ago and have shown good results for businesses optimization since and has many realization by software applications. The present-day demand is to move cities to a digital era. Considering this demand, CRISALIDE project was directed to digital city governance and management.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

As well as a key technological instrument intelligent geographic information system IGIS was applied for visual and analytic 1D, 2D, 3D, 3D+t representations of geographical elements and others features of smart city. According to IGIS idea, a human also can be regarded as an object of GIS presentation and investigation for end users, software agents etc.

CIS approach based on proposed methodology provides means for development and support of decision making process for different levels of governance and management. Governance and management should not be centralized, it should be distributed with weak feedback links.

In the CRISALIDE project an Innovative Decision-Making Tool has been developed for Contributions on

- Urban Information Systems
- Urban Decision Support Systems
- Geo-Information-Infrastructures, Data availability
- Urban Planning

We consider next extension of the CRISALIDE as an instrument for end users. And also we understand an up to date users as an existence that exist inside a specific medium or a space that can be defined as a human digital space (HDS), as a part of smart city digital space. Let us to make some remarks regarding of main existences by our approach (discussion).

3 HDS SPECIFICATIONS

It is very hard to image a DHS as a special physical space around a human. It is a deep abstraction that can be have only mathematical description. DHS contains differed sub spaces that can be presented as a system of ontologies. Some of them might have a digital expression:

- weather data in the vicinity of the point, in the area (2D or 3D) or on the route (data set and/or its interpretation);
- weather analytics (forecast) in the vicinity of the point, in the area (2D or 3D) or on the route;
- medical support in the vicinity of the point, in the area (2D or 3D) or on the route.

Other properties could have digital properties (for example geographical coordinates) and complex information for a human:

- digital networks support capabilities in the vicinity of the point, in the area (2D or 3D) or on the route;
- availability of different markets (food, everyday goods, etc.);
- police stations (offices);
- transport systems nodes (bus & railway stations, harbours, airports etc.)
- leisure venues;
- address and coordinates of hotels, pubs, etc.;
- banks & financial services.

Selected above properties show direct and relatively links between such existence as human and city. Most of them could be realized on computer and visually presented on a screen.

4 COMPUTER REPRESENTATION OF HDS

For computer representation of HDS we should introduce a IGIS system that includes the following main parts at minimum:

- map server;
- weather conditions server;
- business analytic server;
- 2D+t, 3D+t engines;

- artificial intelligence (AI) server;
- system of documents exchanging;
- client's applications (web, etc.), see Fig 1.

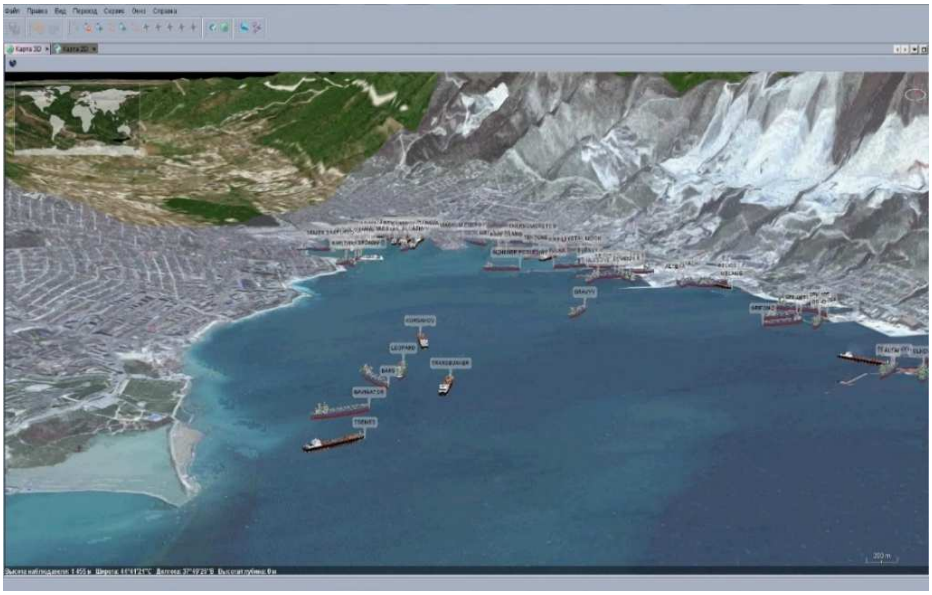


Fig. 1: A variant of end-user screen.

In this situation more important is not only a visual representation of HDS but its numerical estimation. In CRISALIDE projects there are a lot of numerical estimation of human spaces as is shown on Fig. 2.

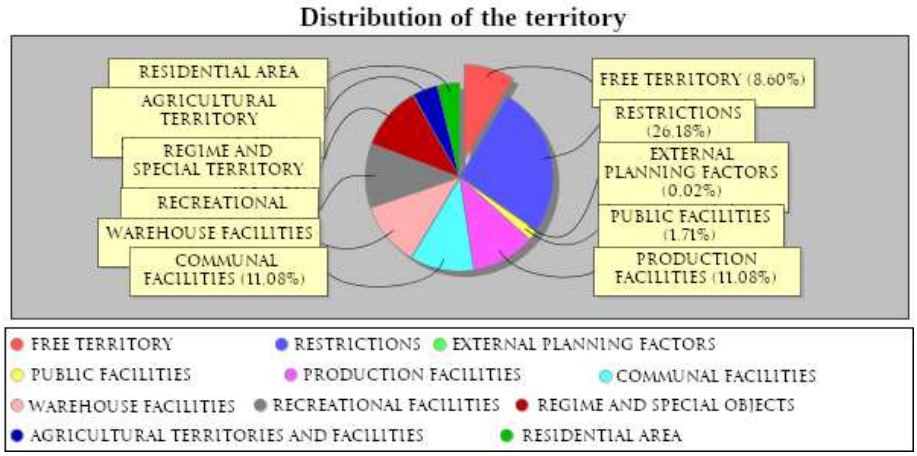


Fig. 2: City area distribution according to human demands.

Decision making support system (DMSS) can help CRISALIDE users to satisfy human's demand for space. But it is evident that data in Fig. 2 does not reflects even HDS properties. And it is a subject for research to detect and to study a functional dependence of HDS properties from the city area parameters shown in Fig. 2.

5 SMART CITY

Despite the evident fact that a modern city can not be described as an isolated entity, physically, citizens are living inside an abstract terrain. There are two worlds: a physical one and an informational one. And there is a big difference between them as well. The physical world is restricted and limited, informational one is unlimited and can not be restricted without special activities and devices. It is a new demand – a contradiction between two worlds: physical one and an informational one. The difference is getting bigger and bigger from year to year. In physical world everything inside a city is typical and suitable for human existence and nature. Informational world is another story. A city and a human are only some points (nodes) inside a global informational matrix. And a city is only a set of human's nodes that have only physical boundaries but without information limitations. In global informational matrix we have lost such useful and understanding phenomena (for human) like a distance and other geometric properties.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

According to our description of human digital space it seams to us the city also has its own digital space together with physical space. But what is a digital space of the city (DSC)? From a technological point of view, a city has a complex information infrastructure (in computer science interpretation):

- supporting system (electricity, energy systems, etc);
- network systems (wired, wireless (GSM, wi-fi, Satellite, etc.);
- network nodes;
- data centers (back end systems);
- private and public front end devices.

Some remarks. During the process of the CRISALIDE project development we have paid main attention on a physical properties of the smart city. But human, as a key elements of the city, was described as a set of demands only but not as an existence for itself. And at this time we are consider that next evolution of CRISALIDE project should be pointed into human's direction.

In a current stage, the system of intelligent decision support for urban environment management (CRISALIDE) is designed to integrate decision-making processes in the field of creating urban strategic and territorial plans, the formation of urban policies, promotion of e-government, management of urban infrastructures and housing stock (facilities and utilities, regeneration of residential areas), retraining of production areas (renovation of ex-industrial zones, temporary use of empty buildings) and their development (science parks, incubators, network of clusters of small and medium-sized enterprises), as well as land use management in urban development areas.

CRISALIDE is a software and hardware complex based on intelligent GIS, which provides the ability to integrate maps of various formats, implement a scenario approach in urban development modelling, 3D modelling, support for 2D + t modelling, support for 3D + t modelling, support for decision-making based on expert knowledge, the ability to monitor changes and assess the possible impact of decisions on the urban environment.

The software and hardware complex provides the consumer with a universal set of technological and functional solutions within the framework of the basic configuration with the possibility of expanding functional tasks in accordance with the requirements of the customer and the subject area, multi-platform and the absence of mandatory additional paid software.

The main end users of the developed CRISALIDE system are state authorities and local self-government, public and private enterprises and organizations directly related to the functioning and development of the urban environment. The introduction of the CRISALIDE system allows us to solve the following tasks: to develop e-government, to improve the quality of public administration through the creation and implementation of modern information technologies. The proposed system of intellectual decision-making support makes it possible to predict the development of urban infrastructure both within the city as a whole and in selected districts and quarters, to identify a deficit or surplus of construction facilities and/or infrastructure, as well as to take into account the socio-economic aspects of the development of municipalities and regions.

Next generation of the CRISALIDE project by our opinion should be focused on the next main problems as follows:

5.1 Information and knowledge clouds of services for an individual development

Our company during recent years has been developing an artificial intelligence (AI) system of tools for decision making support for not trivial tasks as situation assessment and estimation, command and control circle realization, pattern recognitions etc. The AI systems consists of the following main parts: an ontology system, business process management (BPM) system, SVD engine for recognition of abstract and physical entities and objects. Our major idea is to create (automatically) individual information environment for ever human using AI tools. In other words, a private human's digital space (PHDS). The PHDS should aid individuals first of all in the routine of everyday life.

5.2 Private business analytics development

Scenario approach (BPM realisation) with application of SVD engine could help individuals to arrange everyday activities and make right decisions of local scale (to buy wine, fish or other goods, etc.) and up to global scale (to plan trips, to buy a house, etc.).

5.3 An intelligent social networks development

A main goal of such network is to share knowledge via the Internet. Regarding to our concept of information (measurement, data, information, knowledge and understanding) and knowledge representation and sharing (for free or paid, it depends on the specific case).

As one can see, the next generation of CRISALIDE should turn in human direction. And it can become a system or some set of services in current version of CRISALIDE or it can be a separate system similar to a typical social network. This question is under our investigation right now.

6 SYSTEM OF DEVICES

Every system of automatic or automation control has a simple structure, see Fig. 3.

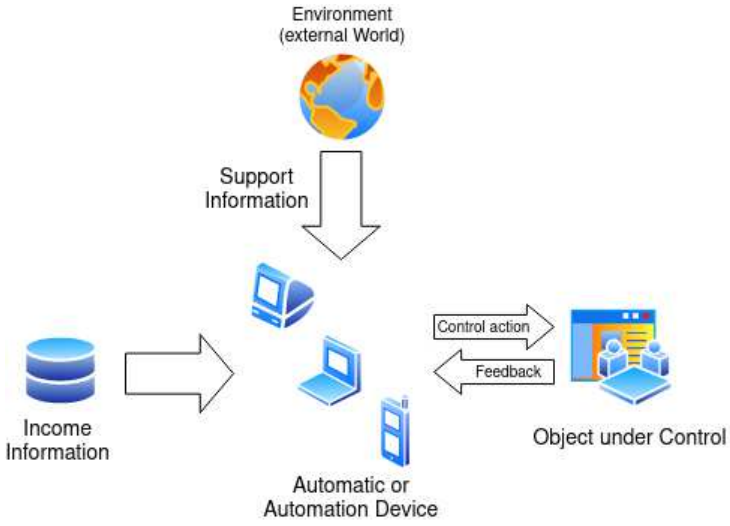


Fig. 3: System of automatic or automation control.

The difference between automatic or automation is that in first case there is a fully autonomous device and in the other case there is a human presence in the control process. Application of automation system in DMSS is justified only when control process can not be formalized by mathematical functions or equations. And a final decision could be made by human.

Let us pay attention to Fig 3. There are flows of information, at least two: income information and support information from environment.

6.1 Income information

This is a specific information (measurements, data, information) from sources that we require. Without this information the system of automation will not work properly. If such information is absent, it is difficult to count on the right decision. Access to such information can be carried out in many ways. Directly device to device, by wired system or by different wireless networks. In our days most of devices have special ports for connecting to wired or wireless systems. And they can communicate with each other by Internet. “Internet of things” is a common name for such opportunities. Devices for receiving such information could be: wi-fi devices, sell network gadgets, satellite receivers, etc.

6.2 Environment’s information

This is a supporting information that can directly or indirectly influence the decision making process. For example, weather conditions directly influence the decision to start a journey by car or by yacht. There are a lot of weather web-sites on the Internet but it is not easy to implement them for other applications. They are oriented on a human perception and interpretation. If you wish to obtain primary information it wont be easy

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

to do, as a rule. There is a wide spectrum of devices for obtaining such information. SPIIRAS-HTR&DO Ltd. also produces many devices for environment's conditions measuring as is shown in the Table 1.

1	Meteorological multisensors 	Measured parameters: relative humidity, atmospheric pressure, temperature. Data transfer via TCP/IP protocol.
2	Wireless sensors for measuring atmospheric parameters 	Measured parameters: relative humidity, atmospheric pressure, temperature. Data transmission over wireless networks: cellular, wi-fi.
3	Inertia-free wind measurement sensor 	Measured wind parameters: speed, direction.
4	Electromagnetic field meter 	Measured parameters of the electromagnetic field: frequency, level, etc.

Table 1: Measuring devices.

The business marketplace for such devices is rather full. For example, Finnish company Vaisala had turnover in RF more than 13 million euros (2020) per year by weather devices producing.

6.3 Healthcare information

Healthcare information is includes two groups of information:

a) information from special devices for human health conditions estimation, such as heart rate, pulse, body temperature, blood pressure etc. Up to date devices such as iPhone, for example, include such devices. Moreover, a special software like "Watson" by IBM can make preliminary analysis of input data and automatically send information to medical emergency, hospital or doctor.

b) information regarding medical systems of the city or village depending on where a human is in a current situation. It helps to make a right decision if something happens. It can be received by different gadgets that have access to the Internet.

7 SYSTEM OF SERVICES

Main services can be presented by text, graphics and voice forms. A list of services is very big and covers all of city life routines. Most of the services are presented by Internet through different gadgets. But, as was noted by Erich Fromm, today people would like to know and can to do primitive operations, especially how to use gadgets, but do not wish to understand things. It is the biggest demand of our civilization. According to this evidently fact our proposal is to include in to a plan of CRISALIDE project next generation a systems of services, pointed to understanding process. So, understanding should be as a service from Internet.

8 CONCLUSION

As it was noted in the presented paper, the CRISALIDE project as an Innovative Decision-Making Tool has been developed for Contributions on

- Urban Information Systems and Decision Making
- Urban Decision Support Systems
- Geo-Information-Infrastructures, Data availability (Basemap, INSPIRE, Open Governmental Data, …)
- Urban Planning context, participation

One can see that the main subject domain of our research was a Digital City as a special existence that has two sides: a limited digital world and a part of a global information system of the Earth (WWW).

The next generation of the CRISALIDE project will be consists next main parts as follows:

(1) Knowledge clouds as services for individuals.

(2) Private business analytics for understanding development.

(3) An intelligent social networks development as a platform or environment for knowledge and understanding existences and processes.

Finally we should underline that the next generation of CRISALIDE should be turned in to a human direction.

9 REFERENCES

E. Fromm. Escape from Freedom — Philosophical arkiv, Nyköping (Sweden), 2016. — 231 стр. ISBN 978-91-983073-5-1

V. Popovich, et al. Digital World of the Future as an Evolution of the Past. CORP 2021, 12-14, May, 2021 Vienna, Austria.

V. Popovich, T. Popovich, O. Smirnova. Intelligent Decision Making Support System for Smart City Governance and Management. Proceedings of the ISAECT Conference, Roma, Italy. 27-29 Nov. 2019. Inspect Association Number: 19536136.

🏆 *reviewed paper*

South Africa's Pursuit of Sustainable Urban Development: a Reality or Rhetoric?

Mueletshedzi Helen Phosho, Trynos Gumbo

(Mueletshedzi Helen Phosho, Postgraduate Student, Dept of Urban and Regional Planning, University of Johannesburg. Cnr Siemert & Beit Streets, Doornfontein 0184 Johannesburg, South Africa- phoshomueletshedzihelen@gmail.com)
(Trynos Gumbo, Associate Professor and Head, Dept. of Town and Regional Planning, University of Johannesburg. Cnr Siemert & Beit Streets, Doornfontein 0184 Johannesburg, South Africa, tgumbo@uj.ac.za)

1 ABSTRACT

The attainment of sustainable urban development is one of the biggest challenges that contemporary governments face across the world. Despite many governments adopting and pursuing sustainable development goals following their adoption in the past years, there is still a huge gap in the implementation of the sustainable development principles and the public declarations that these governments ratified. It has been observed that the implementation and efforts being exerted towards the achievement of the SDGs in most cities of the developing world do not reflect the promises that were made in the declarations. The aim of this paper is to assess South Africa's pursuit of sustainable urban development and make an attempt to determinine the level of sincerity by the government and be able to conlude whether its a reality or rhetoric. The paper looks at sustainable urban development practices and how sustainable urban development has evolved within the South African urban policy context. An analysis of the policies aimed at promoting long-term growth that influences sustainable urban development in the country was conducted. The results showed that in South Arica, there is widespread adoption and growing interest in sustainable urban development principles by government. However, with regards to implemenation, particularly at city levels, sustainable development still needs concerted efforts and commitment to make it reality. In conclusion, the paper opines that there is need for political, economic, institutional and social commitments to support innovative strategies to enhance possibilities for sustainable urban development in South African cities.

Keywords: sustainability, urban development, urban policy, South Africa, sustainable development goals

2 INTRODUCTION AND BACKGROUND

The planet is experiencing the most rapid urbanisation in history. Cities now house more than half of the world's population, and this figure is expected to rise to about 5 billion by 2030 (United Nations, 2018). This translates to around 70% of the population living in cities by the year 2030 (UN & World Bank, 2018). Most of this urbanisation would take place in Africa and Asia (UN Department of Economic and Social Affairs, 2022), resulting in significant social, economic, and environmental changes posing a fundamental question as to whether the current urban structures can sustain the extent of such urban development. Subsequently, most governments across the world face huge challenges in their pursuit of sustainable urban development (Irurah, 2004; Goebel, 2007; Hoeflich de Duque, 2016). The term sustainable development seeks to address "the needs of the present without jeopardising future generations' ability to meet their own needs" (World Commission on Sustainable Development, 1987). For urban areas to achieve the sustainable development goals, they need to strive for a balance between the social, environmental and economic goals.

The ideal future, according to the 1992 Rio Earth Summit, is the one in which sustainable development goals are accomplished at all levels of spatial organisations (Lafferty & Eckerberg, 2013). Agenda 21 of the Summit paid particular attention to the topic of sustainable growth at an urban scale. The Global Forum on Cities and Sustainable Growth considered 50 city studies on sustainable development progress in 1994 (Grubb et al. 2019), then in 1996, Habitat II was used to track the progress that cities across the world had made towards achieving sustainability. Then several international organisations and governments made sustainable urban development a priority after the Rio+10 Earth Summit in 2002. In the year 2000, the millennial development goals were formulated to be achieved by 2015, then the sustainable development goals were adopted in 2015 to be achieved by 2030. Even after all this progress on the sustainable urban development concept, there is still less policy implementation happening in actual cities (Rydin, 2012). As one of the European Commission's Expert Group notes, "The difference between public statements and principles on the one side, and specific steps taken on the other, remains high in most cities". Thus, this paper aims at examining the scale of the difference between the rhetoric and reality of the sustainable urban development in South African cities. The paper will unpack the concept of sustainable urban development in a South African city's perspective and the progress made towards achieving Sustainable Urban Development

in South African Cities. The interpretation of SUD is first considered, as there are various meanings of the broad construct. Following this theoretical introduction, the advent of a sustainable development ideology within the South African government will be established, as well as the policy framework that frames efforts to put SUD's ethos into practice. The latter part of the paper will focus on how some of the policies in the country align to the SDG 11. Lastly the paper will conclude if South Africa's pursuit of sustainable urban development is a reality or rhetoric.

3 CONCEPTUAL AND THEORETICAL FRAMEWORK

Sustainable development is an issue that has attracted a considerable amount of academic interest since the publication of the Brundtland Report. With Agenda 21, it is an issue which has also found its way into the policy and action programmes in many coutries across the world. The World Commission on Environment and Development popularised this concept in 1987. Their report defines sustainable development as a "development which meets the needs of the present without compromising the ability of future generations to meet their needs." However, sustainable urban development implies a process by which sustainability can be attained, emphasising improvement, progress and positive change, incorporating both environmental and social dimensions. It can also be defined as 'the spatial manifestation of urban development processes that creates a built environment with norms, institutions and governance systems enabling individuals, households and societies to maximise their potential, optimise a vast range of services so that homes and dynamic neighbourhoods, cities and towns are planned, built, renewed and consolidated restraining adverse impacts on the environment while safeguarding the quality of life, needs and livelihood of its present and future populations' (UN-HABITAT, n.d). Whitehead (2009) asserts that since its inception, the term urban sustainability has been concerned with ensuring that cities are ecologically sustainable. He also asserts that urban sustainability is about addressing issues of social sustainability within cities, ensuring that the living and working conditions found in cities are tolerable (and particularly so for the most vulnerable in urban society). Habitat II emphasised that urban sustainability draws particular attention to the ways in which social, environmental, and economic processes interact within urban space.

Another prominent definition came from the Council of European Municipalities and Regions in 1996, which describes urban sustainability as "a creative, balance-seeking process extending in all areas of local-decision making. Sustainable development helps cities and towns to base standards of living on the carrying capacity of nature while seeking to achieve social justice, sustainable economies and environmental sustainability". According to Williams et al. (2000), urban form is sustainable if it allows the city to work within its natural and man-made carrying capacities, is user-friendly for its inhabitants, encourages social equality, and requires participatory decision-making. In a South African perspective, the National Development Plan (NDP) recognises that 'sustainable urban development requires not only sustaining economic growth and enhancing social security, but also ensuring that the natural resource base is not irreversibly exhausted or destroyed' (National Planning Commission (NPC), 2012). In reality, the agenda for sustainable urban development is almost endless. 'Each society, country, and generation will have to answer the question of what sustainability means and how it will be done in their own unique circumstances,' (NPC, 2012). Sustainability is a mechanism rather than a fixed or predetermined result, and local experience and practice provide valuable insights into addressing sustainability in different contexts. In addition, urban sustainability does not mean self-containment or separation from global systems, but rather the establishment of sustainable relationships between local and global levels.

Since the official adoption of the 2030 Agenda, some governments have been designing and adopting proactive urban policies aimed at promoting overall sustainability and addressing the unique challenges of cities as highlighted in the SDG 11. SDG 11 is concerned with making "cities and human settlements inclusive, safe, resilient, and sustainable.". To address the challenges of its own cities, the South African government developed policies to emphasise the country's national city agenda. Prior to 1994, national cities were shaped by government-influenced planning practices and legislation intended to implement apartheid policies. The implementation of apartheid's ideology as part of the plan meant that the cities of the country were characterised by sparse development, segregation, and strong racial and class divisions. The NDP was developed to address some of the challenges that the country had, mainly 'eliminate poverty and reduce inequality by 2030' (NPC, 2012). Then the Spatial Planning and Land Use Management Act (SPLUMA) was introduced in 2013 which aimed at providing national, provincial and municipal spheres of government with

a framework relating to the establishment of policies and systems relating to planning and land use management. The 2016 Integrated Urban Development Framework (IUDF) was designed to address the spatial injustices associated with apartheid and the heritage of national planning, with a particular emphasis on the need for sustainable urban development. In line with the SDG 11, it has introduced four broad strategic goals with nine policy instruments that set key priorities for the South African urban agenda. The paper will assess the extent to which the NDP, SPLUMA and the IUDF provides strategic goals and policy instruments for pursuing sustainable cities in South Africa.

4 STUDY AREA

The scope of this study focuses on South Africa. South Africa is located at the southernmost region of Africa. South Africa is bordered by Namibia, Botswana, Zimbabwe and Eswatini as shown on Figure 1 below. South Africa's urban challenges sometimes are considered as distinctive and separate to those of the rest of the continent because of the apartheid legacy of a fragmented and racially splintered urban landscape. Twenty-eight years after democratic transition many of the urban challenges facing South Africa still are tainted by the apartheid past. Nevertheless, the issues that face its cities increasingly exhibit a set of sustainability challenges that typify the problems of many other fast-growing African cities. South Africa is already among the most urbanised countries in Africa and has an urban population that is growing rapidly. Current estimates are that the proportion of the national population living in cities is 62 percent but expected to reach almost three-quarters (71.3 percent) by 2030 (IUDF, 2016). By 2050 the urban population is expected to increase by an additional 13.8 million residents (National Treasury, 2011). The current trend of rapid and unplanned urbanisation is fundamentally unsustainable. The country thus faces significant challenges in implementing its mandate in sustainable development due to the on-going issues with the management of resource consumption to meeting housing and infrastructure needs of the urban residents. The scope of this study focuses on South Africa's pursuit of sustainable urban development.

Figure 1: Map of South Africa (Source: Ontheworldmap, 2019)

Since the introduction of democracy in 1994, South Africa has made a significant break with the past. Many long-term trends created by decades of colonialism, apartheid and inequality have been reversed by far-perceived politics, economics, and societal changes. While the country faces many urban sustainability

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

problems, it has put in place measures to improve its economy and increase fiscal spending to combat poverty. The revamping of public sector governance has been complemented by the introduction of new democratic institutions and processes. These changes have been accompanied by an increasing commitment to sustainable development.

5 METHODOLOGY

This paper used document analysis to collect information. A systematic technique for reviewing or evaluating documents, both printed and electronic (computer-based and Internet-transmitted) material, is known as document analysis. Document analysis, like other qualitative research methodologies, necessitates the examination and interpretation of data in order to extract meaning, gain insight, and develop empirical knowledge (Corbin & Strauss, 2008). The study reviewed relevant policies related to sustainable urban development across the country. The literature review was undertaken at a national level and the review focused on policies and frameworks for urban development within the country.

6 SUSTAINABLE DEVELOPMENT POLICY CONTEXT IN SOUTH AFRICA

When South Africa's first democratically elected government took office in May 1994, it inherited a planning system and legal framework that had been entwined in the economic aspirations and ideological ambitions of previous colonial and Apartheid regimes for more than 150 years. As the new government attempts to replace this structure, it is worth mentioning a few points about its history, features and functions. Planning legislation was first introduced in South Africa in the early 1930s (Oranje & Berrisford, 2016). This followed a long struggle by a small group of visionary planners, mainly architects, to overcome the strong real estate interests and protracted interstate disputes over the location of this legislation (Oranje & Berrisford, 2016). The system stipulated those orderly procedures were to be followed when (1) establishing new settlements and (2) allocating and modifying development rights to land. This was a far cry from the modernist, utopian ideals of many of its early proponents, which involved sweeping futuristic plans and targeted interventions for the common good (Oranje 1998). Prior to the 1990s, South African cities were characterised by planning practices heavily influenced by modernist planning principles characterised by one-way zoning and low-density suburban development (Van der Berg, 2017). Planning laws were drafted in line with apartheid policies, with the result that the design of cities and towns was based on racial discrimination and inequality (Van der Berg, 2017). The result was fragmented, low-density cities that required large-scale displacement of blacks and people of colour from impoverished and underserved areas of the townships to parts of the city or community where the main opportunities lie, higher-order economic and social institutions were located.

It is generally agreed that the apartheid planning system deliberately stifled the development of the majority of the country's population (Van der Berg, 2017). The apartheid was an authoritarian political system predominantly primarily based totally at the ideology of white supremacy or white nationalism which positioned laws which legalised discrimination in all regions of society, inclusive of housing, employment, and public transportation and accordingly suppressing the black majority. Conspicuously, many cities and towns in the country are still faced with the traces of the apartheid system of planning. Given the country's history it was heavily impacted by British legislation. The planning legislation was designed and propagated from the start to be used only in 'European/White zones' of towns and cities. This extensive and enforced planning system allowed for the orderly growth of towns and cities in 'White South Africa,' as well as the production and protection of property wealth in these places. Many of the planning laws and regulations during this time did not offer the legal framework required to prevent and manage the country's spatial governance issues, such as informal settlement regulation and inner-city township regeneration. South African cities are therefore still characterised by 'social, economic and spatial segregation, inadequate access to basic services, irresponsible resource use, and growing poverty and social exclusion' (Abrahams & Berrisford, 2012)

There were significant changes in the planning law after the country gained democracy. While there were many unknowns in the early days of the new regime, one certainty was that the pre-1994 differentiated planning system had to be replaced with a "one equal planning system for everyone". there was little clarity on the specifics of this new system. Should there be a single national planning act, or a single national act that works in tandem with nine provincial acts, or just nine provincial acts? It was thought that this would be rectified as part of the ongoing Constitution-writing process, but it was not to be. A further step had to be

taken and the planning issue had to be addressed by planning policies which meant that a South African spatial planning system had to be created. Such a planning system had to take into consideration the following basic components (1) ensuring participation by all stakeholders in all planning issues; (2) an open, inclusive, and just decision-making process using easily available information; (3) recognition of religion and culture when making planning decisions (4) raising awareness of the environmental issues; and (5) the importance of property and human settlements. The starting point for many of these components was addressed in the Bill of Rights as well as the Constitution of the Republic. These two documents provided a framework for the drafting policies for the planning systems. There were several policies and programmes that were drafted nationally, and the notable ones included the NDP, SPLUMA, IUDF and the newly drafted National Spatial Development Framework (NSDF). At the national sphere, and despite policymaking attempts from 1994 to the present day, the South African government's 'willingness to remove the watermarks of exclusion, inequity and fragmentation leftover by apartheid have not been adequately consolidated or implemented' (Everatt & Ebrahim, 2020). It has been argued that most of these policies and programmes "have failed to achieve measurable progress and have not impinged on social exclusion and poor racial and cultural integration, so that the South African city remains an unjust and inequitable living environment" (SACN, 2016; Van der Berg, 2017).

The NDP was introduced in the country to address mainly challenges that the country has been facing. It is important to highlight that 'South Africa's NDP was finalised before the Agenda 2030 was adopted' (Fourie, 2018). The NPC released its Diagnostic Report in June 2011, summarising the country's achievements and deficiencies since the democratic transition in 1994. (National Planning Commission, 2011a). This served as the foundation for the NDP, which was passed in September 2012. (National Planning Commission, 2011b). The NDP focuses on nine areas: (i) creating jobs, (ii) expanding infrastructure, (iii) transitioning to a low carbon economy, (iv) transforming urban and rural communities, (v) improving education and training, (vi) ensuring quality healthcare, (vii) building a capable state, (viii) combating corruption and improving accountability, and (ix) consolidating social cohesion (National Planning Commission, 2011). It hopes to achieve these goals by 2030. There are links between the NDP and the Agenda 2030 goals, however some of these goals seems to contradict each other (Fourie, 2018). The contradiction between the NDP and the Agenda 2030 is mainly seen on the main focus of the NDP, its explicit focus on rural development (Department of Planning, Monitoring and Evaluation, n.d) which contradicts the goal 11 of the Sustainable Development Agenda. The implementation of the NDP, is mainly through the Medium-Term Strategic Framework (MTSF), and as Fourie (2018) noted, none of the outcomes of the current MTSF prioritises the development of cities. Thus, this impacts South Africa's pursuit of Sustainable Urban Development.

SPLUMA became the first policy framework to guide the planning system in the country. The SPLUMA went into effect in 2015, making the pursuit of spatial justice a fundamental tenet for all ensuing development choices. SPLUMA's goal was to amend laws and policies governing land use and spatial development that were "based on racial inequity, segregation, and unsustainable settlement patterns" (SPLUMA, 2013). In order to promote spatial planning fairness, SPLUMA especially redresses historical spatial and regulatory inequalities that were brought about by racially discriminatory legislation. SPLUMA provided a framework for the country's overall land use management and spatial planning. With SPLUMA, South Africa promotes a unified, effective system for land use management and spatial planning that promotes social and economic inclusion.

Notably, for more than two decades, the country had been without a cohesive national urban policy as SPLUMA did not specifically focus on urban development. Then IUDF was created as a result of the lack of an explicit focus on the urban context and the government's ongoing efforts to create a policy that corrects the nation's apartheid planning past and ensures the sustainability of the country's cities. The IUDF, which was established in 2014 and received council approval in April 2016, aims to promote a common understanding among the government and the general public about how to manage urbanisation and achieve the objectives of economic development, job creation, and improved living conditions for South Africans from all socioeconomic backgrounds (IUDF, 2016). The IUDF seeks to direct the creation of inclusive, robust, and liveable urban settlements while specifically addressing the special circumstances and difficulties that South Africa's cities and towns face (IUDF, 2016). The goals and guiding principles specified in the IUDF must be considered and adhered to by all current and future policies and legislative frameworks that may have an impact on urban space in South Africa. The IUDF emphasises the necessity of sustainable

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

urban development in the country's towns and cities and notably draws inspiration from SDG 11. It introduces nine policy levers and four overarching strategic goals that define the primary policy priorities for South Africa's urban agenda.

7 SOUTH AFRICA'S PURSUIT OF SUSTAINABLE URBAN DEVELOPMENT

The IUDF, a strategic response to South Africa's rising urbanisation trends, aims to foster government and social knowledge of the measures required to manage urbanisation in order to create resilient, inclusive, liveable, and sustainable cities for the country. By addressing the apartheid and planning legacy of racial segregation, poverty, and exclusion from social and economic possibilities, the IUDF seeks to assure the spatial transformation of the nation's cities. The IUDF offers four overarching strategic aims for achieving this end: governance; inclusion and access; growth; and spatial integration. In addition, the IUDF lists nine policy levers. The strategic goals guide the policy levers, which identify important policy priorities for accomplishing the desired spatial transformation of South Africa's cities.

The first policy lever of the IUDF is 'Integrated Spatial Planning' which emphasises the importance of urban design and adminstration in creating compact cities in the country. It highlights the importance of promoting coherent development through the proper allocation of land and resources to build sustainable communities. This policy lever addresses the target 11.3 of the SDG. The implementation of this policy lever has been faced with the lack of intergovernmental alignment and co-ordination of the spatial planning processes. There are still some challenges with the alignment and a clear definition of the roles in the three government spheres. The second policy lever is 'integrated transport mobility' which is one of the vital components of the country's economic infrastructural investments. This is vital because it promotes an efficient urban form which in turn assists with social and economic development and the strengthening of the rural-urban linkages. This policy lever also identifies that there must be proper and informed transport planning which takes into account all forms of transportation in the country. This lever pays attention to the target 11.2 which aims to 'provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport'. Integrated sustainable human settlements is the third policy lever. This policy lever is aimed at redressing the prevailing apartheid geographies, restructuring cities and creating more sustainable human settlements in the country. This also focuses on introducing policies aimed at addressing the challenges of the growing slums in the country due to shortage of affordable housing options in the city. This links with target 11.1 which emphasises the access to adequate and affordable housing in cities.

The fourth policy lever of the IUDF is the 'Integrated Urban Infrastructure'. This lever suggests that infrastructure needs to provide for universal access, more inclusive economic growth and support of efficient and equitable urban forms. The infrastructure needs to promote the rural-urban linkages through transportation and communication infrastructures. By providing the rural-urban linkages, this addresses the objective 11.a. According to the fifth policy lever, maintaining a compact urban form and sustainable land use depends on sustainable urbanisation practices and land-use management. Although the policy lever has a broad scope, it concentrates on the spatial transformation of South Africa's cities, and addresses land tenure security, in a nutshell, it suggests that planning legislation and policies should incorporate mechanisms that encourage public participation in the planning processes. Thus, the policy lever briefly matches target 11.3.

The sixth policy lever focuses on economic development. This policy lever highlights the importance of creating more job opportunities and an environment that attracts investors to invest in the country. The policy attempts to address the unemployment that is on the rise in the country by promoting an equitable economic development and this is to be implemented through technological innovation, focusing on spatial transformation and development, and investing in the social capital and public services. The seventh policy lever is the 'Empowered active communities' which aims at promoting a quality urban life for citizens and cultural diversity within cities as South Africa is made up of several cultures. Bringing these together would promote active citizenship which in turn would help making South Africa work. This would relate to the targets 11.3 and 11.4 by promoting participation and safeguarding the country's cultural heritage respectively. The eighth policy lever acknowledges the critical part that efficient urban governance plays in maintaining overall sustainability in cities. It emphasises the need for city governance to maintain healthy relationships with other spheres of governments in order to fulfil their developmental and growth mandates. This policy lever does not specifically address any SDG 11 target, but its main takeaway may also be

relevant to reaching those targets. Lastly, the nineth policy lever is the 'Sustainable Finances' which emphasises the importance of having sustainable financial management because if the cities have well managed revenue and expenditure, then they are able to expand their financial resources which allow them to 'meet expenditure demands, and to access capital markets, allowing them to achieve greater scale and efficiency when investing in infrastructure' (IUDF, 2016). This policy lever as well does not address any of the targets of goal 11, but it is equally important in achieving a sustainable urban development.

8 SOUTH AFRICA'S PURSUIT OF SUSTAINABLE URBAN DEVELOPMENT: A REALITY OR RHETORIC?

The IUDF clearly intends to promote sustainable urban development in South African cities using strategic goals and policy levers. This framework aims at promoting environmental, social and economic sustainability alongside good governance in the country's cities. Its overall strategic objectives are geared towards achieving access to opportunities; promoting growth in order to harness urban dynamism for an inclusive, sustainable economic growth and development; to promote spatial transformation in order to forge new spatial forms in terms of the country's human settlement, transport infrastructure and planning and economic and social development; and to promote good governance to enable the state and its citizens to work together to make South Africa work and achieve a social integration (IUDF, 2016). As highlighted in the argument above, seven of the nine policy levers in the IUDF are aligned with the targets of Sustainable Development Goal 11. Only two of the policy levers are not aligned with the SDG 11 targets but these two are equally important in achieving urban sustainability. Given that at least seven policy levers deal with issues connected to these targets, four specific SDG 11 targets have received more emphasis in the IUDF.

The SDG 11 targets for the protection of cultural and natural heritage, lowering the per-person environmental impact of cities, and offering financial and technical support and assistance to least developed nations for building sustainably and resiliently all appear to be unaddressed by the IUDF. Instead, the IUDF focuses on issues related to urban sustainability that may not always be immediately addressed by SDG 11 targets. The significance of efficient urban governance and sustainable finances is among these issues. These issues are important since the successful implementation and mobilisation of the SDG 11 targets depend on a wide range of budgetary, legal, and policy supporting institutions, governance procedures, and processes.

Along with the aforementioned, it is noteworthy to highlight that the IUDF acknowledges urban safety as a fundamental human right and a public good. The IUDF emphasises that urban safety is a necessary condition for fully achieving the IUDF's intended outcomes, such as spatial transformation, integrated and sustainable human settlements, economic development, job creation, and active citizenship, even though it does not include a specific policy lever for urban safety. According to the IUDF, each of the nine policy levers can be used to address challenges related to urban safety. The IUDF regards urban safety as a prerequisite for city sustainability. By ensuring that safety problems in the usage of public transportation are addressed, the IUDF singled out policy lever two as important in enhancing urban safety.

In light of the aforementioned facts, it is asserted that South Africa's IUDF is in line with the standards set forth by SDG 11 for the pursuit of the sustainable urban development. One may argue that the IUDF offers a useful illustration of a national policy tool that aims to promote sustainability in a way that is consistent with SDG 11's expectations, while also taking localised urban development issues and context into account. The SDG 11 targets that may be most useful for tackling sustainability-related issues in the urban setting of South Africa are highlighted by the IUDF. Therefore, it is argued that in terms of policy, South Africa is well-informed about SDG 11 and offers a customised strategy for pursuing urban sustainability in South Africa cities. The IUDF also identifies and specifies key aspects of the sustainable city that are significant to the goal of urban sustainability generally and in the South African context in particular but are not directly addressed by SDG 11. However, sustainable urban development implementation in South Africa is very much a work in progress. Widespread implementation of the precepts of sustainable urban development, remains a long-term objective rather than a current reality. The successful implementation of sustainable urban development will require a combination of top-down and bottom-up approaches that embrace the principle of subsidiarity, whereby action is taken at the lowest feasible level (SACN, 2016). In South Africa, municipalities are the ones responsible for the implementation of the policies, however, some of these local municipality still face challenges, such as the lack of coordination of the spatial planning processes with an insufficient use of intergovernmental relations. Thus, to extend current levels of implementation of the

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

sustainable urban development principles will require sensitivity to locally embedded meanings of the concept, and construction of initiatives that address the broad concerns of sustainable urban development within local context.

9 PROPOSALS THAT SOUTH AFRICAN CITIES CAN IMPLEMENT TO ACHIEVE URBAN SUSTAINABILITY

South Africa performs well with regards to the institutional, legal and policy requirements for Sustainable Development Goals, however, Croese, Wright & Primo (2019) notes that there has been little coordinated and consistent guidance on the implementation of the SDGs from the government. Policies and frameworks that are drafted, they are mostly not practical in terms of the implementation, thus the government needs to come up with more practically implementable strategies to implement SDGs in the country. Some of the strategies that can be implemented with joint effort between the public and private sector.

To achieve target 11.1 of the SDGs, there is a need to upgrade the informal settlements in the country. Due to the many people moving to urban areas for greener pastures, the country has about 2 600 informal settlements that supports 1.4 million households (StatsSA, 2016). The conditions in these informal settlements are mostly poor, dangerous and uncomfortable. There is often no sanitation or plumbing, no running water and no electricity and high crime rates. The objective of upgrading informal settlements should be to improve the quality of life of people living in informal settlements through a range of interventions including (but not limited to) improving access to land, security of tenure on a continuum of rights and provision of basic services and social infrastructure, promotion of economic opportunities, financing and additional housing options. Through this upgrading of informal settlements, the country can achieve the creation of integrated, vibrant, resilient and liveable communities. There are already some of strategies that are being implemented across the country to upgrade informal settlements such as Informal Settlement Support Programme (ISSP) in the Western Cape, Alexandra Renewal Project in Gauteng amongst others. However, progress has slowed in recent years and the government is unable to meet housing demand. Government needs to invest more on the informal settlements upgrading projects if they are to meet the demand for housing and ensuring safer access to housing opportunities as enshrined in South African Constitution.

It is believed that in order to create productive, inclusive and liveable cities, planning and land-use management practices must actively integrate infrastructure investment, public transport and human settlements. As noted by many scholars, South Africa's spatial patterns consist of human settlements that are located far away from urban centres which requires long commuting hours to access opportunities and services. A comprehensive and efficient transportation infrastructure is necessary for the growth of cities and regions, as well as for the functioning of economies. Transport networks may enhance productivity and enhance a population's quality of life when they are properly planned. Thus, this would benefit the many residents who live on the peri-urban areas.

There is also a need to improve the level and rate of service delivery in the country. In the context of local government, service delivery refers to the provision of municipal products, benefits, activities, and satisfactions that are deemed public, with the goal of enhancing local jurisdictions' quality of life (Reddy, 2016). Poor governance, poor spatial planning, a lack of social infrastructure, and significant service backlogs have all been identified as barriers to poverty reduction and economic growth in South African cities (Govender & Reddy, 2012:71) and this calls for the need to implement strategies to improve the country's service delivery. Every municipality in the country must create the structures and procedures that will serve as the framework for deliberation, involvement, formulation of policies, and delivery of services under its jurisdiction. Government is increasingly lacking the power structures and procedures needed to address issues affecting individuals, communities, and public servants alike (Ndevu & Muller, 2017). initiatives to meet the community's needs for services to be developed by the local government in collaboration with key stakeholders such as organized labour, business associations, ordinary citizens, and other interested parties (Ndevu & Muller, 2017).

Another strategy that can be implemented to achieve SDG targets is the reverse of the inefficient and exclusionary spatial investment patterns. This can be done through 'spatial rebalancing' which aims to reduce unemployment in poorer areas and narrow the wealth difference across regions (Todes & Turok, 2018). Spatial rebalancing as highlighted by Todes and Turok (2018) involves steering direct investments

and jobs from the affluent regions to the poor regions. To attract investments in these areas would require improved infrastructure and incentives to attract businesses to the poor regions. Corridor development to bridge the gap between urban centres and the peri-urban areas in which most of the country's urban population resides. The concept of a development corridor has been viewed as a crucial tool for urban sustainability and spatial planning (Brand & Geyer, 2017).

10 CONCLUSION

Achieving urban sustainability depends on partnerships between stakeholders, from government, the private sector, civil society, academic and research intuitions, and international agencies. This paper aimed at assessing South Africa's pursuit of sustainable urban development by looking at how sustainable urban development has evolved within the South African urban policy context and its implementation whether it is a current reality or rhetoric. The paper looked at the alignment of the country's policies to the targets of Goal 11 of the SDGs and notes that there is widespread adoption and growing interest in sustainable urban development principles by government. The IUDF In particular, draws aspiration from SDG 11 and it establishes the framework for policy changes aimed at making urban areas more "liveable, safe, resource-efficient cities and towns that are socially integrated, economically inclusive, and globally competitive, where residents actively participate in urban life." However, with regards to implemenation, particularly at city levels, sustainable development still needs concerted efforts and commitment to make it reality. In conclusion, the paper opines that there is a need for political, economic, institutional and social commitments to support innovative strategies to enhance possibilities for sustainable urban development in South African cities.

11 REFERENCES

Brand, A. and Geyer, H.S., 2017. Corridor development in Gauteng, South Africa. GeoJournal, 82(2), pp.311-327.

Croese, S., Wright, C. and Primo, N., 2019. Localisation of the 2030 Agenda and its Sustainable Development Goals in Cape Town. Mistra Urban Futures Report, 3.

De Visser, J., 2016. Devolution by court injunction: The case of land use planning and management in South Africa.

Everatt, D. and Ebrahim, Z., 2020. Urban policy in South Africa. In Developing National Urban Policies (pp. 281-298). Springer, Singapore.

Fourie, W., 2018. Aligning South Africa's National Development Plan with the 2030 Agenda's Sustainable Development Goals: Guidelines from the policy coherence for development movement. Sustainable Development, 26(6), pp.765-771.

Goebel, A., 2007. Sustainable urban development? Low-cost housing challenges in South Africa. Habitat International, 31(3-4), pp.291-302.

Govender, J. & Reddy, P.S., 2012, 'Failing the public through public policy: A review of the local government experience in South Africa', African Journal of Public Affairs 5(1), 69–82

Grubb, M., Koch, M., Thomson, K., Sullivan, F. and Munson, A., 2019. The'Earth Summit'Agreements: A Guide and Assessment: An Analysis of the Rio'92 UN Conference on Environment and Development (Vol. 9). Routledge.

Hayangah, R.A., 2022. THE PLANNING DILEMMA IN UPGRADING OF INFORMAL SETTLEMENTS IN SOUTH AFRICAN CITIES: A PRACTITIONERS PERSPECTIVE ON THE INCLUSIVITY PARADOX. Journal of Inclusive Cities and Built Environment, 2(1), pp.29-34.

Hasna, A., 2007. Dimensions of sustainability.

Hazell, P. and Hazell, P.B., 2013. Comparative study of trends in urbanization and changes in farm size in Africa and Asia: implications for agricultural research.

Irurah, D.K., Malbert, B., Castell, P., Kain, J.H., Cavric, B.I. and Mosha, A.C., 2004. Challenges for sustainable urban development. In From Understanding to Action (pp. 75-114). Springer, Dordrecht.

Hoeflich de Duque, S. (2018), 'The Role of Local Governments in Sustainable Urbanisation', URBANET, Available at: https://www.urbanet.info/local-governments-sustainable-urbanisation/ (Accessed: 22 July 2022)

Naess, P., 2001. Urban planning and sustainable development. European Planning Studies, 9(4), pp.503-524.

Williams, K., 2000. Does intensifying cities make them more sustainable. Achieving sustainable urban form, pp.30-45.

National Planning Commission (2011a).Diagnostic Overview. Pretoria,South Africa: The Presidency of the Republic of South Africa.National Planning Commission (2011b).

National Development Plan: Visionfor 2030. Pretoria, South Africa: The Presidency of the Republic ofSouth Africa.

Ndevu, Z. and Muller, K., 2017. A conceptual framework for improving service delivery at local government in South Africa. African Journal of Public Affairs, 9(7), pp.13-24.

Oranje, M. and Berrisford, S., 2016. Planning law reform and change in post-apartheid South Africa. In Planning by law and property rights reconsidered (pp. 69-83). Routledge.

Pillay, U., 2008, June. Urban policy in post-apartheid South Africa: context, evolution and future directions. In Urban Forum (Vol. 19, No. 2, pp. 109-132). Springer Netherlands.

Reddy, P.S., 2016. The politics of service delivery in South Africa: The local government sphere in context. TD: The Journal for Transdisciplinary Research in Southern Africa, 12(1), pp.1-8.

Rydin, Y., 2012. Governing for sustainable urban development. Routledge.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

United Nations Development Group (2018). Mainstreaming the 2030Agenda for sustainable development: Reference guide to UN country teams. Retrieved from https://undg.org/wp-content/uploads/770FOURIE2017/03/UNDG-Mainstreaming-the-2030-Agenda-Reference-Guide-2017.pdf.

Todes, A. and Turok, I., 2018. Spatial inequalities and policies in South Africa: Place-based or people-centred?. Progress in Planning, 123, pp.1-31.

Van der Berg, A., 2017. South Africa's integrated urban development framework and sustainable development goal 11: policy mismatch or success?. Obiter, 38(3), pp.557-573.

WCED, SPECIAL WORKING SESSION. "World commission on environment and development." Our common future 17, no. 1 (1987): 1-91.

🏆 *reviewed paper*

Spatial and Settlement Development Adapted to Climate Change in Strasshof an der Nordbahn (Lower Austria)

Bente Knoll, Agnes Renkin, Michael Fleischmann, Elisabeth Knasmillner, Andreas Hiller, Ralf Dopheide, Fabian Schiefermair

(Dipl.-Ing. Dr. Bente Knoll, B-NK GmbH Büro für nachhaltige Kompetenz, Schönbrunner Straße 59-61/10, 1050 Wien, bente.knoll@b-nk.at)
(Dipl.-Ing. Agnes Renkin, B-NK GmbH Büro für nachhaltige Kompetenz, Schönbrunner Straße 59-61/10, 1050 Wien, renkin@b-nk.at)
(Dipl.-Ing. Michael Fleischmann MA, RaumRegionMensch ZT GmbH, Hofgartenstraße 11/12A. A-2120 Wolkersdorf im Weinviertel, michael.fleischmann@raumregionmensch.at)
(Mag. MA Elisabeth Knasmillner, RaumRegionMensch ZT GmbH, Hofgartenstraße 11/12A. A-2120 Wolkersdorf im Weinviertel, elisabeth.knasmillner@raumregionmensch.at)
(Andreas Hiller BSc, RaumRegionMensch ZT GmbH, Hofgartenstraße 11/12A. A-2120 Wolkersdorf im Weinviertel, andreas.hiller@raumregionmensch.at)
(Dipl.-Ing. Ralf Dopheide, Dipl.-Ing. Ralf Dopheide e. U., Schönbrunner Straße 59-61/10, 1050 Wien, ralf@dopheide.at)
(Dipl.-Ing. Fabian Schiefermair, Dipl.-Ing. Ralf Dopheide e. U Schönbrunner Straße 59-61/10, 1050 Wien, f.schiefermair@dopheide.at)

1 ABSTRACT

Climate change, increasing urbanisation and densification, not only in inner-city areas, require new approaches and solutions to improve liveability and act against the consequences of climate change, primarily noticeable in cities and their surrounding areas. The introduced projects "Strasshof 2021" and "Strasshof. Klimafit!" (both funded by the Austrian Climate and Energy Fund, Klima- und Energiefonds, under the Smart Cities Initiative in Austria) deal with climate change adaptation measures, exemplified by the Austrian municipality of Strasshof an der Nordbahn, using instruments of spatial planning, such as land development plans, construction plans, zoning plans etc., focussing on soil bioengineering measures to infiltrate rainwater as well as climate-effective design of roadside greenery using a selection of plants appropriate to the climate.

Within the exploratory project "Strasshof 2021. Preparation of climate change-adapted planning instruments and processes for a Smart Village" the municipality of Strasshof examined in cooperation with the project team, how certain climate change adaptation measures could be specifically requested and regulated in the municipality's development plan, including how compliance and implementation of these measures could then be monitored by the municipality. At the level of the land development plan, criteria were developed suitable for implementing climate change-adapted settlement developments. Existing experiences were transferred to Strasshof and measures and options for climate change-adapted rainwater management were developed. For example, potential implementations of the sponge city principle, adapted to the local conditions (no canal for draining rainwater, very permeable soil) were examined in Strasshof. Based on the assessment of potential areas to establish green structures and roadside greenery in Strasshof, measures and options for climate change adapted planting and vegetation in public spaces and on buildings were analysed. A list of "climate-fit" trees (trees that are well-adapted to the changing climate) for public areas as well as for private gardens was drawn up.

"Strasshof. Klimafit! Strasshof as a lighthouse: EVAPO+ green walls, green infiltration troughs, empowerment and practical transfer" is a lighthouse demonstration project that stimulates processes for climate change measures by empowering other municipalities and small towns. The project aims to implement resilient, multifunctional and "climate-fit" solutions that respond to heat and heavy rain, improve the microclimate, increase the quality of life and living while promoting biodiversity and species diversity in existing areas of the municipality. With these measures, Strasshof can act against climate change consequences and improve the liveability of the population. The transferability of the demonstrations shall be guaranteed with the help of various regional, national and international exchange forums. In cooperation with other Austrian municipalities, the lessons learned from Strasshof will be reflected and transferred to the regional network "Climate-Fit Small Towns and Municipalities" along with step-by-step instructions for climate-fit municipalities.

Keywords: strategy, climate adaptation, regulation plan, urban heat island, Lower Austria

2 BASELINE

It is undisputed that climate change has an impact on our daily lives and should be taken into account when planning our living environment and therefore also for matters of spatial planning. Climate change, increasing urbanisation and densification, not only in inner-city areas, require new approaches and solutions to improve liveability and to act against the consequences of climate change, primarily noticeable in cities and their surrounding areas. Urban space, which is also found in the outskirts of large cities, causes an increase in temperature per se which is then, intensified by the change in climate. Due to the high percentage of sealed surfaces evaporation is reduced while the solar irradiation on building and road surfaces is stored at the same time. The consequences of climate change, made especially clear by extreme weather events (heat, drought, heavy rain events), are primarily noticeable in cities and their outskirts. Numerous studies have already proven that through evapotranspiration plants can make an essential contribution to the fight against climate change and, at the same time, improve wellbeing and livability. In many places, however, green areas lose ground due to the creation of housing. More and more people choose to live outside of large cities which burdens the surrounding communities with severe influx. That said, the majority of climate change adaptation is solely concerned with combatting the overheating of large cities. However, surrounding areas, small towns and rural communities are also affected by climate change, hence the need to take measures for climate change adapted spatial planning there too, in order to increase quality of life and improve the microclimate. (Fechner et al. 2020; Krauss et al. 2019)

This paper focusses on actions and measures for climate-change adaptations in smaller cities and villages, demonstrated by the example of the municipality Strasshof an der Nordbahn in Lower Austria. To implement and demonstrate climate-change adaptations in Strasshof an der Nordbahn, two projects designed by the same project consortium were funded: the one-year exploratory project "Strasshof 2021. Preparation of climate change-adapted planning instruments and processes for a Smart Village" (September 2020 to September 2021) laid the foundation for the current three-year Smart Cities follow-up project (experimental development) "Strasshof. Klimafit! Strasshof as a lighthouse: EVAPO+ green walls, green infiltration troughs, empowerment and practical transfer" (April 2022 to March 2025) (both funded by the Austrian Climate and Energy Fund, Klima- und Energiefonds, under the Smart Cities Initiative in Austria). The following paper will present the main results from the completed exploratory project and present an outlook on the planned actions and measures within the follow-up project for experimental development and implementation.

3 EXPLORATORY PROJECT "STRASSHOF 2021. PREPARATION OF CLIMATE CHANGE-ADAPTED PLANNING INSTRUMENTS AND PROCESSES FOR A SMART VILLAGE"

The project "Strasshof 2021" was an exemplary study addressing the above-mentioned issues and interests, carried out in Strasshof an der Nordbahn in Lower Austria. With the help of construction bans, Strasshof has already been taking on municipal tasks that have become pressing in recent years due to enormous population growth. Equally urgent still is the development of climate change-adapted strategies, through which the community can prepare for changing climatic conditions. Through intensive research, possible actions for a local land development plan adapted to climate change issues, as well as possibilities for sustainable rainwater management and roadside greenery were explored: The exploratory study researched ways to integrate climate change adapted measures into spatial planning by especially dealing with the adaptation of the local development plan, analysed vegetation-related soil bioengineering measures to optimize the local rainwater infiltration and addressed the climate-effective design of roadside greenery through a climate change-adapted selection of plants. The research findings led to an assessment of potential measures specifically designed for the community of Strasshof as experimental space. The design of the project was matched to the procedures within the community. An accompanying participative process led to the population becoming sensitised to actions able to be taken and created a knowledge base for understanding and implementing climate-adapted measures in the community. The project exemplifies ways of optimising microclimate effective measures and spheres of activity for communities.

3.1 Creating the baseline: Potential analysis for climate change adapted planning in Strasshof

Already in the initial phase of the project, the project team, consisting of companies from spatial and landscape planning, vegetation technology (the authors of the paper) and the municipality itself (mayor and

head of the building authority), identified specific problem areas and potential fields of action in which measures could and should be taken in order to design a climate-friendly community.

3.1.1 Analysis of the development plans' potential towards climate change measures

Amongst other objectives, one focus of the analysis, in particular, was to examine how certain climate-change adaptation measures could be specifically requested and regulated in the municipality's land development plan, including the question of how compliance and implementation of these measures could then be monitored by the municipality. Basically, the land development plan is an important instrument for for defining the settlement area at the municipal level. Based on the zoning plan, the land development plan contains regulations for the land use – specifically plots of land – with regard to the spatial arrangement and building architecture (including community, semi-detached and detached housing, open development, development height, building lines, building forms, technologies), as well as regulations for transport development. For Lower Austrian municipalities, the following legal bases are relevant: the Lower Austrian Spatial Planning Act [NÖ Raumordnungsgesetz], the Lower Austrian Building Code [NÖ Bauordnung] and the Lower Austrian Building Technology Ordinance [NÖ Bautechnikverordnung]. A positive external driver in this context is the amendment to the Lower Austrian Spatial Planning Act 2014, which was passed on October 22, 2020, according to which, among other things, additional specifications in the land development plan are possible in order to ensure climate- and noise-adapted building. In this way, maximum dimensions of building sites, as well as requirements for green roofs or facades, and the creation of rainwater cisterns or infiltration areas, can be regulated.

3.1.2 Foreseen Measures and Actions

According to identified problem areas and potential fields of action, the following areas of attention and thematic priorities were identified and dealt with – each specifically related to the municipal area of Strasshof:

(1) Development of proposals for a climate change-related adjustment of the local land development plan

(2) Development of proposals for the climate-efficient use of rainwater

(3) Exploring possible locations for green structures and roadside greenery to reduce urban heat and to absorb rainwater in the natural soil

(4) Exploring the possibilities of climate change-adapted planting up to a climate-effective design with plants in combination with buildings, settlement structures, rainwater management, vegetation technology and biological engineering measures

(5) Strengthening the awareness of the population towards climate change adapted spatial measures

As part of the exploratory project, the potentials and possibilities occurring through the spatial planning legislation were examined, especially regarding possible implementations and achievable results. On the other hand, specific potential measures for climate change adaptation such as infiltration areas, rainwater management and climate-friendly planting were defined and examined as to how they could be integrated into the legal framework and into practice in the municipality.

3.1.3 Results of the exploratory project

The results of the exploratory project outline the specific potentials for climate change adaptation regarding spatial planning for the municipality of Strasshof, sorted by measures and thematic areas.

After detailed spatial, vegetation-related and social analyses of areas potentially relevant for climate change adaptation measures in the municipality, areas and precise locations for potential implementations were defined in collaboration with the municipality. Solutions were proposed by the specialist planning project team.

Definition of locations and areas for future implementation

- Climate change adaptation measures in street spaces: Proposals for a vegetation-engineered plant-related design of infiltration areas for selected locations with different street widths and zoning, main and secondary streets in selected housing estates were developed.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

- Climate change adaptation measures on private property and private plots of land with residential buildings: Climate change adaptation measures were created that can be implemented by private individuals in single-family homes with gardens, in particular the promotion of rainwater infiltration, also rainwater harvesting and planting with climate-smart plants.
- Climate change adaptation measures for municipal buildings focussing (vertical) greening: In the new location of the municipal office as well as for more municipal buildings like the education campus in Strasshof different forms of façade greening were exploited. Impetus for the implementation of building greenery and rainwater management through contributions to building competitions was provided.

Recommendations for climate change-adapted spatial planning

At the level of the land development plan, criteria were developed that are suitable for the implementation of climate change adapted settlement developments. Existing experiences were transferred to Strasshof and measures and options for climate change-adapted rainwater management were developed.

- Potential implementations of the sponge city principle, adapted to the local conditions (no canal for draining rainwater, very permeable soil) were examined in Strasshof.
- Based on the assessment of potential areas for the establishment of green structures and roadside greenery in Strasshof, measures and options for climate change adapted planting and vegetation in public space and on buildings were analysed.
- A list of "climate-fit" trees (trees that are well-adapted to the changing climate) for public areas as well as for private gardens was drawn up.

Figure 1: Project folder "What can I do? " (Source: RaumRegionMensch ZT GmbH)

Information campaign

An important aspect of climate change-adapted planning measures is certainly informing the local population, not least about the possible contribution of spatial planning to the topic. The implementation of

climate change-adapted planning instruments and processes requires sensitisation and the involvement of the population. For the exploratory study in Strasshof, the population was involved – taking into account the possibilities under COVID-19 conditions – and the project results were prepared and presented for specific target groups. Thanks to the cooperation with the adult education center in Strasshof, a four-part series of lectures showed how residents can shape their own properties to adapt to climate change. The project and the results were presented as part of an exhibition displaying the changed development plan on September 22, 2021. Feedback from the population was obtained using interactive formats. Information about the project was regularly published in the municipal newspaper.

The detailed results from the exploration study can be accessed at https://smartcities.at/projects/strasshof-2021/

3.1.4 Impact and achievements

In summary, the "Strasshof 2021" exploratory project has led to the following impact and achievements:

- Using the example of one municipality, it was possible to develop solutions for climate change-adapted spatial planning.
- Research results and recommendations for climate change adaptation measures in spatial planning (development planning, rainwater management, sponge city principle, "climate-fit" trees) were linked to specific locations and case studies in Strasshof an der Nordbahn.
- Strasshof an der Nordbahn received specific support on its way to becoming a model municipality in terms of climate change adaptation in spatial planning.
- The amendment to the Lower Austrian Spatial Planning Act in October 2020 has so far been rather hesitantly perceived by the Lower Austrian municipalities. Strasshof is an exception and, with the support of the project team, was one of the first municipalities to actively deal with the extended paragraph 30 (content of the land development plan), which enables an implementation of measures towards climate change-adaptation in the land development plan.
- The project as well as the results were disseminated within the population via articles in the municipalities newspaper, a series of lectures at the adult education center in Strasshof, a project folder addressing individuals and their actions, and an information event. Raising awareness for spatial measures towards climate change adaptation and the examples presented for a "climate-fit" Strasshof, from which all the residents would ultimately profit, contributed directly to the local added value in Strasshof.
- The series of lectures in the adult education center of Strasshof was mostly attended by the same people and contributed to a "community" forming around the topic "our climate-fit Strasshof". The spontaneous excursion to a private garden after the fourth lecture especially contributed to the interaction and networking of interested participants.
- Knowledge transfer and networking within the project team and with relevant stakeholders in spatial planning in Lower Austria took place and contributed to local added value in other municipalities.
- The baseline was established, for the municipality of Strasshof, to improve quality of life for the population using the proposed measures and to prepare optimally for climate change. This would serve as an example for other municipalities as well and might lead to imitation.

4 FOLLOW-UP PROJECT (EXPERIMENTAL DEVELOPMENT) "STRASSHOF. KLIMAFIT! STRASSHOF AS A LIGHTHOUSE: EVAPO+ GREEN WALLS, GREEN INFILTRATION TROUGHS, EMPOWERMENT AND PRACTICAL TRANSFER"

The exploration project "Strasshof 2021" specifically highlighted the possibilities and needs of the municipality of Strasshof an der Nordbahn with regard to climate change adaptation and showed, among other things, that with the local conditions, dealing with rainwater both in public space and on private property is essential. Measures need to be taken to deal with increasingly hot days in order to counteract dry phases and improve the microclimate. It therefore requires, among other things, combined nature-based solutions on the one hand for cooling and, on the other hand, for handling rainwater.As a result, the follow-up demo project "Strasshof. Klimafit!" has been funded for 3 years (April 2022 to March 2025), which

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

allows the implementation and manifestation of the findings and results of the exploratory study towards climate change adaptation in both public and social spaces and in spatial planning processes at Strasshof. The project continuously deals with climate change adaptation measures, exemplary for the Austrian municipality of Strasshof, within instruments of spatial planning, such as land development plans, construction plans, zoning plans etc., focussing on soil bioengineering measures to infiltrate rainwater as well as climate-effective design of roadside greenery using a selection of plants adapted to climate change. The project team continues to support the municipalities' planning projects with their professional expertise regarding climate change adaptation, rainwater management and vegetation technology and will also further implement communication measures to raise the population's awareness of the intersection between spatial planning and climate change. The transferability of the demonstrations shall be guaranteed with the help of various regional, national and international exchange forums. The aim is to implement individual measures highlighted in the exploratory study in the municipality and to highlight the municipality of Strasshof as a pioneer and lighthouse demonstrator for other municipalities in the field of climate-adapted settlement and land use development.

4.1 Implementation of climate change adaptation measures in the municipality of Strasshof

Based on the project "Strasshof 2021", the project "Strasshof. Klimafit!" aims to implement resilient, multifunctional, and climate-fit solutions in the municipality of Strasshof that respond to heat and heavy rain, improve the microclimate, increase quality of life and living and promote biodiversity and species diversity on existing areas in the municipality, specifically through the following demonstrations, which will be evaluated by microclimatic and social scientific monitoring.

- A first implementation of EVAPO+ transpiring green walls: These green walls will be implemented as microclimate-improving measures which have been further optimised with regard to evapotranspirating cooling effects, leading to a better quality of life and supporting biodiversity.
- A demonstration of an innovative multifunctional nature-based biodiverse combination of a plant-based infiltration and water-saving basin as a measure to deal with heavy rain and as a contribution for sustainable rainwater management. The aim is to improve the local water balance through the performance of plants in combination with other techniques in order to ensure drainage security in the event of heavy rain events as well as to increase evaporation and essentially correspond to the natural water cycle. The saving and infiltration of water results in an innovative way of dealing with rainwater, as well as a cooling effect and an increase in biodiversity all of which can mitigate the negative consequences of climate change.

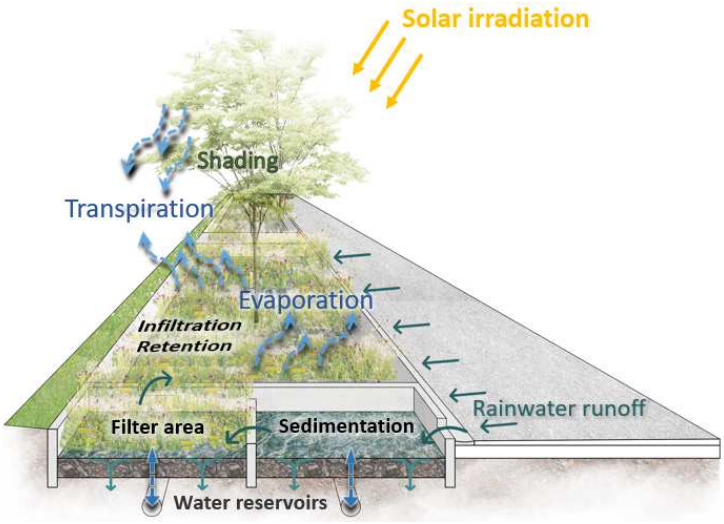


Figure 2: Concept visualisation for possible infiltration areas (Concept and visualisation: Dipl.-Ing. Ralf Dopheide e.U.)

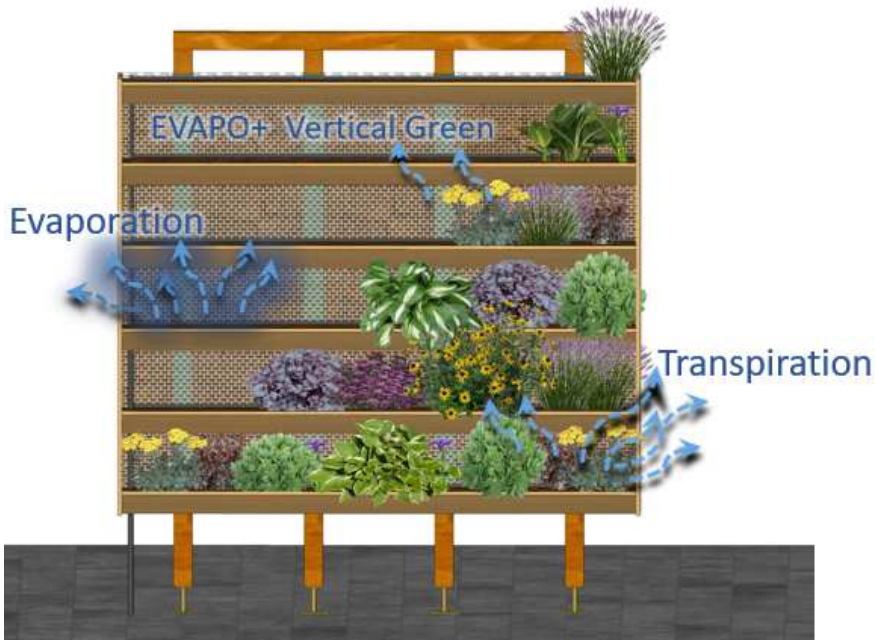


Figure 3: Concept visualisation for the EVAPO+ transpiring green walls (Concept and visualisation: Dipl.-Ing. Ralf Dopheide e.U.)

By targeted empowerment of the municipality, further demonstrative climate change adaptation measures on public, semi-public and private properties, emerging from the exploratory work, are initiated and supported. The municipality of Strasshof will be further supported in future construction projects to implement sustainable and climate change-adapted spatial development. The criteria developed for climate change-adapted development planning (§ 30 NÖ ROG) for usage models to improve the quality of life and living are taken into account. The implementation of the criteria in the development plan leads à la longue to climate change-adapted living conditions. The community is further supported in implementing examples of adaptation measures in public space, which can also be replicated for private space: To help raise awareness in the population, the feasibility and advantages of climate change adaptation measures are shown to the citizens through exemplary implementations in public spaces that encourage replication on private property (interaction between municipality and residents). Empowering the municipality to adapt to climate change means to popularize and promote intertwined fields of action between the community and citizens. The term "empowerment" reflects the circulating call for action between communities and private individuals. The authorisation to implement measures adapted to climate change is a process on the intertwined levels of the political and the private.

With all these measures, Strasshof can act against climate change consequences and improve the liveability of the population. Both the built demonstration measures and the empowerment of the community are intended to be lighthouse demonstrations and role models to promote climate-fit small towns and communities regionally, nationally and internationally.

4.2 Lighthouse demonstration for other municipalities

Other municipalities and small towns in Lower Austria, Austria and around the world are facing the same challenges and can benefit from this demonstration of measures for climate change adaptation in Strasshof. Therefore, "Strasshof. Klimafit!" can be considered as a lighthouse demonstration project that stimulates processes for climate change measures by empowering other municipalities and small towns. The transferability of the demonstrations will be supported by the project through various regional, national and international exchange forums: In cooperation with other Austrian municipalities, the lessons learned from Strasshof are reflected and transferred using a regional network "Climate Fit Small Towns and Municipalities" and step-by-step instructions for climate-fit municipalities. In the course of a steering committee, national and international exchange is also promoted. As a lighthouse demonstration for climate-fit municipalities, Strasshof is intended to create awareness and initiate processes for climate change adaptation measures in other communities.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

4.3 Intended impact and results

The project puts the analysis results and proposed solutions into practice in the community of Strasshof. The following results and impacts are intended:

- Resilient, multifunctional demonstration measures for the combined improvement of the microclimate and the handling of rainwater are implemented on existing public areas and their effectiveness is evaluated. The built lighthouse demonstration measures are multifunctional and combine cooling with rainwater management and aesthetics/quality of stay. Existing technologies are combined and innovatively further developed.
    - First-time implementation of the EVAPO+ transpiring green wall and verification of its effects
    - Demonstration of an innovative multifunctional nature-based biodiverse combination of a plant-based infiltration and water-saving basin as a measure to deal with heavy rain and as a contribution for sustainable rainwater management and verification of its effects
    - Efficient, innovative and smart handling of rainwater as well as cooling effect and increase in biodiversity
    - Mitigation of negative consequences of climate change: heat and flooding due to heavy rain
    - The performance of plants as a "natural air conditioner" is made visible
- Empowering the municipality and raising awareness among the population - climate change adaptation specifically in my community (by providing answers to the question "What can I do?")
    - Implementation of exemplary climate change adaptation measures and actions in public space, which act as a guide for both the municipality and the population, encouraging climate-fit measures and imitation on public and private property
- Specification and climate change related adaptation in planning instruments, procedures and processes at municipality level (using the example of a community with a structured administration)
- Exemplary effect of the lighthouse municipality Strasshof for other municipalities regionally, nationally and internationally by showing the possibilities for climate change adaptation and exchange (transferability of the demonstrations)
    - Step-by-step guide to a climate-fit community
    - Action plan with specific recommendations for actions at international level

5 CONCLUSION

Both funded projects in general aim to promote a spatial, urban and land use planning that is oriented towards dealing with the consequences of climate change – mitigating existing problems and counteracting future problems resulting from climate change – not just in big cities, but also in smaller cities, towns and villages. The aim is to implement certain possibilities to act against climate change through spatial and landscape planning in the municipality of Strasshof, which should then lead as an example for other cities and towns, at least in Austria. The idea is to show clearly what can be done and that every action counts and to communicate that message and the relevant outcomes to different municipalities and local people. It will become more and more crucial to deal with heat waves and heavy rain and the preparations for that need to start now – both, in private property as well as in public space. Starting changes in public space helps to sensitize and inform the population of what can be done on private properties as well, which is important especially in smaller towns, where there are a lot of private garden grounds, which is why, especially there, they are as much as important as the public space. For the increased use of innovative greening technologies as a means of counteracting the increasing sealing, the level of local spatial planning should be applied. For both property types, spatial planning can induce a lot by effectively anchoring innovative solutions against climate change effects, such as greening (for example the greening of buildings) and sustainable rainwater management, into concepts and regulations of spatial planning. On the one hand, this can lead to a facilitation of actions, because often the bureaucratic way towards greening and infiltration measures is complicated and takes time. Ultimately, this should contribute to a simplified implementation of innovative greenery in spatial planning. On the other hand, some mandatory rules applying to all municipalities in

Austria would help immensely to forward the process towards more "climate-fit" cities, towns and villages, which, in the end, is very important for the wellbeing of every individual and for the entire environment.

6 REFERENCES

Fechner, Johannes; Mayr-Ebert, Michael (2020): Regenwasser in der Stadt. Technologie Report. Edited by Wirtschaftsagentur Wien. Wien. Available online at https://wirtschaftsagentur.at/fileadmin/user_upload/Technologie/Factsheets_T-Reports/Technologiereport_Regenwasser_in_der_Stadt_DE_WEB.pdf, checked on 10/13/2021.

Kraus, Florian; Fritthum, Roman; Robausch, Eva; Scharf, Bernhard; Preiss, Jürgen; Enzi, Vera et al. (2019): Leitfaden Fassadenbegrünung. Edited by MA 22 - Wiener Umweltschutzabteilung. Available online at https://www.wien.gv.at/umweltschutz/raum/pdf/fassadenbegruenung-leitfaden.pdf, checked on 1/30/2020.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

🏆 *reviewed paper*

Status and Pathways to Sustainable Development of Growth Centres: Lessons from Makhado Biaba, South Africa

Winny Ngudo-Nthangeni, Trynos Gumbo, Emmaculate Ingwani, Nils Ekelund

(Winny Ngudo-Nthangeni, PhD Candidate Department of Urban and Regional Planning, Faculty of Engineering and the Built Environment, University of Johannesburg, nthangeni19@gmail.com)
(Trynos Gumbo, Associate Professor and Head; Department of Urban and Regional Planning, Faculty of Engineering and the Built Environment, University of Johannesburg, tgumbo@uj.ac.za)
(Emmaculate Ingwani, Senior Lecturer; Department of Urban and Regional Planning, Faculty of Environmental Sciences, University of Venda, emaculate.ingwani@univen.ac.za)
(Nils Ekelund, Professor; Department of Natural Sciences, Mathematics, Society, Faculty of Faculty of Education and Society , Malmö University, nils.ekelund@mau.se)

1 ABSTRACT

Growth centers are a common and prevalent phenomenon that have been in existence for a very long time, particularly in Sub-Saharan African countries. While some growth centers have been developing, physically, economically and socially, others have not been performing well. Although several reasons have been attributable to declining or stagnant growth centers, very little is known about the effective and efficient pathways to developing these centers. For instance, amidst faltering growth centers in South Africa, very few studies have been conducted to determine the appropriate strategies and approaches to developing these spaces sustainably in the country. It has been observed that, the pathways to developing growth centers in South Africa have not been documented in a clear and convincing manner. Consequently, this paper explores the pathways to establishing and developing growth centers in South Africa. The work adopted a mixed methods research approach, which employs both quantitative and qualitative research approaches. A case study research design where Makhado Biaba growth center in South Africa was studied to get insights on the influence of rural growth centers on local economic development and the impact it has on the livelihoods of the people in and around Makhado Biaba area. The growth center was aimed to attain a positive livelihoods outcome through creating a balanced socio-economic development of an area thus, spill over effects covering more than just economic growth. Questionnaires survey and key informative interviews was applied as primary data collection methods, and excel and thematic analysis were employed for data analysis respectively. Findings shows that some parts of the communities lack services because the local municipality cannot meet the service demands. Hence, some areas will remain poor, as social services are necessary for socio-economic growth. Insufficient and inadequate stall structures are a handicap to informal traders in the growth center as in the raining and cold season it becomes both uncomfortable and unprofitable to them. The paper concludes that the level and nature of the services provided confirm that social growth and economic empowerment will have to take on a different shape as some areas still lack access to services. Therefore, the paper ends by recommending policy planning to make innovative adjustments to create more inclusive and advantageous environments for the informal street traders. Borrowing strategies' in organisational networks to create access to economical and livelihoods, which requires the establishment of networks with surrounding growth centres to "tap into" some of the benefits they offer and "borrow" some of their "strategies". Future studies are necessary for evaluating growth centers as a toll in creating a balanced socio-economic development for rural areas.

Keywords: South Africa, Makhado Biaba, Sustainable development, Pathways, Growth Centers

2 INTRODUCTION

A growth center is aimed to attaining a positive livelihoods outcome through creating a balanced socio-economic development of an area thus, spill over effects covering more than just economic growth (Wu, Guo and Zhou, 2020). Regional development strategies have been identified as a fundamental component prominently in the planning of South Africa's socio-economic space since South Africa gained its democracy in 1994 (Mlambo and Adetiba, 2020). Governments have long been trying to promote the approach of rural growth center strategies in an attempt to attract investment and sustainable local economic development. Over the past decade, this strategy has been implemented in developing countries including South Africa, while some growth centers have been developing, physically, economically and socially, others have not been performing well. Consequently, the strategy has deepened the problems of uneven regional development and the slowdown of socio-economic development in most rural towns in South

Africa. Most growth centers lack the necessary potential or a strong human resource base to kick start the processes of increasing subsequent growth (Hardoy and Satterthwaite, 2019). Most growth centers in South Africa currently show a contrasting picture, as they were simply chosen ahead of others without a natural resource base to exploit or an initial locational advantage, resulting in high rates of decline in both service provision and economic growth. Since the dawn of democracy in 1994, efforts have been made to alleviate the negative consequences of disadvantaged areas economic, social, and political exclusion (Makhathini, Mlambo and Mpanza, 2020). Plagerson,Patel, Hochfeld and Ulriksen (2019) argued that South Africa has some of the best policies and legislative frameworks implemented to address the challenges of regional development, however, the sustainable development issues of growth centers have remained the same for many if not all South African rural centers.

While economic growth is an important component of development, it is not the only one. Sustainable development is more than just a financial phenomenon. In the end, it must include more than just the material and financial aspects of people's lives (Bansal, 2019). As a result, sustainable development should be viewed as a multidimensional process involving the organisation and reorientation of both economic and social systems (Souto, 2021). Although several reasons have been attributable to declining or stagnant growth centers, very little is known about the effective and efficient pathways to developing these centers. For instance, amidst faltering growth centres in South Africa, very few studies have been conducted to determine the appropriate strategies and approaches to developing these spaces sustainably in the country. It has been observed that, the pathways to developing growth centers in South Africa have not been documented in a clear and convincing manner. This paper aims at explore the pathways to establishing and developing growth centers in South Africa. The paper starts by discussing the conceptual synopsis of growth centers and sustainable development, followed by the description of the study area which is Makhado Biaba growth center. The research methodology used in this paper was articulated followed by discussions on the finds of the study, and it ends by listing policy implications and the conclusion.

3 CONCEPTUAL SYNOPSIS

The 'growth pole' model, which arose from the work of Francois Perroux, a French economist, is the main theoretical foundation of the growth center concept, whose argument was that economic growth does not occur everywhere at once, but has different points of force in different poles, spreads through various channels on irregular intensities with unpredictable effects, and its final results for the state economy differ in different regions (Guo, 2021). Morison (2020) elaborated on growth centers as a regional planning strategy. He argued that the main problem for the economies of the least developed countries was a series of "interlocking vicious circles" in which the factors of production and abilities were dispersed and underutilised, necessitating "pressures" to mobilise the greatest amount of resources. As a result, some degree of polarisation is expected to stimulate development in disadvantaged areas or regions. Development is a lengthy process in which such interaction occurs not only between two industries, but also up and down and across the entire input-output matrix of an economy (Pahl and Timmer, 2020). Growth centers provide both goods and services to their own population as well as the surrounding population, resulting in a balanced socioeconomic development of an area (Atkinson, Muro, and Whiton, 2019). Growth centers have the potential to achieve a positive livelihood outcome, necessitating an effort to comprehend spill over effects encompassing more than just economic growth (Wu, Guo and Zhou, 2020). This creates growth centers, which are hubs of economic creativity that are spatially directed investment tools and sets of legislation for accelerating economic growth in most developed countries and developing countries such as South Africa.

Sustainable development has recently risen to the top of the international economic and political agenda, with all United Nations (UN) member countries promising to implement Agenda 2030, which includes 17 Sustainable Development Goals (SDGs). Which is about improving human well-being and quality of life for all people, especially those who are most affected by poverty and inequality (De Neve and Sachs, 2020). The purpose of sustainable development is to re-orientate South Africa's development path in a more sustainable direction and that, at the same time, issues of poverty and inequality are effectively addressed (Horner and Hulme, 2019). South Africa is a country in dynamic change and whilst South Africans agree on the broader developmental challenges they face, at present it does not have a common national vision or strategy for achieving sustainable development of growth centers. In development theory, economic sustainability

denotes a production system that meets current consumption levels without jeopardizing future needs (Mensah, 2019). The sustainability sought by economic sustainability is the sustainability of the economic system as a whole. A practical way to put the theory of economic sustainability into practice is to create a method of municipal planning that meets the needs of the general public, particularly the poor communities, while enhancing the natural environment (Fróna, Szenderák and Harangi-Rákos, 2019). However, social sustainability refers to a system of social organization that alleviates poverty. Yet, in a broader sense, social sustainability establishes the link between social conditions such as poverty and environmental decay (Dawes, 2020). The theory of social sustainability advocates for economic growth that is constrained by social equity requirements. To connect these, an enabling environment that optimizes resource use, prioritizes resource allocation, and promotes equitable resource distribution must be created (Yong, Yusliza, Ramayah, Chiappetta Jabbour, Sehnem and Mani, 2020). Consequently, environmental sustainability entails maintaining natural capital as both a provider of economic inputs known as "sources" and an absorber of economic outputs known as "wastes" (Ezimah, 2021).In reality, the theory of environmental sustainability suggests a planning process that allows human society to live within the biophysical environment's limitations.

4 STUDY AREA

Dzanani also known as Makhado Biaba is a town and also the name of a region in the former Venda, now part of Limpopo province of South Africa. According to the 2011 census, Biaba has a population of 2147 with 1157 females and 989 males. Biaba is 40 kilometers (25 min) from the town of Thohoyandou, and 50 kilometers (31 min) from Makhado. There is a tarred road leading to Biaba and other nearby areas. It is usually a warm place but can get very hot in summer and cold in winter; there is much less rainfall in summer. The average annual temperature is 20.3°C having a rainfall average of 822 mm, the area is good for agricultural purposes. Makhado Biaba used to be one of the four districts in the former Republic of Venda, along with Vuwani, Mutale and Thohoyandou (Makhado Municipality IDP, 2018/19).The majority of the surrounding communities in Makhado Biaba growth center survive primarily on subsistence farming and livestock keeping, with vegetables being sold when deemed necessary and appropriate to the market in Makhado Biaba growth center. Farmers rely on rain-fed agriculture and concentrate on both large grain and small grain production. Maize and green vegetables are the main crop types in these areas. In the surrounding communities, there is a clear trend of underdevelopment, unemployment, and poverty. Economic benefits and infrastructure development have yet to reach the surrounding communities, where poverty has continued to define and dictate people's lifestyles and living standards. The main services provided at Makhado Biaba growth center include education, which includes two primary schools (Balila primary and Hillside combine school, ending in grade 9) as well as a secondary school (Nngweni secondary school) and a Multipurpose College. The Makhado Biaba growth center also provides non-farming employment opportunities to the residents. Primary health care at the community clinic, restaurants, ATM banks, and retailing are also available at the growth center. The home ministries have offices at the growth center.

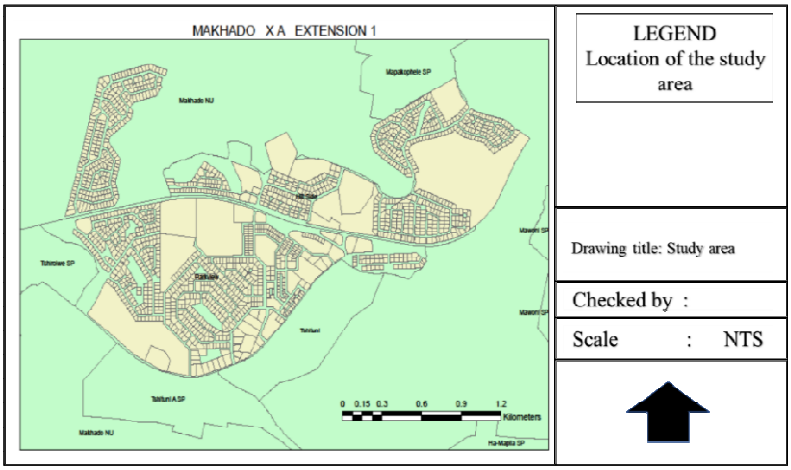


Figure 1: Location of the study area; Source: Makhado local municipality GIS dept.; Modified Authors, 2022

Figure 1 shows the Makhado Biaba growth center, which falls under the Makhado local municipal grow points. The growth centre has relatively small economic sector compared to the district, but more specifically

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

the provincial growth points. The growth center is serving mainly farming areas often having a sizable business sector providing a meaningful number of job opportunities (Makhado SDF, 2011). The growth centre has a few higher order social and institutional activities.

5 RESEARCH METHODOLOGY

This study adopted the case study research design where Makhado Biaba growth center in South Africa was studied to get insights on the influence of rural growth centers on local economic development and the impact it has on the livelihoods of the people in and around Makhado Biaba area. A mixed method approach was used to fully explore the research question: 'What is the current state of growth and development of the growth centre space in Makhado Biaba, South Africa? 'A case study design was chosen to extract insights on the influence of the growth center on local economic development and the impact it has on the livelihoods of the residents living in Makhado Biaba and the surrounding communities. Located in Limpopo Province of South Africa, Makhado Local Municipality is a Category B municipality situated within Vhembe District Municipality. The District is made-up of four (4) local municipalities, namely; Thulamela Local Municipality, Makhado Local Municipality, Musina Local Municipality and the recently established Collins Chabane Local Municipality. Makhado Biaba town is located approximately 156 km from Polokwane City, which is the provincial capital (Makhado Municipality IDP, 2018/19). This work relied heavily on interviews, questionnaires and observations of the situation in Makhado Biaba. Key informant interviews were conducted with key informant personnel from Makhado Local Municipality and the business owners. Interviews were conducted with 17 respondents, in which 4 of them were from the planning department, 13 were business owners within the growth centre and 45 questionnaires were distributed to people who reside in Makhado Biaba and surrounding communities. Interviews with the municipal officials were unstructured and the interviews were conducted physically, and the questioners conducted with residents were structured. Random sampling was used to select households that were targeted for participating in the survey. Observations and literature were also used to support the information gathered using interviews and questionnaires. For the literature review on planning policies and development frameworks, a desktop study was used as the primary means of obtaining data. The data in this study was analysed statistically and thematically. Thematic analysis was applied to qualitative data from interviews and questionnaires. Town planning professionals, business owners and community residents all provided their unique experience which were all used as the basis of analysing the current state of growth and development of the growth center space within Makhado Biaba.

6 FINDINGS

Findings shows that Makhado local municipality has strategies/ approaches to sustainable development of Biaba growth point in place, however implementation is limited due to limited funds. Makhado growth center is smaller than the rest of the growth points in the Makhado local municipal area, because of limited potential for expansion and due to environmental limitations. Insufficient and inadequate stall structures are a handicap to informal traders in the growth centre, due to limited funds, the municipality is unable to implement some projects that can help communities develop both socially and economically. Socio-economic growth is important for achieving sustainable development of growth centers because it provides valuable insight into the shaping of future growth and investment that the municipality may take. Serving as indicators of where the Municipality's priorities should be in terms of development programs and strategic planning. Findings of the study are discussed as follows:

6.1 Strategies/approaches to sustainable development of Biaba growth point

Findings shows that the municipality encourages infill development within urban edges and growth points. The IDP is used as a development tool to promote municipal sustainable development and to promote investment in LED and areas designated as Strategic Development Areas (SDAs). Strategies and approaches towards social and economic efforts to improve the growth centre is promoted.

6.1.1 The principle of infill development within Strategic Development Areas (SDA's)

Infill development is frequently viewed as a way to address sprawl and its associated issues while also revitalizing and growing existing communities. Makhado local municipality has attempted to increase the amount of higher density infill development as a result of these potential benefits. According to Makhado

municipal official, infill will "fill in gaps in existing communities and play a critical role in achieving community revitalization, resource and land conservation, and alternatives to sprawl development." Makhado local municipality encourages infill development within urban edges and growth points, which have been identified as Strategic Development Areas (SDA's) by the municipality as the main focus areas for future residential development and township expansion. Because of limited expansion potential and environmental constraints, the Makhado Biaba growth center is smaller than the rest of the SDAs in the municipal area. The intention with Makhado growth center is to fill the vacant areas between existing settlements and utilise available vacant land to its full potential (Makhado SDF, 2011). Infill development can provide numerous benefits to urban communities, including reduced environmental impact and promotion of resource and land conservation by utilizing already developed land rather than agricultural land (Abedini and Khalili, 2019). Infill development will strengthen the local economy by encouraging a diverse population of residents by providing a variety of housing for people of different income levels, which will increase property values (and thus property taxes) and strengthen the real estate market for all residents within the growth center. Nonetheless, for a variety of economic, political, and regulatory reasons, such new infill development has proven difficult to achieve in practice. Ewing (2019) argued that infill development is not a new development pattern; it is based on previous practices in growth management, land preservation, and community development. One important argument that has gone unnoticed in recent years suggests that policies encouraging infill may even be counter-productive in the long run.

6.1.2 Use of the IDP as a developmental tool

Makhado Local Municipality employs Integrated Development Planning (IDP) processes, and the Spatial Development Framework (SDF) to effectively plan the future development of the municipality's various areas. The goal is to achieve the most economical, environmentally friendly, and socially viable solutions for long-term benefits through development. With the IDP in place, the municipality can more easily attract investments. Using the IDP as a development tool to promote municipal sustainable development. Municipal officials stated that the IDP is used by the municipality to promote investment in LED and areas designated as Strategic Development Areas (SDAs) by the municipality, such as the Makhado Biaba growth center (Makhado SDF, 2011). While most aspects of the Integrated Development Planning documents do not directly relate to LED, almost all of the projects included in the IDP have a significant impact on local economic development (Masilo and Gershwin, 2020). Makhado local municipality defines the strategies and capital projects that they intend to implement to promote sustainable development within the municipal growth points using IDP. The IDP requires the municipality to specify the project's revenue source as well as its role in development and Black Economic Empowerment (BEE). According to the municipal officials, strategies and policies aimed at addressing the "Triple Challenge" of poverty, unemployment, and inequality are in place in the Makhado local municipality's IDP, but implementation is limited due to limited funds. The official went on to say that it is through the IDP that the municipality is able to implement interventions aimed at fostering long-term economic development, job creation, and poverty alleviation. Municipal officials responded that the IDP was used as a developmental tool to address inequalities in social and economic development in order to ensure job creation, eradicate poverty and hunger, improve access to basic services, and promote community skill development (Makhado Municipality IDP, 2018/19).

6.1.3 Social and economic efforts to improve the status quo

Some respondents expressed an interest in starting their own farming business. According to the narratives, these respondents prefer working for themselves to working for others. The respondents appear to prefer a method in which they can make things work for themselves rather than relying on others to create job opportunities for them. Most respondents mentioned agriculture and farming as one of their self-employment ideas. The desire to participate in agricultural and farming activities is there, but the mechanisms to create these types of jobs for rural young people are lacking. The National Youth Policy (RSA, 2015) recognizes that much more needs to be done to promote and support youth participation in agriculture, particularly issues such as access to land, implements and inputs, business skills, access to information, opportunities, and markets. Given their interest in agricultural activities, this could allow rural youth to participate in the economy without having to leave their rural homes for urban areas.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Social efforts	Economic efforts
Standard service delivery by the municipality	Support and empowerment of farmers and small local enterprises
Youth empowerment and skills development	Attraction of investments
Improved quality of life	Economic infrastructure improvement
Availability of social amenities, recreational areas such as parks and entertainment centres.	Employment opportunities

Table 2: socio and economic efforts to improve the status quo; Source: Field work, 2019

Table 2 illustrates the social and economic efforts to improve the growth centre. The growth center strategy is expected to result in the provision of basic services, as communities continue to face challenges such as inadequate service delivery and a high rate of unemployment combined with poverty. Thus, the government is providing strategies and approaches for job creation in the Makhado Biaba growth center through the Expanded Public Works Programme, which aims to provide poverty and income relief for the unemployed in the short to medium term through temporary work (Makhado Municipality IDP, 2018/19). As a result, at the sub-programme level, the program also offers training and business development assistance.

6.2 Current Status of Biaba Growth Point

Findings of the current status quo of the growth center illustrates that 28% of respondents matriculated and youth unemployment is an issue. Informal street traders having inadequate stall structure which is affecting them negatively hence, informal street traders have the lowest monthly turnover in the growth center.

6.2.1 Education and employment

Youth unemployment is one of South Africa's most serious social and economic challenges. According to the findings, an average of 30% of respondents with tertiary education in Makhado Biaba and surrounding communities are employed. An estimated 50% of people with primary, secondary, matriculated, and non-tertiary education are unemployed, while approximately 20% are self-employed. According to Ochilova (2020), education plays a significant role in an individual's ability to find work. As a result, the fact that many of these respondents dropped out before completing their matric puts them at a disadvantage, as many jobs nowadays require a matric certificate or additional skill sets. Education is thus a form of insurance against unemployment, even in difficult economic times. Figure 2 illustrates the educational levels of respondents in Makhado Biaba and surrounding communities.

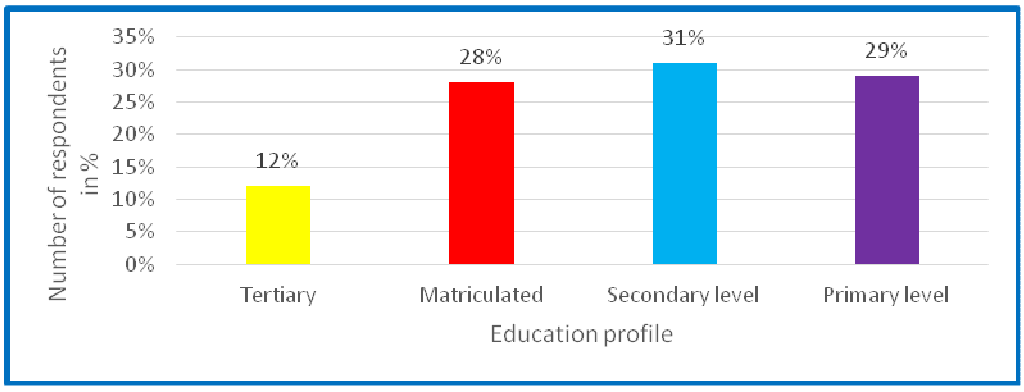


Figure 2: Education profile; Source: field work, 2019

Figure 2 shows that 31% of respondents in the study area have secondary level qualifications, followed by 29% who have primary level education, while 28% have matriculated, and 12% of the respondents who have tertiary qualifications. According to the findings, few respondents in the study area have completed tertiary education. As a result, educational levels are an important indicator of the quality of the work force that the growth center market can attract. Prior work experience and education are important factors in the labor market. Employers frequently prefer candidates with prior work experience and a higher level of education. Unfortunately for the respondents, lack of work experience is a stumbling block that makes it difficult for them to find employment. Another factor that respondents perceived as a barrier to obtaining or creating employment for themselves was lack of access to resources such as formal information sources,

opportunities to apply their skills, and capital to start their own businesses. According to the responses, the communities have considered starting their own businesses, but lack of funds and assistance prevents them from doing so. It is critical that young people are supported in achieving their goals. Most of the respondents mentioned that the government could play a role in helping them with these difficulties.

6.2.2 Informal trading activities in Makhado Biaba growth centre (business)

For the past ten years, activities within the growth center, such as informal traders, have increased. Informal street traders target taxi and bus ranks, as well as major shopping stores. According to the municipal officials from Makhado Local Municipality, informal trading is a popular business venture in the growth center, but it can be problematic if not handled carefully, as informal traders have formed associations that represent them. The Makhado Hawkers Association, for example, was formed to protect the rights of informal street traders. According to observations made during the flied visit, informal traders conduct their businesses in parking lots and pedestrian walkways because the municipality has not designated any planned areas for them. Most informal street traders stated that having inadequate stall structure is a handicap because it becomes both uncomfortable and unprofitable during the rainy and cold seasons as they cannot sell anything if it rains cats and dogs. Informal trading dominates economic activities at the growth center, which some community members argued that it broadens their income base as their livelihoods has generally improved.

Plate 1: Informal trading challenges in the growth centre; Source: field work, 2019

Plate 1 shows that informal traders conduct their businesses in parking lots and pedestrian walkways because the municipality has not designated any planned areas for them. Most informal street traders stated that having inadequate stall structure is a handicap because it becomes both uncomfortable and unprofitable during the rainy and cold seasons as they cannot sell anything if it rains cats and dogs. Informal trading dominates economic activities at the growth center, which some community members argued that it broadens their income base as their livelihoods has generally improved (Makhado Local Economic Development Strategy, 2013).

6.2.3 Outcome of the efforts

Results shows that 60% of the businesses in the Makhado Biaba growth center have a turnover of between R5000 and R10 000, and these include vending activities and salons (informal traders). 22% of business operators in the growth center generate a turnover between R 11 000 and R 20 000 per month, and these include general dealers. Finally, 18% of businesses have a turnover of R21 000-R30 000 or more, and these include grocery stores, fast food outlets, and banking facilities and ATMs from all four major banking groups. This demonstrates that when compared to other businesses in the area, informal street traders have the lowest monthly turnover. Not surprisingly, informal business owners face severe cash-flow issues, which have a knock-on effect on their ability to manage their businesses profitably and maintain adequate stock levels. As a result, a better understanding of the opportunities for and constraints on informal street trading can influence and assist policy planning in making innovative changes to create more inclusive and beneficial environments for informal street traders in the growth center.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

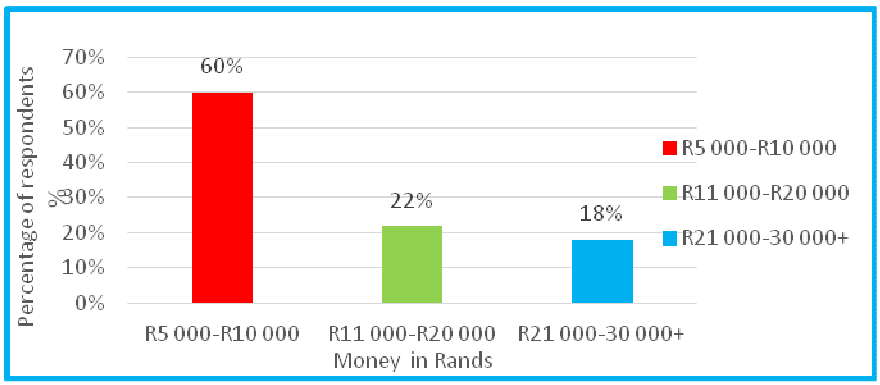


Figure 3: Monthly turnover of business; Source: field work, 2019

Figure 3 shows that small and informal businesses contribute to the gross domestic product of the local municipality and generate income for the majority of South Africans (Makhado Local Economic Development Strategy, 2013. This means that the more help they get, the more people they can hire, and the more prosperous our country becomes. In South Africa, small businesses are frequently viewed as a key potential driver of job creation, equality, and innovation. According to the National Development Plan, small businesses can create new job opportunities while also providing a path to economic empowerment.

6.3 Challenges

The Finding shows that the challenges of land conflicts between traditional and municipal authorities has resulted in slow and inconsistent development. Yet poor service delivery concerns the quality of management on the maintenance of services in the area. The LED division does not have its own budget; they rely on the budget of the corporative services department which is a serious setback.

6.3.1 Limited space for expansion for Makhado Biaba growth centre

Makhado growth centre is smaller than the rest of the growth points in the Makhado local municipal area, because of limited potential for expansion and due to environmental limitations. The intention with the growth point is to complete the vacant areas between the existing settlements and utilise available vacant land to its full potential. However, due to the limitations of the area no large scale expansions are foreseen. Thus, although Makhado Growth point is only 1000 ha in size, it could accommodate 11 667 households and should be the focus area for development due to its size (Makhado SDF, 2011 – 2nd draft). Municipal officials from Makhado Local Municipality stated some villages surrounding the growth centre have not been willing to release part of their land to cater for the expanding growth centre. Chiefs from the surrounding villages refused to give up land they were occupying for Makhado Biaba growth center expansion even after they had been advised that the land they were occupying was part of the growth center development plan. The boundary between the growth center and the surrounding villages has become overly obscured and overlapping. Due to land conflicts, conflict between traditional and municipal authorities has resulted in slow and inconsistent development. Section 81(3) of the Municipal Structures Act 117 of 1998 states that before a municipal council makes a decision on any matter directly affecting the area of traditional authority, the council must provide the leader of that authority with the opportunity to express his or her opinion or views on the matter. Act 41 of 2003 established a cooperative environment for traditional leaders and municipalities to collaborate by elaborating on traditional leaders' functions, though nothing more is said except that traditional leaders should support municipalities. Although the White Paper on Local Government attempted to foster understanding between municipalities and traditional leaders, it fell short of achieving a working relationship between the two because major decision-making powers remain with local municipalities.

6.3.2 Inadequate service deliveries and maintenance of municipal infrastructure

Despite the fact that there might not always be running water at the taps, the respondents from Makhado Biaba stated that they had access to clean water. However, the surrounding communities claimed that they lack such access because water is a major issue for them. Municipal officials from Makhado Local Municipality stated that some areas of the surrounding communities within the growth center lack services because the Local Municipality is unable to meet service demands because it is financially impossible to

provide the same level of services throughout the municipality. Since some communities do not contribute to the municipality's rate base, the Makhado municipality lacks the capacity to fund the same level of service provision in the area as in the growth center (urban area). Municipal infrastructure asset operations and maintenance are critical for municipalities to provide basic services to communities. One of the greatest challenge currently faced by Makhado local municipality is that of infrastructure maintenance. Hence, an element of poor service delivery concerns the quality of management on the maintenance of services like water and roads. As a result of lack of resources, such as funding to provide basic services, poor service delivery is likely to prevail in some areas, as illustrated in plate 2.

Plate 2: Road and storm water drainage challenges; Source: field work, 2019

Plate 2 shows the roads and storm water drainage systems are in poor condition; there are areas that are not paved, as well as several potholes and damaged road storm water systems. The poor state of municipal infrastructure asset operations and maintenance in South African rural municipalities and metros, combined with rapid urbanization, reduces their service delivery performance (DCOGTA, 2019).

6.3.3 Limited resources towards effective Local Economic Development (LED)

Municipal officials from Makhado Local Municipality mentioned that some of the challenges they face are lack of funding, human resources, and technical expertise. Due to limited funds, they are unable to implement some projects that can help communities develop both socially and economically. They stated that sometimes community members bring to them ideas for new projects, only to discover that there is no funding available due to limited resources in the local municipality. However, Rogerson, 2020 indicates that limited resources are impeding LED implementation and emphasizes that local authorities must use public management tools properly and effectively to promote economic development in their area of jurisdiction. Municipal officials have also stated that lack of staff is a major challenge in implementing LED projects. LED projects and LED officials lack the capabilities to carry out LED initiatives. Makamo (2020) supports this by stating that municipal officials and leaders are uninformed and unknowledgeable about local government issues, particularly LED issues. They also stated that the LED division does not have its own budget; they rely on the budget of the corporative services department, despite the fact that LED is viewed as a strategic plan to address poverty, unemployment, and inequalities that affect the majority of the local communities. Musavengane (2019) added that there is lack of funding for LED projects as well as lack of capital for development. These findings show that local municipalities face various challenges that contribute to poor LED implementation. Thus, lack of skills needed to drive growth and development, as well as lack of administrative capacity and ineffective implementation of development policy frameworks.

7 POLICY IMPLICATIONS

The SDF provides the spatial information with regard to development potential and growth areas that will give effect to the implementation of the sustainable development of growth centers. The SDF is utilised as a tool to ensure the eventual realisation of the spatial vision and the Integrated Development Plan of the municipality. Helping to addressing spatial development challenges of growth centers and having to know how the spatial expansion of growth centers will take place within an area. The IDP provides deadlock-breaking mechanisms to ensure that growth center projects and programmes are efficiently implemented. Thus assisting to develop realistic sustainable project proposals based on the availability of resources in the growth center. Consequently IDP plans prepare the government for future community needs.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

8 THE PROPOSED PATHWAYS FOR SUSTAINABLE DEVELOPMENT OF GROWTH CENTRES

The paper come up recommendations of pathways for sustainable development of growth centers as listed and discussed below:

8.1 Open door policy

The municipality should make use of open door policy thus ‘borrowing strategies' in organisational networks to gain access to economic and livelihood benefits available elsewhere, which necessitates the establishment of networks with growth centers that are performing well in order to 'tap into' some of the benefits they provide and 'borrow' some of their 'strategies.' Because it is not only hard infrastructure that provides the opportunity to tap into successful sustainable growth center, the networks can be organisational in nature. Cooperative arrangements between different organizations, such as best-performing municipalities or university partnerships, will allow for knowledge transfer and innovation.

8.2 Generating funding for LED projects.

The local government should figure out ways of creating money for LED. This could be accomplished by applying for funds from the National Treasury, the Province, and the Department of Cooperative Governance and Traditional Affairs, as well as marketing the municipality to attract local and external donor organisations and LED project investors. Since there will be ongoing projects, the municipality will be able to obtain more private funding. This will demonstrate to potential funders that their funds will not be squandered, the availability of funds is critical to the successful implementation of the LED projects. Apart from sector departments, which frequently budget for municipal projects, funding may also come from the private sector. To secure funding from the identified funders, the municipality must conduct extensive preparation. A well-researched and written business plan serves as the foundation for engaging with potential funders because it demonstrates that the municipality is fully aware of its situation and, more importantly, that it is capable of implementing the project. Prospective funders want to see serious commitment from recipients before investing money in a project.

8.3 Creating an entrepreneur-friendly economic climate

Municipalities must work to create an economic environment that is friendly and welcoming to all entrepreneurs in all sectors. It must resist the temptation to select “winning sectors” for special attention and economic incentives. As a result, the government should focus on creating an environment in which any commercial enterprise can thrive, and leave the future of South Africa's economy to the global forces already at work. To boost growth and create more jobs each year, businesses of all sizes, from micro businesses run by individuals and families to multi-million rand corporations run by professional managers, must be encouraged. Allowing the informal sector to thrive while removing regulatory barriers to its success. Recognising that an unregistered township-based entrepreneur who does not pay taxes or minimum wages is beneficial to the economy and will continue to be so for many years to come. Municipalities must regulate with a light touch so that people in the grey economy see more 'pros' than 'cons' in following the rules. Policy planning can be used to develop innovative changes to create more inclusive and advantageous environments for informal street traders, transforming them into ones that provide dignity and livelihood for the majority of households who rely on them on a daily basis.

8.4 Increasing infrastructure efficiency

Within the growth point, there is an urgent need to expand infrastructure and ensure that existing infrastructure is properly maintained. The municipality should improve public service efficiency by making merit-based appointments, utilising all available skills, and holding managers and bureaucrats accountable. Although privatisation will help bring in some of the revenue required to fund new infrastructure, it is unlikely to be sufficient, particularly at the start of the turnaround process. Such public-private partnerships have the potential to quickly revitalise critical economic infrastructure. This could also be used to improve municipal operational efficiency, improve financial management, and reduce fraudulent, irregular, and wasteful spending. Greater private sector participation in the provision, maintenance, and management of economic and social infrastructure would significantly increase capital investment. It would also increase the efficiency of the municipality and stimulate job creation.

8.5 Improving extension services for smallholder and emerging farmers

For smallholders and emerging farmers to transition to higher-value agricultural commodities and play a significant role in reducing poverty and strengthening rural development, intensive and high-quality extension support in collaboration with industry associations is required. Investing in innovative market linkages for smallholders. Thus contract farming and strategic government procurement, can play an important role in assisting smallholder farmers to attain greater productivity, access to inputs, and markets, and ultimately facilitate promotion to emerging and commercial status.

9 CONCLUSION

The paper sought to explore the pathways to sustainable development of growth centers: lessons from Makhado Biaba, South Africa. The paper went on to assess insights on the influence of rural growth centers on local economic development and the impact it has on the livelihoods of the residents living in Makhado Biaba and the surrounding communities. The results revealed development constraints, both economically and socially. Some parts of the communities lack services because the local municipality is unable to meet the service demands. Insufficient and inadequate stall structures are a handicap to informal traders in the growth centre as in the raining and cold season it becomes both uncomfortable and unprofitable to them. Overall, the paper recommends policy planning and an open door policy (borrowing strategies) and creating an entrepreneur-friendly economic climate as a pathway for sustainable development of growth centers.

10 REFERENCES

Abedini, A. and Khalili, A., 2019. Determining the capacity infill development in growing metropolitans: A case study of Urmia city. Journal of Urban Management, 8(2), pp.316-327.

Atkinson, R., Muro, M. and Whiton, J., 2019. The Case for Growth Centers. Brookings Institution: Washington, DC, USA.

Bansal, P., 2019. Sustainable development in an age of disruption. Academy of Management Discoveries, 5(1), pp.8-12.

Dawes, J.H., 2020. Are the Sustainable Development Goals self-consistent and mutually achievable?. Sustainable Development, 28(1), pp.101-117.

DCOGTA. (2019) . Integrated Urban Development Framework–Draft for Discussion. COGTA Pretoria.

De Neve, J.E. and Sachs, J.D., 2020. The SDGs and human well-being: A global analysis of synergies, trade-offs, and regional differences. Scientific reports, 10(1), pp.1-12.

Ewing, R., 2019. Best development practices: Doing the right thing and making money at the same time. Routledge.

Ezimah, M.O.A., 2021. Sustainability: Implications for Economics and the Environment. European Journal of Research and Reflection in Educational Sciences Vol, 9(3).

Fróna, D., Szenderák, J. and Harangi-Rákos, M., 2019. The challenge of feeding the world. Sustainability, 11(20), p.5816.

Guo, J., 2021. Developing Guangdong–Hong Kong–Macao Greater Bay Area into China's Economic Growth Pole. In GUANGDONG-HONG KONG-MACAO GREATER BAY AREA: Planning and Global Positioning (pp. 163-203).

Hardoy, J.E. and Satterthwaite, D., 2019. Why small and intermediate urban centres?. In Small and Intermediate Urban Centres (pp. 1-17). Routledge.

Hirschman, A.O. and Sirkin, G., 1958. Investment criteria and capital intensity once again. The Quarterly Journal of Economics, 72(3), pp.469-471.

Horner, R. and Hulme, D., 2019. From international to global development: New geographies of 21st century development. Development and Change, 50(2), pp.347-378.

Makamo, W.P., 2020. Interrogating the implementation of local economic development for poverty alleviation in Nkomazi Municipality, Mpumalanga (Doctoral dissertation).

Makhado Local Economic Development Strategy, 2013

Makhado Municipality IDP, 2018/19

Makhado Municipality IDP, 2018/19 Final IDP review

Makhado SDF, 2011 – 2nd draft).

Makhathini, M.S., Mlambo, V.H. and Mpanza, S., 2020. Infrastructure provision as a catalyst for local economic development in South Africa. Strategic Review for Southern Africa, 42(1).

Masilo, T. and Gershwin, G., 2020. The Perceived Impact Of Integrated Development Planning (Idp) On The Social And Economic Development Of Local Communities Of Magareng Local Municipality, Northern Cape Province.

Mensah, J., 2019. Sustainable development: Meaning, history, principles, pillars, and implications for human action: Literature review. Cogent social sciences, 5(1), p.1653531.

Mlambo, D.N. and Adetiba, T.C., 2020. Post-1994 South Africa's peacekeeping and military intervention in Southern Africa, reference from the Democratic Republic of Congo (DRC) and Lesotho. Journal of Public Affairs, 20(1), p.e1984.

Morison, I., 2020. The corridor city: planning for growth in the 1960s. In The Australian Metropolis (pp. 113-130). Routledge.

Musavengane, R., 2019. Using the systemic-resilience thinking approach to enhance participatory collaborative management of natural resources in tribal communities: toward inclusive land reform-led outdoor tourism. Journal of Outdoor Recreation and Tourism, 25, pp.45-56.

Ochilova, B., 2020. Educatıon and Prosperıty. Архив Научных Публикаций JSPI.

Pahl, S. and Timmer, M.P., 2020. Do global value chains enhance economic upgrading? A long view. The journal of development studies, 56(9), pp.1683-1705.

Rogerson, C., 2018. Local economic development in the changing world: The experience of Southern Africa. Routledge.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Statistics South Africa Annual Report 2015/2016.
Souto, J.E., 2021. Organizational creativity and sustainability-oriented innovation as drivers of sustainable development: overcoming firms' economic, environmental and social sustainability challenges. Journal of Manufacturing Technology Management.
Wu, J., Guo, Y. and Zhou, J., 2020. Nexus between ecological conservation and socio-economic development and its dynamics: Insights from a case in China. Water, 12(3), p.663. Neural Processing Letters, 51(3), pp.2575-2587.
Yong, J.Y., Yusliza, M.Y., Ramayah, T., Chiappetta Jabbour, C.J., Sehnem, S. and Mani, V., 2020. Pathways towards sustainability in manufacturing organizations: Empirical evidence on the role of green human resource management. Business Strategy and the Environment, 29(1), pp.212-228.

🏆 *reviewed paper*

Stresstest Fußverkehr: Eine experimentelle Studie zur Messung des Stressempfindens Zufußgehender am Marienplatz in Stuttgart

Céline Schmidt-Hamburger, Peter Zeile, Johannes Herbeck

(MA. Céline Schmidt-Hamburger, Karlsruher Institut für Technologie KIT, Professur Stadtquartiersplanung STQP, celine.schmidt-hamburger@kit.edu)
(Dr.-Ing. Peter Zeile, Karlsruher Institut für Technologie KIT, STQP, peter.zeile@kit.edu)
(Dr. Johannes Herbeck, Universität Bremen, artec Forschungszentrum Nachhaltigkeit, Johannes.herbeck@uni-bremen.de)

1 ABSTRACT

Gehen als Teil der alltäglichen Mobilität ist gesund, kostengünstig und für breite Teile der Bevölkerung nutzbar (Ausserer et al. 2013: 34f.). Zugleich tragen verschiedene Faktoren dazu bei, dass der Fußverkehr an Attraktivität einbüßt – darunter ganz zentral das Empfinden von Stress im Straßenraum. Ziel des NRVP-Projektes „Cape Reviso“ ist es, Wissen über das Zusammenspiel von Stress und Zufußgehen zu generieren. Dabei wurde speziell untersucht, welche baulichen und sozialen Faktoren zum Empfinden von Stress bei Zufußgehenden im urbanen Raum führen können und welche Rolle soziale bzw. psychologische Charakteristika dabei spielen.

Grundlage für den Stresstest war einer Studie mit 15 Teilnehmenden am Marienplatz in Stuttgart, der eine Vielzahl an Flächen- und Nutzungskonkurrenzen aufweist und durch eine große Nutzungsmischung sowie dem Status als Verkehrsknotenpunkt gekennzeichnet ist. Bei der Erhebungs- und Auswertungsmethodik) wurde ein triangulierendes Verfahren (Flick 2008: 12ff.) angewandt und durch einen Testlauf, während dem die Teilnehmenden mit einer Kamera und einem Abstandsmesser ausgestattet waren, die baulich-verkehrlichen Einflussfaktoren einbezogen. Es wurden vier exogene (Raummangel, Unterbrechung der Wunschlinie, Lärm und die Qualität der Infrastruktur) und einige endogenen Einflussfaktoren, wie Geschlecht, Ortskenntnis und psychologische Merkmale, untersucht. Die exogene Einflussfaktoren wurden anhand der gemessenen Biomarker Hautleitfähigkeit und -temperatur in einen Algorithmus zur Detektion von „Moments of Stress“ überführt (nach Kyriakou et al. 2019). Die georeferenzierten Aufzeichnungen gaben Aufschluss über die räumliche Häufung von MOS und damit Hinweise auf (stress-)relevante Stellen am Untersuchungsort.

Die meisten Häufungen an MOS befinden sich an großen, viel befahrenen Kreuzungen, wo mehrere Stressoren auf einmal wirken. Zudem gab es einen hohen Anteil an MOS dort, wo Gehsteige beispielsweise durch Stadtmobiliar verschmälert wurden. Die Analyse der endogenen Einflussfaktoren lieferte Ergebnisse dahingehend, dass die Frauen im Sample eher dazu neigten, Stress zu empfinden als die Männer. Ortskundige Menschen tendierten zu weniger MOS. Bei den psychologischen Charakteristika zeigte sich, dass die Faktoren Neurotizismus, Verträglichkeit und internale Kontrollüberzeugung die Entstehung von Stress eher beförderten. Sind Menschen eher extravertiert, offen, gewissenhaft, risikobereit und haben ein höheres Maß an externaler Kontrollüberzeugung, wiesen sie eine Tendenz zu weniger MOS auf. Identifiziert wurden zudem drei Clustergruppen (Zögerliche Einzelgängerinnen mit Pioniergeist, Sicherheitsabenteurerinnen, Sicherheitsabenteurer und sicherheitsaffine Einzelgänger), die in ihrem Stressempfinden ähnliche Muster aufweisen. Diese Cluster können als Vorlage dienen für weitere Untersuchungen der Wirkung von Planvorhaben der gebauten Umwelt auf bestimmte Gruppen von Zufußgehenden.

Keywords: Konfliktforschung, Emotion Sensing, Stresstest, Fußverkehr, Psychologie

2 EINLEITUNG

Das Zeitalter der autogerechten Stadt neigt sich dem Ende zu, diese Erkenntnis ist nicht neu. Die Mobilitätswende wird als essenzieller Faktor zur Bekämpfung der Klimakrise betrachtet, im Zuge dessen Verbrennungsmotoren leidenschaftlich und motorisiertem Individualverkehr zögerlich abgeschworen werden sollen. Unlängst hat der Radverkehr starken Zuspruch erhalten, durch dessen Verbreitung ist aber auch die teilweise mangelhafte Infrastruktur zu Tage getreten. Bei Betrachtung der Nutzung des Straßenraumes von Verkehrsteilnehmenden wird schnell ersichtlich, dass der Fußverkehr als Restgröße verbleibt und bislang noch eher spärlich Aufmerksamkeit erfahren hat (Umweltbundesamt 2018). Spazieren gehen ist aber nicht nur in der Freizeit wichtiger geworden, Zufußgehen wird auch als Verkehrsmittel präsenter (Knie et al. 2021:14).

Damit stellt sich die Frage nach der Relevanz einer guten Fußverkehrsinfrastruktur. Die positiven Effekte sind mannigfaltig. Nicht nur dient das Zufußgehen auf individueller Ebene der Gesundheit, auch kann die Umgebung intensiver wahrgenommen werden (Umweltbundesamt 2018). Darüber hinaus bietet diese Art der Fortbewegung keine finanziellen, sprachlichen oder kulturellen Hürden und es bedarf keiner Befähigung ein Fahrzeug zu führen. Das Gehen fördert die Belebung des öffentlichen Raumes und sichert die Teilhabe am öffentlichen Leben, auch für z.B. Ältere (Ausserer et al. 2013:34f.). Die Stärkung des Fußverkehrs kann auch zu einer Senkung der Luft- und Lärmemissionen beitragen (Umweltbundesamt 2018).

Gehemmt wird die Zunahme des Fußverkehrs durch Faktoren wie der Luftqualität, städtebauliche Hindernisse, Unfallgefahren mit anderen Verkehrsmitteln oder auch alte Gewohnheiten bei der Verkehrsmittelwahl (Umweltbundesamt 2018). Besonders präsent ist die Rolle des Fußverkehrs in Städten. Gebaute Enge, ein Mehr an Lärm- und Schadstoffemissionen und ein erhöhtes Verkehrsaufkommen bestimmen den Alltag von Fußgängerinnen und Fußgängern (Gehl 2018:14).

Eine weitere prominente Dynamik im urbanen Kontext stellt der stetig steigende Teil an stressbedingten Krankheiten dar. Neben der Verbreitung von Herz-Kreislauf-Erkrankungen werden zunehmend psychische Krankheiten wie Depressionen beobachtet (Adli 2017:16). Subjektive Faktoren, die mit dem Empfinden von Stress im Zusammenhang stehen, beeinflussen mitunter, auch unbewusst, die Verkehrsmittelwahl (Zeile et al. 2021:613). Nicht nur führt also der urbane Raum zu stressbedingten gesundheitlichen Risiken, auch ist die dortige knappe Ressource Raum maßgeblich für eine hohe Flächenkonkurrenz zwischen den verschiedenen Verkehrsmitteln. Die zunehmende globale Urbanisierung unterstreicht die Relevanz von Wissensgenese hinsichtlich Stressoren im urbanen Raum.

Vor diesem Hintergrund soll nun der Fußverkehr in den Blick genommen werden. Die Förderung des Fußverkehrs ist hinsichtlich künftiger Stadt- und Verkehrsplanungen ein zentraler Baustein.

Die Zielsetzung dieses Beitrags gliedert sich folglich in die Beantwortung zweier Forschungsfragen:

1. Welche baulichen und sozialen Faktoren führen zum Empfinden von Stress bei Zufuß-gehenden im urbanen Raum?

2. Welche Rolle spielen soziale bzw. psychologische Charakteristika?

Analysiert wird in dieser Studie also das Stressempfinden Zufußgehender. Der praktische Teil der Untersuchung wurde beispielhaft am Marienplatz in Stuttgart durchgeführt. Dieser Ort ist für die Beantwortung der gestellten Forschungsfragen spannend, weil er eine Vielzahl an Flächen- und Nutzungskonkurrenzen aufweist. Städtebaulich ist er durch eine große Nutzungsmischung sowie dem Status als Verkehrsknotenpunkt gezeichnet und daher gut für die Untersuchung geeignet. Die Studie kann als Prototyp weiterer Forschungen im Themenfeld von urbanem Stress bei Zufußgehenden gelesen werden.

3 THEORETISCHE KONZEPTE

Im Folgenden werden die für den Beitrag wichtigsten theoretischen Grundlagen zu den Themenfeldern „Stress“ und Mobilitätsverhalten im Kontext der Arbeit erläutert.

3.1 Stress, ein emotionales Konstrukt

Stress als Untersuchungsgegenstand zu operationalisieren sowie probate Messmethoden zu identifizieren ist komplex. Die interdisziplinäre Gestalt der aktuellen Stressforschung, führt zu Unstimmigkeiten zwischen den Forschenden, wodurch auch die Definitionen von Stress variieren (Kaluza 2007:4). Der Begriff Stress ist vielschichtig und im allgemeinen Sprachgebrauch weitverbreitet. Stress kann unterteilt werden in einen Reiz, der als positiv (eustress) oder negativ wahrgenommen wird (distress) (Schmidt 2021).

Die verschiedenen Stresstheorien unterscheiden sich nach Anpassungsleistung und Operationalisierbarkeit. Stress entsteht immer dann, wenn, je nach theoretischem Unterbau, die Physis (Stress als Reaktion) oder Psyche (Stress als Reiz oder Stress als Transaktion) zur Verarbeitung Ressourcen aufbringen muss (Bercht 2013:142 ff.). Am prominentesten ist das transaktionale Stressmodell nach Lazarus (1999), gleichzeitig ist es aber auch das komplexeste, da Stress immer in der Wechselwirkung von Mensch und Umwelt situativ entsteht. Auf der anderen Seite gibt es Stress als Reaktions-Modelle (Selye 1956, Cannon 1932), auf denen auch aktuelle psychophysiologische Stressforschung aufbaut, die die körperlichen Reaktionen auf einen äußeren Reiz untersuchen. Kritisch ist hierbei die Annahme, dass ein Stimulus alle Menschen gleichermaßen „stresst“(Lyon 2005:27f.). Die dritte theoretische Gruppe, die Stress als Reiz versteht, lenkt den Blick auf

psychische Auswirkungen. Angenommen wird hierbei, dass es „kritische Lebensereignisse“ (Holmes und Rahe 1967) gibt, die objektiv in gewissem Maße Stress auslösen. Zur Messung wurde durch zwei Psychologen Holmes und Rahe eine Skala entwickelt.

Aufgrund von Entwicklungen der Emotionsforschung in diesem Gebiet, ist die stresstheoretische Grundlage dieser Arbeit eher den Modellen aus Stress als Reaktion – Sicht zuzuordnen. Subjektive Komponenten werden jedoch bei der Erhebung und Auswertung der Daten einzubezogen.

3.2 Das Mobilitätsverhalten Zufußgehender

Die menschliche Wahrnemung und folglich das Verhalten bzw. konkret das Mobilitätsverhalten wird durch eine Reihe von Faktoren bestimmt. Diese können in exogene und endogene Einflüsse unterteilt werden (Śleszyński 2012:16f.).

Resultieren Einflussfaktoren aus der Umwelt, wird von exogenen Faktoren gesprochen. In diesem Fall stimuliert die gebaute oder natürliche Umwelt die Sinneswahrnehmung der Personen (Śleszyński 2012:18). Diese Arbeit klassifiziert aufbauend nach empirischen Befunden diese in Raummangel (Enge), Widerstände (Barrieren), die Qualität der Umgebung bzw. Wegeführung und Lärm. Diese bilden sogleich die Basis für die Arbeitshypothesen, die folgendem Schema folgen:

Wahrnehmung → Stress (als Reaktion) → negatives Stressempfinden.

Raummangel – Enge: Die Hauptinfrastruktur Zufußgehender sind Gehwege. Diese abgegrenzten Wege limitieren den Bewegungsraum von Fußgängerinnen und Fußgängern, was als Einengung des Bewegungsraumes wahrgenommen werden und zu Umwegen führen kann. Eine unzulängliche Breite der Wege führt zu nicht ausreichenden Abständen bei Begegnungen und einer hohen Personendichte. Die angemessene Breite der Wege variiert je nach Alter und Modus (Einzelperson, Paar, Mobilitätseinschränkung, Transport etc.) (Knoflacher 2007:183). Auch die Abstände zur Fahrbahn oder die Existenz von Hindernissen, können ein Gefühl der Bedrängung auslösen (Śleszyński 2012:30f.). Des Weiteren kann es aufgrund eines Mangels an Raum zu Konflikten zwischen dem Fuß- und Radverkehr kommen (Śleszyński 2012:34). Sog. „Beinahe-Unfälle“ können das subjektive Sicherheitsempfinden Zufußgehender beeinflussen (Zeile et al. 2021:613). Beinahe-Unfälle resultieren zu Teilen aus einem zu geringen Abstand, vor allem bei Überholvorgängen. Der kritische Wert beträgt 150cm, welcher dem gesetzlichen Mindestabstand bei Überholvorgängen entspricht (Zeile et al. 2021:619). Beinahe-Unfälle werden jedoch oft nicht statistisch erfasst, wodurch es an Datenmaterial fehlt (Zeile et al. 2021:618). Der Mangel an Raum kann also, bei entsprechender individueller Bewertung der Situation bei Zufußgehenden, Stress auslösen (Spiegel 1992:44). Nach der Theorie der „Behaglichkeitssonne“ (Pirath 1934), spielt bei der Wahrnehmung nicht nur die Erfahrung, sondern auch die Erwartung eine Rolle (Knoflacher 2007:108f.). Übertragen auf eine Stressreaktion aufgrund von Raummangel, spielt also nicht nur die tatsächliche Enge durch die gebaute Umwelt oder Individuen eine Rolle, sondern auch die Erwartung von Enge. Das Gefühl von Enge kann durch verbaute oder temporäre Objekte in der Umgebung aber auch aus menschlichem Verhalten, wie Überholvorgängen entstehen.

Folglich ist Hypothese (H1): Das Gefühl von Enge bzw. potenzieller Enge führt zu einem negati-ven Stressempfinden Zufußgehender.

Barrieren: Zufußgehende benötigen beim Gehen ausreichend persönlichen Freiraum. Sie möchten sich ungern bei der Fortbewegung stören lassen. Durch die Möglichkeit der freien Fortbewegung zu Fuß, visieren Zufußgehende eine Route an, welche ihren Start- mit ihrem Zielort verbindet (Kim et al. 2014:674). Kriterien sind dabei die Direktheit und Länge, denn Menschen möchten bei der Fortbewegung ihren Energiebedarf geringhalten. Die Präferenz zu kurzen und direkten Wegen führt häufig auch zu Abkürzungen, bei denen Bequemlichkeit wichtiger als Sicherheit eingeordnet wird. Diese imaginäre Strecke oder auch „Wunschlinie“ (Śleszyński 2012:23f.) nutzen Fußgängerinnen und Fußgänger, um sich fortzubewegen. Auf eine Störung der individuellen Wunschline wird mit einer Geschwindigkeitserhöhung, Warten oder Ausweichen reagiert, mit dem Ziel, den persönlichen Freiraum zu erhalten (Lee und Kim 2017:3). Barrieren verändern die Raumwahrnehmung und nehmen Einfluss auf die individuellen Wunschlinien. Der Straßenraum wirkt durch die Unterteilung anders. Sichtbeziehungen können gestört werden, das Umfeld wird als nicht mehr überschaubar eingeordnet. Dies kann zu Unsicherheit führen, aber auch Stress auslösen (Spiegel 1992:42). Eine prominente Barriere ist die Fahrbahn, diese gilt es zügig und auf kürzestem Wege zu

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

überqueren. Das Queren wird durch verschiedene Arten von Querungshilfen, wie Aufpflasterungen, Mittelinseln oder Lichtsignalanalgen ermöglicht. Jedoch queren Zufußgehende häufig die Fahrbahn an freien Abschnitten, um Wartezeiten oder Umwege zu vermeiden. Häufig kommt es zu einer Geschwindigkeitsbeschleunigung der Querenden, was als Signal von Stress gedeutet werden kann (Śleszyński 2012:24ff.).

Hypothese 2 (H2) lautet also: Die Unterbrechung der Wunschlinie führt zu einem negativen Stressempfinden Zufußgehender.

Lärmemissionen: Lärm zählt, neben der Luftverschmutzung zu den signifikantesten Umweltbelastungen für den Menschen (Adli 2017:81). Die Biopsychologie bezeichnet Dauerlärm als gesundheitsrelevanten Stress. Die Wirkung von Lärm ist mit einer Stressreaktion gleichzusetzen. Die Stresshormone Adrenalin, Noradrenalin und Cortisol werden emittiert, der Blutdruck und die Herzfrequenz steigen. Dauerlärm kann so Krankheiten wie Hörschäden, Herz-Kreislauf-Erkrankungen und psychische Probleme auslösen (Adli 2017:81).

Im Großen und Ganzen kann bei der Einordnung von Lärm aber eine Abstufung vorgenommen werden: Bis 30 Dezibel ist ein ungestörter Nachtschlaf möglich, bei 30 bis 40 Dezibel kann es zu Schlafstörungen kommen, ab 55 Dezibel kommt es bei den meisten Menschen zu gravierenden Schlafstörungen. Ab 65 bis 70 Dezibel kommt es zu einer Stressreaktion des Körpers, 75 bis 85 Dezibel führen auf Dauer zu einem Hörschaden, ab 85 Dezibel muss am Arbeitsplatz Gehörschutz getragen werden und ab einer Lautstärke von 135 Dezibel kann es zu körperlichen Schäden kommen (Adli 2017:84f.).

Somit ist Hypothese 3 (H3): Lärmemissionen führen zu einem negativen Stressempfinden Zufußgehender.

Qualität der Wegeführung und Umgebung: Eine Studie aus dem Jahr 2021 von LaJeunesse et al. ging der Frage nach, wie Stress für Zufußgehende in Querungssituationen reduziert werden kann. Dafür wurden eine Woche lange die Herzfrequenz und Hautleitfähigkeit von 15 Teilnehmenden in Chapel Hill, North Carolina auf den Alltagswegen aufgezeichnet. Die Ergebnisse der Studie legen nahe, dass nicht das Queren als solches die Probandinnen und Probanden stresste, sondern der Zustand der Umgebung bzw. der Straßen eine hohe Korrelation mit Stressreaktionen aufwies. Ein besonders hohes Stresslevel wurde in der Nähe von Zubringer- und Durchfahrtsstraßen gemessen. Auch die Umgebungen, die durch eine hohe Nutzungsmischung oder Industrie geprägt waren, standen mit dem Erleben von Stress im Zusammenhang (LaJeunesse et al. 2021:1ff.).

Auch eine unklare Wegeführung/Leitsysteme (Ausserer et al. 2013:6), Steigungen, ein suboptimaler Straßenbelag oder mangelhafte Einsehbarkeit tragen zu einem Mehraufwand an Energie Zufußgehender bei. Dadurch wird die Qualität der Fußinfrastruktur abgewertet, was Menschen vom Zufußgehen abhalten und im Extremfall auch Angst auslösen kann. Im Hinblick auf die Qualität der Umgebung können die Ansprüche je nach Alter, Mobilitätseinschränkung, Ortskenntnis oder Wegezweck variieren (Śleszyński 2012:24).

Hypothese 4 (H4) lautet also: Eine geringe Qualität der Infrastruktur führt zu einem negativen Stressempfinden Zufußgehender.

3.2.1 Endogene Einflussfaktoren

Endogene Faktoren bestimmen zudem die Stärke des Effektes von Stressoren. Die endogenen Einflussfaktoren beziehen sich auf individuelle demographische, sozioökonomische und soziokulturelle Attribute von Individuen und deren sozialer Umgebung (Wermuth 2005:247). Hierbei kann zusammengefasst werden, dass es eine Reihe von endogenen Aspekten gibt, die die Wahrscheinlichkeit des Auftretens von Stress abmildern bzw. verstärken. Relevante Stützhypothesen sind hierbei das Geschlecht, das Alter, das Mobilitätsprofil, der Wegezweck, Gewohnheit und verschiedene psychologische Charakteristika. Diese verschiedenen Faktoren werden im Folgenden kontrollierend hinzugezogen:

Geschlecht: Aus der Literatur geht hervor, dass das Geschlecht einen Einfluss auf das unterschiedliche Stressempfinden hat. Es wird davon ausgegangen, dass Frauen schneller Stress empfinden, als Männer (Dörrzapf et al. 2014:852, Kyriakou et al. 2019:13).

Alter: Die unterschiedliche Wahrnehmung ihrer Umwelt und die unterschiedliche Gehgeschwindigkeit unterstellt Kindern (bis 14 Jahre) und Älteren (ab 70 Jahre) eine besondere Vulnerabilität im Verkehr. Es

wird angenommen, dass ein fortgeschrittenes Alter das Empfinden von negativem Stress eher begünstigt (Schoon 2010:66, Ausserer et al. 2013:57f.).

Mobilitätsprofil: Ein Mobilitätsprofil umfasst Angaben, ob Menschen beispielsweise eine Geh- oder Sehbehinderung haben. Es wird davon ausgegangen, dass eine Geh- oder Sehbehinderung das Empfinden von Stress eher begünstigt (Schoon 2010:66, Dörrzapf et al. 2014:852.).

Wegezwecke: Zufußgehender stellen, je nach Wegezweck, verschiedene Ansprüche an die Umwelt. Wegezwecke können das Pendeln zur Arbeit, das Einkaufen bzw. Erledigungen oder Freizeit sein. Es wird davon ausgegangen, dass Pendelnde tendenziell eher gestresst sind, da ihre Präferenz zugunsten einer schnellen und direkten Verbindung zum Ziel liegt (Schoon 2010:66, Śleszyński 2012:26).

Gewohnheit: Wird ein Verkehrsmittel alltäglich verwendet, wird davon ausgegangen, dass, sofern die Wahl freiwillig auf dieses Mittel fällt, weniger schnell Stress ausgelöst wird. Es liegt eine Unterscheidung nach Viel- und Weniggeherinnen sowie Viel- und Weniggeher bei der Entstehung von Stress nahe. Nicht nur das gewohnte Verkehrsmittel, auch die gewohnte Umgebung können einen Einfluss auf das Auftreten von Stress üben. In ungewohnten Umgebungen wird schneller Stress ausgelöst, als an Orten, die häufiger frequentiert werden (Ausserer et al. 2013:57f.).

Psychologische Charakteristika: Ferner werden auch psychologische Prädispositionen ausgemacht, die sich auf die Stressreaktion unterstützend oder reduzierend auswirken können (Schandry 2016:324f.). Zu diesen Faktoren psychologischer Natur zählen u.a. die Persönlichkeit, Kontrollüberzeugung und Risikobereitschaft. Die Relevanz des Einbezugs von psychologischen Merkmalen gründet sich auch auf die Bedeutung individueller Bewertungen bei der Empfindung von Stress (Kovaleva et al. 2012:5).

4 METHODIK

Das Kapitel zur Methodik stellt die Teilbereiche der Datenerhebung, Durchführung und Auswertung der Messkampagne am Marienplatz im Einzelnen vor.

4.1 Datenerhebung und Operationalisierung

Diese Arbeit unternimmt den Versuch, durch die Verwendung einer Triangulation zwischen Methoden ein möglichst umfassenderes Bild bei der Beantwortung der Fragestellung zu zeichnen. Triangulation bedeutet das Zusammendenken verschiedener Methoden bei der Datenerhebung, Messung und Interpretation (Flick 2008:12ff.). Der Untersuchungsgegenstand, das Stressempfinden Zufußgehender, wird, möglichst ausgewogen, qualitativ und quantitativ erforscht. Die Triangulation wurde bei der Studie sowohl bei der Datenerhebung (standardisierter sowie offener Fragebogen, körpernahe Daten), der Auswertung (räumlich und statistisch) und der Interpretation angewendet.

Die abhängige Variable dieser empirischen Untersuchung ist das emotionale Konstrukt Stress. Dieses zu messen ist ein komplexes Unterfangen. Es kommt darauf an, welche theoretische Grundlage angesetzt wird.

Stress im Sinne einer Reaktion lässt sich praktikabel messen, wenngleich theoretische Einschränkungen in Kauf genommen werden müssen. Dieser Ansatz der Stressmessung scheint vor allem dann sinnvoll, wenn Stress durch extrinsische Stressoren gemessen wird. Das bedeutet, wenn Stress auf einen Stressor zu einer bestimmten Zeit an einem eindeutigen Ort zurückgeführt werden soll (Kyriakou et al. 2019:2). Für diesn Beitrag werden zunächst biologische Indikatoren herangezogen, um stresshafte Momente zu identifizieren. Erweitert wird diese Betrachtung um den Einbezug persönlicher Merkmale und Selbsteinschätzungen, um dem subjektiven Erleben und Bewerten Rechnung zu tragen. Psychobiologisch stellt Stress eine komplexe psychische und physiologische Reaktion des Körpers dar, welche aus einem unangenehmen Zustand resultiert, der in als herausfordernd oder gefährlich wahrgenommenen Situationen ausgelöst wird (Kyriakou et al. 2019:1f.). Durch diese Definition wird Stress synonym zu distress, also als negativ wahrgenommener Stress verwendet. Durch die Konfrontation mit einem Stressor, zielt die Aktivierung des Autonomen Nervensystems (ANS) durch die Ausschüttung von Stresshormonen darauf ab, das Individuum zu schützen. Im Zusammenspiel mit der HPA-Achse reguliert das ANS die körperinternen Stressreaktionen mit dem Ziel eine Homoöstase herzustellen. Die Reaktionen von ANS und HPA sind anhand einer Vielzahl von körperbezogenen Parametern nachweisbar und werden als probate Methode anerkannt, um Stress durch externe Stressoren zu messen (Kyriakou et al. 2019:2). Es eignen sich Biosignale, die einfach,

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

minimalinvasiv messbar sind und sich eineindeutig der Aktivität eines Organes zurechnen lassen (Schandry 2016:537). Zu diesen zählen:

Die Hauttemperatur: Das Grundniveau der menschlichen Hauttemperatur liegt normalerweise zwischen 32 und 35 °C. In bestimmten Situationen kann diese jedoch stark schwanken. Hierzu zählen Hitze, Fieber, Unterernährung aber auch physiologische Veränderungen. Die Temperatur der Haut lässt sich mittels Thermometer über die Haut erfassen. Hinsichtlich der Richtung der Schwankungen herrscht Uneinigkeit. Teilweise wird in stressigen Situationen ein Anstieg verzeichnet, in anderen Fällen aber auch ein Absinken (Kyriakou et al. 2019:3).

Die Elektrodermale Aktivität (EDA): Anhand der EDA, auch galvanischen Hautreaktion oder Hautleitfähigkeit, lässt sich eine Aktivierung des Sympathikus identifizieren. Sie gilt als ein valider und sensibler Biomarker für eine Stressreaktion und findet breite Anwendung in der Stressforschung. Bei Konfrontation mit einem Stressor steigt die Schweißproduktion, was über Sensoren an Stellen mit vielen Schweißdrüsen, wie den Handflächen und Fußsohlen messbar ist (Schandry 2016:540f.). Es wird von einem linearen Zusammenhang zwischen emotionaler Erregung, also z.B. Stress und der Hautleitfähigkeit bis zu einem gewissen Sättigungspunkt ausgegangen (Kyriakou et al. 2019:3).

Ergänzend können standardisierte Fragebögen, die Aufschluss über persönliche Merkmale gewähren hinzugezogen werden oder auch eine Selbsteinschätzung der als stressig erlebten Momente Anwendung finden, um die physiologischen Reaktionen zu spezifizieren (Kyriakou et al. 2019:14).

Aufbauend auf der Funktionsweise dieser Biosignale haben Kyriakou et al. (2019) einen Algorithmus entwickelt, welcher das Stressempfinden von Menschen mittels tragbarerer Biosensoren messen kann. Dieses Verfahren wurde zu dem Zweck erarbeitet, Stressmomente (MOS) minimalinvasiv in Echtzeit im öffentlichen Raum durchzuführen. Zur Messung der Biosignale wurde das Biosensorarmband „E4“der Firma empatica verwendet. Dieses misst verschiedene Vitalwerte wie die EDA und Hauttemperatur, kann Bewegung erfassen und ist mit einem Global Navigation Satellite System (GNSS)- Sensor verbunden, um die gemessenen Daten geolokalisieren zu können. Die Daten werden in einer App (e-diary) auf einem mit dem Sensor verbundenen Smartphone gesammelt und es wird im Sekundentakt eine Zeitmarke angefügt, die auf der Systemzeit des Smartphones basiert. Ergebnis ist eine Datenbank, in der eine Zeile einer Sekunde des Messzeitraums entspricht und Auskunft über einen MOS (ja/nein) und dessen geographischen Koordinaten gibt, die so in ein Geoinformationssystem (GIS) eingelesen und visualisiert werden können.

Zur Überprüfung, ob die exogenen Stressoren Einfluss auf die MOS nehmen, wurde ein Mixed-Methods-Ansatz gewählt. Zur Überprüfung ursächlicher Faktoren für das Zustandekommen eines MOS, wurden Kameraaufzeichnung, Abstandsmessungen und Fragebögen verwendet.

Die Teilnehmenden wurden, neben den Biosensoren mit Kameras der Firma GoPro ausgestattet. Diese wurden auf Brusthöhe platziert und zeichneten während der Messung die Umgebung auf. Dadurch konnten Rückschlüsse auf die in den Hypothesen abgebildeten stressauslösende Faktoren gezogen warden (Kyriakou et al. 2019:14). Um den Faktor Raummangel und insbesondere Überholvorgänge unter dem gesetzlichen Mindestabstand näher zu untersuchen, wurden die Teilnehmenden mit Abstandsmessern ausgestattet. Dabei handelt es sich um den OpenBikeSensor, der mittels Ultraschallsensoren Abstände zwischen teilnehmenden Personen und ihrer Umgebung erfassen und georeferenziert abspeichern kann. Die Sensoren wurden für die Benutzung am Fahrrad konzipiert, können aber, durch Montage an einem Rucksack auch bei Zufußgehenden angewendet werden (Zeile et al. 2021:616). Zur Überprüfung der gemessenen MOS, wurden offene Fragebögen hinzugezogen, die Aufschluss über subjektive Stressmomente gewähren sollen.

Neben exogenen Faktoren beeinflussen auch endogene Faktoren das Stressempfinden. Aus der Literatur gehen gewissen Tendenzen hervor, die die Wahrscheinlichkeit einer Stressreaktion und deren Intensität positiv bzw. negativ beeinflussen können. Für die Erfassung der endogenen Faktoren wurde ein standardisierter Fragebogen konzipiert. Der erste Teil erfragte Angaben über die Person und ihren soziodemographischen Hintergrund. Des Weiteren wurde das (Fuß-)Verkehrsverhalten sowie psychiologische Merkmale erfragt. Verwendet wurden valdierte Skalen der Mobilität in Deutscland (2019) des BMVI (Nobis und Kuhnimhof 2018) und des Leibniz Instituts für Sozialwissenschaften (GESIS) (Persönlichkeit (BMVI): Rammstedt et al. 2012, Kontrollüberzeugung: Kovaleva et al. 2012, Risikobereitschaft: Beierlein et al. 2014). Die Persönlichkeit von Personen wird traditionell anhand der sog. Big Five bestimmt, welche die Eigenschaften Extraversion, Neurotizismus, Offenheit, Gewissenhaftigkeit

und Verträglichkeit umfasst. Den Big Five kann eine gute Vorhersagekraft bestimmter Lebensaspekte nachgesagt werden (Rammstedt et al. 2012:7f.).

Die Kontrollüberzeugung beschreibt den Glauben einer Person, die Kontrolle über verschiedene Situationen zu haben und sie als Resultat eigener Handlungen zu begreifen (internal) bzw., das Schicksal, Zufälle oder mächtige Andere, seien für das Zustandekommen bestimmter Ereignisse verantwortlich (external) (Kovaleva et al. 2012:7). Das Maß an Kontrollüberzeugung ist ein relevanter Faktor bei der Bewertung einer Stressreaktion (vgl. Brosschot et al. 1994).

4.2 Durchführung der Studie und Auswertung der Daten

Die Durchführung der Studie zur Messung des Stressempfindens Zufußgehender rund um den Stuttgarter Marienplatz fand in der Zeit vom 07.07.-15.07.2021 statt. Auf Basis der Schilderungen über kritische Stellen rund um den Marienplatz, an denen es vermehrt zu Konflikten zwischen den Verkehrsteilnehmenden kommt, einer Analyse der Unfallstellen mit Beteiligung des Fußverkehrs und einer eigenen Sondierung der Situation vorab, wurde eine Route für die Messung erstellt. Anvisiert war eine Strecke von rund drei Kilometern, für die die Teilnehmenden im Schnitt 35 Minuten brauchten. Die Teilnehmenden sollten vorab einen Fragebogen ausfüllen. Die Rahmenbedingungen der einzelnen Testläufe unterlangen witterungsbedingt leichten Abweichungen. Den Testpersonen wurde die Testung erläutert, die abzulaufenden Route auf Papier ausgehändigt und darauf hingewiesen, dass sie versuchen sollen, so zu laufen, wie sie es alltäglich tun. Nachdem die Teilnehmenden wieder zurückkehrten, wurde ihnen ein Fragebogen ex-post verteilt, auf dem subjektiv empfundene stressige oder entspannte Orte markieren konnten. Für die Überprüfung der exogenen Faktoren wurde ein Mixed-Methods-Ansatz aus psychophysiologischen Messungen, Kameraaufzeichnungen und Abstandsmessungen mittels dem OpenBikeSensor gewählt. Zunächst wurden die verzeichneten MOS auf Vollständigkeit und Plausibilität überprüft. Anschließend wurden die Daten anhand der zeitstemple mit den OpenBikeSensor- Daten zusammengeführt. Dann fand eine Überprüfung und Klassifizierung der Videosequenzen hinsichtlich Gründe der entsprechenden MOS statt. Weiter wurden einige Hypothesen durch zusätzliche Informationen überprüft. H1 (Raummangel-Enge) wurde mittels der OBS-Daten überprüft (Wert kleiner 150 cm). Zur Überprüfung der anderen Hypothesen wurden bekannte Unfallstellen sowie kritischen Stellen (H2: Unterbrechung der Wunschlinie) und Lärmkarten (H3: Lärm) hinzugezogen. In QGIS wurden nun auf Basis der MOS entsprechend der Hypothesen und endogenen Faktoren sog. Heatmaps erstellt. Dadurch können Erkenntnisse über Orte, an denen es zu einer Vielzahl von MOS verschiedener Personen kam, gewonnen werden. Diese wurden schließlich auch den Angaben der Fragebögen ex-post gegenübergestellt.

Variable	**$N_{Teilnehmende}$=15***	**N_{MOS}=379***
Alter (>31)	20	17,94
Geschlecht (weiblich)	66	70,45
Pendelnde (zu Fuß)	53	58,33
Vielgehende	13,33	12,66
Ortskundige	33,33	31,13
Big Five Persönlichkeitsmerkmale		
Extraversion (überdurchschnittlich)	66,66	63,06
Neurotizismus (überdurchschnittlich)	93,33	94,20
Offenheit (überdurchschnittlich)	53,33	49,60
Gewissenhaftigkeit (unterdurchschnittlich)	86,66	88,39
Verträglichkeit (unterdurchschnittlich)	53,33	50,13
Kontrollüberzeugung		
Internal (unterdurchschnittlich)	73,33	70,45
External (unterdurchschnittlich)	80	82,06
Risikoaffine	53,33	56,20

Table 1: Tabelle 1: Verteilung der Anteile der Subgruppen und deren MOS, eigene Berechnungen. *Angaben in %

Weitere Analysen mit Fokus auf die endogenen Faktoren der Teilnehmenden wurden durch entsprechende statistische Analysen getätigt. Hierbei galt es in einem ersten Schritt einen Überblick über die Verteilung der Ausprägungen zu erhalten. Zudem wurden die Verteilungen der Ausprägungen und der MOS untersucht (vgl. Tabelle 1). Für die weitere Analyse der Zusammenhänge der endogenen Faktoren und der Entstehung der MOS insgesamt und nach exogenen Faktoren gegliedert (den Hypothesen), wurden hauptsächlich Gruppenvergleiche vorgenommen. Ziel hierbei war es herauszuarbeiten, ob bei verschiedenen Ausprägungen der soziodemographischen und psychologischen Faktoren überdurchschnittlich viele bzw. wenige MOS im Vergleich zum Anteil der Ausprägung des Merkmals in der Stichprobe auftraten. Dazu wird der prozentuale

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Anteil der MOS mit dem Anteil der Stichprobe verglichen. Das Vorzeichen der Differenz kann als Hinweis auf eine über- bzw. unterproportionale Anfälligkeit für eine Stressreaktion gelesen werden. Unterstellt wird dabei ein Hinweis auf subjektive Bewertungsmechanismen, die bei der Stressgenese eine Rolle spielen. In einem weiteren, explorativen Schritt wurden auf eine hierarchische Clusteranalyse nach dem Ward-Verfahren zurückgegriffen, um ein genaueres Bild verschiedener „Stressgruppen“ (Bacher et al. 2010:19) innerhalb der Stichprobe zu erhalten. Als Distanzmaß erwies sich die Euklidische Distanz als treffend. Um die Vergleichbarkeit der Variablen zu gewährleisten, wurden diese z-standardisiert. Die Transformation zur Standard-normalverteilung gewährleistet, dass Variablenwerte absolut vergleichbar gemacht werden können, auch wenn sie auf verschiedenen Skalen gemessen wurden (Wooldridge 2012:736).

5 DISKUSSION DER ERGEBNISSE

Die 15 Datensätze umfassten nach Bereinigung insgesamt 379 MOS, im Durchschnitt waren das 25 MOS pro Probandin oder Proband. Der tatsächliche Wertebereich der MOS erstreckte sich von 18 bis 36. Nach der räumlichen Analyse der MOS und ihrer Ursachen konnten im Einklang mit aufgestellten Hypothesen Aussagen über Stellen am Stuttgarter Marienplatz getroffen werden, die als „stressend“ empfunden wurden (vgl. Abb.1). Diese Hypothesen bildeten Annahmen über exogene und endogene Einflüsse auf das Stressempfinden ab, welche anschließend räumlich (exogen) und statistisch (endogen) analysiert wurden.

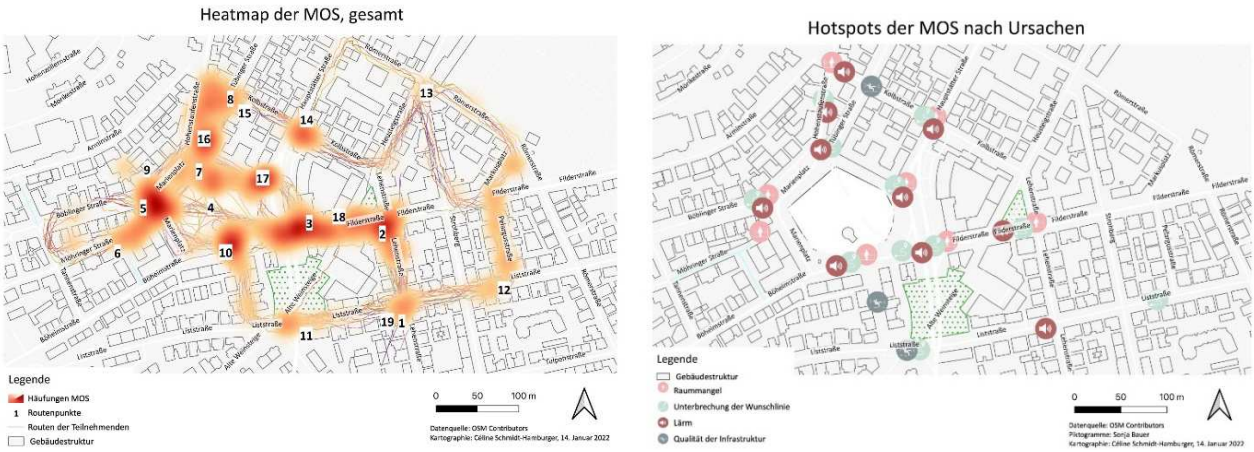


Abb. 1: Heatmaps der gemessenen Moments of Stress im Bereich Marienplatz (links) und Aufschlüsselung der Ursachen der Stressreaktionen (rechts)

Als exogene Faktoren wurden Raummangel, Unterbrechung der Wunschline, Lärm und Qualität der Infrastruktur als Ursachen für die Entstehung von MOS identifiziert und überprüft. Es zeigt sich, dass all diese Faktoren einzeln, aber auch in Kombination tatsächlich ursächlich für das Stressempfinden sein können. Hinzugezogen wurden an dieser Stelle zudem Angaben über subjektiv als stressend empfunden Stellen aus Fragebögen, die die Teilnehmenden nach Beendigung des Testlaufes machten. Es zeigt sich, dass Raummangel der häufigste Stressor im Zusammenhang mit der gebauten Umwelt bei Zufußgehenden war und zu einem MOS führte (68 %). Lärm (40 %) und die Unterbrechung der Wunschlinie (32 %) schlossen sich an und letztlich wurde auch die Qualität der Infrastruktur für einige MOS als Ursache ermittelt (12 %). Diese scheint also im Vergleich zu den anderen exogenen Einflussfaktoren eine geringere Rolle bei der Stressgenese zu spielen. Hierbei könnte die Studiensituation eine Rolle gespielt haben, wodurch die Teilnehmenden womöglich weniger Aufmerksamkeit auf ihre Umgebung als die Erfüllung ihrer Aufgabe gerichtet haben. Beim Großteil (66 %) der MOS war eine Kombination aus mehreren Stressoren ausschlaggebend. Letztlich konnten aber alle eingangs formulierten Hypothesen beibehalten werden. Zusammenfassend gibt Abbildung 1 einen Überblick über die Stellen mit der jeweils höchsten Konzentration an Stresspunkten, welche den einzelnen Hypothesen zugeordnet werden können. Anzumerken ist, dass die MOS lediglich ausdrücken, ob an einer gewissen Stelle eine Stressreaktion stattgefunden hat. Auf eine Aussage über die Intensität der Stressreaktion wurde im Gegensatz zum Ansatz von Kyriakou et al. (2019) verzichtet, da für das vorliegende Untersuchungsdesign in Kombination mit der geringeren Stichprobengröße der Faktor des Stressors interessanter war. Besonders auffällig war, dass sich die meisten MOS an großen Kreuzungen rund um den Marienplatz befanden (vgl. Abb.1). Diese entsprechen durch ihre Trennwirkung dem Stressfaktor Unterbrechung der Wunschlinie, da die Fußgängerinnen und Fußgänger dort auf ihrer

Route unterbrochen wurden. Auch der Faktor Lärm ist eng mit großen und ergo stark frequentierten Kreuzungen verknüpft. Der Faktor Raummangel wirkt ebenso an großen Kreuzungen, durch z.B. eng vorbeifahrende Autos wie auch in Bereichen von Seitenstraßen, wo Gehwege sehr eng sind und vor allem dann, wenn es zur Konfrontation mit anderen Zufußgehenden, die teilweise auch mit dem Kinderwagen o.ä. unterwegs sind, kommt. Auch in Bereichen des „Shared Space" von Fuß- und Radverkehr kam es zu MOS aufgrund von Enge. Hierbei wird die marginale Rolle des Fuß- und Radverkehrs besonders deutlich und implizit auch dessen kompetitive Nutzung knapper Verkehrsflächen. Der Einfluss der Qualität der Infrastruktur war weniger ausschlaggebend. Allerdings stellte hier der Bereich der Liststaffel eine Besonderheit dar, an dem auch eine vermehrte MOS-Konzentration festgestellt werden konnte: Die Überwindung der Höhe stellte einen zusätzlich stressauslösenden Faktor dar. Aufgrund der Homogenität der Stichprobe hinsichtlich Alter und der Abwesenheit von Mobilitätseinschränkungen, entspricht dieser Befund den Erwartungen.

Um den Aspekt der subjektiven Sicht und der individuellen Ausgangsvoraussetzungen der Teilnehmenden an-zunähernd einzubeziehen, wurden in dieser Forschung einerseits entsprechende Daten erhoben (standardisierter Fragebogen ex-ante, Kameraaufzeichnungen aus der Ego-Perspektive und offener Fragebogen ex-post). Andererseits wurden in einer tiefergehenden Analyse bestehend aus deskriptiven Statistiken und einer Clusteranalyse, die sozialpsychologischen Charakteristika der Teilnehmenden mit den MOS abgeglichen (vgl. Tab.1). Ziel war es, eine Regelmäßigkeit der Stressreaktionen auf diese zurückzuführen, um somit ein genaueres Bild der Bewertung von Stress zu erhalten. Einige vermutliche Einflussfaktoren erwiesen sich für die weitere Analyse als irrelevant, da es keine Varianz im Antwortverhalten der Teilnehmenden gab oder keine Schwankungen der MOS auf diese zurückzuführen waren. Somit wurden die Faktoren Mobilitätsprofil, Wegezweck (Pendeln) und Gewohnheit (Vielgeherinnen und Vielgeher) als messbare Ein-flussfaktoren auf das Stressempfinden verworfen. Interessante Befunde wurden hinsichtlich des Geschlechts, der Gewohnheit (Ortskenntnis), welche gemäß der Theorie verhältnismäßig zu mehr bzw. weniger MOS führten, aber auch der psychologischen Charakteristika herausgearbeitet. Hierbei konnte festgestellt werden, dass Menschen mit den Merkmalen überdurchschnittliche ausgeprägte Verträglichkeit, einem überdurchschnittlich hohen Maß an internaler Kontrollüberzeugung und bei überdurchschnittlich ausgeprägtem Neurotizismus verhältnismäßig mehr MOS aufweisen. Diese letzte Erkenntnis deckt sich mit Befunden aus der Forschung, die bei neurotischen Menschen eine hohe Stressanfälligkeit (Medical Tribunal Verlagsgesellschaft 2021).). Bei Menschen mit höherer internaler Kontrollüberzeugung liegt die Vermutung nahe, dass diese ggf. einen mildernden Effekt auf die MOS haben könnte, da die Personen eher denken, dass sie die Konsequenzen ihrer Handlungen selbst in der Hand haben. Mutmaßlich könnte dadurch auch das Stressemp-finden gesteigert werden, da diese Personen auch die Verantwortung bei sich sehen könnten. Vice versa gestaltet sich die Erkenntnislage bei den Komponenten überdurchschnittliche Extraversion, Offenheit, Gewissenhaftigkeit, externale Kontrollüberzeugung und Risikobereitschaft. Menschen mit diesen Eigenschaften, verzeichneten weniger MOS. Am stärksten war hier der Effekt bei Extraversion, was, wie auch der Einfluss der anderen Faktoren, plausibel erscheint. Bei dem Faktor externale Kontrollüberzeugung könnte der gegenteilige Effekt ihres internalen Pendants eintreten. Ist diese bei Menschen ausgeprägt, glauben diese, dass die Kontrolle von außen kommt, wobei sie in Bezug auf Stress vielleicht auch ihre Empfindungen externalisieren.

Abschließend wurde eine Clusteranalyse durchgeführt, um etwaige Gruppen hinsichtlich der sozialpsychologischen Charakteristika zu bilden, welche im Hinblick auf das Stressempfinden statistische Ähnlichkeiten aufweisen. Es konnten drei etwa gleichgroße solcher Cluster gebildet werden, welche ihrem Wesen nach als Zögerliche Einzelgängerinnen mit Pioniergeist (Cluster 1), Sicherheitsabenteurerinnen und Sicherheitsabenteurer (Cluster 2) und Unsichere Einzelgänger (Cluster 3) beschrieben wurden:

Cluster 1: Das erste Cluster umfasst sechs weibliche, mittelmäßig ortskundige Teilnehmende. Sie sind durchschnittlich extravertiert und neurotischer, eher weniger offen, eher weniger gewissen-haft sowie eher weniger verträglich als der Durchschnitt. Sie haben eine überdurchschnittliche internale, eine unterdurchschnittliche externale Kontrollüberzeugung und sind eher risikoaffin. Die Teilnehmenden weisen im Schnitt mehr MOS (28), als jene aus den anderen Clustern und als der globale Durchschnitt auf.

Cluster 2: Das zweite Cluster umfasst sechs ortskundige Teilnehmende. Angehörige dieses Clusters sind weniger extravertiert, eher neurotischer, eher offener, weniger gewissenhaft, eher weniger verträglich als der Durchschnitt. Sie haben eine eher unterdurchschnittliche internale, eher überdurchschnittliche externale

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Kontrollüberzeugung und sind risikoaffin. Die Teilnehmenden weisen durchschnittlich viele MOS (25) im Vergleich zu den anderen Clustern und dem globalen Wert auf.

Cluster 3: Das dritte Cluster umfasst drei männliche, ortsunkundige Teilnehmende. Angehörige dieses Clusters sind extravertierter, weniger neurotisch, offen und gewissenhaft und eher verträglicher als der Durchschnitt. Sie haben eine eher überdurchschnittliche internale und durchschnittliche externale Kontrollüberzeugung und sind eher risikoavers. Die Teilnehmenden dieses Clusters weisen durchschnittlich weniger MOS (20) im Vergleich zu den anderen Clustern und dem globalen Wert auf.

Kritisch anzumerken sind an dieser Stelle einige Punkte. Die Daten des OpenBikeSensors (OBS) sind bei dieser Forschung nicht hinlänglich auf die Anwendung bei Zufußgehenden angepasst, da die Sensoren lediglich den Abstand nach links zuverlässig messen. Die originäre Konstruktion des OBS für die Abstandsmessung zwischen Radfahrenden und überholenden Autos ist dafür ursächlich. Notwendig wäre es, die Messdaten auch für alle anderen Richtungen aufzeichnen zu können. Auch ist, wie bereits mehrfach erwähnt, die Homogenität der Gruppe sehr hoch. Um ein diversifizierteres Bild zu erhalten, wäre eine breiter angelegte Akquise der Teilnehmenden, v.a. in Bezug auf das Alter, Menschen mit Mobilitätseinschränkungen und mehr sozioökonomischer/-kultureller Vielfalt, vonnöten gewesen. Um eine bessere Vergleichbarkeit der Messergebnisse zu erzielen, wäre es von Vorteil gewesen, die Durchführung der Studie für alle Teilnehmenden zum selben Zeitraum stattfinden zu lassen. Auch ist die Wahl des Stuttgarter Marienplatzes nicht unkritisch zu sehen. Die Wahl des Platzes ist durch Nutzungsmischung und Flächenkonkurrenz zwar gut begründet, jedoch an sich bereits gut gestaltet und zentral gelegen.. Es stellt sich allerdings die Frage, ob es im gesamtstädtischen Kontext sinnstiftend ist, einen passablen Ort aufgrund einer Vielzahl von Studien zu verbessern oder alternativ peripherere Orte zu untersuchen, welche sich der gemeinen Aufmerksamkeit häufig entziehen, für viele Gruppen aber eine zentrale Bedeutung haben. Vor allem für Gruppen, die häufig nicht am Stadtdiskurs teilnehmen und somit nicht Wissenschaft, Politik und Verwaltung auf den Plan rufen.

6 FAZIT

Um mehr Wissen über das Zusammenspiel von Stress und Zufußgehen zu generieren, wurden in einem triangulierenden Prozess gemessene Stressdaten, gemeinsam mit Angaben zur Soziodemographie, dem Mobilitätsverhalten und der Psyche der Teilnehmenden erhoben, um eine umfassende Analyse der Stressoren vor Ort durchzuführen. Im Einklang stehen sollten hierbei exogene und endogene Einflussfaktoren, um die Entstehung von Stress gezielter untersuchen zu können. Die exogenen Faktoren wurden anhand der gemessenen Biomarker Hautleitfähigkeit und -temperatur in einen Algorithmus überführt, welcher nach bestimmten Kriterien die Aussage trifft, ob es eine Stressreaktion, bzw. einen MOS gab oder nicht. Die Aufzeichnungen waren georeferenziert, wodurch sie räumlich mithilfe von Geoinformationssystemen in Heatmaps Aufschluss über die räumliche Häufung von MOS und damit Hinweise auf relevante Stellen am Untersuchungsort geben konnten. Um die subjektiven Unterschiede bei Stressreaktionen (endogene Faktoren) zu berücksichtigen, wurden also bei der Analyse der MOS auch die sozialpsychologischen Angaben und die als subjektiv stressend empfundenen Stellen einbezogen.

Die relevantesten Stressoren waren hierbei Raummangel, die Unterbrechung der Wunschline und Lärm. Bei der Analyse der Stützhypothesen zeigte sich dass in dieser Studie einerseits Frauen eher dazu neigen Stress zu empfinden. Ortskundige Menschen neigen zu weniger MOS. Bei den psychologischen Charakteristika zeigte sich, dass die Faktoren Neurotizismus, Verträglichkeit und internale Kontrollüberzeugung die Entstehung von Stress eher befördern. Sind Menschen eher extravertiert, offen, gewissenhaft, risikobereit und haben ein höheres Maß an externaler Kontrollüberzeugung, weisen diese eine Tendenz zu weniger MOS auf. Zudem konnten mithilfe einer hierarchischen Clusteranalyse drei Clustergruppen (Zögerliche Einzelgängerinnen mit Pioniergeist, Sicherheitsabenteurerinnen, Sicherheitsabenteurer und Sicherheitsaffine Einzelgänger) berechnet werden. Diese Cluster dienen als Vorschlag für eine genauere Untersuchung der Wirkung von Planvorhaben, die mit der gebauten Umwelt in Verbindung stehen, auf bestimmte Gruppen. Diese Unterteilung hatte den Zweck, den „Faktor Mensch“ bei der Messung des Stressempfindens differenzierter zu fassen, aber gleichzeitig durch eine Gruppenbildung von Einzelfallbetrachtungen Abstand zu nehmen.

Zusammenfassend kann gesagt werden, dass die Forschungsfragen vollumfänglich beantwortet wurden und dadurch, im Rahmen dieser Studie, aussagekräftige Ergebnisse generiert werden konnten. Nicht nur wurden

bauliche Stressoren herausgestellt, die von außen Einfluss nehmen, sondern auch das innere Milieu von Personen einbezogen, die das Stressempfinden Zufußgehender am Marienplatz in Stuttgart konstituieren. Zudem stellte sich die Methodenmischung als geeignet dar, um diese verschiedenen Informations- und Kontextebenen zu erfassen, abzubilden und zu interpretieren. Zwar ist diese Untersuchung durch ihre Stichprobe nicht als repräsentativ einzuordnen, kann und soll aber als Anreiz für weitere Forschungen dieser Art dienen. Wie eingangs erwähnt kann durch die Reduktion des Stressempfindens das Zufußgehen attraktiver gestaltet werden, um somit zu nachhaltigeren, gesünderen und sozial gerechteren Städten beizutragen.

7 REFERENCES

AUSSERER, K., Füssl, E., Risse, R.: Nutzerinnen- und Nutzerbefragung: Was gefällt am Gehen und was hält davon ab? Vienna, 2013.

BACHER, J., Pöge, A., Wenzig, K.: Clusteranalyse: Anwendungsorientierte Einführung in Klassifikationsverfahren. München, 2010.

BEIERLEIN, C. et al.: Eine Single-Item-Skala zur Erfassung von Risikobereitschaft: Die Kurzskala Risikobereitschaft-1 (R-1). In: GESIS-Working Papers 34, 2014.

BERCHT, A.L.: Stresserleben, Emotionen und Coping in Guangzhou, China: Mensch-Umwelt-Transaktionen aus geographischer und psychologischer Perspektive. Stuttgart, 2013.

BROSSCHOT, J.F., Gebhardt, W.A., Godaert, G.L.R.: Internal, powerful others and chance locus of control: relationships with personality, coping, stress and health. In: Personality and Individual Differences 16(6), S. 839-852, 1994.

CANNON, W. B.: The wisdom of the body. New York, 1932.

DÖRRZAPF, L. et al.: Walk & Feel – a new integrated walkability research approach. REAL CORP 2019, 2014.

FLICK, U.: Triangulation: Eine Einführung. Wiesbaden, 2008.1-26. Basel, 2019.

HOLMES, T. H., Rahe, R.H.: The social readjustment rating scale. In: Journal of Psychosomatic Research 11(2), S. 213-218, 1967.

KALUZA, G. (2007): Gelassen und sicher im Stress. Heidelberg, 2007.

KIM, S. et al.: Personal space, evasive movement and pedestrian level of service. In: Journal of Advanced Transportation 48, S. 673-684, 2014.

KNIE, A., Zehl, F., Schelewsky, M.: Mobilitätsreport 05: Ergebnisse aus Beobachtungen per repräsentativer Befragung und ergänzendem Mobilitätstracking bis Ende Juli. Bonn/Berlin: 7331 – MOBICOR, 2021.

KNOFLACHER, H.: Grundlagen der Verkehrs- und Siedlungsplanung. Wien, 2007.

KOVALEVA, A., Beierlein, C., Kemper, C.J., Rammstedt, B.: Eine Kurzskala zur Messung von Kontrollüberzeugung: Die Skala Internale-Externale-Kontrollüberzeugung-4 (IE-4). In: GESIS-Working Papers 19, 2012.

KYRIAKOU, K. et al.: Detecting moments of stress from measurements of wearable physiological sensors. In: Sensors, Vol. 19, Issue 17, pp

LAJEUNESSE, S. et al.: Measuring pedestrian level of stress in urban environments: naturalistic walking pilot study. In: Transportation Research Record 2675(10), S. 109-119, 2021.

LAZARUS, R.S.: Stress and emotion: A New Synthesis. New York, 1999.

LEE, J., Kim, T.: Development of comfort level assessment measures for pedestrian traffic flow. Conference Paper TRB Annual Meeting, 2017.

LYON, B.L: Stress, Bewältigung und Gesundheit: Konzepte im Überblick. In: Rice, V.H. (Hrsg.): Stress und Coping. Lehrbuch für Pflegepraxis und -wissenschaft. Bern, 2005. S. 25-47.

MEDICAL TRIBUNAL VERLAGSGESELLSCHAFT: Neurotischen Menschen geht es während der Coronakrise emotional schlechter, 2021.

NOBIS, C., Kuhnimhof, T.: Mobilität in Deutschland - MiD Nutzerhandbuch: Fragenübersicht. Bonn: Bundesministerium für Verkehr und digitale Infrastruktur, 2018.

RAMMSTEDT, B. et al.: Eine kurze Skala zur Messung der fünf Dimensionen der Persönlichkeit: Big-Five-Inventory-10 (BFI-10). In: GESIS-Working Papers 23, 2012.

SCHANDRY, R.: Biologische Psychologie. 4. Auflage. Weinheim, 2016.

SCHMIDT, L. R.: Stress. Bern, 2021.

SCHOON, J. G.: Pedestrian facilities - engineering and geometric design. London, 2010.

SELYE, H.: The stress of life. New York, 1956.

SLESZYNSKI, M.: Modellierung und Analyse des Verhaltens von Fußgeherinnen und Fußgehern vor und nach Beruhigung einer Geschäftsstraße. Wien, 2012.

SPEIGEL, T.: Die Empfindung des Widerstandes von Wegen unterschiedlicher Verkehrsmittelbenützung und deren Auswirkung auf das Mobilitätsverhalten [Dissertation]. Wien, 1992.

UMWELTBUNDESAMT: Fußverkehr, 2018.

WERMUTH, M.: Modellvorstellungen zur Prognose. In: Gerd Steierwald, Hans D. Künne und Walter Vogt: (Hrsg.): Stadtverkehrsplanung: Grundlagen, Methoden, Ziele. 2. Auflage, S. 243-295. Berlin, 2005.

WOOLDRIDGE, J.: Introductory econometrics: A modern approach. 5.Auflage. Toronto, 2012.

ZEILE, P. et al.: Radfahren auf realen und virtuellen Flächen – Das NRVP-Projekt Cape Reviso. REAL CORP 2021, 2021.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

🏆 *reviewed paper*

Strukturiertes Vorgehen zur Entwicklung von Szenarien für die Entscheidungsunterstützung

Corinna Schittenhelm, Charlotte Knab

(MSc. Corinna Schittenhelm, TU Kaiserslautern, Pfaffenbergstraße 95, 67663 Kaiserslautern, corinna.schittenhelm@ru.uni-kl.de)
(MSc. Charlotte Knab TU Kaiserslautern, Pfaffenbergstraße 95, 67663 Kaiserslautern, charlotte.knab@ru.uni-kl.de)

1 ABSTRACT

Der Demographische Wandel stellt Politik, Wirtschaft, Verwaltung und Gesellschaft vor vielfältige Herausforderungen, insbesondere durch den raschen Anstieg des Altenquotienten: Standen 1950 noch 16 Personen im Rentenalter 100 Erwerbstätigen gegenüber, waren es 2020 bereits 37 (Statistisches Bundesamt 2022). Für das Jahr 2030 wird ein Altenquotient von 47 prognostiziert (Statistisches Bundesamt 2021). Die Ausprägungen unterscheiden sich wesentlich zwischen verschiedenen Raumtypen sowie zwischen den alten und neuen Bundesländern (Statistisches Bundesamt 2022).

Bevölkerungsentwicklung und -verteilung unterliegen diversen Einflussfaktoren, die gleichzeitig auch Bedürfnisse und Lebensweisen der Gesellschaft verändern. Alterung, Klimawandel und auch unvorhergesehene Ereignisse wie Corona-Pandemie oder Ukraine-Krieg gehören zu den Faktoren der Veränderung und erschweren gleichzeitig genaue Prognosen über deren Entwicklung. Ein Ziel der Bundesregierung ist es, „gleichwertige Lebensverhältnisse überall“ (BMI 2019: 3) zu schaffen und die Grundfunktionen im Sinne der Daseinsvorsorge zu sichern (BMI 2019: 9). Die Stadtplanung befasst sich bereits seit einigen Jahren mit dem Demographischen Wandel und dessen Folgen für Städte und Gemeinden. Der Fokus liegt hierbei häufig auf der Entwicklung geeigneter Ansätze für das Wohnen oder der Anpassung sozialer Infrastruktur (Hochstadt 2006: 553 ff., von Mackensen 2007: 317ff.). Damit sich die Stadtplanung zukünftig zielgerichteter, begründeter und präventiver auf veränderte gesellschaftliche Anforderungen ausrichten kann, könnte ein Ansatz sein, Lösungsansätze auf verschiedene mögliche Zukünfte auszurichten. Im Sinne eines „Was wäre, wenn?“ müssen entsprechende Szenarien für eine frühzeitige Unterstützung von Entscheidungen entwickelt werden.

Der vorliegende Beitrag knüpft an dieser Stelle an und stellt ein strukturiertes Vorgehen zur Entwicklung von Szenarien mit Hilfe von Geoinformationssystemen vor, das Kommunen dabei unterstützen kann, Entscheidungen in Bezug auf die Ausstattung und Gestaltung der Daseinsgrundfunktionen zu treffen. Als erste Annäherung wird die Daseinsgrundfunktion „sich versorgen“ betrachtet.

Am Beispiel der Gemeinde Remshalden wird die Erreichbarkeit von Nahversorgern im Bereich Lebensmittel untersucht. Anhand von Szenarien wird die bestmögliche räumliche Anordnung und deren potenzielle Veränderung in Lage, Art und Anzahl aufgrund der Verteilung der Kohorte der Babyboomer im Stadtgebiet dargestellt. Durch diese Methode können Kommunen Erkenntnisse darüber gewinnen, welche Einrichtungen sie entsprechend der Bevölkerungsentwicklung in den Quartieren möglichst optimal verorten und in welcher Form diese ausgestaltet sein müssen, um die Daseinsvorsorge zu sichern.

Die Forschung findet im Rahmen des Projekts „Ageing Smart – Räume intelligent gestalten“ statt, das durch die Carl-Zeiss-Stiftung gefördert wird.

Keywords: Demographischer Wandel, Daseinsvorsorge, Bevölkerungsentwicklung, Babyboomer, Szenarien

2 EINLEITUNG

Die Bundesregierung hat das Ziel, „gleichwertige Lebensverhältnisse überall“ (BMI 2019: 3) zu schaffen und die Grundfunktionen im Sinne der Daseinsvorsorge zu sichern (BMI 2019: 9). Unter Daseinsgrundfunktionen „[…] werden […] solche grundlegenden menschlichen Daseinsäußerungen, Aktivitäten und Tätigkeiten verstanden, die allen sozialen Schichten immanent, massenstatistisch erfaßbar, räumlich und zeitlich meßbar sind und sich raumwirksam ausprägen.“ (Maier et al 1977: 100) Die Grundfunktionen umfassen „[…] ‚in Gemeinschaft leben‘, ‚wohnen‘, ‚arbeiten‘, ‚sich versorgen‘, ‚sich bilden‘ und ‚Freizeitverhalten‘.“ (ebd.) Durch den Demographischen Wandel v.a. in Verbindung mit der Digitalisierung verschiebt und verändert sich die Nachfrage nach unterschiedlichen Gütern und Dienstleistungen.

Als eine grundsätzliche Herangehensweise an die Verteilung von Standorten der Daseinsgrundfunktion stellte sich das Zentrale-Orte-Konzept heraus, das auf Walter Christaller zurückgeht. Gemäß dem Konzept übernehmen Grund-, Unter- und Oberzentren festgeschriebene Versorgungs- und Entwicklungsfunktionen

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

der Bevölkerung. Vor allem aufgrund der Digitalisierung, Lieferdiensten und weiteren on-demand Angeboten verändern sich die Versorgungsanforderungen jedoch stark. Da die zukünftigen Bedarfe und Verhaltensweisen der Gesellschaft, insbesondere der Babyboomer, nicht vorhersehbar sind, werden auf Basis von Annahmen verschiedene Szenarien entwickelt.

In diesem Paper wird ein strukturiertes Vorgehen zur Entwicklung von Szenarien zur Entscheidungsunterstützung mit Geoinformationssystemen am Beispiel der Stadt Remshalden vorgestellt.

3 VERÄNDERUNG DER RAHMENBEDINGUNGEN IM DEMOGRAPHISCHEN WANDEL

Der Demographische Wandel beschreibt „[…] die Veränderung der Bevölkerung nach Zahl und Struktur." (Gans 2018: 376) Die Bevölkerung in Deutschland schrumpft und wird zunehmend älter. (Sange, von Wulffen 2022: 2) Die Geburtenrate war in den 1950ern und 1960ern hoch und erreichte ihren Peak 1964 mit durchschnittlich 2,53 Kindern pro Frau. (Bundesinstitut für Bevölkerungsforschung 2022a) Derzeit liegt sie bei 1,53 Kindern pro Frau. (Bundesinstitut für Bevölkerungsforschung 2022a) Gleichzeitig steigt die Lebenserwartung. 2016/2018 betrug die Lebenserwartung der Männer bei Geburt 78,5 Jahre, die der Frauen 83,3 Jahre (BPB 2020). 1871/1881 betrug sie bei beiden Geschlechtern weniger als die Hälfte (Männer: 35,6 Jahre, Frauen: 38,4 Jahre) (BPB 2020). Derzeit „[…] nimmt die durchschnittliche Lebenserwartung pro Jahr um etwa drei Monate zu, also in vier Jahren um etwa ein ganzes Jahr." (Sange, von Wulffen 2022: 2).

Die geburtenstärkste Kohorte sind die sogenannten Babyboomer, die zwischen 1955 und 1969[1] geboren wurden. Die Babyboomer wuchsen in einer Zeit auf, in der sich die Rolle der Frau in der Gesellschaft veränderte. Mit dem Gesetz über die Gleichberechtigung von Mann und Frau auf dem Gebiet des bürgerlichen Rechts (sog. Gleichberechtigungsgesetz), das am 03.05.1957 vom Bundestag beschlossen wurde, erlangten Frauen in der BRD neue Rechte (Deutscher Bundestag 2022). Das Gesetz förderte die soziale und gesellschaftliche Gleichstellung von Frauen und Männern und führte u.a zu den rückläufigen Geburtenzahlen und einem veränderten Arbeitsmarkt.

Durch die Rentenreform im Jahr 2012 wurde das Regelrentenalter (schrittweise bis 2031) von 65 auf 67 Jahre angehoben (Bundesinstitut für Bevölkerungsforschung 2022b). Die Babyboomer treten sukzessive in den Ruhestand ein, sodass im Jahr 2030 die meisten Babyboomer im Ruhestand sein werden. (Sange, von Wulffen 2022: 2) Nichtsdestotrotz sind die Menschen bei Renteneintritt durchschnittlich fitter als die vorangegangenen Generationen. Dies liegt unter anderem daran, dass die sportliche Aktivität von Erwachsenen laut dem Gesundheitssurvey des Robert Koch Instituts (Stand 2015) über den Zeitraum von 1998-2012 deutlich zunahm. (RKI 2015: 191)

Die Kohorte der Babyboomer unterscheidet sich auch in weiteren, für die Ausgestaltung von Daseinsgrundfunktionen relevanten Merkmalen wesentlich von den vorherigen Generationen. Es handelt sich um die bislang geburtenstärkste Kohorte. Die Babyboomer stellen derzeit ca. 30% der Gesamtpopulation in Deutschland dar (Körber Stiftung 2018: 2). Aus dieser Entwicklung ergibt sich ein Mehrbedarf an Infrastrukturen, die für die Versorgung der Bedarfe dieser Altersgruppe notwendig sind. Die Babyboomer sind mobiler als vorhergehende Generationen. Das liegt primär an den positiven Entwicklungen im Gesundheitsbereich der älteren Bevölkerung.

Neben den gesellschaftlichen Entwicklungen ändern sich die Ausgestaltungsmöglichkeiten der Angebote zur Sicherung der Daseinsvorsorge. Die Anzahl der Personen, die Zugang zum Internet haben, stieg von 2002 bis 2018 in allen Altersklassen zwischen 43 und 84 Jahren an. (BMFSFJ 2020: 62) In der Altersklasse 55-60 Jahre stieg der Anteil von 2002 bis 2017 von 34,2 % auf 90 % an, bei den 61–66-jährigen im gleichen Zeitraum von 17,2 % auf 79,7 %. (BMFSFJ 2020: 62) Diese Ausstattung ermöglicht es den Nutzerinnen und Nutzern, ihre Gewohnheiten in allen Lebensbereichen zu verändern. Homeoffice, Online-Handel und Anwendung von (Liefer-)Apps sind mitunter Ursache für Veränderungen in den räumlichen Bewegungsmuster von Personen sowie einem veränderten Nachfrageverhalten.

Zusammenfassend lässt sich festhalten, dass die Bevölkerung in Deutschland im Durchschnitt u. a. älter wird, fitter bleibt, technikaffiner und mobiler ist als die Generationen zuvor. Zusätzlich treten die Babyboomer in den nächsten Jahren in den Ruhestand ein, sodass sich der Alltag einer großen

[1] Entsprechend der Definition im Projekt "Ageing Smart - Räume intelligent gestalten", gefördert durch die Carl Zeiss Stiftung.

Bevölkerungsgruppe verändern wird. Die Bewegungsmuster werden sich u. a. durch den Wegfall des Arbeitswegs ändern. Die Nachfrage nach verschiedenen Dienstleistungen kann sich durch die gewonnene Freizeit ebenfalls stark verändern. Aufgrund dieser Entwicklungen sind sowohl der Umfang als auch die Ausgestaltung notwendiger Angebote zu überdenken. Gleichzeitig müssen die Bedürfnisse der übrigen Generationen bei der Planung von Einrichtungen zur Sicherung der Daseinsgrundfunktionen berücksichtigt werden. Die Diversität der Einflussfaktoren erschwert Prognosen zur Bevölkerungsentwicklung und verteilung. Eine genaue Vorhersage der zukünftigen Verhaltens- und Nutzungsmuster dieser Bevölkerungsgruppe ist nicht möglich, allerdings sind raumrelevante Veränderungen zu erwarten. Eine mögliche Lösung für die Planung besteht darin, Lösungsansätze auf verschiedene mögliche Zukünfte auszurichten. Mit Hilfe der Szenariotechnik müssen für eine frühzeitige Unterstützung von Entscheidungen verschiedene Szenarien im Sinne eines „Was wäre, wenn?“ entwickelt werden. Diese können Kommunen und der Politik in Zukunft als Entscheidungsunterstützung dienen. Am Beispiel der Nahversorgung im Bereich der Lebensmittel wird dieser Wandel im Folgenden verdeutlicht.

4 SZENARIEN FÜR DIE ENTSCHEIDUNGSUNTERSTÜTZUNG ZUR SICHERUNG DER DASEINSVORSORGE DER BABYBOOMER IN SUBURBANEN RÄUMEN

4.1 Die Szenariotechnik

Die (raumrelevanten) Verhaltens- und Nutzungsmuster lassen sich in der Planung aufgrund unvollständiger oder unsicherer Information nicht vorhersagen. Es ist allerdings möglich, potenzielle Wirkungsketten aufzuzeigen. „[...] [B]ei Raumplanung [geht es] v.a. um das Offenhalten von Zukunftsoptionen für kommende Generationen (nachhaltige Entwicklung) und um Aktivitätsfolgenabschätzung [...]”. (Scholles 2008: 358). Als Methode für die Entscheidungsunterstützung bezüglich zukünftiger Bedarfsentwicklungen wird häufig die Szenariotechnik angewendet. Hiermit „[...] sollen realistische Entwicklungsmöglichkeiten bzw. -korridore in vergleichsweise ferner Zukunft und bei relativ großer Unsicherheit innerhalb eines bestimmten Rahmens und unter bestimmten Annahmen systematisch aufgezeigt werden.” (Scholles 2008: 381)

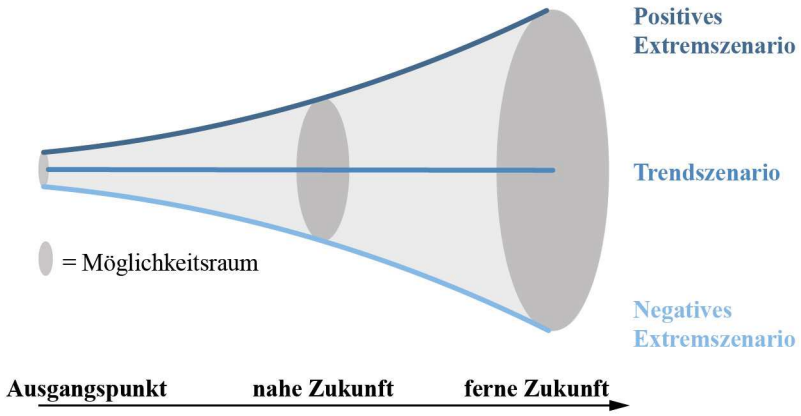


Abbildung 1: Szenariotrichter

Bei dieser Methode müssen Annahmen getroffen werden über Ereignisse, die in der Zukunft liegen. Eine Annahme kann z. B. sein, dass es immer wieder zum gleichen Ergebnis führt, wenn „[...] die gleichen Kräfte [unter denselben Umgebungsbedingungen] auf dieselben Objekte einwirken.” (Shearer 2005: 67) Annahmen, die Menschen betreffen, sind weniger prognostizierbar, da die Möglichkeit besteht zwischen verschiedenen Optionen zu wählen. (ebd.)

Nach Scholles bedarf es bei der Erstellung von Szenarien die folgenden Bausteine: „Systemanalyse, Rahmenbedingungen der Entwicklung, Entwicklungspfade, Zukunftsbilder” (Scholles 2008: 382).

In diesem Paper werden am Beispiel der Stadt Remshalden Szenarien entwickelt, die die Kommunen bei der Entscheidung folgender Fragestellung unterstützen können: Wo müssen Nahversorger verortet werden und wie müssen diese ausgestaltet sein, damit die Grundversorgung mit Lebensmitteln für die alternde Kohorte der Babyboomer sowohl heute als auch zukünftig durch aktive Mobilität erreichbar ist?

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

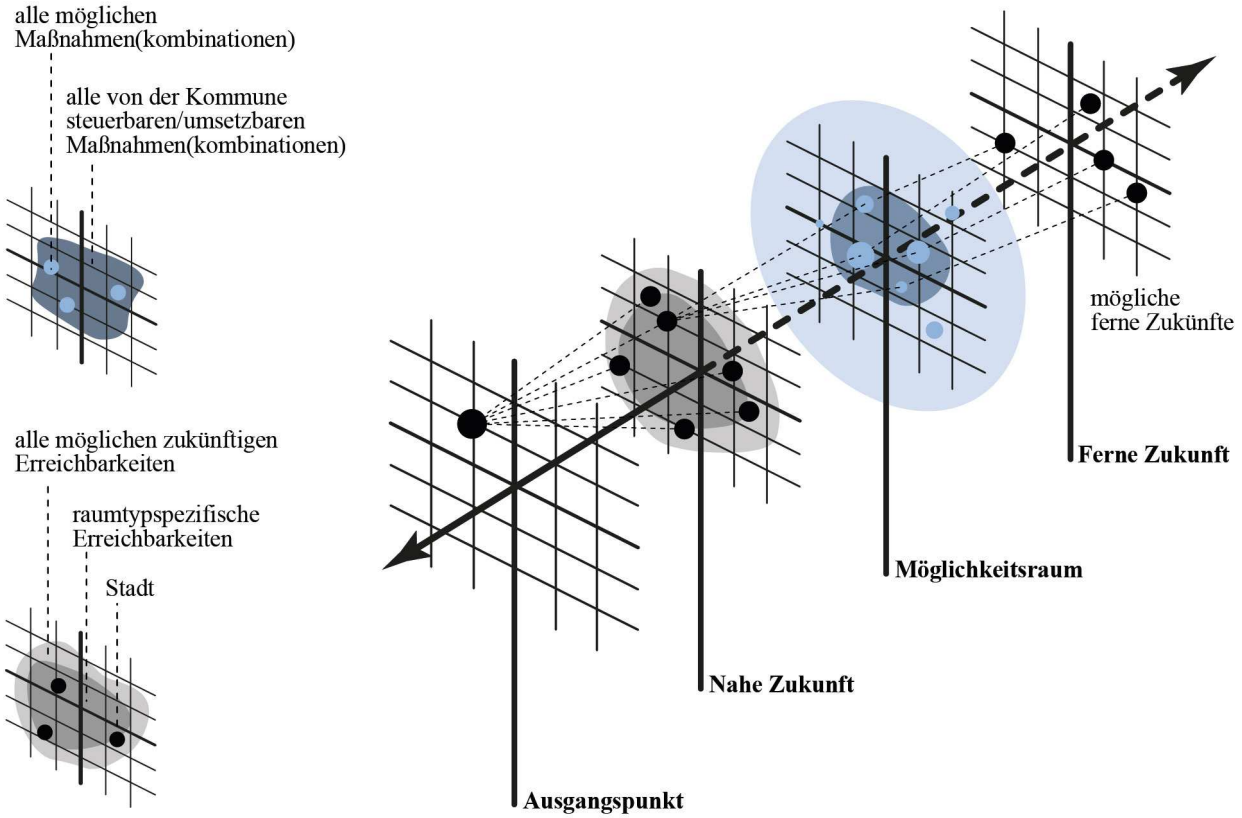


Abbildung 2: Szenarienstrang (Eigene Darstellung in Anlehnung an Shearer 2005: 71)

Der Ausgangspunkt beschreibt den Ist-Zustand, der eindeutig definiert werden kann. Für die nahe Zukunft ergeben sich verschiedene neue Ausgangssituationen, die von den Erreichbarkeiten in verschiedenen Raumtypen sowie von den Rahmenbedingungen der Stadt selbst abhängen. Entsprechend des in naher Zukunft eintretenden Zustandes kann die ferne Zukunft beeinflusst werden. In einem bestimmten Möglichkeitsraum sind verschiedene Maßnahmen oder Maßnahmenkombinationen enthalten, die die Erreichbarkeiten der Versorgungsangebote in der fernen Zukunft bestimmen. In diesem Fall sind sie auf alle von der Kommune steuerbaren oder umsetzbaren Maßnahmen(kombinationen) beschränkt.

Die Untersuchung basiert auf der Annahme, dass die aktuell überwiegend fitten und mobilen Babyboomer in den nächsten zehn Jahren altern und ihre Mobilitätsmöglichkeiten infolgedessen eingeschränkt werden.

4.2 Analyse der Erreichbarkeit von Nahversorgern am Beispiel der Stadt Remshalden

Hierfür wird zuerst der Ist-Zustand analysiert: Wo wohnen die Babyboomer in Remshalden? Dazu wurde eine GIS-basierte Analyse auf Grundlage der Daten des Zensus 2011 durchgeführt, um die Schwerpunktbereiche für die Altersklasse der 40–59-jährigen zu ermitteln. Die untersuchte Zielgruppe, im folgenden Babyboomer genannt, ist derzeit entsprechend 51 bis 70 Jahre. Wie bereits dargelegt sind die Babyboomer per Definition derzeit zwischen 53 und 67 Jahre alt. Es ergibt sich eine Differenz aufgrund einer abweichenden Aggregation der Daten durch den Zensus, die im Zuge dieses Papers vernachlässigbar ist.

Um die Schwerpunktbereiche zu ermitteln, wurde zuerst eine Punktdichteanalyse durchgeführt. Diese Methode eignet sich gut, wenn sehr kleinräumige Daten zur Verfügung stehen, die einzeln nicht mehr handhabbar sind, sodass sich keine konkreten Schwerpunkte ablesen lassen. Durch die Punktdichte entstehen allerdings keine konkreten Schwerpunkte, sondern lediglich Bereiche mit hoher Dichte. Soll eine Erreichbarkeit ausgehend von diesen Schwerpunktbereichen gerechnet werden, ergeben sich bei der weiteren Bearbeitung Schwierigkeiten, da eine Erreichbarkeitsanalyse immer von einem Punkt und nicht von einem Polygon ausgeht. Eine Möglichkeit wäre es, den geometrischen Mittelpunkt des Schwerpunktbereichs als Ausgangspunkt für die Erreichbarkeit zu wählen. Dieser spiegelt jedoch i.d.R. nicht die Erreichbarkeit der Randbereiche wieder. Eine weitere Möglichkeit besteht darin, die Schnittpunkte zwischen dem Wegenetz und der Kanten des Schwerpunktbereichs zu verwenden. Dadurch wird bei großen Bereichen wiederum eine

größere Erreichbarkeit für die zentralen Lagen des Schwerpunktbereichs suggeriert, sodass es ebenfalls zu einer Diskrepanz in der Aussage kommt. Dichteanalysen verwenden Suchradien und Ausgaberaster, um eine räumliche Konzentration darzustellen. Je gröber die Eingangsdaten, desto diffuser das Ergebnis. Die vorliegenden Hektarrasterdaten des Zensus stellen solch eine grobe Körnung dar, wodurch die analysierten Schwerpunktbereiche anhand der Punktdichte sich von der eigentlichen Konzentration der Babyboomer unterscheidet. (siehe Abb. 3: rote Überzeichnungen decken zum Teil nicht die Hektarrasterpunkte mit einer hohen Anzahl an Babyboomern ab)

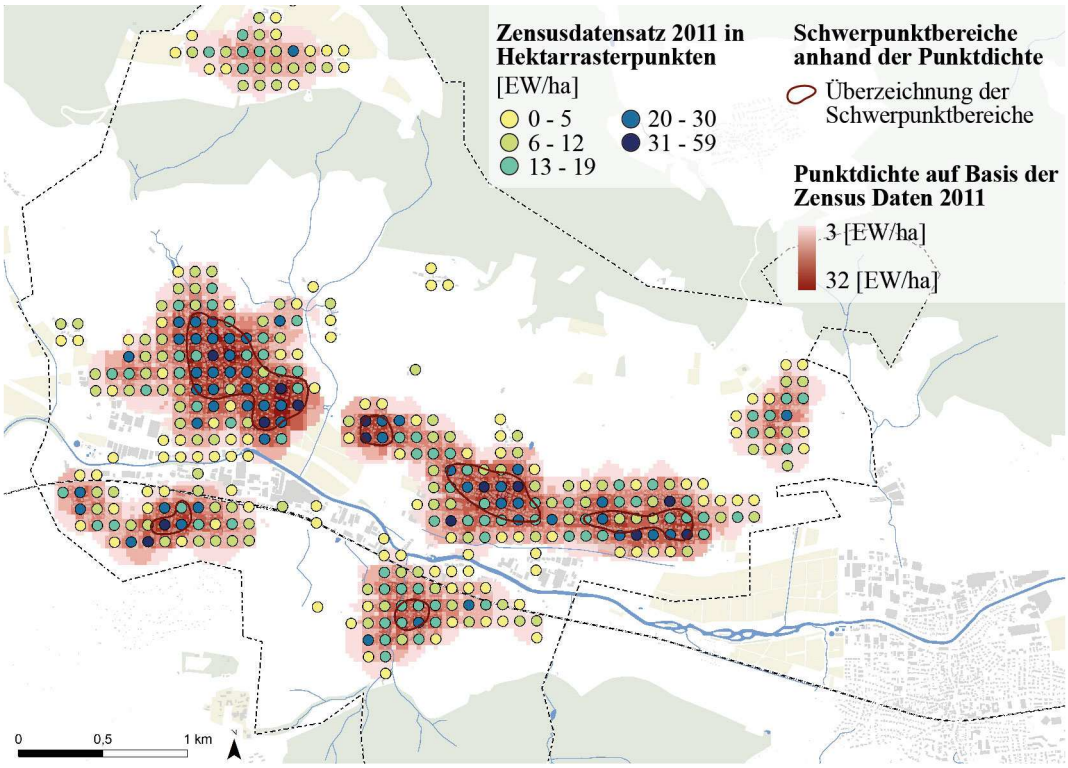


Abbildung 3: Schwerpunktbildung anhand der Verteilung der Babyboomer – Vergleich Punktdichte vs. Hektarrasterpunkte

Neben der Verwendung der absoluten Anzahl der Babyboomer je Hektarrasterpunkt, kann außerdem der Anteil zur Gesamtbevölkerung betrachtet werden. Je nach Betrachtungsweise entstehen hier unterschiedliche Schwerpunkte. Beide Varianten haben jedoch ihre Berechtigung. Zum einen ist es interessant zu wissen, wo sich eine hohe Anzahl an Babyboomern befindet, da hier eine höhere Nachfrage besteht. Zum anderen stellen die anteiligen Schwerpunkte Bereiche dar, in denen es ein spezifisches Bedürfnis gibt, dem entsprechend entgegengewirkt werden muss und die lokale Nachfrage an spezifischen Angeboten höher ist.

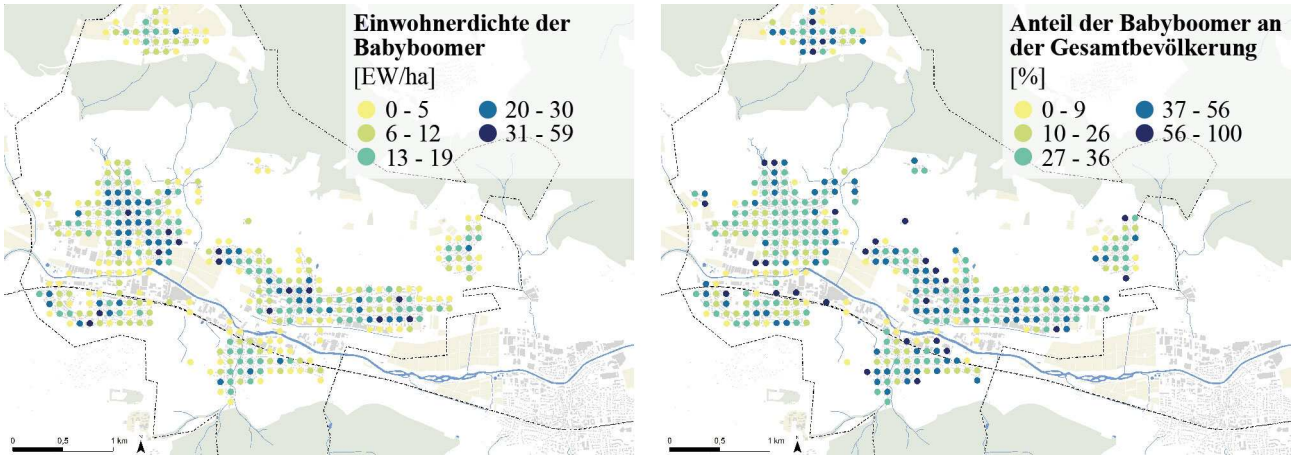


Abbildung 4: Verteilung der Babyboomer absolut und anteilig zur Gesamtbevölkerung

Die Schwerpunkte der Verteilung der Babyboomer nach ihren Absolutwerten liegen hauptsächlich in den zentralen Lagen sowie in den dichteren Gebieten der peripheren Siedlungsstrukturen. Durch die homogene Verteilung der Bevölkerung in Remshalden entspricht die absolute Verteilung der Babyboomer nahezu der

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

der Gesamtbevölkerung. Die anteilige Verteilung der Babyboomer zur Gesamtbevölkerung weicht davon ab und zeigt, dass sie v.a. an den Ortsrändern und Hanglagen einen großen Anteil ausmachen. Dies könnte auch darauf zurückzuführen sein, dass an den Ortsrändern mehr Einfamilienhäuser durch Babyboomer bewohnt werden.

Im nächsten Schritt wurden zur Untersuchung der Ausgangslage die vorhandenen Versorgungsangebote für Lebensmittel in Remshalden verortet, um die Erreichbarkeit für die Babyboomer sowohl zu Fuß, mit dem Fahrrad und dem E-Bike zu analysieren. Hierfür wurden die osm-Daten als Basis herangezogen und mithilfe einer Internetrecherche vervollständigt. Bei der Recherche wurden die administrativen Grenzen der Gemeinde Remshalden bewusst überschritten und auch Versorgungsangebote außerhalb der Gemeinde mit in die Ausgangssituation aufgenommen. Ziel ist es, Synergien zwischen den Gemeinden zu identifizieren und durch gemeinsame Planung ressourcenschonende und optimierte Standorte für die Angebote zu ermitteln. Um das bestehende Versorgungsangebot abzubilden, wurden zwei Gruppen gebildet: Supermärkte und Angebote mit einem umfassenden Sortiment sowie spezifische Angebote mit einem reduzierten Sortiment, wie z. B. Bäcker, Metzger oder Obst- und Gemüsehändler.

Ausgehend von den Versorgungseinrichtungen wurden für die Analyse folgende Geschwindigkeiten angenommen:

- Fußgängerin oder Fußgänger: Die Durchschnittsgeschwindigkeit liegt bei 4 km/h bei einer Reichweite von 10 Minuten
- Fahrradfahrerin oder Fahrradfahrer: Die Durchschnittsgeschwindigkeit liegt bei 14 km/h bei einer Reichweite von 10 Minuten
- E-Bike: Die Durchschnittsgeschwindigkeit liegt bei 20 km/h bei einer Reichweite von 10 Minuten

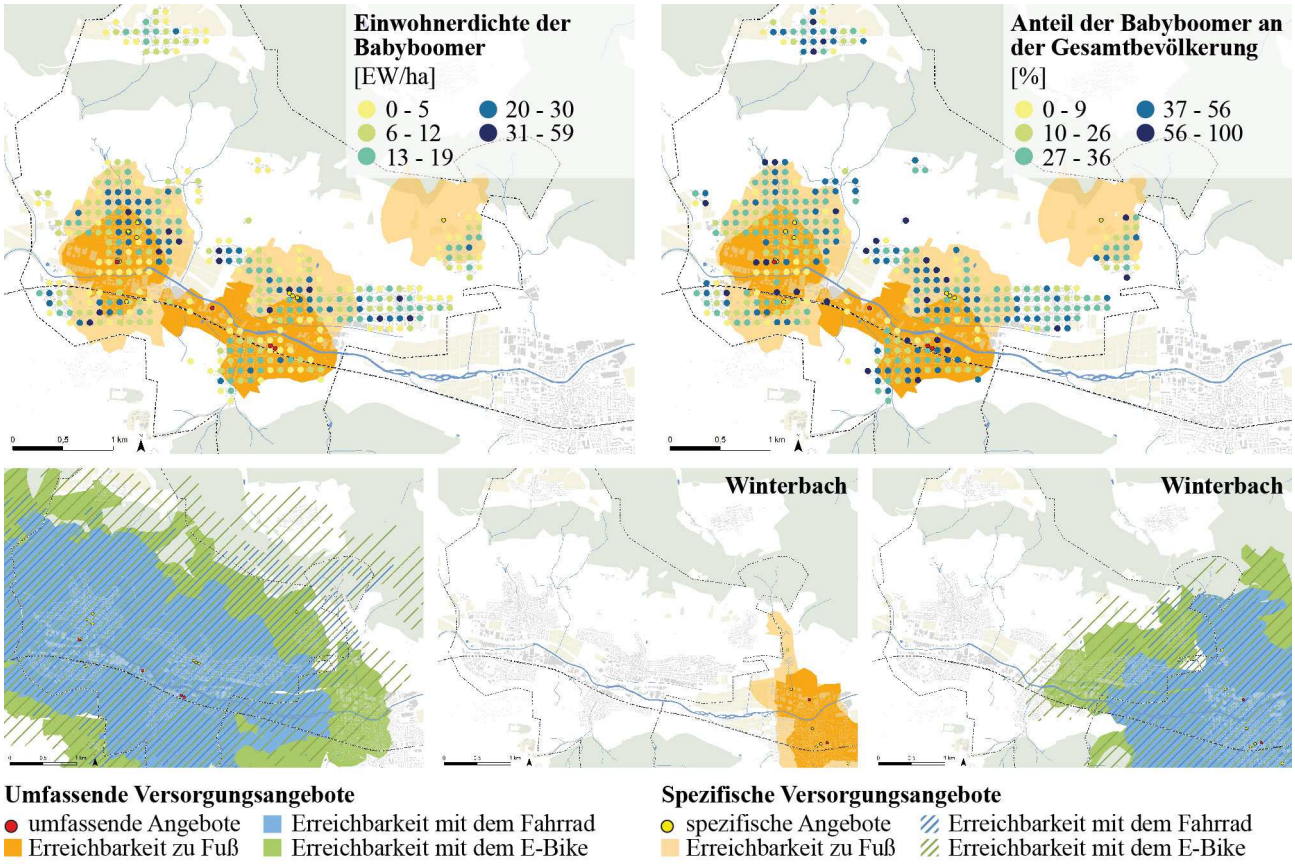


Abbildung 5: Ausgangslage der Versorgungsangebote und deren Erreichbarkeit durch aktive Mobilität

Die fußläufige Erreichbarkeit der umfassenden Versorgungsangebote in Remshalden decken nur einen kleinen Bereich des Siedlungsgebietes ab. Durch die Ergänzung spezifischer Angebote wird die Versorgungssituation bereits erheblich verbessert, jedoch müssen viele Personen weite Wege zu Einrichtungen mit einem umfassenden Sortiment zurücklegen. Die Überlagerung der absoluten bzw. anteiligen Verteilung der Babyboomer zeigt, dass die vorhandenen Angebote die Schwerpunkte der

absoluten Verteilung bereits in einem akzeptablen Rahmen abdecken, die Schwerpunkte der anteiligen Verteilung jedoch nicht. Die Analyse der bestehenden Versorgungseinrichtungen der Nachbargemeinde Winterbach zeigt, dass diese die Versorgung in Remshalden nur mit dem Fahrrad oder dem E-Bike verbessert. Fußläufig sind diese Angebote durch die räumliche Distanz nicht innerhalb der vorgegebenen Zeit und Reichweite zu erreichen und werden deshalb im weiteren nicht mehr berücksichtigt.

4.3 Szenarien für die zukünftige Erreichbarkeit von Nahversorgern

Schließlich wurden anhand der von Scholles aufgestellten Methodik Szenarien entwickelt. Hierfür wurde eine Systemanalyse durchgeführt, die Rahmenbedingungen der Entwicklung zugrunde gelegt und Zukunftsbilder entworfen.

Systemanalyse:

„interne Steuerelemente oder Stellgrößen, über die der Entscheider die völlige Kontrolle hat." (Scholles 2008: 328 nach Shearer 2005: 76f.) „Der Entscheider" ist die Kommune.

- Bauleitpläne (Flächennutzungsplan, Bebauungsplan)
- städtebauliche Verträge
- kommunale Wirtschaftsförderung
- aktive Ansiedlungspolitik

„externe Steuerelemente oder Stellgrößen, die der Entscheidungsträger zwar nicht voll kontrollieren, aber beeinflussen kann" (Scholles 2008: 328 nach Shearer 2005: 76f.)

- Impulse für Händler über die Möglichkeiten der Ausgestaltung der Angebote sowie deren strategisch optimalen Standorte

„Strukturelemente, die vom Entscheidungsträger nicht beeinflusst werden können." (Scholles 2008: 328 nach Shearer 2005: 76f.)

- Entscheidung, wo Geschäfte sich ansiedeln
- Nutzung der Angebote durch die Babyboomer

Rahmenbedingung der Entwicklung:

In diesem Schritt wird ein Entwicklungskorridor skizziert, in dem „[…] sich später die einzelnen Szenarien [bewegen]." (Scholles 2008: 383) Zusätzliche Schwellenwerte geben an, wann das System nicht mehr funktioniert. Die Rahmenbedingungen und Entwicklungen wurden bereits ausführlich in Kapitel 3 erläutert und betreffen hauptsächlich den Demographischen Wandel und die Digitalisierung.

Schwellenwerte sind in der Raumplanung nur schwer zu bestimmen. Anders als in Naturwissenschaften, in denen es eindeutige Schwellenwerte wie z. B. Schmelzpunkte gibt, sind in der Raumplanung vielfältige Faktoren einzubeziehen, die voneinander abhängen und i.d.R. auf Annahmen basieren. In diesem Beitrag wird angenommen, dass das System nicht mehr funktioniert, wenn keine auskömmliche Nachfrage besteht oder es keine Möglichkeit gibt, eine Nahversorgung von Lebensmitteln wohnstandortnah aufrecht zu erhalten.

Entwicklungspfade und Zukunftsbilder:

Entsprechend des Szenariotrichters (siehe Abb. 1) werden unter Berücksichtigung der Rahmenbedingungen der Entwicklung auf der Basis von Annahmen drei Szenarien entwickelt, ein Trendszenario sowie ein positives und ein negatives Szenario. Das Trendszenario zeigt den Stand in zehn Jahren auf, wenn sich alles weiterentwickelt wie bisher. Ausgehend von den ursprünglich angenommenen Geschwindigkeiten sind die Annahmen bezüglich der Erreichbarkeiten von Lebensmittelnahversorgern im Trendszenario folgende:

- Fußgängerin oder Fußgänger: Die Durchschnittsgeschwindigkeit bleibt bei 4 km/h bei einer Reichweite von 7 Minuten
- Fahrradfahrerin oder Fahrradfahrer: Die Durchschnittsgeschwindigkeit verlangsamt sich von 14 km/h auf 10 km/h bei einer Reichweite von 7 Minuten
- E-Bike: Die Durchschnittsgeschwindigkeit verlangsamt sich von 20 km/h auf 15 km/h bei einer Reichweite von 7 Minuten

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Das positive Szenario basiert auf der Annahme, dass die Mobilität der Babyboomer sich nicht verschlechtert. Die Annahmen der Analyse entsprechen dem Ist-Zustand:

- Fußgängerin oder Fußgänger: Die Durchschnittsgeschwindigkeit bleibt bei 4 km/h bei einer Reichweite von 10 Minuten
- Fahrradfahrerin oder Fahrradfahrer: Die Durchschnittsgeschwindigkeit bleibt bei 14 km/h bei einer Reichweite von 10 Minuten
- E-Bike: Die Durchschnittsgeschwindigkeit bleibt bei 20 km/h bei einer Reichweite von 10 Minuten

Das negative Szenario basiert auf der Annahme, dass die Babyboomer weiterhin Lebensmittel benötigen, jedoch in den nächsten 10 Jahren altern und in ihrer Mobilität eingeschränkt werden. Das bedeutet:

- Fußgängerin oder Fußgänger: Die Durchschnittsgeschwindigkeit verlangsamt sich von 4 km/h auf 3 km/h bei einer Reichweite von 5 Minuten.
- Fahrradfahrerin oder Fahrradfahrer Die Nutzung eines nicht elektrisch betriebenen sowie elektrisch betriebenen Fahrrads ist nicht mehr möglich.

4.4 Analyse der Szenarien für die zukünftige Erreichbarkeit von Nahversorgern am Beispiel der Stadt Remshalden

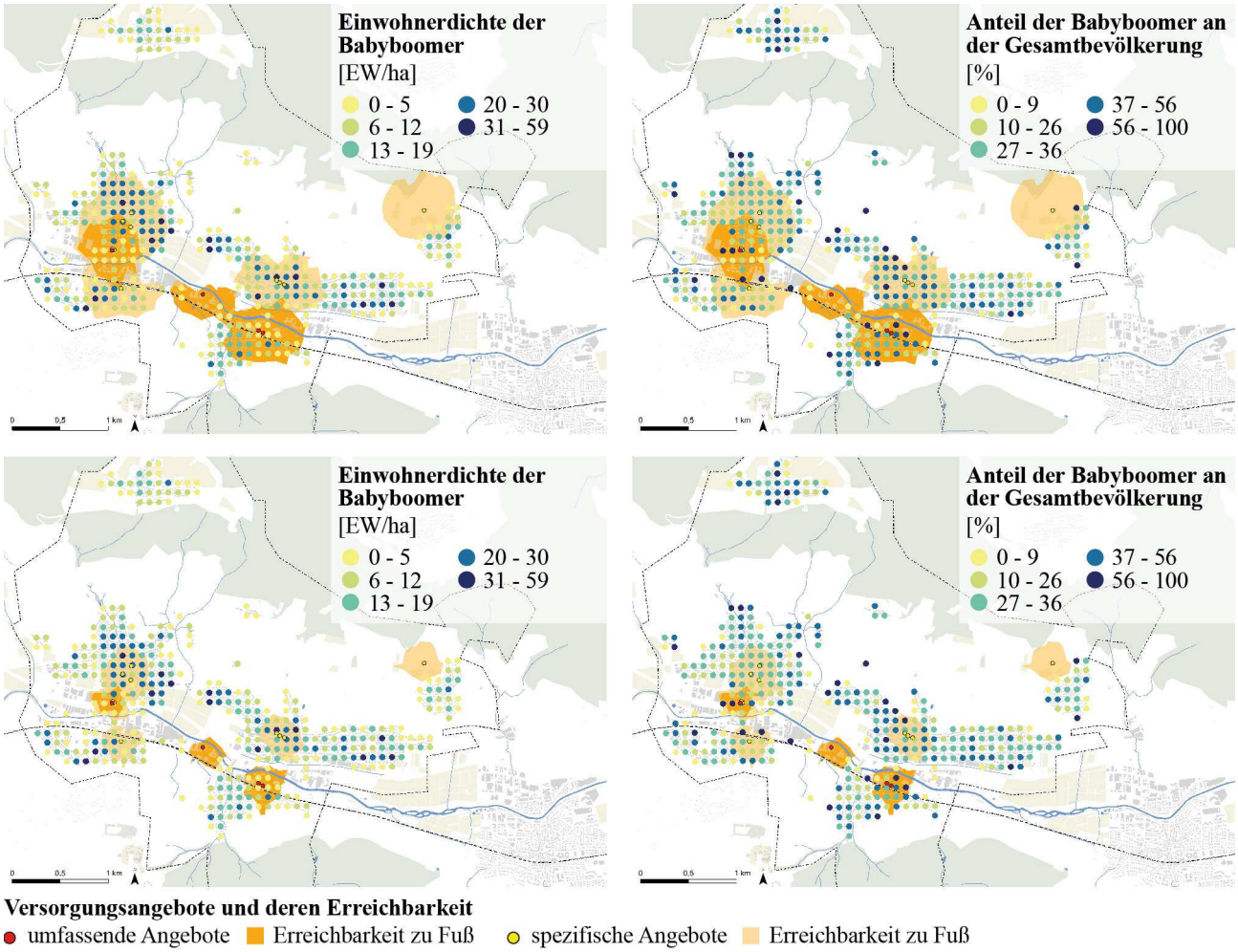


Abbildung 6: Fußläufige Erreichbarkeit in Relation zur absoluten und anteiligen Verteilung der Babyboomer (oben: Trendszenario, unten: negatives Szenario)

Da bereits in der Analyse der Ausgangslage offensichtlich wurde, dass die Nahversorger mit dem Fahrrad und dem E-Bike erreicht werden können, wurden in diesem Schritt lediglich die fußläufigen Erreichbarkeiten analysiert. Das positive Szenario wird hier ebenfalls nicht dargestellt, da es der Ausgangslage entspricht (siehe Abb. 5). Im Trendszenario ist erkennbar, dass sich die fußläufige Erreichbarkeit, durch die reduzierte Geschwindigkeit und Reichweite deutlich verringert. Erreichten zum Ausgangszeitpunkt 1.183 von insgesamt 4.192 Babyboomern die umfassenden Versorgungseinrichtungen, sind es im Trendszenario noch

483. Die Erreichbarkeiten der Nahversorger mit dem Fahrrad und E-Bike bleiben trotz der reduzierten Geschwindigkeit und Reichweite weiterhin gut.

Im negativen Szenario reduzieren sich die Versorgungsmöglichkeiten drastisch, sowohl bei der absoluten als auch der anteiligen Verteilung. Das liegt vor allem daran, dass die Babyboomer in diesem Szenario keine Fahrräder oder E-Bikes mehr nutzen. Zusätzlich reduziert sich die fußläufige Erreichbarkeit. In diesem Szenario erreichen lediglich noch 125 Babyboomer die umfassenden Versorgungseinrichtungen. Die Versorgung ist hier sowohl in der absoluten als auch der anteiligen Betrachtung unzureichend.

4.4 Analyse bestmöglicher Standorte für Nahversorger in fußläufiger Erreichbarkeit

Nachdem die Schwerpunktbereiche der Babyboomer ermittelt wurden, stellt sich die Frage, an welchen Orten weitere oder zusätzliche Angebote eingerichtet werden müssen (bei ungenügender Versorgung) und in welcher Form diese ausgestaltet sein sollten. Die bestmögliche Platzierung ist dabei jene, die am meisten Babyboomer versorgt. Für die entsprechende Analyse wird, ausgehend von jedem Zensus Hektarrasterpunkt, jeweils eine Erreichbarkeitsanalyse berechnet. Die Anzahl der erreichten Babyboomer wird daraufhin anhand einer lagebezogenen Verbindung wieder auf die einzelnen Hektarrasterpunkte überschrieben. Diese Analyse wird mit den Absolutwerten sowie mit den anteiligen Werten berechnet. Wie oben aufgezeigt, besteht ein Versorgungsdefizit vor allem bei der fußläufigen Erreichbarkeit. Um den optimalen Versorgungsgrad zu erreichen, wird in dieser Analyse die fußläufige Erreichbarkeit mit den Angaben aus dem negativen Szenario verwendet. Ist die optimale Versorgung durch die Kommune nicht umsetzbar, muss sie die bestmögliche Versorgung unter den gegebenen Rahmenbedingungen anstreben. Hierfür wurde in einem zweiten Schritt die selbe Analyse mit den Werten der Trendszenarios durchgeführt. Durch die größere Erreichbarkeit in dieser Variante ergibt sich ein größerer Möglichkeitsraum.

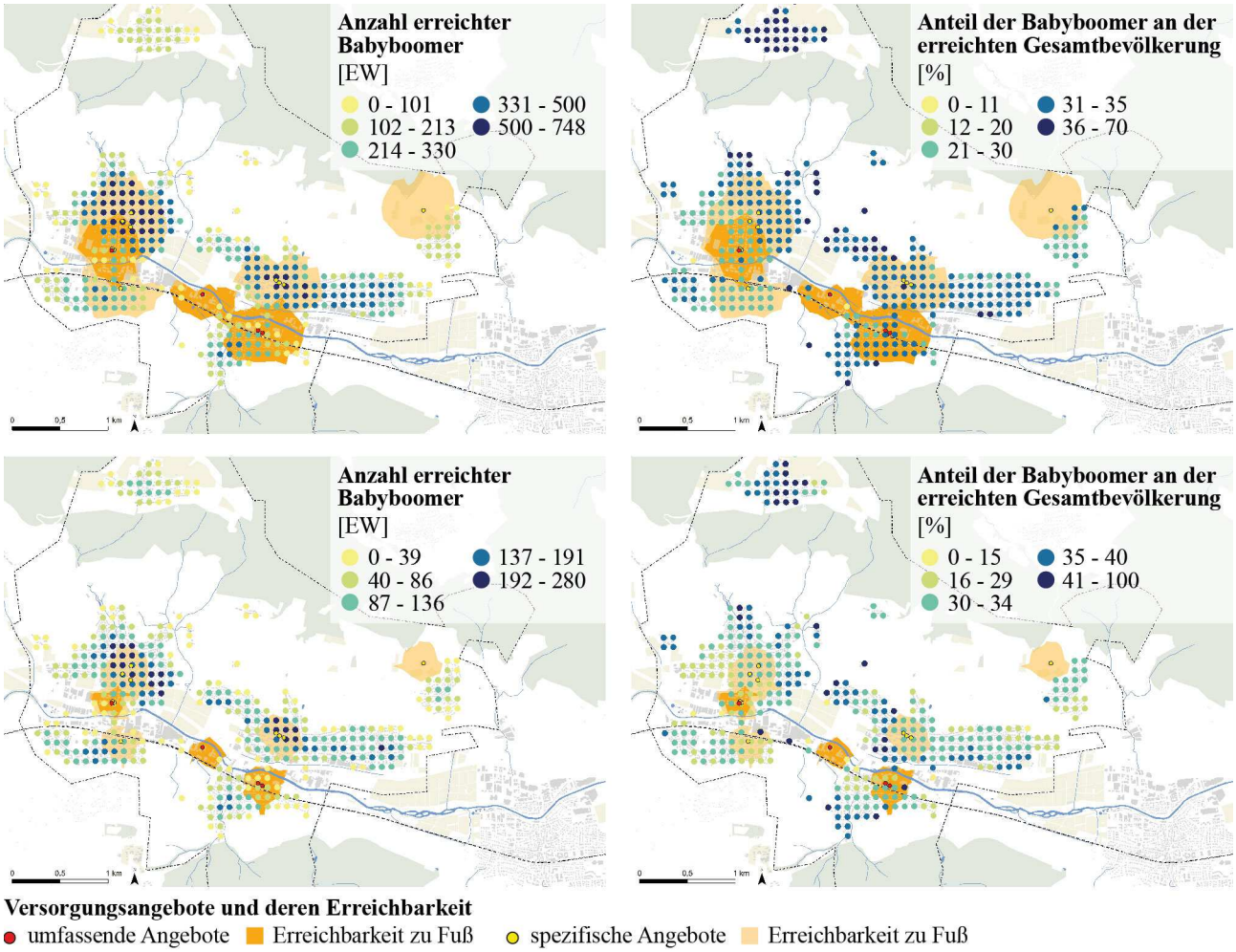


Abbildung 7: Optimierte Standorte für die bestmögliche Versorgung in Bezug auf die absolute bzw. anteilige Verteilung der Babyboomer mit den Annahmen des Trendszenarios (oben) und des negativen Szenarios (unten)

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Wie zu erwarten unterscheiden sich die Standorte der bestmöglichen Verteilung der Versorgungseinrichtung je nach Betrachtung der absoluten oder anteiligen Werte. In beiden Fällen orientieren sich die optimalen Standorte an den jeweiligen Schwerpunktbereichen. Die Ergebnisse der Absolutwerte zeigen, dass die vorhandenen spezifischen Angebote bereits gut mit den optimalen Standorten übereinstimmen. Die umfassenden Angebote weichen jedoch erheblich davon ab. Wie bereits in Kapitel 4.2 analysiert, deckt sich die absolute Verteilung der Babyboomer mit der der Gesamtbevölkerung. Strategisch ist es demnach sinnvoll, an den optimalen Standorten der Absolutwerte umfassende Angebote oder Zentren zu errichten, um so auch die restliche Bevölkerung in Remshalden besser zu versorgen.

Bei der Betrachtung der anteiligen Werte zeigt sich die Relevanz zusätzlicher Angebote v. a. in fußläufiger Erreichbarkeit. Die Bevölkerung überaltert und möchte trotzdem häufig für sich selbst sorgen (siehe Kapitel 3). Die zusätzlichen Angebote müssen kein umfassendes Versorgungsangebot aufweisen. Vielmehr ist darüber nachzudenken, eine Kombination aus verschiedenen Angeboten zu schaffen, die nicht zwangsläufig dauerhaft verfügbar sein müssen. Zu nennen wären hier u. a. Lieferdienste, on-demand Angebote, ehrenamtlich geführte Ladengeschäfte, Regiomaten oder auch Abholstationen, die z. B. durch ein Zahlenschloss gesichert sind und auch ohne digitale Kompetenz nutzbar sind. Um etwaige Barrieren bei der Nutzung digitaler Dienste abzubauen, wäre es möglich, den Nutzern eine Unterstützung zu bieten, z. B. in Form eines (ehrenamtlichen) Ansprechpartners im Bürgerhaus, Weiterbildungen zur Nutzung digitaler Angebote o. ä. Gleichzeitig ist aufgrund der beschriebenen Entwicklungen anzunehmen, dass einige bestehende Einrichtungen und Angebote zukünftig obsolet werden.

5 FAZIT

Anhand der unterschiedlichen Szenarien lässt sich gut abbilden, wie sich die Versorgungssituation je nach angenommener Entwicklung verändert. Zusätzlich können anhand der Analyse der optimalen Standorte Konzepte entwickelt werden, die die zukünftige Versorgung in allen Bereichen der Stadt sichern. Ebenso können Prioritätsräume definiert werden. Anhand der Ergebnisse lassen sich Ansprüche an die Ausprägung der Angebote identifizieren, die in das Versorgungskonzept aufgenommen werden können. Da die Angebote i.d.R. von privaten Akteuren betrieben werden, hat die Kommune nur begrenzt Einfluss auf die Sicherung der Nahversorgung. Bei diesbezüglichen Entscheidungen muss sie sich zuerst ihre Steuerungsmöglichkeiten bewusst machen und ggf. neue Anreize schaffen. Unter anderem haben Kommunen die Möglichkeit im Sinne einer Anreizpolitik Grundstücke oder Immobilien vorzuhalten und dadurch gezielt niederschwellige Optionen für potenzielle Inhaber zu schaffen.

In einem nächsten Schritt ist zu überprüfen, ob die Erreichbarkeit von Nahversorgern in Remshalden, stellvertretend für andere suburbane Gemeinden steht oder welchen Unterschied bspw. eine andere Bevölkerungsverteilung macht. Zusätzlich ist zu überprüfen, ob die Erreichbarkeit von Nahversorgern wie anzunehmen in urbanen Räumen tendenziell besser und in ruralen Räumen schlechter ist. Weiterer Forschungsbedarf besteht überdies darin den Unterschied zu klären, der zwischen der Analyse auf Basis von kleinräumigen Daten im Vergleich zu Hektarrasterdaten liegt. Dementsprechend sind auch die geeigneten Methoden der Erreichbarkeitsberechnung im Hinblick auf den Startpunkt der Berechnung zu erforschen. Zusätzlich könnten die Schwerpunktbereiche ggf. mit genaueren Daten und weiteren Gebäudeinformationen noch konkreter definiert werden.

6 REFERENCES

BMI – BUNDESMINISTERIUM DES INNERN, FÜR BAU UND HEIMAT (2019): Unser Plan für Deutschland – Gleichwertige Lebensverhältnisse überall. Schlussfolgerungen von Bundesminister Horst Seehofer als Vorsitzendem sowie Bundesministerin Julia Klöckner und Bundesministerin Dr. Franziska Giffey als Co-Vorsitzende zur Arbeit der Kommission „Gleichwertige Lebensverhältnisse“, Berlin. Stand Juli 2019.

BUNDESINSTITUT FÜR BEVÖLKERUNGSFORSCHUNG (2022a): Demografieportal 2022. Natürliche Bevölkerungsentwicklung. Abgerufen unter: https://www.demografie-portal.de/DE/Fakten/natuerliche-bevoelkerungsentwicklung.html;jsessionid=5CE8CA2284E09DCE141CAE7A115F9B78.intranet661?nn=676848, Zugriff: 20.06.2022.

BUNDESINSTITUT FÜR BEVÖLKERUNGSFORSCHUNG (2022b): Demografieportal 2022. Renteneintrittsalter. Abgerufen unter: https://www.demografie-portal.de/DE/Fakten/renteneintrittsalter.html, Zugriff: 20.06.2022.

BMFSFJ - BUNDESMINISTERIUM FÜR FAMITIE, SENIOREN, FRAUEN UND JUGEND, REFERAT ÖFFENTLICHKEITSARBEIT (2020): Achter Altersbericht. Ältere Menschen und Digitalisierung. Deutscher Bundestag 19. Wahlperiode. Drucksache 19/21650. Berlin. Abgerufen unter:

https://www.bmfsfj.de/resource/blob/159938/3970eecafb3c3c630e359379438c6108/achter-altersbericht-langfassung-data.pdf, Zugriff: 29.07.2022.

BUNDESZENTRALE FÜR POLITISCHE BILDUNG (2020): Lebenserwartung. Fernere Lebenserwartung im Alter von 60 Jahren nach Geschlecht, 1871 bos 2060. Abgerufen unter: https://www.bpb.de/kurz-knapp/zahlen-und-fakten/soziale-situation-in-deutschland/61547/lebenserwartung/, Zugriff: 05.08.2022.

DEUTSCHER BUNDESTAG (2022): Vor 65 Jahren: Bundestag beschließt Gleichberechtigungsgesetz. Abgerufen unter: https://www.bundestag.de/dokumente/textarchiv/2022/kw17-kalenderblatt-gleichberechtigungsgesetz-504286, Zugriff: 21.06.2022.

HOCHSTADT, STEFAN (2006): Auswirkungen des demographischen Wandels auf Stadtentwicklung und Bauwirtschaft. In: Bundesinstitut für Bau-, Stadt- und Raumforschung (Hrsg.): Informationen zur Raumentwicklung. Bauwirtschaft und räumliche Entwicklung. Heft 10.2006. S. 553-565.

KÖRBER STIFTUNG (Hrsg.) (2018): Die Babyboomer gehen in Rente. Was das für die Kommunen bedeutet. Thesenpapier des Berlin-Instituts für Bevölkerung und Entwicklung für die Körber-Stiftung. Hamburg.

MAIER, JÖRG (1977): Sozialgeographie. Das geographische Seminar. Braunschweig.

GANS, PAUL (2018): Demografischer Wandel. In: ARL – Akademie für Raumforschung und Landesplanung (Hrsg.): Handwörterbuch der Stadt- und Raumentwicklung, Hannover. S. 375-396.

RKI – ROBERT KOCH INSTITUT (2015): Gesundheit in Deutschland. Gesundheitsberichterstattung des Bundes Gemeinsam getragen von RKI und Destatis. Berlin. Stand November 2015.

SANGE, RALF VON WULFFEN, Katrin (2022): Senior Social Entrepreneurship. Wie man mit 50plus sinnstiftend gründet. Wiesbaden.

SCHOLLES, FRANK (2008): Prognosemethoden. Szenariotechnik. In: Fürst, Dietrich; Scholles, Frank (Hrsg.) (2008): Handbuch Theorien und Methoden der Raum- und Umweltplanung. 3. Aufl. Dortmund, S. 380-392.

SHEARER, Allen W (2005): Approaching scenario-based studies: three perceptions about the future and considerations for landscape planning. In: SAGE Publications Ltd (Hrsg.) (2005): Environment and Planning B: Planning and Design 2005, Volume 31. S. 67-87.

STATISTISCHES BUNDESAMT (2021): Anteil vom Menschen im Rentenalter, die erwerbstätig sind, hat sich binnen 10 Jahren verdoppelt. Pressemitteilung Nr. N 041 vom 24. Juni 2021. Abgerufen unter: https://www.destatis.de/DE/Presse/Pressemitteilungen/2021/06/PD21_N041_12.html;jsessionid=0E03AB5A8E46C5812EB8E0C378129308.live711, Zugriff: 16.05.2022.

STATISTISCHES BUNDESAMT (2022): Altenquotient – Bevölkerung im erwerbsfähigen Alter und Senioren. Abgerufen unter: https://www.destatis.de/DE/Themen/Querschnitt/Demografischer-Wandel/Aspekte/demografie-altenquotient.html, Zugriff: 16.05.2022.

VON MACKENSEN, EVA (2007): Wohnen in der Stadt und demographischer Wandel. Anfragen an die Stadtplanung. In: Baum, Detlef (Hrsg.): Die Stadt in der Sozialen Arbeit. Ein Handbuch für soziale und planende Berufe. 1. Aufl. Wiesbaden. S. 316-328.

🏆 *reviewed paper*

Surveillance and Control: the Regulation of Everyday Behaviour under Covid-19 in South African Cities

Vuyiswa Letsoko, Eric Makoni

(Vuyiswa Letsoko, University of Johannesburg, Department of Urban and Regional Planning, Cnr Siemert & Beit Streets, Doorfontein, 0184, Johannesburg, South Africa, 2028, vuyisway@uj.ac.za)
(Dr. Eric Makoni, University of Johannesburg, Department of Urban and Regional Planning, Cnr Siemert & Beit Streets, Doorfontein, 0184, Johannesburg, South Africa, 2028, emakoin@uj.ac.za)

1 ABSTRACT

On 5 March 2020 the National Institute for Communicable Diseases (NICD) reported the first case of COVID-19 in South Africa. Since then, COVID-19 has caused unprecedented shifts in every sector of urban and social life and has reminded us of the critical role cities play in global health governance whilst also revealing their vulnerabilities when hit by an unknown virus. Cities have proved to be particularly vulnerable to the virus given their high population rates as well as socio-economic activity. As many parts of the globe continue to grapple with the COVID-19 crisis, researchers from various disciplines are constantly working to shed more light on the pandemic. Although a large share of this research is focused in the medical field, the dynamics of the pandemic and its impacts on cities has started to receive significant attention. In this paper, we reflect on how the state used various technologies of power to regulate and control everyday urban practices during COVID-19. In its endeavor to control the virus, the state was compelled to arguably radically infringe on people's everyday activities; from the food they could purchase and consume, to spaces where they could congregate, right through to the manner and fashion at which they could worship, and even bury their loved ones. While this was warranted given the urgent need to curb the virus, we argue that these actions have the potential of transforming the manner by which cities are governed. This is particularly so in highly unequal cities where the chasm between the wealthy and the poor has been made gravely stark by the pandemic. Cities might have to find that they have to expand their social security nets further, given the near collapse of the informal economy and the subsequent growth in poverty and unemployment.

Keywords: Regulations and Behaviour, South Africa, COVID-19, Urban inequality, Townships

2 INTRODUCTION

In December 2019, the first case of COVID-19 was identified in Wuhan, China and it has since engulfed the whole world having reached over 200 countries in the globe (Schröder et al, 2021;Schmidt et al 2020). The World Health Organisation declared the disease a global pandemic in January 2020 after worldwide cases totalled 7818 (Mutanga and Abayomi, 2020). As of 24 March 2021 the global confirmed cases of COVID-19 stand at 123 419 065 with the African continent being in the top five of countries with the highest number of active cases (WHO, 2021). Of those, the highest number of COVID-19 patients in Africa have been reported in South Africa with 1 538 451 cases and 52 196 deaths, as of 24 March 2021 (WHO, 2021). As the virus continues to spread, very little is known about the disease and how much of a threat it is to human life. Indications on how the virus is transmitted, which is through respiratory droplets from sneezes and coughs within a 1-metre distance of an infected person and via contact with contaminated surfaces led governments around the world to frantically strategise on ways to curb the spread of the pandemic by implementing social distancing measures and other preventative measures recommended by WHO (Chan et al. 2020). These preventative measures included mask wearing, social distancing, handwashing, and isolation for 14 days if one presents symptoms of the virus.

These measures alone proved to be insufficient in curbing the spread of the virus thus closed borders and lockdowns became a global response to force the general population to stay at home and avoid crowded spaces (Ndlovu-Gatsheni, 2020). South Africa, like many other countries of the Global North and South, adopted this approach and introduced a five phased lockdown programme with each phase having its own set of restrictions on public movement and economic activity (Odendaal,2020). Although the lockdown strategy proved to be successful in containing the virus in Italy and China (see Qian and Hanser,2021), this strategy was met with mixed feelings in South Africa given the varied socio-economic milieu in the country and as a result the enforcement of these measures proved to be quite challenging within some communities in the country. De Groot and Lemanski (2020) highlight that the hardest-hit areas (in terms of the highest concentrations of COVID-19 infections) are in low-income, densely populated townships, where unlike

wealthier spaces in the city, people cannot withdraw from social interactions in a single home, work remotely, buy large quantities of supplies to avoid regular visits to the shops, or drive alone in a car to secure supplies. As such, the pandemic has further exposed and intensified the divide between the have and have-nots in society. In fact, the South African governments' draconian enforcement of the lockdown regulations has been often critiqued for reinforcing socio-spatial inequalities and historic racial and structural tensions in the country. For instance, police used rubber bullets, tear gas, water bombs and whips to ensure social distancing, especially amongst poor black communities (Odigbo, Odigbo and Eze, 2020;Human Rights Watch, 2020;Grootes,2020). This was often not the case in communities of middle to upper class neighbourhoods.

A distinct urban feature of these neighbourhoods are residential gated communities which are defined as privatised physical locations whose access is restricted by walls, fences, gates or booms and are characterised by legal agreements which tie residents to a common code of conduct (Atkinson and Blandly, 2005;Liu and Song, 2017). Residential gated communities embody a new form of collective governance as they are managed and maintained by homeowners associations and/or body corporates (Landman, 2006). Given the restricted nature of these developments, their self-regulation was upheld and respected by the government during the lockdown as state policing never surpassed the gates with the belief that law and order will persist in these spaces.

What is critical to note is that to the present day, very few cases of such police brutality and violence with the intention of implementing lockdown measures exist in the middle to upper class neighbourhoods of South African cities. While the pandemic has adversely affected virtually everybody, such deleterious effects have not been uniform, with the possibility that certain sections of society are more likely to be affected than others. It can be hypothesised that already vulnerable individuals such as those who have lost their jobs, individuals in precarious employment, those living in poor housing and neighbourhoods and the poor in general are more likely to bear the brunt of the pandemic than the relatively well off (Nwosu and Oyenubi, 2021).

It is against this backdrop that this chapter intends to critically reflect on what COVID-19 has revealed about inequalities that exist in the South African society. Additionally, given the varied socio-economic and urban landscape of the country due to the legacy of apartheid, racial capitalism and neoliberalism we ask the question how lockdown regulations were implemented in different urban settings in the country by means of comparing the realities presented by COVID-19 and lockdown in townships and gated communities. Specifically, we intend to juxtapose the experiences of lockdown in a township and a residential gated community.

3 LOCKED DOWN: REFLECTING ON THE STRATEGY TO "FLATTEN THE CURVE"

At the beginning of March 2020 the first case of COVID-19 hit South African shores and the country soon became the most affected country in Africa by the SARS-CoV-2 virus (Stieglera and Bouchard, 2020). From one single case on, the number of cases increased rapidly, forcing the South-African Government to swiftly react and place the country under strict lockdown for what was initially meant to be three weeks in an attempt to "flatten the curve". Stieglera and Bouchard, (2020) argue that South Africa's lockdown was one of the most restrictive in the world and lockdown become the image of the country. A series of measures and restrictions which cut across all facets of daily life as well as death, were put into place limiting the rights of South Africans (Stauton,2020).

These included the complete closure of childcare, institutions of primary and higher education as well as all public leisure activities, severe physical distancing rules, an estimated 70% reduction of shopping activities, 85% of on-site work force and a 90% reduction in other activities (Schröder, 2021). On 24 April 2020, the South African President, together with the National Command Council set up by government to strategise responses to the pandemic, unveiled a de-confinement plan in phases of "alert levels" (Dekel, 2021). This plan, organised in five stages, made provision for gradual reopening of the economy and social life as per 1 May 2020 (ibid).This clear system was organised in a way that the alert levels would move up or down depending on the level of the pandemic.

Although the lockdown has proved to be effective in curbing the spread of the virus, its application and effects in Africa have been criticised. For instance, Macamo (2020) critiqued African governments for

replicating responses to COVID-19 from European countries with the lockdown being one of them. In this context, Ndlovu-Gatsheni (2020) argument makes sense:

"This pandemic provides an opportunity for Africa in particular and the Global South in general not to look up to the Global North for salvation but to shift the geopolitics of knowledge by using African endogenous knowledge and the epistemologies of the Global South."(p5)

The above is particularly important in the reading of the realities of countries in the Global South who have previously grappled with and subsequently managed epidemics and pandemics before. For example, many African countries learnt very difficult lessons from their responses to the Ebola and HIV outbreaks, thus it is important for the Global South to consider the lessons learnt from managing and overcoming these outbreaks and apply them in their response fighting COVID-19 (Getachew and Tih, 2020).

COVID-19 and lockdown have also brought the steep inequalities in South Africa into sharp focus, while people were invited to stay home and practice social distancing when out, not all communities within the country could afford such practice. For instance, Shani's (2020) captures this and outlines:

"What are the subjects which states are seeking to protect? [...]. But what of those who have no home? Or hand sanitiser or face mask? Or access to running water? The referent object of Coronavirus discourse is a homeowner with economic means to take time off work and stockpile food. For the majority of mankind, this isn't an option. [...]. The subject that states protect is a racialised, bourgeois and gendered subject."

This was particularly true for vulnerable communities living in informal settlements and townships who found the lockdown more unbearable (Nwosu and Oyenubi, 2020). In many cases, the residents of these communities depend mostly on informal economy, however the lockdown re-enforced anti-informality bias which saw these communities become more vulnerable and living in lack (Battersy, 2020).

The above emphasises the inequalities that COVID-19 and the lockdown present in society and the realities these present in different urban, social and, economic settings. Hulchanski (2011) highlights that neighbourhoods represent spaces in the city which contain a mix of physical, social and psychological attributes which embody the demographic and economic situation of its residents. As such, these spaces shape the lived experiences of the residents of the city therefore provide very important insights into numerous dynamics in the city. This is particularly true in the time of COVID-19 and lockdown, we find that the lived experiences of lockdown have been more unfavourable for communities of informal settlements and townships and this is in stark difference to the realities which communities in wealthier parts of the city have experienced. These experiences are closely linked to the persistent inequalities embedded in the system and society of our country.

4 CEMENTED DIVISIONS AND INEQUALITIES: CONSEQUENCES OF LOCKDOWN IN AN UNEQUAL STATE

Exclusion, inequality and urban segregation are key social concerns in developed and developing cities around the world (OECD 2018; Nel and Rogerson 2009; Warwick-Booth 2013). Gelderblom (2006) highlights that inequality is a multidimensional concept which speaks to structural and spatial differences in society relating to income, facilities, resources, skills, opportunities and power. In the context of South Africa, our structural legacies and socioeconomic inequalities have been inherited from decades of colonial and apartheid rule as a result of the purposeful marginalisation of the black population into poorly developed and overcrowded neighbourhoods popularly known as townships. In fact, twenty-seven years post democracy this racial-biased spatial segregation remains in place and South Africa is still one of the most unequal countries in the world with a Gini coefficient[1] of 0.7 (StatsSA,2019).

In contemporary cities, one of the major urban trends globally which contributes to inequality is the proliferation of gated communities (Duca, 2016). These developments are seen as a manifestation of an increasing buffer between the rich and the poor and "an expression of the flight of the successful" (ibid,2016:p405) which limit the poor from accessing most amenities, services and infrastructure (K'Akumu & Olima, 2007; Ramoroka, 2013). The same gated communities offer security as a private market commodity rather than a public good or right thereby perpetuating the socio-economic inequalities between

[1] The Gini coefficient ranges from 0 to 1, where 0 indicates perfect equality (all individuals have the same income) and 1 indicates prefect inequality (where one person has all the income and the rest have none)

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

the rich and poor who are residing in towns and cities (Ramoroka, 2014). Hook and Vrdoljak (2002) opine that "gating" in South Africa is driven by societies' desire to detach themselves from the broader civic engagement and responsibility.

Furthermore, Ballard (2004) identifies this form of civic detachment as "semigration" which he describes as partial emigration where people create Western utopias which further remove themselves from the broader South African community and their contributions to nation-building but instead produce an alternative representation of reality. As a result, these developments represent elite spaces within society where liberal democracy has granted residents with the choice to enclave at the expense of socio-spatial integration.

Ndlovu-Gtasheni (2020) outlined that the global pandemic hit at a time where the world was already consumed with "walling-in for other reasons such as security and obsession with migrants" (p14) however responses to COVID-19 have reinforced enclaves and cemented the differences in elite and poorer spaces within the city. From an international perspective, communities of middle class neighbourhoods as well as residential gated communities have proven to be more resilient and equipped to deal with the adverse effects of pandemics and epidemics. For example, in Bray's (2008) study of two Wuhan community residence committees (similar to gated communities found in South African cities) during the SARS outbreak in 2003, he found that the mobilisation of shequ[2] assisted in the implementation of public health measures and enforcing quarantine and screening.

Although this was well over seventeen years ago and China has since gone through significant economic, social and urban reforms, the rationale for enclosures persisted and have been strengthened in the current day. In fact, Qian and Hanser (2020) highlight that shequ, played an important role in curbing COVID-19 numbers during the peak of the pandemic. Scant literature exists on the role and experiences of residents of gated communities and middle to upper class neighbourhoods during the pandemic, particularly in the South African context. However, Lindeque (2020) reported that at the beginning of the pandemic in the country, there were concerns on how lockdown measures would be upheld within these enclosed spaces and further indicated that there was confusion among Homeowners Associations and Body Corporates around whether or not their residents are allowed limited freedom of movement inside their gated communities. Furthermore, an article on BusinessTech (2020) highlighted that since the beginning of lockdown various residential gated communities have been making their own rules which are not necessarily in alignment to the national regulations imposed under the Disaster Management Act.

It is interesting to note that even during a global pandemic, when global populations are fighting a common enemy, their choice and desire for detachment from the broader society is re-enforced. Once again, at the peak of a global pandemic, these spaces present a challenge for authorities due to their private management where government has very little control on their socio-spatial dynamics within these spaces. This further echoes the challenges these developments present to spatial transformation in cities (Landman and Badenhorst, 2012). However, Ren (2020:3) argues that a "thick network of territorial institutions and authorities" is key in managing and enforcing lockdown, thus gated communities and their privatised management could in fact be alleviating the pressure from government by ensuring compliance to lockdown regulations.

What is critical to note is that government also considered the communities of these spaces as being capable of self-regulation and this is evident in the lack of state policing and enforcement of lockdown regulations in the middle to upper class neighbourhoods (Hornberger, 2020). In fact, it is this level of "self-regulation" which enables one to critically reflect on government's responses and enforcement of the lockdown through the lens of Frantz Fanons'(1962:68) assertions on "zones of being" and "zones of non-being" in a colonial society. Middle to upper class neighbourhoods represent zones of being that are:

"…strongly-built town, all made of stone and steel. It is a brightly-lit town; the streets are covered with asphalt, and the garbage-cans swallow all the leavings, unseen, unknown and hardly thought about. The settler's feet are never visible, except perhaps in the sea; but there you're never too close enough to see them. His feet are protected by strong shoes although the streets of his town are clean and even, with no holes or stones. The settler's town is a well-fed town, an easy-going town; its belly is always full of good things. The settler's town is a town of white people, of foreigners."

[2] A form of privatized street-level governance in China which are very similar to management bodies that are found in residential gated communities in South Africa

With the above in mind, these urban utopias can be viewed as zones of orderliness that do not require any form of policing as they are capable of policing themselves and maintaining control and order. Here, de Sousa Santos' (2006) reflections apply as conflicts in the zone of being (above the abyssal line) are managed through regulation and emancipation. This is in stark contrast to how conflicts in lower class neighbourhoods are managed, where disorder and inhumanity reside,where communities incapable of saving and protecting themselves from the virus need state intervention through policing and force. This polarity is particularly disturbing in a post-apartheid South Africa where the quest to unify and undo injustices of the past is a key national priority. The next section provides further reflections on the realities of those "outside the gates" in township spaces.

5 EXPERIENCES FROM OUTSIDE THE GATES LOCKED DOWN AND LOCKED OUT?

The township space, as well as other spaces outside the gates, on the other hand is in stark contrast to middle to upper class neighbourhoods. The township space as explained by Jürgens et al (2013:) represent: "dormitory settlements without any substantial 'urban' elements, as witnessed by their rudimentary infrastructure (public services, recreation industry, transport, green spaces). As a rule the townships were, and still are located on the city peripheries, and were deliberately separated from the characteristically 'European' city centre by natural or artificial buffer zones"

Adversely, townships in South Africa are still characterised by high population density, informality, poverty, crime and general socio- economic backwardness (Mbambo and Agbola, 2020). They represent zones of non-being "a world without spaciousness; men live there on top of each other, and their huts are built one on top of the other…a hungry town, starved of bread, of meat, of shoes, of coal, of light" (Fanon, 1962:p38). The COVID-19 pandemic showed clearly that social and urban justice is still far from being an achieved goal in our contemporary societies. The concept of just cities declines profoundly when we move to the context of developing counties as Balbo (1993) illustrates: [the city] is splitting into different separated parts, with the apparent formation of many "micro-states". Wealthy neighbourhoods provided with all kinds of services, such as exclusive schools, golf courses, tennis courts and private police patrolling the area around the clock intertwine with illegal settlements where water is available only at public fountains, no sanitation system exists, electricity is pirated by a privileged few, the roads become mud streams whenever it rains, and where house-sharing is the norm. Each fragment appears to live and function autonomously, sticking firmly to what it has been able to grab in the daily fight for survival (Balbo, 1993).

The above captures the painful disparities between the elite and the poor and these inequalities have been worsened by COVID-19 (Wilkinson, 2020). This is also evident in the treatment of these black low-income communities during the lockdown period. For example, a few days into the lockdown, police shot Sbusiso Amos on the veranda of his house in Vosloorus, east of Johannesburg, during a quarrel about adherence to regulations (Knoetze,2020). Not long after, Collins Khosa was beaten up and pushed against a concrete wall by military men who sought to teach him a lesson of respect and submission and such force lead to his death (ibid,2020).

To the current day, such accounts of violence in middle to upper class neighbourhoods are almost unheard of. Such cases also speak to the daily anxieties and fears which a black man carries on his shoulders when navigating the city. It is this aspect of criminalisation that immediately provokes the idea that history is once again repeating itself. After all, it was the apartheid "pass laws" that landed hundreds of thousands of "black South Africans in prison, where they were violated, abused and destroyed – a trauma which is passed on through family and sexual violence, and crime until today" (Hornburger,2020: p4-5). But back then people had no choice. Pass laws regulated people's access to the city and yet the city was the only place where work was to be found. Black people carried the brunt of the contradictions between "industry's demands and the fantasies of the state" (ibid,2020). This speaks to Ndlovu-Gatsheni's (2020:15) assertion where he indicates that:

"Lockdowns have literally destroyed the "political economy of everyday life," where a majority of African people are found. The concept of the "political economy of everyday life" is better than that of "informal economy," which does not make sense in many parts of Africa, where the "formal economy" collapsed long ago. What also arises from this analysis of the political economy of COVID-19 and, indeed, that of lockdowns based on the ideas of capable states and formally employed people is to map out a possible decolonised post-COVID-19 world order"

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

The above is particularly true in that it was only after two weeks of lockdown when informal food vendors, who were selling uncooked foods, with existing municipal permits were allowed to start selling again (Battersy, 2020). Additionally, Battersy (2020) outlines that prior to the lockdown, most township vendors operated without municipal permits and in most cases the state was aware of this but often turned a blind eye. However, ever since the advent of lockdown law enforcement has been forcefully closing down these businesses. Therefore, under lockdown "bare lives are becoming even more bare" (Agamben, 2005 cited in Ndlovu-Gatsheni, 2020) as more and more people whose lives depend on informality are being met with more sudden vulnerabilities.

South Africa's fragmented spatial landscape due to poor physical planning have also contributed to challenges faced by township communities under the lockdown. For instance, given the spatial positioning of townships in relation to the city, the transport challenge in townships, even in the face of COVID-19, also remained unresolved. Mbambo and Agbola (2020) highlight long distances to workplaces resulted in higher transport costs which were exacerbated during COVID-19 as mini-bus taxis, the main form of public transport for communities in townships, were compelled by government not to take full loads of passengers and were limited to operating at 70% capacity in an attempt to adhere to social distancing. According to the South African National Taxi Council (SANTANCO), this would see the taxi industry losing about 45% of the taxis over a period of 6 months due to repossessions by banks (Pijoos & Masweneng, 2020). The responses to these challenges were the increase in taxi fares and nationwide taxi protests, which consequently added further economic strain to the low-income communities. Later during the lockdown period, mini-bus taxi operators defiantly loaded at 100% of their capacity, which was in conflict with government's regulations (eNCA, 2020). This came as the mini-bus taxi businesses were failing to cope with the loss of income due to the lockdown restrictions imposed. As a result, social distancing became impossible for the residents travelling by mini-bus taxis. Due to the unaffordable cost of mini-bus taxis, most township commuters resorted to using the government train services as an alternative mode of transportation, but unfortunately the trains remained largely un-refurbished since the apartheid period. These trains were normally overloaded, which made it impossible to practice social distancing.

A key urban feature of South African townships are informal settlements as well as hostels which also present additional challenges to fulfilling lockdown regulations. These are also considered hotspots of the virus because of the population concertation as well as space concerns given that these settlements are densely packed together. The Human Settlements Minister, Lindiwe Sisulu, alluded to this and indicated that "[hostel overcrowding] makes it impossible for the residents to adhere to some of the COVID-19 regulations. The risks posed by overcrowding in our settlements are real. This requires all of us in the sector to work in unison to save lives by containing the spread of COVID-19" (SA News, 2020, March 12: par. 5).

6 A WAY FORWARD: CONFRONTING INEQUALITIES AND MAKING A CHANGE? OR AN OLD STORY, NEW CONTEXT?

From the above, it is evident that COVID-19 has illustrated new levels of inequalities and vulnerabilities. More than a decade ago, Harvey (2008) argued that we increasingly live in divided and conflict-prone urban areas. In the past three decades, the neoliberal turn has restored class power to rich elites and this is evident in the consequences of lockdown. The government's lockdown regulations have demonstrated considerable bias in their enforcement of lockdown regulations which have had adverse effects on the communities of low-income black individuals. The disease is worsening present inequalities in society along the lines of class and race disparities, uneven patterns of mobility, access to sanitation infrastructures and ability to self-isolate (Mirsha et al., 2020; Heinberg, 2020).

These social and infrastructural imbalances can influence responses to an outbreak and must be perceived as part of the answer to mitigating against future epidemics (Connolly et al., 2020). COVID-19 is being called a once-in-a-century pandemic (Gates, 2020). As such, one needs to question if it will be a turning point for people living in precarious urban environments. Here, Ndlovu-Gatshenis' (2020:p21) call for a "post-COVID-19 life of conviviality underpinned by moral economies of care as opposed to the present society of enmity and economies of profit" is most important. Historically, epidemics have acted as catalysts in transforming how diseases are handled (De La Barra, 2000). However, the extent and direction of transformation depend on how an epidemic and its context are interpreted and by whom, thus it is important for government to reflect on these lessons for the future. More importantly, these inequalities also indicate

that there is an urgent need for more research and policy development on how governments of developing and underdeveloped nations (who have large populations living in poverty) can develop lockdown strategies that are not only feasible but take into consideration the socio-economic climate that is specific to their context (Eyawo, Viens and Ugoji,2021).

7 REFERENCES

Santos, B. de. S.2007. Beyond abyssal thinking: From global lines to ecologies of knowledges. Review (Fernand Braudel Center), XXX(1), 45–89.

Macamo, E.2020. The normality of risk: African and European responses to COVID-19. Available from: https://www.coronatimes.net/normality-risk-africa-europeanresponses/

Fanon, F.1968. The wretched of the earth. Grove Press.

Ramoroka,T.,2014. Gated-Communities in South Africa's Urban Areas 20 Years into Democracy: Old Wine in Newly Designed Bottles? Mediterranean Journal of Social Sciences, 5 (15),106-110.

Ramoroka, T. (2013a) Building safer urban human settlements in South Africa: a case of the National Development Plan 2030. JournaL of Public Administration, 48(2), 321-333.

Agamben, G.2005. State of exception. University of Chicago Press.

Schmidt, T., Cloete, A., Davids, A., Makola, L.,Zondi, N.,& Jantjies,M.2020.Myths, misconceptions,othering and stigmatizing responses to Covid-19 in South Africa: A rapid qualitative assessment. PLoS ONE,15(12).

Qian,Y. & Hanser,A.2021. How did Wuhan residents cope with a 76-day lockdown? Chinese Sociological Review, 53:1, 55-86.

Schröder,M., Bossert,A.,Kersting,M., Aeffner,S., Coetzee,J.,Timme,M.,&Schlüter,J.2021. COVID‑19 in South Africa: outbreak despite interventions.Scientific reports,11.

Mutanga,M.B.,& Abayomi,A.2020.Tweeting on COVID-19 pandemic in South Africa: LDA-based topic modelling approach, African Journal of Science, Technology, Innovation and Development, 1-9.

Ndlovu-Gatsheni,S.J.2020.Geopolitics of Power and Knowledge in the COVID-19 Pandemic: Gecolonial Reflections on a Global Crisis, Journal of Developing Societies,1-24.

Nwosu,C.O.&Oyenubi,A.2021.Income-related health inequalities associated with the coronavirus pandemic in South Africa: A decomposition analysis, International Journal for Equity in Health, 1-12.

Eyawo,O.,Viens,A.M,&Ugoji,U.C,.2021.Lockdowns and low- and middle-income countries: building a feasible, effective, and ethical COVID-19 response strategy, Globalization and Health,2-5.

Hornberger,J.2020. Policing the Pandemic in South Africa: Beware of the Remedy, City & Society,1-5.

Mbambo,S.B,&Agbola,S.B.2020. The Impact of the COVID-19 Pandemic in Townships and Lessons for Urban Spatial Restructuring in South Africa, African Journal of Governance and Development,9,1.1,329-351.

Pijoos, I., & Masweneng, K. (2020, June 22). Soldiers, police intervene as taxi strike leaves commuters stranded in Gauteng. Times Live. Retrieved from https://www.timeslive.co.za/news/south-africa/2020-06-22-taxi-strike-leaves-commuters-stranded-across-gauteng/

eNCA. (2020, June 29). Mbalula appeals to taxi bosses to keep calm. Retrieved from https://www.enca.com/news/santaco-and-mbalula-meet-over-taxi-operations

South African Government News Agency. (2020, March 12). Plans afoot to address over-crowding at Mamelodi hostels. South African Government News Agency. Retrieved from https://www.sanews.gov.za/south-africa/plans-afoot-address-over-crowding-mamelodi-hostels

Wilkinson, A. (2020), "The impact of COVID-19 in informal settlements – are we paying enough attention?", available at: https://www.ids.ac.uk/opinions/ (accessed 6 October 2020).

Balbo, M. (1993), "Urban planning and the fragmented city of developing countries", Third World Planning Review, Vol. 15 No. 1, pp. 23-35.

De La Barra, X. (2000), "Fear of epidemics: the engine of urban planning", Planning Practice and Research, Vol. 15 Nos 1-2, pp. 7-16.

Dekel B, Abrahams N. 'I will rather be killed by corona than by him…': Experiences of abused women seeking shelter during South Africa's COVID-19 lockdown. PLoS One. 2021 Oct 28;16(10):e0259275. doi: 10.1371/journal.pone.0259275. PMID: 34710174; PMCID: PMC8553161.

Mishra, S.V., Gayen, A. and Haque, S.M. (2020), "COVID-19 and urban vulnerability in India", Habitat International, Vol. 103, 102230.

Heinberg, R. (2020), "Coronavirus, economic networks, and social fabric", available at: https://www.resilience.org/stories/ (accessed 12 November 2020).

Ren, Xuefei. 2020. "Pandemic and Lockdown: A Territorial Approach to COVID-19 in China, Italy and the United States." Eurasian Geography and Economics.

Harvey, D. (2008), "The right to the city", Published in, available at: https://newleftreview.org/issues/II53/articles/david-harvey-the-right-to-the-city#_ednref4

Jürgens,U., Donaldson,R.,Rule,S.,& Bähr,J.2013. Townships in South African cities-Literature review and research perspectives, Habitat International,39,256-260.

De Groot,J.,& Lemanski,C.2020. COVID-19 responses: infrastructure inequality and privileged capacity to transform everyday life in South Africa, Environment & Urbanization,1-17.

Chan,J.F.,Yuan,S.,Kok,K.,To,K.K.,Chu,H.,&Yang,J.2020. A familial cluster of pneumonia associated with the 2019 novel coronavirus indicating person-to-person transmission: a study pf a family cluster,The Lancet,395,10223,514-523.

WHO (2021), Coronavirus Disease (COVID-19) Pandemic, accessed 15 April 2020 at https://www.who.int/emergencies/diseases/novelcoronavirus-2019.

Battersby,J.2020. South Africa's lockdown regulations and the reinforcement of anti‑informality bias, Agriculture and Human Values,1-2.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

🏆 *reviewed paper*

Sustainable Multi-objective Optimisation in Land-use Planning based on Non-dominated Sorting Genetic Algorithm (NSGA-II): a Case Study in Alexandria, Egypt

Sarah M. Abdel-Ghany, Hany M. Ayad, Ingi A. Elcherif

(MSc Candidate Sarah M. Abdel-Ghany, Department of Architecture, Faculty of Engineering, Alexandria University, sarahemadmikaeil@alexu.edu.eg)
(Professor Hany M. Ayad, Department of Architecture, Faculty of Engineering, Alexandria University, hany.m.ayad@alexu.edu.eg)
(Lecturer Ingi A. Elcherif, Department of Architecture, Faculty of Engineering, Alexandria University, ingi.el-cherif@alexu.edu.eg)

1 ABSTRACT

Due to urban sprawling, the world's land-use patterns have rapidly changed, leading to conflict and competition among urban land-uses. This conflict resulted in a range of inefficient land-use patterns. The negative impacts of such patterns suggest the need to improve the efficiency of land-use planning strategies to support better sustainable development. To attain such efficiency, many researchers have adopted algorithmic approaches perceiving land-use planning as a multi-objective optimization problem. These approaches allow encompassment of the numerous variables and constraints that are introduced in the planning process by decision makers and stakeholders. In this regard, a meta-heuristic method; the Non-dominated Sorting Genetic Algorithm (NSGA-II), could provide an efficient decision support tool for land-use planning through offering pareto optimal land-use allocation alternatives.

This paper aims at adopting NSGA-II to enhance sustainable land-use planning strategies at a neighborhood scale in the city of Alexandria, Egypt. The research suggests the adaptation of the Constrained Multi-objective Optimization of Land-use Allocation model (CoMOLA) for three main objectives: (i) maximizing the value of economic benefit, (ii) spatial compactness, and (iii) land-use compatibility. Several land-use allocation scenarios are investigated through an iterative process which includes the variables of spatial units' number, population sizes and significance of allocation objectives. The scenarios are then compared to the existing condition of land-use distribution. The results show that the proposed approach using CoMOLA tool exhibits good potential to support interactive land-use planning processes by searching over multiple plans for optimal sets of non-dominated solutions. The optimized results could provide the scientific basis for defining suitable interventions for improving sustainability measures and spatial optimization of land-uses at the neighborhood scale.

Keywords: Land-use allocation, Non-dominated Sorting Genetic Algorithm (NSGA-II), Multi-objective optimization, Constrained Multi-objective Optimization of Land-use Allocation model (CoMOLA), Land use planning

2 INTRODUCTION

Land-use allocation is a complex process that involves efficient arrangement of land-uses across a region. Its main purpose is providing the best land-use layout scenario while satisfying the demands of various activities (Huang & Zhang, 2014; Li & Parrott, 2016; Ligmann-Zielinska, Church, & Jankowski, 2005; Stewart, Janssen, & van Herwijnen, 2004; Yao, Murray, Wang, & Zhang, 2019). Land-use resources are identified in the sustainable development definition by World Commission on Environment and Development (WCED) in 1987. Thus, the configuration of land resources is critical to promote sustainable utilization of these resources, efficient land-uses, and plausible spatial distribution of activities (Ma, He, Liu, & Yu, 2011; Mohammadi, Nastaran, & Sahebgharani, 2015). In this regard, when considering macro-scale objectives of strengthening social, economic, and environmental characteristics of the city, sustainable land-use allocation is considered a primary policy of sustainable development (Li & Parrott, 2016; Lubida, Veysipanah, Pilesjo, & Mansourian, 2019; Ma et al., 2011; Yao et al., 2019). On the other hand, sustainable land-use planning is indispensable for addressing the current population trends and urban growth that lead to conflicting land-uses and excessive demand on services and activities (Yao et al., 2019). On this account, inefficient management of land-use change, and unbalanced land-use allocation, are the main drivers of environmental deterioration, ethnic and economic segregation, loss of heritage, and corrosion of land and habitat (Li & Parrott, 2016; Ligmann-Zielinska et al., 2005; Mohammadi et al., 2015). The negative impacts of such occurrences are demonstrated by the inefficient patterns of land-uses in the current urban form such as low densities, leapfrog fragmentation, edge development surpassing redevelopment of the inner cities and patches of single land-

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

uses (Leccese & McCormick, 2000; Ligmann-Zielinska et al., 2005). Thus, sustainable land-use planning is essential to mitigate such patterns and maintain long term balanced development (Yao et al., 2019).

The involvement of various conflicting factors, as well as multiple stakeholders, defines sustainable land-use allocation as a multi-objective spatial optimization problem, which requires rational manipulation of land-uses locations and quantities by urban planners (Balling, Taber, Brown, & Day, 1999; Huang & Zhang, 2014; Li & Parrott, 2016; Lubida et al., 2019; Yang, Zhu, Shao, & Chi, 2018). In this regard, an urgent need exists for tools that utilizes such optimization approaches to assist planners with decision making. Computer-based techniques offer a potential tool, that can support handling unstructured, nonlinear multiple objectives, countless solutions, and spatial considerations of the problem (Huang & Zhang, 2014; Li & Parrott, 2016; Porta et al., 2013; Sharmin, Haque, & Islam, 2019). Nevertheless, conventional mathematical models cannot be relied upon to generate optimal solutions in a reasonable timeframe. Hence, intelligent algorithms have been developed for multi-objective land-use allocation MOLUA optimization (Yaolin Liu et al., 2015).

In correspondence to the problem of inefficient and unsustainable land-use patterns, and the necessity of competent tools that deals with MOLUA complex procedures, much research has attempted to examine the possibilities of quantitative assessment and comparison of sustainability measures for different land-use scenarios. However, the majority of existing literature disregards current land-use patterns in models' initializations and proposes a hypothetical framework instead (Ligmann-Zielinska et al., 2005). Furthermore, it mostly tackles land cover scale, whereas only a few research considered neighbourhood land-uses scale such as Cao et al. (2011), Cao et al. (2020), Huang and Zhang (2014), Lubida et al. (2019), Mohammadi et al. (2015) and Sharmin et al. (2019). Lastly, the abundant research works on developing MOLUA models that serve specific objectives rather than offering a generic decision support tool that comprehensively addresses urban sustainability and could be implemented by practitioners (Rahman & Szabó, 2021).

Within this context, this paper addresses the degree of reliability of MOLUA models to generate spatially plausible solutions, when dealing with real planning and development constraints at the neighbourhood scale.

Thereby, the objectives of this research are formulated as follows:

- To explore the possibilities of integrating spatial-related objectives into MOLUA models.
- To evaluate the efficiency and applicability of utilizing NSGA-II oriented models as a decision support tool for the local context of Egypt.
- To propose an extension to the generic CoMOLA model that promotes spatial and economic objectives along with ecological ones.

Therefore, this paper is organized into the following sections. Firstly, a literature review of related studies on multi-objective optimization problems and algorithms is demonstrated. Secondly, the paper investigates several methods to quantitatively evaluate spatial objectives and how to incorporate them in land-use optimization models. Thereafter, it adopts a generic tool for Constrained Multi-objective Optimization of Land-use Allocation (CoMOLA) to apply NSGA-II algorithm to a case study area in Alexandria, Egypt, such that three main objectives are considered: (i) maximizing spatial compactness, (ii) maximizing compatibility, and (iii) maximizing economic benefits. Consequently, the results of optimization are analyzed and evaluated according to various tests. Finally, concluded remarks and recommendations for future research are discussed.

3 LITERATURE REVIEW

3.1 Multi-objective Optimization problem

Land-use allocation constitutes an optimization problem where predefined objectives are represented as a fitness function, to be minimized or maximized. This enables quantitative assessment of alternative solutions, while conferring to constraints that determines the feasible solution set (Porta et al., 2013). Multiple variables of the problem arise from the diversity of land-use categories along with numerate spatial units (Li & Parrott, 2016; Porta et al., 2013).

Research has conducted two main approaches to multi-objective land-use allocation problems: scalarization and pareto-optimum (Li & Parrott, 2016; Mohammadi et al., 2015; Yang et al., 2018). Scalarization converts multiple objectives into a single-objective problem through techniques as weighted sum and goal

programming (Yang et al., 2018). Some research has applied the weighted sum approach as Aerts, Van Herwijnen, Janssen, and Stewart (2005); Yaolin Liu et al. (2015); Yang et al. (2018). However, such approach relies much upon experts' opinions and requires prior knowledge besides its inefficiency in a non-convex solution space(Lubida et al., 2019; Yang et al., 2018; Yao et al., 2019). As for goal programming, it was adopted by Li and Ma (2018); Li and Parrott (2016); Sahebgharani (2016). It is argued that such approach is more convenient when different stakeholders can identify their demands as a preset reference goal although it may result in poor sub-objective values (Aerts et al., 2005; Li & Parrott, 2016; Yao et al., 2019). On the other hand, pareto-optimum approach resolves this issue, as it supports the evaluation of all trade-offs of multiple objectives seeking the pareto optimal set of solutions (Lubida et al., 2019; Yang et al., 2018). Gao et al. (2020) applied pareto-optimum methods as well as Cao et al. (2011); Cao, Zhang, and Wang (2019); Huang and Zhang (2014); Karakostas (2016); Lubida et al. (2019); Song and Chen (2018a). A solution is identified as a pareto optimal provided that no other solution is better or equivalently good regarding all the objective functions, besides being the best solution in at least one objective (Lubida et al., 2019; Yang et al., 2018). Although the pareto approach holds an advantage of manageable computation with respect to the attained results, some research doubts the efficiency of the pareto approach with an increased number of objectives (Li & Parrott, 2016; Mohammadi et al., 2015; Yang et al., 2018). Nonetheless, a compromise among a set of acceptable solutions is necessary because the concept of one best solution likely doesn't exist in the nation of land-use planning (Yao et al., 2019).

3.2 Multi-objective Optimization Algorithms

Researchers have run against several limitations when applying exact optimization models in MOLUA including: the inability to handle spatial interactions due to their nonlinear characteristics, the limited spatial area handled by the models, and the necessity of identifying a single objective (Aerts, Heuvelink, & Stewart, 2018; Aerts et al., 2005; Huang & Zhang, 2014; Li & Parrott, 2016). To overcome these limitations, research has suggested several non-deterministic approaches that rely on iterative heuristics for examining the search spaces in search for near optimal solutions (Porta et al., 2013). The meta-heuristic algorithms are mainly Swarm Intelligence (SI), Simulated Annealing (SA), and Evolutionary Algorithms (EA) (Aerts et al., 2005; Yaolin Liu et al., 2015; Lubida et al., 2019; Yang et al., 2018). Particle Swarm Optimization (PSO), Ant Colony Optimization (ACO) and Artificial Bee Colony (ABC) are argued as the most successful among SI, however, Genetic Algorithms is considered the most common evolutionary algorithm (Lubida et al., 2019; Mohammadi et al., 2015; Yao et al., 2019).

Since the 1970s, numerous studies have applied Genetic Algorithms in the urban field (Huang & Zhang, 2014). The algorithm relies on the theories of natural evolution and genetics to solve large complex computational problems. It is a global optimization algorithm that undergoes an iterative process of an operational sequence in order to produce high fitness child solutions from the parent individuals (Aerts et al., 2005; Porta et al., 2013; Yao et al., 2019). It is debated whether the evolutionary mechanism of the GA provides better convergence[1], or in fact affects genetic diversity leading to local optimal solutions (Li & Parrott, 2016; Yang et al., 2018). Among the several techniques developed from the GA is the elitist Non-dominated Sorting Genetic Algorithm (NSGAII) which will be adopted in this research and further explained in section 4.2. (Lubida et al., 2019; Yao et al., 2019).

4 METHODS AND TOOLS

4.1 Objective Functions

Objectives of land-use allocation can be divided into two main categories: additive objectives and spatial objectives (Li & Parrott, 2016). According to Stewart, Janssen, & Van Herwingen, additive objectives can be calculated through the attribute values of each cell (land parcel), while spatial objectives attend to the spatial characteristics of land-use patterns e.g., connectivity, contiguity, … etc. (Li & Parrott, 2016; Rahman & Szabó, 2021). With respect to sustainable land-use planning, the spatial arrangements and interrelations among land parcels are of primary significance, along with socioeconomic and environmental objectives

[1] Convergence refers to the stable point found at the end of a sequence of solutions via an iterative optimization algorithm. Premature convergence refers to a stable point found too soon, perhaps close to the starting point of the search, and with a worse evaluation than expected.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

(Yao et al., 2019). Within this context, two spatial objectives have been selected for this paper: maximizing spatial compactness and maximizing compatibility. In addition to one additive objective which is maximizing economic benefits.

4.1.1 Spatial Compactness

Spatial compactness is an expression of the degree of fragmentation or connectedness of land-uses. It encourages allocation of the same land-uses into clusters and in the vicinity of each other to maximize the assets of land-uses (Aerts et al., 2005; Li & Parrott, 2016; Rahman & Szabó, 2021; Yao et al., 2019). Compact forms are sought in sustainable land-use planning as they contribute to environmental quality, energy efficiency, and social equity (Aerts et al., 2005; Ligmann-Zielinska et al., 2005; X. Liu, Li, Shi, Huang, & Liu, 2012; Rahman & Szabó, 2021; Yao et al., 2019). Indicators of spatial compactness would involve cluster shape indices as: perimeter, area, and area to perimeter ratio. Therefore, when quantitatively evaluating compactness, four main strategies have been commonly used:

(i) Maximizing the number of land parcels in each land-use cluster,

(ii) Minimizing the land-use cluster perimeter,

(iii) Minimization of the number of clusters of each land-use type, and

(iv) Maximizing the area of the largest cluster (Aerts et al., 2005; Yao et al., 2019).

X. Liu et al. (2012); Porta et al. (2013); Yang et al. (2018) adopted the second strategy through the concept of circularity (Yao, Murray, Wang, & Zhang, 2019). Moreover, Ma et al. (2011) applied the third strategy through calculating the length of the public edge of adjacent similar cells. Meanwhile, the first strategy is the most common one among researchers, either through applying a summation equation for all land parcels with the exact land-use, or through the eight-neighbour method (Gharaibeh, Ali, Abo-Hammour, & Al Saaideh, 2021; Li & Ma, 2018; Masoumi, Coello Coello, & Mansourian, 2019; Sahebgharani, 2016; Song & Chen, 2018b; Yang, Sun, Peng, Shao, & Chi, 2015). Therefore, in this paper the eight-neighbour method is adopted and formulated as expressed in Eq. (1), where xijk is the land use of the core cell. If the land-use of the core cell and the neighbouring cell (m,n) is equal then neig(m,n) =1, if not neig(m,n)=0 (Li & Parrott, 2016; Song & Chen, 2018b).

$$Max \sum_{K=1}^{K} \sum_{i=1}^{R} \sum_{j=1}^{C} \left(\sum_{m=i-1}^{i+1} \sum_{n=j-1}^{j+1} \frac{neig(m,n)}{8} \right) \quad (1)$$

$$neig(m,n) = \begin{cases} 1 & x_{ijk} = x_{mnk} \\ 0 & otherwise \end{cases}$$

4.1.2 Compatibility

Compatibility indicates the coexistence among various land-use types of an area without inducing adverse and undesirable impacts on one another (Cao et al., 2020; Lubida et al., 2019; Masoumi et al., 2019; Mohammadi et al., 2015; Rahman & Szabó, 2021; Yao et al., 2019). The majority of published research follows the same approach for quantitatively evaluating compatibility, which is the sum of the conflict degrees for each pair of adjacent land unit, where the higher the sum, the more compatible the land-use scenario is (Cao et al., 2020; Cao et al., 2019; Karakostas, 2016; Ligmann-Zielinska et al., 2005; Lubida et al., 2019; Sahebgharani, 2016; Sharmin et al., 2019). Compatibility indices are demonstrated in a compatibility matrix, which is developed through gathering the opinions of experts, stakeholders, and urban practitioners using the Delphi method or Analytic Hierarchy Process (AHP) method (Cao et al., 2011; Masoumi et al., 2019; Mohammadi et al., 2015; Sharmin et al., 2019; Yao et al., 2019).In this regard, the compatibility indices in this paper are adopted from Mohammadi et al. (2015) and illustrated in Table 1. Compatibility is addressed in sustainable urban planning as it promotes accessibility, enhanced social interactions, liveability and overall, a healthier environment (Cao et al., 2019; Lubida et al., 2019). Furthermore, higher compatibility rates indicate competent use of land and reduces the social and economic burdens of conflict, which reflects economic prosperity and stable communities (Y. Liu, Wang, Ji, Liu, & Zhao, 2012; Rahman & Szabó, 2021). For each land parcel (i,j), it has neighbours (m,n) . Kij, Kmn represent the land-uses of cells (i,j) and (m,n) respectively. $Co_{K_{ij}K_{mn}}$ is the compatibility value between Kij, Kmn (Mohammadi et al., 2015). Hence the compatibility objective is formulated as follows:

$$\max \sum_{i=1}^{R} \sum_{j=1}^{C} \sum_{m=i-1}^{i+1} \sum_{n=j-1}^{j+1} Co_{K_{ij}K_{mn}} \quad (2)$$

	Arid [1]	*Recreational* [2]	*Mixed Residential -Commercial* [3]	*Medical* [4]	*Religious* [5]	*Educational* [6]	*Commercial* [7]	*Public Amenities* [8]	*High density Residential* [9]	*Offices* [10]
Arid	1	0.8	0.4	0.8	0.6	0.8	0.8	0.6	0.4	0.6
Recreational	0.8	1	0.8	0.6	0.8	0.8	1	0.8	1	0.8
Mixed Residential -Commercial	0.4	0.8	1	0.6	0.8	0.6	1	0.6	1	0.6
Medical	0.8	0.6	0.6	1	0.6	0.8	0.4	0.6	0.6	0.8
Religious	0.6	0.8	0.8	0.6	1	1	1	0.8	0.6	0.6
Educational	0.8	0.8	0.6	0.8	1.0	1	1	0.8	0.8	0.8
Commercial	0.8	1.0	1.0	0.4	1.0	1.0	1	1	1	0.8
Public Amenities	0.6	0.8	0.6	0.6	0.8	0.8	1.0	1	0.4	0.8
High density Residential	0.4	1.0	1.0	0.6	0.6	0.8	1.0	0.4	1	1
Offices	0.6	0.8	0.6	0.8	0.6	0.8	0.8	0.8	1	1

Table 1: Land-uses Compatibility Matrix (source: Authors adopted from Mohammadi et al. (2015))

4.1.3 Maximizing Economic Benefits

Researchers followed multiple approaches to evaluate economic benefits for land-use scenarios, being one of the three dimensions of sustainability. Some relied on comparing development costs for each land-use (Aerts et al., 2005). Others used conversion costs, whether as an independent objective or a sub-objective of land-use

suitability (Aerts et al., 2005; Li & Parrott, 2016). Another common strategy is evaluating the economic benefit of each land-use category and how they contribute to the Gross Domestic Product GDP. In this regard, some land-uses provide to GDP in a direct way such as commercial and industrial land-uses, while others support in an indirect way as hotels, businesses, … etc. (Cao et al., 2019; Li & Parrott, 2016; Mohammadi et al., 2015). On another account, Sharmin et al. (2019) has computed the economic factor through the values of employment capacity per land-use type. Based on the previous attempts, the available data sources, and the analogy that industrial land-uses are incompatible for neighbourhood scale, this paper considers maximizing the area of commercial land-uses for better economic benefits. Hence, the third objective equation is formulated as follows:

$$\max \sum_{i=1}^{R} \beta_{ij} x_{ij}^{commercial} \quad (3)$$

Where βij is the area of land parcel (i,j) and xij commercial is a binary variable equals 1 if (i,j) unit is assigned a commercial land-use and ‘zero’ otherwise (Mohammadi et al., 2015).

4.2 Constraints

For land-use allocation, constraints control the randomity of the attained scenarios and qualify more rational ones by including regulatory knowledge to the optimization process (Cao et al., 2019; Yaolin Liu et al., 2015). According to Yaolin Liu et al. (2015), constraints of land-use allocation may be divided into two types: (i) area constraints, and (ii) spatial constraints. The area constraints are of the most frequently applied constraints, which are accounted for managing a reasonable land-use structure in a given area without exploiting land resources or violating land-use policies (Yaolin Liu et al., 2015; Rahman & Szabó, 2021). Moreover, these constraints coincide with sustainability concerns of urbanization and urban expansion as it limits the built-up land growth (Cao et al., 2019; Rahman & Szabó, 2021). On the other hand, spatial constraints reflect the regional perspective of land-use planning into the equation (Li & Parrott, 2016). Meanwhile, some additional constraints may be derived due to computational complexities. In this regard, most authors disregarded mixed uses for the same land parcel despite being an impractical assumption (Aerts et al., 2005; Li & Parrott, 2016; Ligmann-Zielinska et al., 2005; Rahman & Szabó, 2021). Accordingly, this paper considers minimum and maximum land-use areas as an area constraint, where the Per capita demand for land-use types should be acquired. Eq. (5) and (6) illustrate that the area of land-use type k (Ak) should be within an upper and lower limit expressed as Uk and Lk respectively, where aij is the area of cell (i,j). In addition, transition rules that guide land-use change of different categories are applied as a spatial constraint. As per the optimization algorithm, one and only one use is allowed to be located in each cell in order to

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

alleviate the computational complexity, as illustrated in Eq. (4), where the binary variable xijk must be 0 or 1 (Aerts et al., 2005).

$$\sum_{K=1}^{K} x_{ijk} \quad (4)$$

$$\forall\, i = 1, \ldots..R, j = 1, \ldots..C, x_{ijk} \in \{0,1\}$$

$$L_k \leq A_k \leq U_k \quad (5)$$

where,

$$\sum_{i=1}^{R}\sum_{i=j}^{C} x_{ijk} a_{ij} = A_k \;\forall\, K = 1,,,,,K \quad (6)$$

4.3 NSGA-II

NSGA-II is a variant of Genetic Algorithms that aims at providing a set of equally distributed non-dominated solutions to a multi-objective optimization problem (Masoumi et al., 2019; Song & Chen, 2018b). According to the basic concept of genetic algorithms, NSGA-II undergoes a sequential iterative process, which is illustrated in Fig. 1. It initiates with creating an initial population of solutions Pt, also called candidates or individuals. Secondly, parents selection takes place, based on fitness function evaluation, to create the offspring population Qt through the primary GA operators: crossover and mutation. Thereafter, the GA loop is repeated until the termination criteria is satisfied (Gao et al., 2020; Mohammadi et al., 2015). According to GA, parents are selected randomly by means of selection strategies as tournament selection or roulette wheel selection. As per NSGA-II, an elitist approach is applied to maintain diversity and pareto optimality of generated solutions. This approach consists of non-dominated sorting method followed by crowding distance method, that are used to rank population Rt, so that the fittest are selected (Cao et al., 2011; Gao et al., 2020; Lubida et al., 2019; Masoumi et al., 2019; Song & Chen, 2018b). Furthermore, the crowding distance method generates a well distributed diverse set of solutions through calculations of the density of solutions around a specific solution i in the population (Deb, Pratap, Agarwal, & Meyarivan, 2002; Masoumi et al., 2019).

4.3.1 Elements of NSGA-II

With respect to the land-use optimization problem, each land-use arrangement scenario is regarded as a solution or an individual which is encoded into NSGA-II in the form of a chromosome (Mohammadi et al., 2015). The definition of a chromosome within the optimization model has varied in literature, depending on whether spatial data are expressed in a raster (grid) or vector format. It is argued that vector format adds to the algorithm complexity (Cao et al., 2011). Hence, the prominent one relies on a grid representation that constitutes the chromosome of genes or cells, which represent different land units, each with an assigned value that represents the land-use type in this cell (Masoumi et al., 2019; Mohammadi et al., 2015). This paper adopts a generic tool for Constrained Multi-objective Optimization of Land use Allocation (CoMOLA), that applies NSGA-II to optimize raster maps proceeding from python “inspyred” library (Strauch et al., 2019). In the following section, operators of NSGA-II according to CoMOLA procedures are illustrated.

4.3.2 Initialization

The selection of initial feasible population influences how fast the algorithm would attain the pareto front (Cao et al., 2011; Mohammadi et al., 2015; Strauch et al., 2019). Therefore, CoMOLA adheres to Problem-Based Initialization Operators, which include the status quo of land-use arrangement into the iterative process (Cao et al., 2011; Masoumi et al., 2019). To further guarantee the feasibility of the initial individuals, constraint-controlled genome generation CG is applied (i.e., the genome expresses the chromosome of the initial individual). CG generates a genome gene-by-gene, where at each point the generated sequence of genes is tested for satisfying the algorithm constraints, so that it proceeds to the next gene, or it is regarded as an infeasible solution (Strauch et al., 2019).

4.3.3 Constraint Handling Methods

Integrating real world constraints into optimization models has commonly followed three strategies. The first is feasibility operators which allow only generation of solutions satisfying all constraints. The second

strategy is to convert the constrained problem to an unconstrained one using Penalty Functions or Lagrange Multipliers (Mohammadi et al., 2015). The third strategy, and the one adopted by CoMOLA, is repair mechanisms. In this regard, constrained-controlled repair mutation is developed to repair infeasible individuals into feasible ones provided that the repaired ones are as close as possible to the originally suggested individuals by NSGA-II (Strauch et al., 2019).

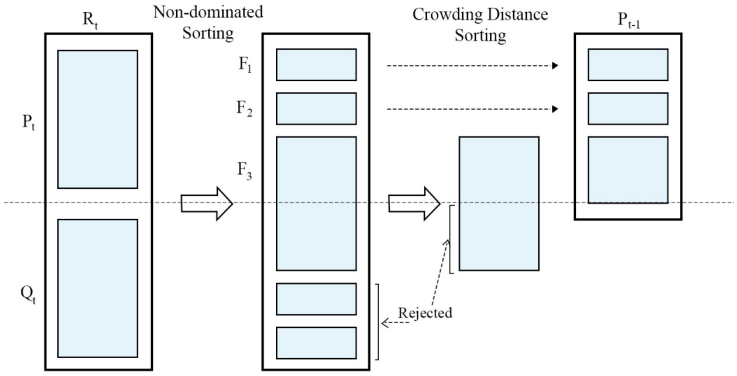


Fig. 1: Illustration of NSGA-II Algorithm procedure (source: Deb et al., 2002).

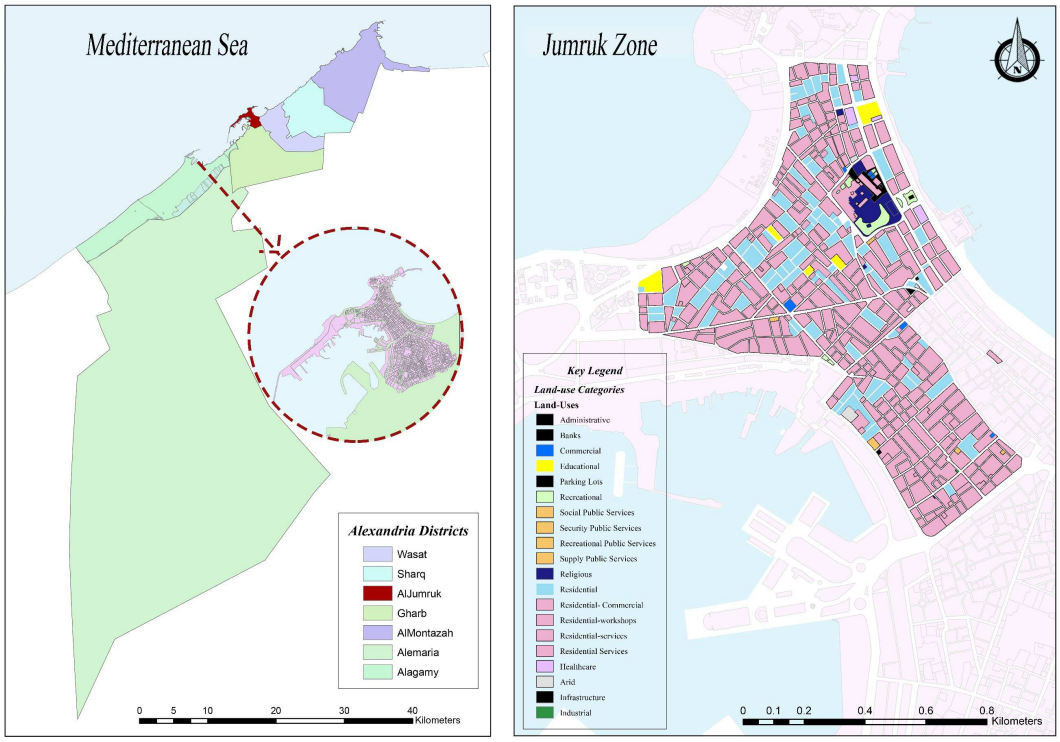


Fig.2: Location of the Study Area of Jumruk District (source: Authors)

4.4 Study Area

Al-Jumruk district is located in the centre of Alexandria city, Egypt as illustrated in Fig. 2. It covers an area of 4.7 Km2 and has 6083 plots of 409,329 population according to 2017 statistics by Central Agency for Public Mobilization and Statistics CAPMAS. It covers four main zones: Al-Jumruk, Al-Mansheyya, Al-Labban and

Alexandria's port. It accommodates a variety of activities and land-uses including administrative, cultural, educational, workshops, religious, public services, touristic, healthcare, residential, mixed-uses, warehouses, and industrial services. Since this district is considered the oldest district of the city, in addition to its unique history, multiple stakeholders are concerned with its development plans. Moreover, several revitalization and rehabilitation projects have been suggested for the area by researchers, urban practitioners, and governmental planning sectors (GOPP,2022). However, the district suffers from some challenges concerning its land-use

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

urban structure, unsustainable conditions, and overcrowding. Hence, this paper recommends supporting urban planners with a design tool as illustrated in section 4.3., that could promote plausible interventions for managing the area in the future.

4.4.1 Data Collection and Preparation

Data required for land-use allocation optimization such as governmental guidelines, maps and statistical data were obtained from the General Organization for Physical Planning of Egypt (GOPP) and the National Organization for Urban Harmony. In addition, GIS data of the district including layers of land-uses, services, roads, infrastructure, transport, … etc. was gathered and adapted for the current research. Following the predominant course of sustainable development, land-use optimization for the study area aims at promoting sustainable land-use arrangements whilst preserving heritage and maintaining proper mix of land-uses.

4.4.2 Model Implementation

A study area of Al-Jumruk zone of an area 1 Km by 1.2 Km is selected for optimization, where the input variables are arranged as follows. CoMOLA model collects three categories of input variables: (1) Model Variables, (2) Map variables, and (3) Algorithm Variables. The model variables are expressed in the range of land-use classes to be optimized and the external models of objective functions. Concerning the land-use classes, the existing land-uses were re-categorized into the fundamental uses at a district level while maintaining an adequate percentage of mixed-uses (Mohammadi et al., 2015). Thus, ten classes of land-uses are considered in the model as shown in Table 2. As per objective functions models, the three objectives illustrated in section 4.1. are formulated into a python code and integrated into CoMOLA. Concerning the third objective, both commercial and mixed residential-commercial land-uses are promoted.

	Arid	*Recreational*	*Mixed Residential -Commercial*	*Medical*	*Religious*	*Educational*	*Commercial*	*Public Amenities*	*High density Residential*	*Offices*
Minimum Area	0	116,446	704,118	2,183	86,715	36,681	472	1997	133300	7312
Maximum Area	625	241,626	977,668	15,720	151,380	641,911	1348	2439	152100	8938

Table 2: Minimum and Maximum Areas Required for Land-use Classes (source: Authors, adapted from GOPP,2022)

The map variables deal with the land-use map and the constraint-related input data. For land-use optimization problems, the study area is defined as a two-dimensional array of R rows and C columns, where K land-use categories need to be assigned (Li & Parrott, 2016; Porta et al., 2013; Yang et al., 2018). Thus, using GIS, a raster map with resolution (cell size) of 25 m was created from the available database of the study area. The resolution is identified experimentally to best reflect the land-use categories of the area, besides following the recommended number of spatial units advised by Strauch et al. (2019). The raster map is thereafter introduced

into the model in ASCII format, where land-use classes are assigned consecutive integers starting with 1. As discussed by Porta et al. (2013), it is advised to adhere to the existing legal boundaries of land parcels when dealing with spatial allocation. Therefore, a patch ID map is generated for the study area, that groups the neighbouring raster cells of the same land plot into a patch or a cluster (Porta et al., 2013; Strauch et al., 2019). The patch ID doesn't only serve planning purposes, but also alleviates the computational load through reducing the number of spatial units, where 252 patches are computed instead of 470 plots. Furthermore, patch ID map is supplied by the indices of static cells (i.e., cells that aren't allowed to change during the optimization process). This serves the conservation of important touristic and heritage sites such as Abu-Al abbas Complex, that is located in the far east of the study area. As for the constraint-related input data, conversions between all land-use classes are permitted in the transition matrix aside from the static elements defined in the patch ID map. Additionally, the minimum and maximum demanded area for the ten land-use classes is deduced and presented in Table 2. In this regard, economic activities, represented in offices category, as well as public amenities are kept within the limits of the current areas. On the other hand, according to the analogy that already developed land isn't converted to undeveloped ones, arid category is prohibited from growth. Furthermore, the ratio of mixed-use plots is preserved and expressed into the area calculations. Since the CoMOLA model perceives the area limits as an absolute constraint, a variation of the current land-use distribution is developed to qualify as the first individual of the first generation. Contextual constraints of allocating land-use categories are applied to this variation using GIS buffer tools.

Finally, the algorithm variables represent the parameters of the different iterations and directly impact the computation time and efficiency (Strauch et al., 2019). Required parameters of the algorithm include maximum number of generations, population size, crossover rate and mutation rate. Based on the rule of thumb crossover rate is set to 0.9, while mutation rate is set to 0.01. Multiple runs of the algorithm are executed to reach the optimum number of generations and population size.

5 RESULTS AND DISCUSSION

In this section, results from CoMOLA model implementation are discussed in detail. As a result of several trials, the model was executed for a population size of 20 and 400 iterations. Execution of the model for such parameters for the three identified objectives in the study area takes 17 hours on a laptop with an Intel(R) Core(TM) i7-7700HQ CPU @ 2.80GHz and 16 GB RAM. Fig. 3 (Right) illustrates the values of objective functions throughout the different iterations. The results show how the solutions gradually enhanced as the iterations proceeded during optimization, which advocates the abundant literature assertions.

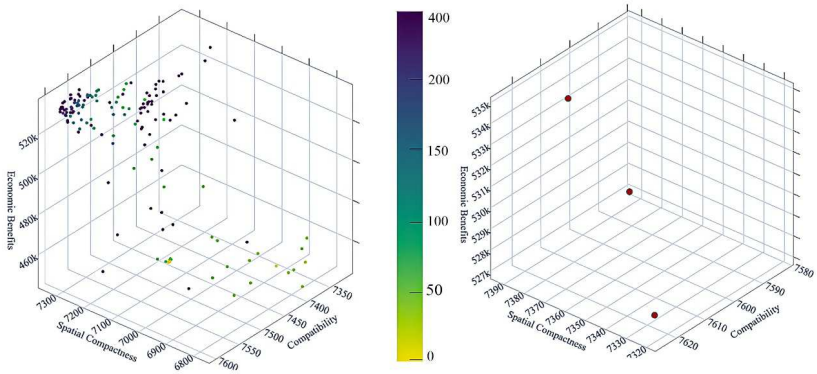


Fig. 5: (Left) The Evolutionary Process of Searching the Solution Space of Objectives and (Right) The Resulting Pareto Front Solutions generated by NSGA-II. The colour bar refers to the order of iterations (source: Authors)

Objectives	*Status Quo*	*Pareto 1*	*% of Improvement*	*Pareto 2*	*% of Improvement*	*Pareto 3*	*% of Improvement*
Spatial Compactness	7242	7394	2.10	7376	1.85	7318	1.05
Compatibility	7599	7581	-0.24	7615	0.21	7626	0.36
Economic Benefits	528125	526875	-0.24	535000	1.30	528125	0.00

Table 3: Comparison of Objective Functions Values of Pareto Solutions with Status quo (source: Authors)

The spatial compactness value ranges from 6760 to 7394. The compatibility objective ranges from 7335 to 7626, while the economic benefits objective increases from 450000 to 535000. However, it is noticed that the speed of generating solutions significantly decreases with each new generation. Different trade-offs among the objectives have been tested. Fig. 3 (Left) demonstrates the compared objective values in three different scenarios. Firstly, when spatial objectives are coupled together, secondly, when the additive objective is coupled with one spatial objective and lastly, when all objectives are pursued simultaneously. The results show that the spatial compactness objective values are enhanced when coupled with the objective of maximizing economic benefits. On the other hand, premature convergence is noticed when only spatial objectives are selected for optimization. In addition, the finest economic objective values are obtained when coupled with spatial compactness objective, whereas its mean values significantly deteriorate when coupled with compatibility. Finally, the results obviously depict that the least values are achieved when all three objectives are combined. The solution space for the algorithm run, along with the resulting pareto solutions, are plotted in Fig.5.

The model suggests three different scenarios as optimum ones for the study area. Each scenario offers a possible intervention that would improve a certain objective value. Table 3 shows the values of the objective functions of the pareto solutions compared to the current state. The comparison reveals slight degrees of improvement for both spatial compactness and economic objectives. However, the compatibility objective values are minimally improved as a trade-off to achieve better comprehensive values.

Fig.6 shows the three pareto land-use maps suggested by the algorithm. The three maps present different objectives preferences, such that the first pareto solution offers the highest spatial compactness value while

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

the third one best supports maximizing compatibility. In addition, the second pareto solution displays a balanced improvement of all three objectives with maximum economic values.

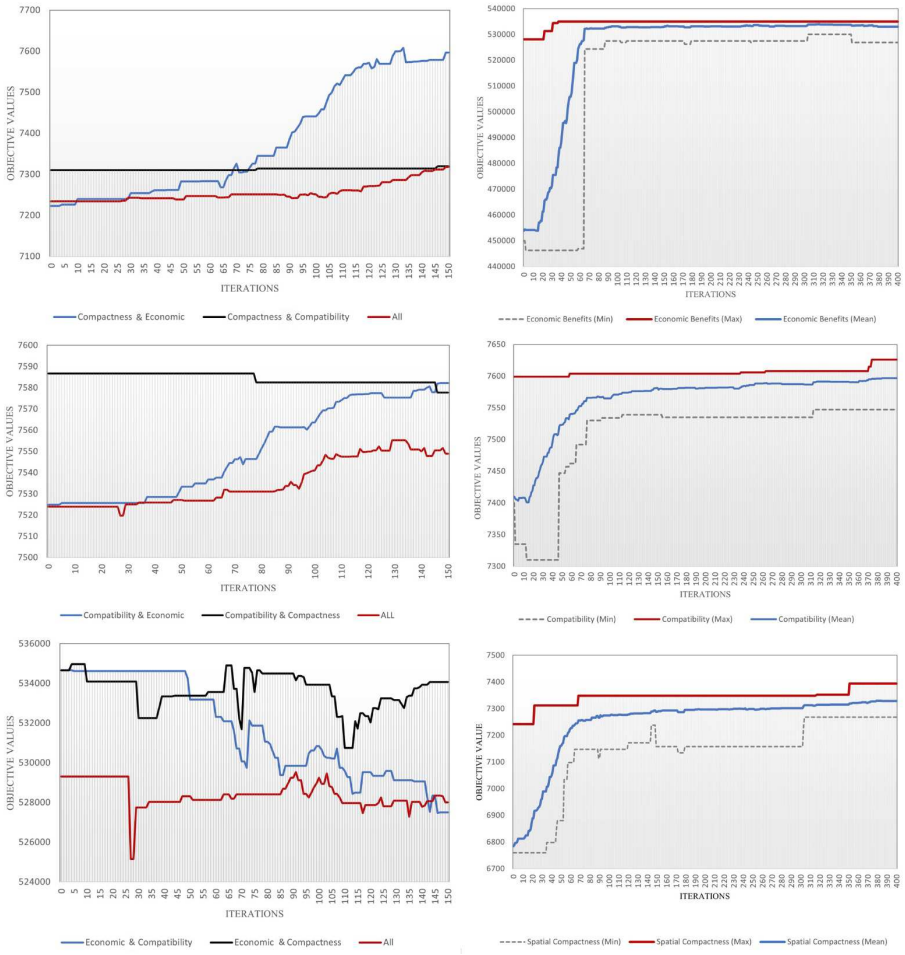


Fig. 3: (Left) Result Values for Trade-offs among Objective Functions and (Right) Maximum, Mean and Minimum Values for the Objective Functions at Each Iteration (source: Authors)

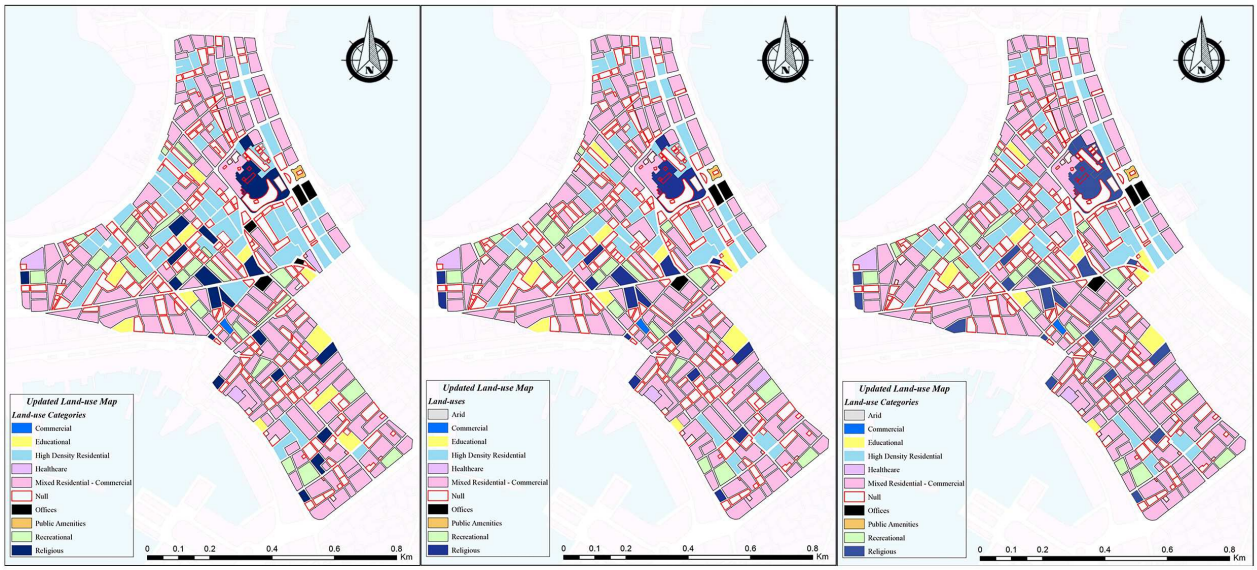


Fig.6: Optimized arrangements of land-uses under different objective preferences as suggested by NSGA-II (source: Authors)

It is noticed in pareto 1 that high density residential lots are promoted into clusters, also religious and healthcare land-uses are distributed in close proximity. With respect to pareto 2, it is observed that the percentage of mixed-use parcels is enlarged. Lastly, the third pareto proposes minimal adjustment to the second one concerning the educational land-uses arrangement, in order to promote better compatibility. The

proposed land-use structures are generally more rational than status quo land-uses regarding the distribution of different land-use categories. The proposed intervention implies an increase in the areas of medical, recreational and religious land-uses by 12%,482% and 200% respectively. These rates can be justified due to the low per-capita demand for such uses in the area. The illustrated solution can be regarded as a preliminary step to support decision makers with general guidelines on how to pursue with the study area future plans.

Nevertheless, a number of plots can be observed missing from the pareto solutions due to raster representation of the study area map. Due to limitations in transferring maps into raster format, some plots might be ignored for their size or orientation. In this regard, different cell sizes might present better inclusion of plots, however, it may cost the optimization process additional running time and complexity. The analysis of results reveals the extensive time needed by the model to run a couple of hundred iterations which can be traced back to the constraint handling logic of the algorithm. In this respect, the area constraints are applied in an absolute manner, where all individuals that don't satisfy the minimum and maximum boundaries are completely neglected by the algorithm. This process consumes a large amount of time and imposes greater challenges for each generation to generate feasible solutions. Incorporation of such constraints into the selection procedures as penalty functions might lead to more diverse solutions in a better time frame. This would enable the algorithm execution with higher iteration values to attain better improvement results. Additionally, this approach is more rational when dealing with optimizing current land-use distribution, where it is expected to work on several scenarios of area constraints violations. On the other hand, the study area is regarded as a very dense residential region which limits the flexibility of land-use changes without compromising the per-capita demand of the region. Therefore, considering a less dense area with more vacant lots might result in better intervention scenarios. Finally, the spatial compactness approach adopted in this paper, can be observed in the results that it promotes adjacency of similar uses even for service land-uses.This might contradict the general urban planning guidelines for land-uses distribution where services as educational, medical, religious, etc. should be allocated within a maximum distance of served residential units. Hence, additional contextual constraints could be incorporated when developing objective functions.

6 CONCLUSION

Land-use allocation is one of the practices of land-use planning that involves arrangement of land-uses into different spatial units of land. It is a complex process as it is constrained by, as well as influencing on, the economic, social, and environmental conditions of the city. Hence, it is an important policy for sustainable development. Due to the numerity of the variables, objectives and constraints involved in the process, land-use allocation is considered a multi-objective spatial optimization problem. This paper addresses the use of land-use optimization models in real contexts through employing an NSGA-II optimization model to the local neighborhood of Aljumruk in Alexandria. It also provides an approach of integrating spatial and economic objectives into a generic CoMOLA model, where they are interpreted into a set of quantitative evaluation operations. GIS software was used to visualize the exports of the algorithm and compare them to the status quo land-uses. The application of the model depicted its potential to interactively support decision making processes through generating numerous alternatives and offering a multitude of near optimal solutions for land-use distributions. It also demonstrated the capacity of models to accommodate spatial objectives through mathematical expression. Nevertheless, the paper highlights a set of limitations that could be the scope of future work including the need for a framework that employs vector representation of land-use maps without adding further complexities. This could provide improved optimization for real contexts scenarios. Moreover, it is recommended to apply further tests to investigate the interrelation between constraint handling techniques and the algorithm running time. Finally, only three objectives were the scope of this research. Thus, incorporating more objectives in the future could give better insights for comprehensive sustainable land-use planning.

7 REFERENCES

Aerts, J., Heuvelink, G., & Stewart, T. (2018). Using Linear Integer Programming for Multi-Site Land-Use Allocation.

Aerts, J., Van Herwijnen, M., Janssen, R., & Stewart, T. (2005). Evaluating Spatial Design Techniques for Solving Land-use Allocation Problems. Journal of Environmental Planning and Management, 48(1), 121-142. doi:10.1080/0964056042000308184

Balling, R., Taber, J., Brown, M. R., & Day, K. (1999). Multiobjective Urban Planning Using Genetic Algorithm. Journal of Urban Planning and Development-asce, 125, 86-99.

Cao, K., Batty, M., Huang, B., Liu, Y., Yu, L., & Chen, J. (2011). Spatial multi-objective land use optimization: extensions to the non-dominated sorting genetic algorithm-II. International Journal of Geographical Information Science, 25(12), 1949-1969. doi:10.1080/13658816.2011.570269

Cao, K., Liu, M., Wang, S., Liu, M., Zhang, W., Meng, Q., & Huang, B. (2020). Spatial Multi-Objective Land Use Optimization toward Livability Based on Boundary-Based Genetic Algorithm: A Case Study in Singapore. ISPRS International Journal of Geo-Information, 9(1), 40. doi:10.3390/ijgi9010040

Cao, K., Zhang, W., & Wang, T. (2019). Spatio-temporal land use multi-objective optimization: A case study in Central China. Transactions in GIS. doi:10.1111/tgis.12535

Deb, K., Pratap, A., Agarwal, S., & Meyarivan, T. (2002). A fast and elitist multiobjective genetic algorithm: NSGA-II. IEEE Transactions on Evolutionary Computation, 6(2), 182-197. doi:10.1109/4235.996017

Gao, P., Wang, H., Cushman, S. A., Cheng, C., Song, C., & Ye, S. (2020). Sustainable land-use optimization using NSGA-II: theoretical and experimental comparisons of improved algorithms. Landscape Ecology, 36(7), 1877-1892. doi:10.1007/s10980-020-01051-3

Gharaibeh, A. A., Ali, M. H., Abo-Hammour, Z. S., & Al Saaideh, M. (2021). Improving Genetic Algorithms for Optimal Land-Use Allocation. Journal of Urban Planning and Development, 147(4). doi:10.1061/(asce)up.1943-5444.0000744

Huang, B., & Zhang, W. (2014). Sustainable Land-Use Planning for a Downtown Lake Area in Central China: Multiobjective Optimization Approach Aided by Urban Growth Modeling. Journal of Urban Planning and Development-asce, 140, 04014002.

Karakostas, S. M. (2016). Land-use planning via enhanced multi-objective evolutionary algorithms: optimizing the land value of major Greenfield initiatives. Journal of Land Use Science, 11(5), 595-617. doi:10.1080/1747423x.2016.1223187

Leccese, M., & McCormick, K. (2000). Charter of the new urbanism: McGraw Hill.

Li, X., & Ma, X. (2018). An improved simulated annealing algorithm for interactive multi-objective land resource spatial allocation. Ecological Complexity, 36, 184-195. doi:10.1016/j.ecocom.2018.08.008

Li, X., & Parrott, L. (2016). An improved Genetic Algorithm for spatial optimization of multi-objective and multi-site land use allocation. Computers, Environment and Urban Systems, 59, 184-194. doi:10.1016/j.compenvurbsys.2016.07.002

Ligmann-Zielinska, A., Church, R. L., & Jankowski, P. L. (2005). Sustainable Urban Land Use Allocation With Spatial Optimization.

Liu, X., Li, X., Shi, X., Huang, K., & Liu, Y. (2012). A multi-type ant colony optimization (MACO) method for optimal land use allocation in large areas. International Journal of Geographical Information Science, 26(7), 1325-1343. doi:10.1080/13658816.2011.635594

Liu, Y., Tang, W., He, J., Liu, Y., Ai, T., & Liu, D. (2015). A land-use spatial optimization model based on genetic optimization and game theory. Computers, Environment and Urban Systems, 49, 1-14. doi:10.1016/j.compenvurbsys.2014.09.002

Liu, Y., Wang, H., Ji, Y., Liu, Z., & Zhao, X. (2012). Land use zoning at the county level based on a multi-objective particle swarm optimization algorithm: a case study from Yicheng, China. Int J Environ Res Public Health, 9(8), 2801-2826. doi:10.3390/ijerph9082801

Lubida, A., Veysipanah, M., Pilesjo, P., & Mansourian, A. (2019). Land-Use Planning for Sustainable Urban Development in Africa: A Spatial and Multi-Objective Optimization Approach. Geodesy and cartography, 45(5), 1-15. doi:10.3846/gac.2019.6691

Ma, S., He, J., Liu, F., & Yu, Y. (2011). Land-use spatial optimization based on PSO algorithm. Geo-spatial Information Science, 14(1), 54-61. doi:10.1007/s11806-011-0437-8

Masoumi, Z., Coello Coello, C. A., & Mansourian, A. (2019). Dynamic urban land-use change management using multi-objective evolutionary algorithms. Soft Computing, 24(6), 4165-4190. doi:10.1007/s00500-019-04182-1

Mohammadi, M., Nastaran, M., & Sahebgharani, A. (2015). Sustainable Spatial Land Use Optimization through Non-Dominated Sorting Genetic Algorithm-II (NSGA-II): (Case Study: Baboldasht District of Isfahan). Indian Journal of Science and Technology, 8(S3), 118. doi:10.17485/ijst/2015/v8iS3/60700

Porta, J., Parapar, J., Doallo, R., Rivera, F. F., Santé, I., & Crecente, R. (2013). High performance genetic algorithm for land use planning. Computers, Environment and Urban Systems, 37, 45-58. doi:10.1016/j.compenvurbsys.2012.05.003

Rahman, M. M., & Szabó, G. (2021). Multi-objective urban land use optimization using spatial data: A systematic review. Sustainable Cities and Society, 74, 103214. doi:10.1016/j.scs.2021.103214

Sahebgharani, A. (2016). Multi-Objective Land Use Optimization through Parallel Particle Swarm Algorithm: Case Study Baboldasht District of Isfahan, Iran. Journal of Urban and Environmental Engineering, 10(1), 42-49. doi:10.4090/juee.2016.v10n1.042049

Sharmin, N., Haque, A., & Islam, M. M. (2019). Generating Alternative Land-use Allocation for Mixed Use Areas: Multi-Objective Optimization Approach. Geographical Analysis, 51(4), 448-474. doi:https://doi.org/10.1111/gean.12181

Song, M., & Chen, D. (2018a). A comparison of three heuristic optimization algorithms for solving the multi-objective land allocation (MOLA) problem. Annals of GIS, 24(1), 19-31. doi:10.1080/19475683.2018.1424736

Song, M., & Chen, D. (2018b). An improved knowledge-informed NSGA-II for multi-objective land allocation (MOLA). Geo-spatial Information Science, 21(4), 273-287. doi:10.1080/10095020.2018.1489576

Stewart, T. J., Janssen, R., & van Herwijnen, M. (2004). A genetic algorithm approach to multiobjective land use planning. Computers & Operations Research, 31(14), 2293-2313. doi:10.1016/s0305-0548(03)00188-6

Strauch, M., Cord, A. F., Pätzold, C., Lautenbach, S., Kaim, A., Schweitzer, C., . . . Volk, M. (2019). Constraints in multi-objective optimization of land use allocation – Repair or penalize? Environmental Modelling & Software, 118, 241-251. doi:10.1016/j.envsoft.2019.05.003

Yang, L., Sun, X., Peng, L., Shao, J., & Chi, T. (2015). An improved artificial bee colony algorithm for optimal land-use allocation. International Journal of Geographical Information Science, 29(8), 1470-1489. doi:10.1080/13658816.2015.1012512

Yang, L., Zhu, A., Shao, J., & Chi, T. (2018). A Knowledge-Informed and Pareto-Based Artificial Bee Colony Optimization Algorithm for Multi-Objective Land-Use Allocation. ISPRS International Journal of Geo-Information, 7(2), 63. doi:10.3390/ijgi7020063

Yao, J., Murray, A. T., Wang, J., & Zhang, X. (2019). Evaluation and development of sustainable urban land use plans through spatial optimization. Transactions in GIS. doi:10.1111/tgis.12531

🏆 *reviewed paper*

Sustainable Revolution for a Greener Planet – Possibilities in the Indian Context

Kurada Sharmila Dharani, Basudatta Sarkar

(Kurada Sharmila Dharani, Department of Planning and Architecture, National Institute of Technology Rourkela, Rourkela, 769008, Odisha, India, sharmilakurada@gmail.com)
(Dr. Basudatta Sarkar, Department of Planning and Architecture, National Institute of Technology Rourkela, Rourkela, 769008, Odisha, India, sarkarb@nitrkl.ac.in)

1 ABSTRACT

The key challenge of the urbanisation process is the rise in population at a rapid pace. Although the reason is the aim of a better life for people, it is costing the environment and healthy living to a great extent in diverse ways. This sudden rise in population attracts uninvited guests like pollution, traffic, congestion, lack of green spaces, urban heat island effect, etc. The paper aims to study the environmental effects of the increased urban population, to bring sustainable awareness and environmental justice to the planet. The study draws comparisons of effects between the countries of the world and India, which in turn helps in formulating diverse ways to raise a sustainable revolution, and their applicability in developing countries like India. The approach helps understand the impact that can cause if not implemented at the earliest. The 2022 ranking of the Environmental Performance Index (EPI) and Sustainable Development Report (SDR) shows that India occupied the 180th position out of 180 countries, and the 121st position out of 163 respectively, indicating the necessity for a sustainable revolution in the context of India at a much bigger scale than the present. This not only shows different parameters affecting the planet but also the roles of diverse people in the revolution. The sustainable revolution can be achieved by the use of renewable energy techniques, energy-saving fixtures, control mechanisms, and responsive measures. The key methodology here is to apply these to the cities around the globe which would draw inspiration and awareness to others, thereby transforming the whole planet into sustainable practice. This revolution should start right from the smaller products at the building and the community level. The concern for health and luxury needs to be combined to form a single sustainable by-product. The perspective of products for a single-use needs to be changed and addressed. Sustainable awareness of different products, materials, and standards should be raised among diverse individuals, like students, teachers, employees, government servants, etc. Awareness campaigns at various places would help to revolutionise sustainable practice on a large scale, especially when the results are seen straight away. The paper concludes with the diverse ways of raising sustainable revolution that help in making a greener planet, which reduces expenses drastically and boosts people's confidence. Once, people get used to this, it would be a game-changer for the planet's health. The paper also discusses the role of government and people, where the former play a key role in taking the revolution to further heights.

Keywords: Sustainable, Sustainable Revolution, Awareness, Greener planet

2 INTRODUCTION

With time, humans' thought process and lifestyle changed over the years and centuries and is constantly changing in the quest to be better, intelligent, and more productive. The agricultural era helped them to understand nature, the value of resources, climate changes, seasons, animals, and much more, which can be called the best sustainable method of living to date, with the use of minimal resources, natural products, required amount of food production, clear and clean water resources and natural pathways. There is no record of human-made threats to the environment back then. After industrialisation, everything changed along with the human way of thinking and quest to expand, gain more opportunities, economy boost, and betterment of life. During this era, with the production of more goods, transportation, new factories and living quarters, the demand increased for resources at a larger scale right from land for construction to the breathing air. Pollution started everywhere on land, water, air, and human minds as well. Mankind adapted and believed to use their surroundings as they owned them. They utilised the resources of the environment as if they were never-ending, without even thinking of the circumstances.

Gradually over time, with their intelligence, betterment of life on earth, but on the verge of the most worsening circumstances, they understood that these natural resources are not infinite but limited. Although this thought process started some years ago it picked up acceleration a decade ago. People started to understand the terms of sustainability and its effects. Depleting resources and national calls for environmental betterment are the talks of the town and laid the foundation for sustainability in the world.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

When the COVID-19 pandemic hit the world, people started to realise the importance of health, clean surroundings, nature, and life on earth. It is also observed that nature cures itself without the intervention of humans in a very practical way. Nevertheless, it should not be thought that the depleting natural resources will emerge with all their power in a few days. The resources that we used over the years need some centuries to gain their natural state and to be plenty as needed. Although the past cannot be changed but can be rewritten now, the future ahead should be well-thought through, planned, and implemented at its best to foster the health and wealth of the environment.

2.1 Sustainable Revolution

According to McManners, the term "sustainable revolution", is the revolution caused by the actions to combat climate change. It can also be called the change of methodology, process, and usage to overthrow the unsustainable means of overexploitation of resources, pollution, and damage to the environment, through measures, actions, policies, frameworks, and awareness. (Burns, 2012). The sustainable revolution can improve issues like extreme weather changes, decline in water resources, pollution, health, and safety, and the economy. (The Sustainability Revolution: What investors should know, 2021).

The Sustainable revolution helps achieve sustainability across sectors to make progress towards holistic sustainable development in the world. This not only ensures environmental health and well-being but also boosts social, and economic growth in each country (Burns, 2012). Among the other aspects, environmental sustainability is on the verge of a knife, which not only does affect mankind, but also every life on the earth, and the planet itself. So, environmental sustainability is of highest importance on the immediate basis.

2.2 Necessity

According to (Burns, 2012), the greenhouse gases that have been released over the years will settle in the atmosphere for millions of years and will increase if it is not realised at the earliest that this has enormous impacts on climate change, sea level rise, floods, droughts affecting agriculture, severe storms, the spread of pandemics and epidemics. Burn's study (2012) shows that environmental change has been happening since 1760 due to pollution, natural resources consumption, marine loss, deforestation, biodiversity loss, tourism, etc. All these challenges and issues are turning the world unsustainable in the modern era. This led to treaties, agreements, and policies in many countries nationally and internationally. The sustainable revolution helps in achieving these goals and sets targets in a more fast-paced advanced way than before. It is not limited to the developed countries, but every nation on the Earth. Mutual cooperation and respect can help each other in combating environmental changes, as each nation has a different set of measures and strategies for its diverse and unique biodiversity.

3 RANKING SYSTEMS

The sustainable measures followed across the world are measured by varied tools in different categories. The holistic approach by different countries to meet the seventeen Sustainable Development Goals (SDGs) is assessed globally by the United Nations, by providing a Sustainable Development Index through annual reports. The fundamental principles of SDGs are much more than environmental protection, like inclusion, cooperation, in-control production and consumption, and global access to clean energy. So, to spotlight environmental sustainability, encourage competition and help the countries to keep track of their climate target goals by 2050, the Yale Centre for Environmental Law & Policy and the Centre for International Earth Science Information Network (CIESIN) at Columbia University's Earth Institute developed a common ranking system called Environmental Performance Index (EPI). (Wolf, 2022).

The Environmental Protection Index (EPI) helps provide a summary of the sustainable ranking of different countries using 11 issue categories, which are further divided to 40 performance indicators on ecosystem vitality, environmental health, and climate change performance. (Wolf, 2022). This EPI ranking is released biennially in even-numbered years. In the year 2022, the EPI ranked 180 countries across the world to measure the state of sustainability in each country, using the data from international organisations, research institutes, academia, and government agencies upon verification by a third party. Denmark with its overall EPI score of 77.90 secured first place in EPI 2022 results, followed by the United Kingdom, Finland, Malta, and Sweden. (Wolf, 2022). From this analysis it is quite evident that most of the European countries are in

the top tiers with sustainable measures and policies, whereas Asian countries like India, Myanmar, Vietnam, Bangladesh, Pakistan, and Papua New Guinea were placed the lower tiers going off track towards their environmental goals and targets. According to the report released by the EPI which is the Summary for Policymakers, EPI data analysis shows that financial resources, good governance, human development, and regulatory government policies are some of the reasons for the elevated rankings of sustainability of top-tier countries. Although EPI helps with comparisons of different countries regarding sustainability, strategies and policies followed by pioneering nations are beyond their scope of analysis. Hence, this paper studies the best practices, strategies, and policies implemented in top-tier nations for the betterment of sustainable approaches worldwide.

3.1 EPI Analysis

The analysis of the Environmental Performance Index (EPI) framework, based on policy objectives, issue categories, and indicators has resulted in a trend score for the last decade in which Malta has increased its score most by 25.4 points and Burundi decreased by 13 points in the overall category. Wolf (2022) emphasises that this trend scores much more than the actual EPI score of each country, because the trend score implies the country's actions over the last decade, thereby enhancing the policy gauge, measures, and strategies that helped uplifting the trend score drastically over the decade. The top three nations with greater trend scores against each policy and issue category are listed below in Table 1 and Table 2 respectively.

Sl.no.	Policies	Abbrev.	Trend Score - Top-tier Countries
1	Ecosystem Vitality	ECO	Malta, Kuwait, Croatia
2	Environmental Health	HLT	Estonia, Lithuania, Portugal
3	Climate Policy	PCC	Finland, United Kingdom, Afghanistan

Table 1: Environmental Performance Index (EPI) policies with top-tier nations in trend score, 2022

Sl.no.	Policies	Issues	Abbrev.	Trend Score - Top-tier Countries
1	Ecosystem Vitality	Biodiversity & Habitat	BDH	United Arab Emirates, Bahamas, Croatia
2		Ecosystem Services	ECS	Malta, Mauritius, Micronesia
3		Fisheries	FSH	Mozambique, Cabo Verde, Panama
4		Acid rain	ACD	Montenegro, China, Republic of Congo
5		Agriculture	AGR	Saudi Arabia, Oman, Tonga
6		Water Resources	WRS	Denmark, Finland, Netherlands
7	Environmental Health	Air Quality	AIR	Estonia, Lithuania, Moldova
8		Sanitation & Drinking Water	H20	Iraq, Sao Tome and Principe, Sudan
9		Heavy Metals	HMT	United Arab Emirates, South Korea, Singapore
10		Waste Management	WMG	Georgia, Mauritius, Norway
11	Climate Change Policy	Climate Change Mitigation	CCH	Finland, United Kingdom, Afghanistan

Table 2: Environmental Performance Index (EPI) policies and issues with top-tier nations in trend score, 2022

3.1.1 Ecosystem Vitality

Ecosystem vitality policy gauges the measures followed by different nations to protect and preserve the ecosystems and their services. It is assessed based on various categories like biodiversity and habitat, ecosystem services, fisheries, acid rains, agriculture, and water resources. Malta, Kuwait, and Croatia lead the ecosystem vitality policy with their enormous development over the last decade.

Malta addressed the causes of biodiversity loss, with a target of creating awareness of the term “biodiversity” and steps to protect and conserve it sustainably for its citizens. Malta valued and understood the advantages of conservation by integrating national policies, and decision-making. It promoted incentives and addressed environmental harmful subsidies and shifted all the directly benefitting sectors by the ecosystem services to the sustainable approach. It also made significant contributions to reducing the rate of loss of natural habitats, forest cover, overexploitation of resources, managing agriculture and aquaculture in sustainable approaches, addressing pollution through effective measures, maintenance of marine biodiversity areas, and

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

reducing the extinction of threatened species through improved conservation status. Safeguarding ecosystems, reducing the impacts of climate change, regulating access to national genetic resources, and recognising the contribution of local communities towards sustainable biodiversity are some of the measures followed by Malta during its process of attaining sustainability. (CBD Strategy and Action Plan - Malta, 2012).

Kuwait kickstarted the measures with a detailed process of documenting its biodiversity to understand and ensure its continual characterisation and monitoring, planning the biodiversity to prevent and mitigate adverse impacts and their causes to help the ecosystem to function better, managing and strengthening the conservation policies, enforcing the legislative laws, using biological resources within sustainable limits, and reviewing and valuing them at regular intervals. It educated and involved public participation through programmes, refining school curricula, advertising issues, and promoting national programmes to develop a deep understanding of the values of biodiversity in society. Every measure it planned has a clear objective based on analysis of research, past policies, issues, training required and main constraints. It prepared a strategic response with an agenda for action, short-term of initial 3 years, medium-term of within the next two years, and long-term goals for 5-10 years. This helped Kuwait to gauge its policies and measures to a great extent. (CBD Strategy and Action Plan - Kuwait, 2010).

Croatia prevented the loss of terrestrial biodiversity, and reduced marine and coastal biodiversity by increasing the number of protected areas. It implemented its plans for the protection of endangered species, established landscape management plans, conserved characteristic landscape features, planned the use of natural resources, and promoted restoration initiatives for agricultural and degraded forest lands. It encouraged cultivation on arable lands to achieve sustainable agriculture and to maximise the required products. It aimed to demine all mine-infested areas at the earliest, provided economic measures to ensure utilisation of abandoned spatial reserves and the transformation and remediation of industrial zones with closed-down factories. In planning its settlements, it reduced the growth of large cities to functionally equip the medium and smaller towns with 7000 to 30000 inhabitants, promoted development models – which improve the space and preserve the physical and ecological integrity of resource areas. (Strategy for Sustainable Development of the Republic of Croatia, 2009).

3.1.2 Environmental Health Policy

Environmental Health Policy measures the countries' protection against the risks to environmental health. Protection is assessed based on the air quality, access to sanitation and drinking water, pollution by heavy metals, and management of waste (Wolf, 2022). Estonia, Lithuania, and Portugal lead this policy with their strategies over the last ten years.

Estonia identified that biodiversity in wetlands, and forests are affected by air pollution and has taken steps to reduce their impact. Measures were taken for the exhaust of harmful gases from vehicles, conservation of aquatic habitats like lakes, rivers, streams, and springs, treatment plants for wastewater. Policies to strengthen the laws have helped for their betterment. (Nature Conservation Development Plan until 2020, 2012). Lithuania's policies for the reduction of harmful risks to the environment are strengthened by action on the level of pollutants, air quality, illegal waste, safe drinking water supply, wastewater, and sanitation facilities. Campaigns to promote environmentally friendly transportation are some of the measures they adopted over a few years. (Environment and health performance review - Lithuania, 2009). Portugal has devised strategic laws and policies to ensure better environmental health for its citizens by reducing the main emission sources and harmful concentrations of oxides, especially in urban and industrial areas. They improved the water quality by close monitoring and reducing diffuse and organic pollution with treatment facilities, management of waste by separate collection, landfill diversion targets, reduction of waste generation, and by limiting energy recovery to non-recyclable materials (The Environmental Implementation Review 2019 - Country Report Portugal, 2019).

3.1.3 Climate Policy

Climate change policy is the latest policy in EPI 2022, which has a single-issue category, climate change mitigation, which measures the progress of each country in combating climate change. This policy helps the mitigation of environmental threats and improves human health and safety. It is composed of various indicators: emission growth rates of greenhouse gases (GHG), carbon dioxide, methane, fluorinated gases,

nitrous oxide, black carbon, projected GHG emissions in 2050, growth rate in carbon-dioxide emissions from land cover, GHG intensity growth rate, and GHG per capita. Adjusted emissions for GHG measure the rate of average annual emissions over the years and the reduction in emissions. In each country this needs to be at least ≥7.59% per year for CO2, ≥5.0% for CH4, ≥3.94% for F-gases, ≥1.95% for N2O gases, and ≥1.87% for black carbon to achieve the fullest sustainable score in EPI. Projected GHG Emissions in 2050 help track countries path to zero emissions of GHG (CO2, CH4, F-gases, and N2O set for the 2050 climate target, calculates the average emissions and extrapolates them for 2050. The growth rate in carbon-dioxide emissions from land cover needs to be the lowest possible for each country. The GHG intensity growth rate highlights the need for action in all the countries in this regard. Finland, the United Kingdom, and Afghanistan lead this category over the last decade (Wolf, 2022).

Finland increased the adaptation measures for climate change to cut down greenhouse gas emissions, assessed the impacts of climate change, and developed required frameworks in policies with close monitoring systems (CBD Strategy and Action Plan - Finland, 2007). The United Kingdom improved its climate change rankings with its increase in green infrastructure, promotion of sustainable materials, increase in the use of digital services, webinars, conferences, etc, to reduce travel needs. ecological initiatives, water and energy efficient equipment and raising sustainable awareness through education, and programs (Preparing for Climate Change: A Climate Change Adaptation Strategy, 2020). Afghanistan prioritized low emission and climate-friendly energy projects, especially in rural areas to provide accessible energy to stimulate rural economic growth, aims to reduce GHG emissions utilizing support from the Climate Technology Initiative Private Financing Advisory Network (CTIPFAN), and promoted low-carbon, sustainable development, and renewable energy usage for the better tomorrow. (Climate Change and Governance in Afghanisthan, 2015).

From, the strategies initiated by the pioneering nations, enumerated above, it can be observed that countries tend not to aim for complete 100% of success at once, but are setting targets for some issues for specific time horizons, analyzing and evaluating them, and moving forward by gradually improving their policies and measures.

4 EXISTING SUSTAINABLE PRACTICES IN INDIA

With its diverse cultural and biodiversity species, India is a major contributor to the world's biodiversity. From assessments and studies over many years, India came up with some sustainable targets for the nation with their updated strategic plans by including Aichi biodiversity targets, and Millennium development goals. As a part of the process, India aligned the concerned bodies to these strategic goals to conserve biodiversity. The government of India assigned many departments at different levels to keep the track of the goals. Although this eased the process for central monitoring, the inclusion of many ministries at the national, state, and local levels, but this lags the decision-making to move forward.

India addressed the Aichi biodiversity strategic goals by taking into consideration of few main topics like awareness, integration, and upgradation of policies, phasing out the unsustainable and harmful practices, promotion of sustainable practices through subsidies and incentives, and involving stakeholders and other business elites for sustainable production and consumption. These not only pave way for the conservation of biodiversity but are also helpful in bridging the gap between the people and the government.

The government of India made the mandatory curriculum for the students at the school level through National Council of Education Research and Training (NCERT) and Ministry of Human Resource Development (MoHRD) programs across the country to raise awareness among the students, and also introduced electives for higher education, awareness campaigns through the Paryavaran Mitra program, National Green Corps Programme, etc. The government also integrated and updated policies like the Mahatma Gandhi National Rural Employment Guarantee Act (MNREGA), initiatives like Environmental Performance Index (EPI), and The Economics of Ecosystems and Biodiversity (TEEB - India) for the evaluation of vast biodiversity in India. India is also investing in improving medicinal plants, organic farming and forest cover through National Mission on Medicinal Plants (NMMP) and National Project on Organic Farming Scheme (NPOF). Green National Accounting and other green certification initiatives are advising bodies on the tools for sustainable practices and encouraging the conservation initiatives taken in the private sector. For the prohibition of the use of harmful chemicals and fertilizers, the government reduced

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

the prices for potassium and phosphorous to encourage their usage and increased the prices for urea which is harmful to agriculture.

Few of the other things India is currently working on are, the reduction of loss of natural habitats, marine, and coastal ecosystems, agriculture, pollution, and measures for invasive alien species, etc. For the conservation of these systems and services, India is investing in various programs and schemes. For the reduction of afforestation, and to control and mitigate climate change, National Afforestation and Eco-development Board (NAEB) is set up for monitoring and guiding the forest development agencies. India also added around 3 million hectares of forest cover over the last decade, through the Green India Mission afforestation program. These programs not only facilitated the forests and the beneficiaries but also reduced the emissions from afforestation and forest fires. Green India Mission also helped in the restoration of Chilika lake in Odisha. For the conservation of lakes and wetlands, the National Programme on Conservation of Aquatic Ecosystem (NPCAE) scheme helps in, by preventing the degradation of aquatic ecosystems through sustainable conservation measures. The government of India is also exploring the marine and aquatic life in Indian waters, through more research centres like Central Marine Fisheries Research Institute (CMFRI), National Centre for Sustainable Coastal Management (NCSCM), etc. Actions were also being taken on the brackish water, research and education on fisheries, animal husbandry, expansion of fisher folk, etc. These are all being scaled by the Integrated Coastal and Marine Management (ICMAM) Programme, National Institute of Ocean Technology (NIUT), and Fisheries Survey of India (FSI) under the Ministry of Agriculture (MoA), and Ministry of Earth Science (MoES). Sustainable management of agriculture and other ecosystem services fosters the wealth, health, and welfare of direct beneficiaries and the environment. The government seeks to manage sustainability through the National Agricultural Policy (NAP) and National Mission for Sustainable Agriculture, Coastal Aquaculture Authority for the regulation of coastal activities. Not only these, but Government also taking conservation measures for degraded areas, and forests. The best example is Madhya Pradesh's land use management to combat land degradation. (CBD Fifth National Report - India, 2014).

The country is also investing in reducing pollution levels, through Central Pollution Control Board (CPCB). Through CPCB, the air quality is controlled and monitored by National Air Quality Monitoring Programme (NAMP), and for the improvement of the environment in urban areas, Eco-city program has been initiated. CPCB is also responsible for water quality, noise pollution, and control of pesticides and fertilizers under MoA. The control and eradication of invasive alien species are being implemented through NBAP 2008 by the Forest Invasive Species Cell in the Indian Council of Forest Research and Education, Dehradun. And for the reduction of the anthropogenic threats on coral reefs and ecosystems, extinction of threatened species, plant genetic species, soil erosion, and Himalayan eco-system conservation, measures are taken by the government of India.

Although India has well-addressed the majority of the above-discussed issues affecting environmental sustainability, the results are not up to the mark as aimed for. These results show that either the laws and policies framed are not implemented to their fullest, lack stringent monitoring and applicability, lack promotional awareness of the applicable bodies, lack financial resources, or irresponsibility of the citizens for a better tomorrow.

5 ANALYSIS OF STRATEGIES ADOPTED IN INDIA

The Fifth National Report that is submitted to Convention on Biological Diversity (CBD) by India showed various strategic action plans that the country has for different issues, regulated by the multi-tier heads at national, state, and regional levels. Not only does India sign to abide by CBD but also others like Aichi Biodiversity Targets and Millennium Developmental Goals along the way, showing its interest in sustainability and responsibility for Earth. It is fairly seen that India progressed towards the set targets and goals by incorporating them into the planning process at every level, and also allocating respective departments to take responsible charge of the actions that help in achieving the goals set. Until here, there is not much difference observed between India and the other pioneering nations, but it is seen that India when setting their targets for the future or the upcoming years, there is no measurable gauge, like no quantitative targets are found, as like reducing the emissions by some percentage in a set of time or increasing the awareness to a maximum of at least some percentage of youth. This quantitative framework against each strategic goal is missing in the report, hence on a bigger picture, the fact that India is constantly improving

on the reports is not on the global indicators and indices as they are not improving to their full potential. The term Improvement is subjective, either less or more, is also improved. It is also observed that when analysing a target, the entire report needs to be taken into account, not just the immediate beneficiaries. For example, when analysing the awareness goal, it is important to know the number of schools or organizations enrolled in the last few years, or the number of students opting for the respective electives, but it is also very important to know how many people are actually in the same field practicing after the tenure of the course. The reasons for the people's shift to different sectors are numerous, but the government needs to try to identify and resolve them to the core, for the positive result of the goal. These kinds of holistic approaches at different levels for different targets need to be thought of to cover future improvements.

While the rest countries are progressing towards development and invention, India is still in the stage of basic eradication and prevention measures at the primary level in terms of the environment. The major missing quantitative framework for every issue is the vital reason for the least ranking. According to CBD reports, it is evident that India is constantly putting work into environmental sustainability, through many schemes, programs, and strategies, goals like Aichi biodiversity targets, millennium developmental goals, etc. but the outcome is not on par with measures across the globe. This is due to varying many reasons like vast areas, more schemes and policies, failure of the government for not being stringent, awareness in people, the responsibility of the citizens, and lack of drive to be sustainable powering countries.

6 DIVERSE WAYS OF IMPLEMENTING ENVIRONMENTAL SUSTAINABILITY

Although India has been constantly updating and analysing its position in attaining sustainability, there are some intakes from other neighbouring countries which could help this sustainable revolution. The amount of incentives for the stakeholders needs to be increased to encourage a particular strategy that requires effective and frequent communication and cooperation between central, state, and local bodies, enforcing and strengthening laws, and promoting public participation.

Among the many diverse ways of achieving environmental sustainability: increase in infrastructure facilities for waste management, green cities, access to safe sanitation and drinking water, increase in investment in renewable energy, updating and developing more policies for the usage of renewable energy standards, promotion of sustainable awareness through creative programmes and advertisements, introducing various environmental educational programmes for youth and volunteers, assisting the stakeholders to shift to sustainable practices through online and offline programs and workshops, encouraging environmental friendly vehicles for transportation, ban on environmental harmful products like plastic and dangerous chemicals, increase in recycling stations and treatment plants, regulation of fishing in only designated protected areas, encouraging and close monitoring of sustainable fish-catching practices and communities, regulations and standards for industrial and vehicle emissions, ban on unsustainable pesticides, promotion of organic and sustainable farming, and more generally increase in applicability of advanced technology systems.

The necessity of the sustainable revolution for the concern of the whole planet needs to be accelerated right from the grassroots level. Just at the thought of any needs, the question of "is it sustainable?", needs to be rolled out in every human mind on this earth. Only with that thought process, we can achieve absolute sustainability on this planet. The thought process needs to start right from the basic needs like food, water, air, and shelter.

Upon the consideration of every first aspect of food – the thought process needs to start from the food grain level to the actual recipe. When a buyer approaches the farmer, it is necessary to know the use of manures used, and their quantity, agricultural practices, land use, water composition, etc. for the benefit of sustainability. To make this process, much easier, there must be a checklist of the things, that need to be standardized by the related departments in the government, for different food products, which need to be checked by the concerned office in the area, before selling to the buyer. This can be best possible with sustainable practice by the farmer, stringent monitoring at the office level, and a responsible buyer. This also leads to the awareness, that is needed by the farmer - for the use of the products to the practices, the officer-in-charge - for the quality checks and monitoring progress, and the buyer – for the responsible use of sustainable products. Although this is a very basic example of the process, can change the whole process of unsustainability on this Earth. These small steps in weaving sustainability into the minds of the people can draw a bigger revolution as it is connected to many aspects and processes. This not only brings changes to

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

the food system but fosters health and well-being, food product businesses, packaging businesses, sustainable education, environment, waste management, land and ocean pollution, health and well-being of all species on earth, etc. This list can go on with just the small thought process and steps, turning the table of unsustainability on Earth.

If similar changes go on simultaneously with water, air, and shelter, the world of sustainability is not so far. Applying the grassroots level strategy, immediate measures need to be taken care of the water available in the house, by using the required amount of water as needed without wastage, mandatory installation of percolation pits, usage of grey water, the community level installation of water treatment plants at regular intervals, measures for the conservation of ponds, lakes, wetlands, rivers, oceans, etc. Stringent measures on the dumping of waste into water, conservation and expansion measures of aquatic species, etc, need to be improved in a much faster way than the present. Even for better air quality, a mandatory percentage of green space needs to be standardized by the government for every plot, rules for the plantation on either side of the roads need to be enforced, and usage of environmentally friendly vehicles and cycle paths need to be encouraged at least around few zones in a region, which can be multiplied further. Both the government and the citizens should encourage the use of public transportation across.

Building shelter by whatever means, became one of the most essential habits for humankind, say for stay, work, worship, gather, dine, etc. which can't be denied for security and protection purposes, but not at the risk of the environment. The use of sustainable building materials for construction can reduce the impact on the environment. At least the upcoming new buildings need to be built through the use of eco-friendly materials during the initial stages. Also within each household, the maximum number of products used in the house needs to be as sustainable as possible. This cannot be possible without the eco-friendly product's availability, awareness and research. Incentives need to be given for the manufacturing of eco-friendly products for the revolution to spread wider.

In this way, we not only built a better sustainable Earth but also can improve employment opportunities for youth, especially in India, and can generate abundant wealth and knowledge on sustainability as well. Through employment, a better family, a better community, a better country, and a planet can be created.

7 ROLE OF DIFFERENT INDIVIDUALS

When the world promises to be sustainable, it is the responsibility of every nation to keep that up. Similarly, for a nation, the citizens and the ruling body play a major role in this sustainable contribution. Here citizens may be students, workers, employees, government servants, or politicians while the ruling body is the government. Although the former are greater in numbers, but the complete power lies in the latter, as the process of effective execution of policies and laws that makes it to the top. The stringent monitoring and administration of the government in implementing the policies play a key role in achieving this kind of target. However, the common people have also to be accountable for their awareness, usage, and follow-up of sustainable products and practices in their day-to-day life. Their check on everyday activities in terms of sustainability can improve their own and environmental health to a great extent.

Also, the students can take up a few small tasks every week as part of their curriculum, to plant saplings round, attend workshops on sustainable practices, and demonstrate the practices learned to illiterates around at least once in two months as a part of their excursions, encouragement on innovative thinking and experimentation, taking oaths on the conservation measures of the environment, avoiding the use of environmentally harmful products in school premises, charging fines on the usage of the environmentally harmful transportation systems around 2km radius of the schools, encouragement on the use of public transportation whenever required, by explaining to them the benefits of the use. These not only help in making the place sustainable in small means but also cultivates habits for the students for a lifetime. These should not be limited to the school level but also upscaling them to the university level can be beneficial. By their actions and thoughts, they can influence their immediate surroundings for a better change.

Workers and employees play a major role in society, their wave action can hit the planet very strongly, as they are the ultimate power in the majority of their families. Their thoughts and actions can influence both the older and the younger generations in the family, and peers in society. Hence, it is very important to bring a change in their thought process, which can be achieved through the things they are mostly glued to, like articles, news, podcasts on sustainability, the environment, etc. Not only these advertisements, and news

articles, but also the organizations they are a part of, can bring much impact on them. Organizations need to take part in environmental protection, workshops, etc. Through healthy competition on conservation measures between each organization, incentives can be given by the government, for a better world, which could inspire other organizations to take part in the revolution.

Although the above two play a vital role in this revolution, the whole power of turning the table of unsustainability lies in the hands of the government. The effective execution of all the processes discussed in the entire paper needs a helping hand that takes the country to the top place in sustainability. The government needs to take stringent actions and be responsible for the sustainable revolution for a better planet. It also needs to encourage sustainable actions from all bodies, and invest more in these green practices and sustainable ways of life. Subsidies, incentives, and allowances are some of the few giveaway awards for encouragement. Prohibition and ban of harmful products, laws, policies, and practices can help the revolution to a great extent.

8 CONCLUSION

The study concludes with the approaches of different countries toward sustainability, which can help developing countries follow and craft their path in achieving the common goal. The given time period, policies, execution, management, and individuals play a key role in achieving the target goal. The fact that India is constantly working on sustainability, but the results are not seen in the rankings, is mostly due to the lack of a quantitative framework and stringent monitoring system. Hence, it is suggested that first to set the priority towards these environmental rankings, work on the calculations that can take them to secure the topmost place, and work towards achieving it, which can enhance better results in the end in all aspects. Although there are many indicators and issues for sustainability environmental sustainability is of utmost priority in the present scenario for a better life and a better planet.

9 REFERENCES

A mid-term review of the Finnish strategy and action plan for the conservation and sustainable use of biodiversity in 2016. (2017, May). Retrieved from Convention on Biological Diversity: https://www.cbd.int/doc/world/fi/fi-nbsap-v3-p3-en.pdf

Air quality policies in Estonia. (2015). Retrieved from UN Environment Programme: https://wedocs.unep.org/bitstream/handle/20.500.11822/17190/Estonia.pdf?sequence=1&isAllowed=y

Baig, M., Straquadine, G., Baig, M., & Chair, G. (2014, May). Sustainable Agriculture and Rural Development in the Kingdom of Saudi Arabia: Implications for Agricultural Extension and Education. Retrieved from Research Gate: https://www.researchgate.net/publication/276232693_Sustainable_Agriculture_and_Rural_Development_in_the_Kingdom_of_Saudi_Arabia_Implications_for_Agricultural_Extension_and_Education

Burns, T. R. (2012, December). The Sustainability Revolution: A Societal Paradigm Shift? Retrieved from Researchgate: https://www.researchgate.net/publication/235330779_The_Sustainability_Revolution_A_Societal_Paradigm_Shift/references

Cao, J., Garbaccio, R., & Ho, M. (2009, July). China's 11th Five-Year Plan and the Environment: Reducing SO2 Emissions. Review of Environmental Economics and Policy - REV ENV ECON POLICY. Retrieved from Research Gate: https://www.researchgate.net/publication/247577646_China's_11th_Five-Year_Plan_and_the_Environment_Reducing_SO2_Emissions

CBD Fifth National Report - India. (2014). Retrieved from Convention on Biological Diversity - India: https://www.cbd.int/doc/world/in/in-nr-05-en.pdf

CBD Fifth National Report - Micronesia. (2014, December). Retrieved from Convention on Biological Diversity: https://www.cbd.int/doc/world/fm/fm-nr-05-en.pdf

CBD Fifth National Report - The Netherlands. (2014, April). Retrieved from Convention on Biological Diversity: https://www.cbd.int/doc/world/nl/nl-nr-05-en.pdf

CBD Strategy and Action Plan - Finland. (2007). Retrieved from Convention on Biological Diversity: https://www.cbd.int/doc/world/fi/fi-nbsap-v2-en.pdf

CBD Strategy and Action Plan - Kuwait. (2010, June). Retrieved from Convention on Biological Diversity: https://www.cbd.int/doc/world/kw/kw-nbsap-01-en.pdf

CBD Strategy and Action Plan - Malta. (2012, December). Retrieved from Convention on Biological Diversity: https://www.cbd.int/doc/world/mt/mt-nbsap-01-en.pdf

CBD Strategy and Action Plan - Republic of Korea. (2018, November). Retrieved from Convention on Biological Diversity: https://www.cbd.int/doc/world/kr/kr-nbsap-v4-en.pdf

CBD Strategy and Action Plan - Sao Tome and Principe. (2015). Retrieved from Convention on Biological Diversity: https://www.cbd.int/doc/world/st/st-nbsap-v2-en.pdf

CBD Strategy and Action Plan - Singapore. (2006). Retrieved from Convention on Biological Diversity: https://www.cbd.int/doc/world/sg/sg-nbsap-v2-en.pdf

CBD Strategy and Action Plan - Tonga. (2006, June). Retrieved from Convention on Biological Diversity: https://www.cbd.int/doc/world/to/to-nbsap-01-en.pdf

Climate Change and Governance in Afghanisthan. (2015). Retrieved from UN Environment Programme: https://wedocs.unep.org/bitstream/handle/20.500.11822/22447/Report_CC_Governance_Afghanistan_EN_v2.pdf?sequence=1&isAllowed=y

Democratic Republic of Congo - 2013-2017 - Country Strategy Paper. (2013, June). Retrieved from African Development Fund: https://www.afdb.org/fileadmin/uploads/afdb/Documents/Project-and-Operations/Democratic%20Republic%20of%20Congo%20-%202013-2017%20-%20Country%20Strategy%20Paper.pdf

Democratic Republic of Congo Country Plan. (2008, May). Retrieved from Organisation For Economic Co-operation And Development.

Environment and health performance review - Lithuania. (2009). Retrieved from UN Environment Programme: https://wedocs.unep.org/bitstream/handle/20.500.11822/9495/-Lithuania_Environment_and_health_performance_review_-2009Lithuania_EnvirandHealthPerfRevi.pdf?sequence=3&isAllowed=y

Environmental protection. (2022). Retrieved from UAE Government Portal: https://u.ae/en/information-and-services/environment-and-energy/environmental-protection

Fisheries Co-Management in Mozambique. (2014, October). Retrieved from World Bank: https://documents1.worldbank.org/curated/en/626561586942285958/pdf/Fisheries-Co-Management-in-Mozambique-Lessons-from-the-Artisanal-Fisheries-and-Climate-Change-Project-FishCC-2015-2019.pdf

Guzman, H., Cipriani, R., Vega, A., & Morales-Saldaña, J. (2019, December). Fisheries and conservation assessment of sharks in Pacific Panama. Aquatic Conservation: Marine and Freshwater Ecosystems. Retrieved from Research Gate: https://www.researchgate.net/publication/337843332_Fisheries_and_conservation_assessment_of_sharks_in_Pacific_Panama/references

Kotagama, H. (2018, December). Final Report on Agricultural Land use and Land Tenure in Oman. Retrieved from Research Gate: https://www.researchgate.net/publication/329999870_Final_Report_on_Agricultural_Land_use_and_Land_Tenure_in_Oman/citations

Lithuania Air Quality Policies. (2015). Retrieved from UN Environment Programme: https://wedocs.unep.org/bitstream/handle/20.500.11822/17042/Lithuania.pdf?sequence=1&amp%3BisAllowed=

Moldova Environmental Strategy for the years 2014-2023. (n.d.). Retrieved from UN Environment Progarmme: https://wedocs.unep.org/bitstream/handle/20.500.11822/9507/-Environmental_Strategy_for_the_years_2014-2023-2014Moldova_EnvironmentalStrategy_2014-202.pdf?sequence=3&amp%3BisAllowed=

National Report of the Republic of Mauritius. (n.d.). Retrieved from United Nations Sustainable Development: https://sustainabledevelopment.un.org/content/documents/1109215Mauritius%20National%20Report.pdf

Nature Conservation Development Plan until 2020. (2012). Retrieved from Convention on Biological Diversity: https://www.cbd.int/doc/world/ee/ee-nbsap-v2-en.pdf

Overview of Wastes Management in Mauritius. (2012, September). Retrieved from UN centre for Regional Development: https://www.un-page.org/files/public/final_report_-industrial_waste_assessment_-opportunities_for_industrial_symbiosis.pdf

Preparing for Climate Change: A Climate Change Adaptation Strategy. (2020). Retrieved from GOV.UK: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/885242/moj-climate-change-adaptation.pdf

Rosendal, R. (2014, November). Danish Policy on Waste Management – Denmark without waste. Retrieved from Research gate: https://www.researchgate.net/publication/287210935_DANISH_POLICY_ON_WASTE_MANAGEMENT_-_DENMARK_WITHOUT_WASTE

Strategy for Sustainable Development of the Republic of Croatia. (2009, February). Retrieved from United Nations Environment Programme: https://wedocs.unep.org/bitstream/handle/20.500.11822/9452/-Strategy_for_Sustainable_Development_of_the_Republic_of_Croatia-2009Croatia_StrategyforSu.pdf?sequence=3&amp%3BisAllowed=

The Bahamas. (2018, July). Retrieved from UN Sustainable Development: https://sustainabledevelopment.un.org/content/documents/19874VNR_document_03.07.18_master_document.pdf

The Environmental Implementation Review 2019 - Country Report Portugal. (2019). Retrieved from European Commission: https://ec.europa.eu/environment/eir/pdf/report_pt_en.pdf

The National Environmental Strategy and Action Plan (2013 – 2017) for Iraq. (2014). Retrieved from UN Environment Programme: https://wedocs.unep.org/bitstream/handle/20.500.11822/8726/-The%20National%20Environmental%20Strategy%20and%20Action%20Plan%20%20(2013%20%E2%80%93%202017)%20for%20Iraq-2013National_Environmental_Strategy.pdf?sequence=4&isAllowed=y

The State of World Fisheries and Aquaculture 2020 - Sustainability in Action. (2020). Retrieved from FAO: https://www.fao.org/3/ca9229en/ca9229en.pdf

The Sustainability Revolution: What investors should know. (2021). Retrieved from ecofininvest: https://tortoiseecofin.com/media/4252/ecofin-sustainability-revolution.pdf

UAE National Air Emissions Inventory Project Final Results. (2019). Retrieved from Ministry of Climate Change Environment: https://www.moccae.gov.ae/assets/download/fa2f8dd4/Air%20Emissions%20Inventory%20Report.pdf.aspx?view=true

Voluntary National Reviews at HLPF 2016 Montenegro. (2016). Retrieved from NSSD 2030: http://www.nssd2030.gov.me/animations/MORTuvod-zakljucak/NSSD2030.pdf

Waste Management - Switzerland. (n.d.). Retrieved from UN Sustainable Development: https://sustainabledevelopment.un.org/content/documents/dsd/dsd_aofw_ni/ni_pdfs/NationalReports/switzerland/waste.pdf

Waste Management Technologies in Regions, Georgia. (2018). Retrieved from US Agency for International Development: https://pdf.usaid.gov/pdf_docs/PA00TBD7.pdf

Wolf, M. J. (2022). 2022 Environmental Performance Index. Retrieved from New Haven, CT: Yale Center for Environmental Law & Policy: https://epi.yale.edu/

🏆 *reviewed paper*

Sustainable Transportation in the 4IR Era: Case of the City of Johannesburg

Siphiwe Mbatha, Trynos Gumbo

(Siphiwe Given Mbatha, University of Johannesburg, Department of Urban and Regional Planning, Doornfontein campus, Beit and Siemert Street, 2028. Johannesburg, South Africa, gmbatha@uj.ac.za)

(Prof Trynos Gumbo, University of Johannesburg, Department of Urban and Regional planning, Office 6062, Sixth Floor, John Orr Building, Beit and Siemert Street, 2028. Johannesburg, South Africa, tgumbo@uj.ac.za)

1 ABSTRACT

Sustainable transportation development promotes efficient and easy accessibility to socio-economic areas affording opportunities and good movement from one location to the next. High connectivity and the smooth movement of people and goods define a well-functioning city. Without technological change, the traditional, car-dominated cities of the 20th century will not survive rapid urbanization and increasingly stringent air pollution regulations. The City of Johannesburg has various modes of transportation from motorized transportation to non-motorized transportation, however, issues of sustainability in transportation are in question. This paper analyses the sustainability and sustainable development of public transportation in the 4IR era, modes of public transportation available for commuting and the level of non-motorized transportation used for completing a journey across the City of Johannesburg and how 4IR technology can be exploited and harnessed to promote smart transportation. Mixed method approach was deployed in this study were spatial approach and qualitative approach was used to glean data from commuters, relevant officials, and documented studies. Results revealed that there is high percentage of trips made by mini-bus taxis and railway trains. Moderate use of Bus Rapid transit system (Rea Vaya), Gautrain system, taxify/ubers, and other form of buses. Consequently, the results showed that there is low use of bicycles to make trips and cycling to connect to public transportation stations is not visible as most public transport users walk or drive private vehicles to connect to public transportation, and walking to complete journeys is only feasible for trips that are under 5km. In addition, there is sustainability in the current existing public transportation, however, with the population explosion that the city is facing there will be difficult movement for modes of transportation, increasing percentages of car accidents and air pollution. Further, there is lack of sustainability in non-motorized transportation as many trips are completed with motorized transportation. The paper concludes that there is visibility of 4IR technologies in public transportation but not all the modes of transport have deployed them to ensure efficient, reliable, safe, convinient public transportation system, hence, this calls for interventions for enhancement towards develoment of smart sustainable transportation systems as the level of private motorized transportation in the city are high. The paper recommends that there should be exploitation of 4IR technologies which will bring integrated intra- and inter-urban transport systems, reducing the need for private vehicles, promoting real-time transport and traffic management and monitoring, cleaner vehicles and low-carbon mobility solutions that allow people to walk and bike more freely, platforms to better utilize existing and new forms of shared and ambient mobility, e.g. bikes, buses, and autonomous vehicles.

Keywords: City of Johannesburg, 4IR, Public Transportation, Sustainability, Journey

2 INTRODUCTION

Sustainable transportation development promotes efficient and easy accessibility to socio-economic areas affording opportunities and good movement from one location to the next. High connectivity and the smooth movement of people and goods define a well-functioning city. Without technological change, the traditional, car-dominated cities of the 20th century will not survive rapid urbanization and increasingly stringent air pollution regulations. The City of Johannesburg has various modes of transportation from motorized transportation to non-motorized transportation, however, issues of sustainability in transportation are in question. Many people across the city with private motor vehicles prefer using their own transportation even if this leads to high congestion during peak hours and even with other factors such as petrol high price, and the cause mostly is due to different factors in unreliability in public transportation. The City of Johannesburg needs to find ways of affording public transportaion that is attractive, integrated, hassle-free, good accessibility and that will provide ease of mind when travelling by public transportation. Smart sustainable transportation is critical in any city globally to avoid many road related challenges which these goes to such an extent of affecting many things including economy. This paper analyses the sustainability and sustainable

development of public transportation in the 4IR era, modes of public transportation available for commuting and their functionality, and gives a brief background on the existing level of non-motorized transportation used for completing journey‘s across the City of Johannesburg. Further, suggests the need of 4IR technologies on how their can be exploited and harnessed to promote smart sustainable transportation creating switch from private vehicles to more usage of public transport that will be leveraged by service providers and also benefits that could be gained by commuters.

3 LITERATURE REVIEW

3.1 Sustainable public transportation

The concept of sustainable transportation is vital to ensure clean environment, healthy and high quality. The concept also emphasis on the human life and the environment, to meet current and future needs. Today, the transportation systems in major cities have shown a bad image due to heavy traffic congestion, accidents, lack of good access to public transport and carbon emissions to the atmosphere of space contributes to environmental pollution and imbalance in terms of quality of life in general mobility. Along with the promising concept of sustainable transport services to consumers and at the same time ensure the safety of road users and also help towards the welfare and the environment. Transportation facilities and activities have significant sustainability impacts, including those listed in tab.1.

Economic	Social	Environmental
Traffic congestion	Inequity of impacts	Air and water pollution
Mobility barriers	Mobility disadvantaged	Habitat loss
Accident damages	Human health impacts	Hydrologic impacts
Facility costs	Community interaction	Depletion of non-renewable resources
Consumer costs	Community liveability	
Depletion of non-renewable resources	Aesthetics	

Table:1 Transportation impacts on sustainability [Source:Litman and Burwell, 2006]

The concept of sustainable development emerged from the Earth Summit in Rio de Jeneiro in 1992, and concerns Brundtland Commission Report 1987 : Sustainable development “meets the needs of the present without compromising the ability of future generations to meet own needs.”(World Commision on Environment and Development, 1987) . Sustainable transport system can be defined also as a transportation demand but does not affect future transport demand (Black, 1997) and sustainability is not about threat analysis; sustainability is about systems analysis. Specifically, it is about how environmental, economic and social systems interact to their mutual advantage at various space-based scales of operation (World Commision on Environment and Development, 1987). For transport to become sustainable, in practice this means:

(1) Boosting the uptake of zero-emission vehicles, vessels and aeroplanes, renewable & low-carbon fuels and related infrastructure - for instance by installing 3 million public charging points by 2030.

(2) Creating zero-emission airports and ports – for instance through new initiatives to promote sustainable aviation and maritime fuels.

(3) Making interurban and urban mobility healthy and sustainable - for instance by doubling high-speed rail traffic and developing extra cycling infrastructure over the next 10 years.

(4) Greening freight transport – for instance by doubling rail freight traffic by 2050.

(5) Pricing carbon and providing better incentives for users – for instance by pursuing a comprehensive set of measures to deliver fair and efficient pricing across all transport.

3.2 Smart transportation system

Smart transportation deploys new and coming up technologies such as Intelligent transport system (ITS), Internet of Thing (IoT), Artificial Intelligence (AI) etc., to make travelling across a city more convenient, effecient, more cost effective (for both the city and the individual), sustainable and safer (DIGI, 2022). ITS apply different technologies to control, assess, and keep track of transportation systems to improve effectiveness and safety (US Department of Transportation, 2009). Consequently, IoT provides excessive required communication speed for managing and controlling transportation systems in real time with minimal latency (DIGI, 2022). Further, AI improve transport planning by optimising routes for transport

operators, reducing commuters' journey times particularly significant move given our urban layouts (Marwala, 2020).

Digital technologies have the potential to revolutionise the way we move, making our mobility smarter, more efficient, and also greener. Innovation and digitalisation will shape how passengers and freight move around in the future if the right conditions are put in place. The strategy foresees, (i)Making connected and automated multimodal mobility a reality, for instance by making it possible for passengers to buy tickets for multimodal journeys and freight to seamlessly switch between transport modes, (ii) Boosting innovation and the use of data and artificial intelligence for smarter mobility, for instance by fully supporting the deployment of drones and unmanned aircraft and further actions to build a global common mobility data space (European Commision, 2021).

3.3 Global Roadmap of Action Towards Sustainable Mobility

Global Roadmap of Action (GRA) tackles head-on to this question faced by many decision-makers in transport without focusing on one policy goal at the time e.g. safety or access. It is unique in two ways, (i) it proposes a logical and integrated set of choices of policy measures to achieve the Sustainable Development Goals (SDGs), and (ii) accomplish the four policy goals specifying sustainable mobility (i.e., comprehensive access, effectiveness, security, and green mobility). Consequently, it defines a path for countries to follow to achieve the SDGs and achieve the four policy goals that define sustainable mobility. This path is made up of a series of action plans to be implemented over time depending on progress on mobility and the objectives of the countries themselves. Further, the GRA is a tool that enables any country in the world to: (i) measure how far it is from achieving that ambition, (ii) explore more than 180 policy measures that have been tested around the world, and (iii) prioritize those that are most impactful and lay out a path forward (The World Bank, 2022).

In 2020, the Global Tracking Framework for Transport (GTF) to the GRA online tool was added to enable to both diagnosing issues (based on data) and recommending policy action given country context. The GTF was expanded to include new indicators, updated data and time series for all indicators. With that, the international transport community is equipped with a structured framework to track country-level progress toward sustainable mobility (The World Bank, 2022). Therefore, with the successful release of the GRA 2019, sustainable mobilty for all initiatives (SuM4All) has established solid foundations to engage countries on a comprehensive policy agenda for sustainable mobility, and the priority in 2020 was GRA implementation. Five workstreams were launched in 2020, each deep dive into the catalog of policy measures from the GRA with a focus on specific, cutting-edge aspects of the transport agenda (gender, data framework, e-mobility, energy and mobility nexus) that will have impact to transport knowledge work and investments.

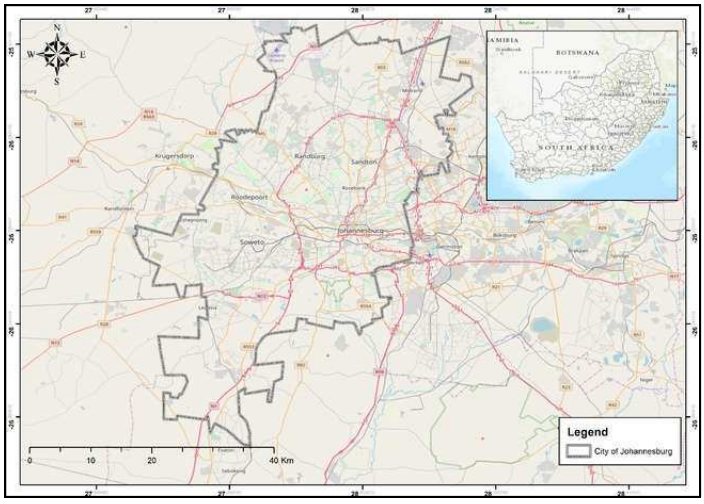


Figure 1: Study area [Source: Authors, 2022]

4 STUDY AREA

The City of Johannesburg is the focus area of study. The city is home to 7 regions and is the largest city in the country and contributor to the country's GDP. The City of Johannesburg is the biggest contributor to

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

South Africa's economic growth and is also the most polluted city in the country as of the 2011 population survey (Stats SA, 2012). The city was founded prior to the discovery of gold which led to high employment of the South African populace through gold mines (Rand Refinery, 2013). The city is home to numerous townships, one of which is Soweto, the oldest and big township in the country (Mbatha et.al., 2021).

As the City of Johannesburg afford many economic and education opportunities, people come in numbers daily in the city for such opportunities and many believe that their lives will change when they get to Johannesburg ''City of Gold'', hence, the move. The city then is challenged in response to this with population explosion infrastructure becomes overwhelmed such as for public transportation. Therefore, a need to provide sustainable smart public transportation to accommodate people residing in and across the city.

5 METHODOLOGY

A mixed method research design was adopted where qualitative data and spatial data analysis was used. Various research instruments were employed in the study. Ten interviews were carried out with officials from different departments, including the Department of Transport and Metropolitan Municipalities transport planners whom assisted in providing insights for the study about the possibility of having a sustainable smart public transportation in the city. Accordingly, commuters were also interviewed to understand how commuting is with and without the use of 4IR technologies. Purposive sampling was adopted as it was necessary to conduct interviews with informed officials and can be able to give proper insight about the public transportation that exist in the city. Interviews, observations and documented studies relating to this study were the sources of data. Further, content analysis was employed to review previous documented studies and used for strategies to explain the methods of providing sustainable smart public transportation. Consequently, Geographic Information Systems (GIS) data was obtained from the City of Johannesburg Metropolitan Municipalty (Transport Department) which assisted in creating various public transportation route networks and stations maps. Secondary information used was obtained from larger data base such as Scopus, Science direct, Sage and Google scholar.

6 RESULTS

The City of Johannesburg has various modes of public transportation across the city. Each and every part of the city has the provision of public transportation and many locations are serviced by more than one mode or system. The below tables 1 and 2 indicate the most popular public transportation found across the city and the available use of non-motorized transportation.

Public transportation	Minibus Taxis	Rea Vaya	Gautrain system	MetroBus	Eyakho PUTCO	MetroRail	Uber& Taxify
number of users daily	15 million trips made	50 000+	55 000+	90000	230 000	1.4million +	156 000
How many buses/trains/ taxis/ vehicles	150 000	277	24 trains and 125 busses	532	1600	270+	62 000

Table 2: COJ public transporation [Source: Authors,2022]

Non-motorized transportation	Cycling	Walking	Other (wheel-chair, chariots etc.)
Trips completed	1,5%	8%	0.5%
Users	3%	70%	1%

Table 3: COJ Non-motorized transportation [Source: Authors, 2022]

Table 2 indicates the number of public transportation daily commuting and how many fleets does each mode or system has. The table indicates that the most used mode of public transportation in the city is mini-bus taxis followed by the metrorail trains. The two modes of public transportation indicate that there is a huge difference of trips made by commuters daily as compared to the other modes and this idicates that there is lack of equal distribution and there is a challenge in other modes, and there is a need of balance in distribution. Howerever, there can be different factors leading to such which could include price and locations serviced. Further, table 3 indicates the use of non-motorized transportation in the City of Johannesburg. Non-motorized transportation across the city is not a popular phenomena to complete journeys as there is less visbility of trips made by cycling and only few people cycle in comparison to the

residents that are found in the city and using public transportation. Consequently, walking is only natural for many people who use public transportation and many people walk to reach public transportation stations, however, they do not walk to complete trips. Only short distance journeys are completed through walking and many of them are done by residents who resides in the CBD and residents who resides few kilometres from bussiness, industrial and commercial areas, and other locations such as recreational areas. Therefore, it can be concluded that across the city there is high percentage of trips made by mini-bus taxis and metro-railway trains. Moderate use of Bus Rapid transit system (Rea Vaya), Gautrain system, Eyakho PUTCO, Metrobuses, Ubers and Taxify. Accordingly, there is low usage of bicycles, and walking to complete journeys. Consequently, there is sustainability in the current existing public transportation due to the number of daily commuters transported effeciently by the cities public transportation, however, with the population explosion that the city is facing and more private vehicles found on the roads there will be difficult movement for modes of transportation in the coming years, the numbers of car accidents will increase and leading to a higher rate of air pollution. Further, there is lack of sustainability in non-motorized transportation as many trips are completed with motorized transportation.

6.1 Taxify and ubers

Taxify and ubers are private motor vehicles that provide public transportation services to individuals. Services of this mode of public transportation operations are available everyday and 24hours a day ensuring that commuters can travel from origin to destination. They do not have proper stations where you can directly access them but they are mostly found in busy areas eg. business locations, commercial areas etc., and easily accessible through smart phone apps. They service all routes to complete destinations and pick up passengers from a location where the request was done. This mode provide smart transporation services, howerever, there are questions with security and safety for passengers using this mode as private motor vehicles get hijacked and on some occassions some drivers pretend to offer taxify/ubers services but kidnap passengers. Initiatives by service providers are made to ensure that the security is increased for this mode of public transportation through verifications a requestor engage.

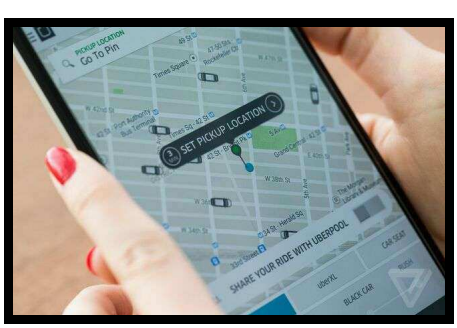


Figure 2 (left): Uber/Taxify [Source: Authors, 2022]. Figure 3 (right): Metrorail train [Source: https://en.wikipedia.org/wiki/Metrorail_Gauteng, 2022]

Taxify/ubers services are attractive to many City of Johannesburg commuters as they deliver services in a form appreciated by the city individuals or residents. These modes of transportation use technological innovations, a passenger does not need to have any physical communication or engagement with the driver as you switch on to the app select a pick up location and destination, the driver arrives in less than 5minutes unless rush hour. The navigation system give directions and the payment is done through the app or an individual can pay physically, and the trip cost is calculated per distance wereby all details are showed before a passenger can confirm to make a trip. Further, in selection of the trip a passenger has an option to request for a bigger motor vehicle if they will be travelling by a group of more than four people. The usage of taxify/ubers services are cheap when travelling by a group as the fare could be divided by individuals but expensive if its used by one person especially if its a long distance trip made.

6.2 Metro railway train

Metrorail rail is an operator of commuter rail services in the major urban areas of South Africa. It is the division of Passenger Rail Agency of South Africa (PRASA), a state-owned enterprise which is responsible for most passenger rail services in South Africa. The Metrorail services consists of 471 stations, 2228km

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

(1384 mi) of track, and carries an average of 1.4 million passengers per week (Metrorail, 2017). It is a dominant train system in the country that is found in most provinces and it was official know as Metrorail in 1996.

The metrorail does not service the northern suburbs of the City of Johannesburg. The services are provided from the south of the city to the centre and most of the areas serviced in the south are townships. This mode of transportation is used mostly by black population and mostly from low class income, the metrorail services are there to ensure that johannesburg residents manage to travel from origin to destination and reach areas of interest. The services are delivered effeciently but rather passengers might not feel the same way and the reason being, this mode is overwhelmed by the population using this mode. It is very cheap compared to all modes of transportation across the city and the Republic as a whole.

6.3 Gautrain System

The introduction of Gautrain system in the City of Johannesburg and Gauteng province as a whole was a game changer to public transportation as it provides three different modes in one such as train, bus and Midi-bus with technological innovations integrated within their services for information dissemination and payment system, and also has a provision of a mobile app that is effecient and precise for all its services. This system is evident of smart sustainable transportation and that the city is capable of having such a system and operating well.

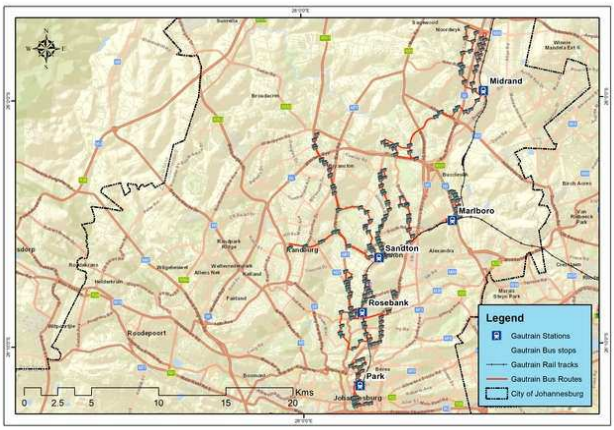


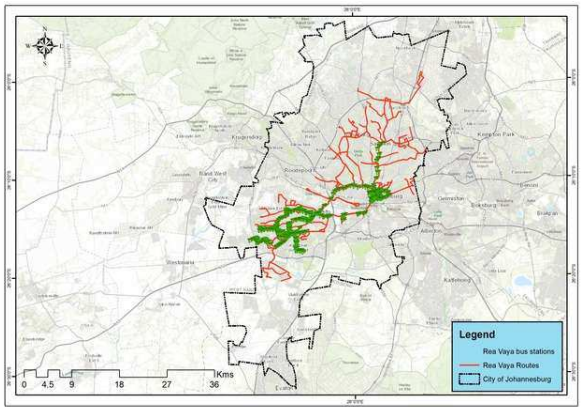
Figure 4: Gautrain system network patterns [Source: Authors, 2022]

Gautrain system services the northern surburbs of the City of Johannesburg from the Johannesburg CBD. There are four Gautrain stations in the city which include Park station, Rosebank station, Marlboro station and Midrand station. The rail tracks run from the City of Johannesburg, to Ekurhuleni and City of Tshwane. The system has provided public transportation services to the northen surburbs that have lack enough services of public transportation, especially, rail services. The strategy of providing different modes to this system has made sure its a sustainable mode of public transportation as not all locations can be serviced by the train could be serviced by the bus and the bus penetrates through the inner locations of neighbourhoods and transport commuters from origin to destination as well as to Gautrain stations for commuters who switch in-between to complete their journeys or make journeys across the province. Locations such as Sandton/Brynston, Midrand and Randburg that afford some of economic opportunities in the city are serviced by the Gaubus system. This system has the provision of proper infrastructure and strategically located from surburbs to economic areas in the City of Johannesburg and the province as a whole. The bus and train services transport a large number of commuters effeciently with reliability and safety for all commuters using the system.

6.4 Bus Rapid Transit System “Rea Vaya“

Development of Rea Vaya system improved the services of public transportation in the City of Johannesburg as it provided bus services that transport commuters efficienlty in large numbers and fast with special designed lanes designated only for Rea Vaya to provide rapid movement. With also the development of technological innovation in the system such as payment system consisting of smart card payment for bus fare and information dissemination which included the use of platform information display, inside bus

information display and online information distribution about the system with the provision of timetabling. Further, Rea Vaya provide free transportation for people with disabiities and 60 years and older pupil but must register for such services to be rendered.



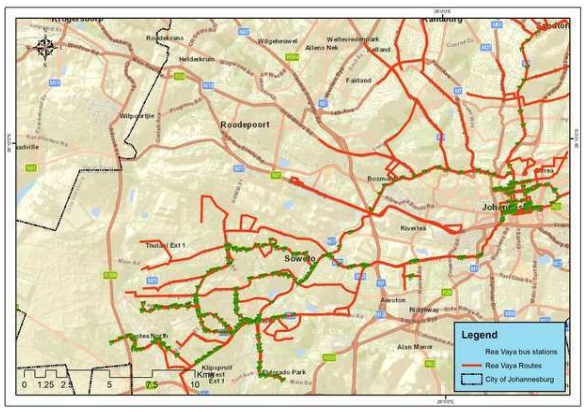
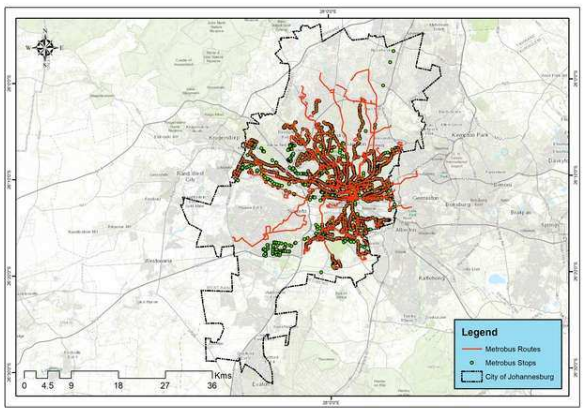


Figure 5 (left): Rea Vaya network patterns. Figure 6 (right): Rea Vaya most serviced areas [Sources: Authors, 2022]

The above figures 5 and 6 indicate the network patterns of the routes and locations serviced in the City of Johannesburg. The Rea Vaya system services most of the sourthern areas to Johannesburg CBD. Most stations are developed in Soweto which is the biggest township in the city and the country as a whole. Most of the neighbourhoods in Soweto are serviced by Rea Vaya from starting point in Protea Glen, Thokoza Park servicing many location to Orlando East and Diepkloof then moving out of Soweto to Johannesburg CBD. The fleet of buses are the most modern available, with sophisticated engineering to ensure carbon emissions are as low as possible. This mode of transportation has brought another perspective in transportation planning moving towards the direction of the 4IR as it shows technological innovations are important in public transportation to provide smart sustainable transportation for commuters. Looking at that it is one of the newly developed modes of public transport in the city and there are still extensions taking place to servicing the entire city, transport planners are still finding technological innovations that can fit well in this system as there are developments of self-service payment systems that are being installed in the bus stations, there is a high tech area that track all bus movement and the conditions of commuting in the bus stations providing communication to bus drivers to provide rapid movement and ensure solutions are there for eventualities.

6.5 MetroBus

Metrobus services are very vital which is indicated by its daily usage or commuting. Its services are mostly used by the working class and students or school learners. It is mostly found in the morning to develiver commuters to schools and areas of work, and in the afternoon and evening transporting commuters from work or school to home. This mode of public transportation is there to provide another dimension of commuting, it is not a mode that an individual could just use as an alternative during the day to travel around but has a specific targeted group.



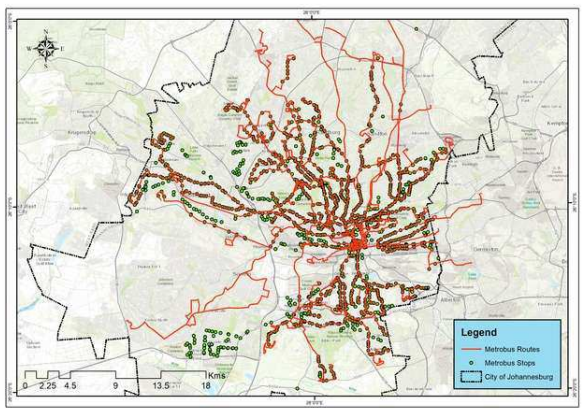


Figure 7 (left): Metrobus network patterns. Figure 8 (right): Metrobus most serviced areas [Sources: Authors, 2022]

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Figure 7 and 8 indicate the network patterns of this mode of public transportation and the nothern and eastern areas in the city are the most serviced areas, and western and south western areas are fairly serviced by this mode of public transportation. This mode does not service all locations in the city and could be stated that it services 50% of the city. However, locations that it services, it transport a large number of commuters daily. The Metrobus system has usage of technological innovations as it provides an online app that assist commuters with timetabling, routes they can use to complete a journey. Further, the app assist with bus fare as it it assist individuals to know how much a trip would cost for a certain trip. This mode provide both smart and sustainable public transportation for coummuters.

6.6 Mini Bus Taxi system

The City of Johannesburg offers a public transportation mode that is found in every part of the city known as mini-bus taxi which is a sixteen (16) seater and is deemed to be informal public transportation mode. Mini-bus taxi system was established in the 1975 which has been struggling to be formalised to date (Baloyi, 2013). It is a mostly used mode of public transportation nationwide due to network flexibility that this mode of transportation offers, it is more accessible than trains (rail transport) and easily connect to public than any other mode thus far with a cheap fare, therefore, more intensely used. Consequently, it is also much faster than the bus services as it does not operate on a fixed schedule (Binza & Siyongwana, 2012).

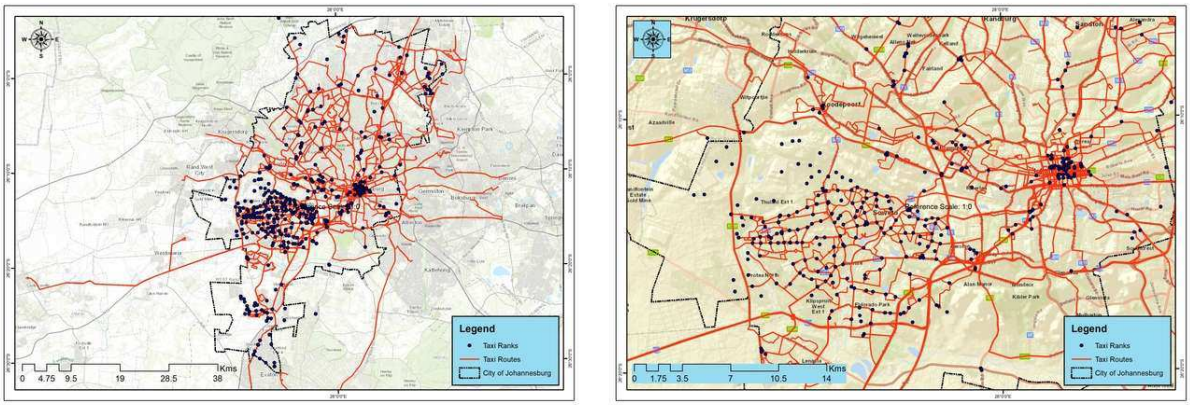


Figure 9 (left): Mini-bus taxi network patterns. Figure 10 (right): Mini-bus Taxis most serviced areas [Sources: Authors, 2022]

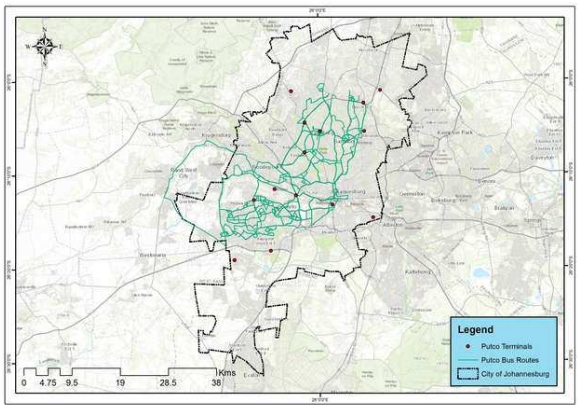
Figure 9 and 10 indicates the mini-bus taxi routes and ranks that are found in the City of Johannesburg. This is the largest system of public transportation that is found in the city and the country as a whole. All locations across the city even the hidden locations are serviced by this mode of public transportation. Most serviced areas by this mode of transportation is the southern areas of the city which include the Soweto neighbourhoods as they are the mostly highly serviced locations. However, other locations across the city are very much serviced by this mode. There are different kind of association from different location that regulate the taxi industries. Each location is serviced by the taxi association from that area to a specific destination. Taxi's registered from a certain location are not allowed to service another area they are not registered to and also with routes serviced, a taxi should remain servicing that particular route is registered for. Passengers on certain specific routes are not allowed to be transported by taxi drivers not registered to service that specific route, if such is done, it leads to taxi war fighiting for routes which this become a serious war as there are shootouts and many people get injured and some shootouts results to death. Further, this also lead to mini-bus taxi strikes leading to un-availability of this mode in that particular area for a number of days. Consequently, when there are new initiatives and developments of new public transportation by the city this leads to taxi strike and war.

This mode of public transportation is effecient, however, it does not use any form of technological innovations as there is no information dissemination distrubuted to commuters, information can only be received at a taxi rank or in the taxi by word of mouth and payment system is hard cash payment in the taxi. The taxi fare differ by locations and some are fixed from origin to any destination. The increase of prices increase mostly with petrol price increase but not by big margins. This mode lacks smart transportation elements, it is sustainable to a certain point as it also have its own negative impacts due to lack of commuter safety at points and can not deliver commuters in time at points in some locations. Which this bring question

of how much sustainable is this mode of public transportation and the importatnce of introducing technological innovatons within the mini-bus taxi system to improve the reliability, efficiency and safety.

6.7 Eyakho PUTCO bus

Public Utility Transport Corporation (PUTCO) was established many decades ago in 1945 which is still operating to date. This mode of public transportation is popular in transporting working class and operates during the morning transporting passengers to work and in the evening transporting commuters back home. It has many city commuters that depend on it as it provide cheap services and it transport a large number daily.



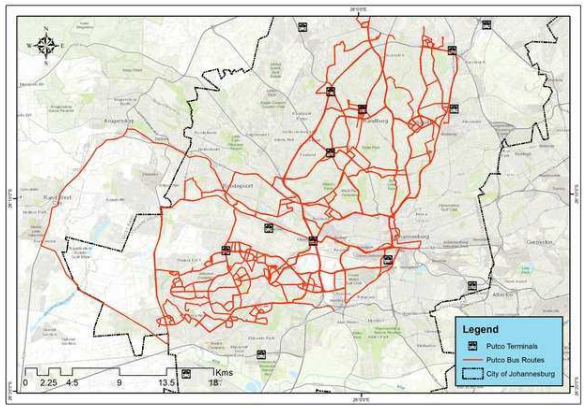


Figure 11 (left): PUTCO network patterns.Figure 12 (right): PUTCO most serviced areas [Sources: Authors, 2022]

The above figure 11 and 12 indicate PUTCO route network patterns and most serviced areas. Accordingly, this mode of public transportation service many areas across the city. However, most commuters using this mode come from Soweto neighbourhoods to the CBD and northern areas of the city were there are many economic opportunities as this mode is used for working class. Most commuters prefer this mode as it collect commuters inside the neighbouhoods servicing many main roads and collecting commuters from different locations even the undesignated bus terminal areas. There is a provision of many buses that service different locations from different neighbourhoods some travelling to the CBD, some travelling to nothern areas such as Sandton, Midrand, Randburg, Brynston and others to Rooderport etc. This mode of transportation lack technological innovations in many areas including smart payment systems, information dissemination, and on many occassions it has had many broken down bus through making journeys and there are complains which happens daily regarding such inconviniences by this mode. Further, this mode of transport has been found in many accidents across the city which all these raises the questions of lack of safety, reliability and effeciency. This mode needs many intervention to improve it services and the consideration and deployment of the 4IR technologies could make a difference.

7 DISCUSSIONS

Smart transportation is not just a theory for the future; it is being implemented today in several cities with their successes and failures being used to improve systems in new locations. Some of the cities that are implementing new transportation technologies. Of course, global hubs like New York City have embraced smart transportation for their ever increasingly intelligent city. However, the rural state of Wyoming is also a leading testbed for connected vehicles. This is because the state is a major freight corridor autonomous transportation of goods across the country can drastically improve supply chain efficiency and reduce the need for long-haul drivers forced to balance tight timelines with their human need for rest (European Commision, 2021). Smart transportation provide fast commuting for public transportation users with convenience in different aspects of using pubic transportation which is improving transportation services in every form as it provide modern technology applications in every aspect and enhanced magement systems in transportation. In the City of Johannesburg some of advanced technologies in transportation are used such as car navigation which uses satellite navigation to get position data which is then correlated to a vehicle's position on a road. When directions are required, routes are calculated in-real time; traffic signal control systems wereby newer traffic control systems are adapted to function smart, the development coressespond to its surrounding adjusting to traffic as when driving at rush hour and seeing green light all the way from

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

origin to destination its dynamic signals that have turned all traffic lights to green to maintain traffic flow; automatic number plate recognition which deploys character recognition on images to identify and scan vehicle registration plates as this creates vehicle location data, used for law enforcement, electronic toll collection and pay-per-road systems; speed cameras use detectors placed on roads or radar technology to detect vehicles exceeding the speed limit of a particular road, and the digital image is captured and forwarded to the driver which this is a solution to prevent accidents caused by excessive driving and encourage safer driving.

In South Africa, the Development Bank of Southern Africa (DBSA) is working with the World Bank and SuM4All partners to pilot the use of the GRA to guide the future investment program of the country and accelerate progress towards the SDGs. These include: (i) the GTF to diagnose and benchmark country performance relative to the rest of the world; and (ii) the GRA to prioritize policies and investments based on global experience. This is a unique undertaking in which expertise and data from partner organizations are collated with those from the World Bank to engage with decision makers in South Africa on the investment programs of South Africa (The World Bank, 2022).

The City of Johannesburg has different kinds of public transportation mode and systems which function differently but all with one goal to provide a sustainable public transportation services. Most of the public modes that are found in the city are old public transportation that have been offering public transportation services for many decades which are technological behind and still lack the 4IR innovation as they are still focusing on traditional ways in their services. (i) The mini-bus taxis have no technology adopted in their services including payment system which is still done by hard cash in and payment is done while travelling or entering a taxi, (ii) Eyakho Pucto buses is one of the modes that focuses on working class and operate during working days in the mornings and later afternoons, it does not have well developed infrastructure and does not afford any advance technologically innovations for users, (iii) Metrobus provide services for both working class and school learners or students, this system of transportation has invested in technological innovations and already working towards shifting to smart sustainable transportation, (iv) MetroRail is the oldest train system in the coutry which transport a large number of commuters and favoured mostly by low income class as it is very cheap, there is somewhat technology used by this mode of transport such as platform information display, however, still use paper ticket system, and this mode is not safe as during peak hours it transport too many passengers in one train and there will be no movement for a passenger in a train, (v) Bus Rapid Transit system (Rea Vaya) is one of the innovative public transportation implemented in the city with proper infrastucture, servicing most areas across the city and uses technological innovations in their services which also need advancements such as information distribution in real-time, (vi) Gautrain System offer services with high technological innovations in their services as they provide accurate platform information displays and inside train information display as well as an online app for the system services, with proper infrastucture, (vii) Taxify/ uber provide services for an individual commuter or group of four people which also uses technological innovations such as on-line payments, information dissemination and navigations.

The city is thriving to have a world class public transportation and in regards to providing sustainable transportation, one could agree that public transportation that is found across the city is sustainable transportation as it manages to offer different modes that transport commuters effeciently in large numbers. With regards to smart public transportation, the city's public transportation still need improvement and be more technological eqquiped to provide smooth services that elliminate reasons for a need to have more private motor vehicles on the roads. The use of technologies in public transporation makes commuting easy for both public transportation users and service providers. Service providers are able to strengthen their services through data that is collected to ensure that commuting is better, by ensuring that areas that lack services are provided with. Further, 4IR technologies can bring integrated intra- and inter-urban transport systems, reducing the need for private vehicles, allowing real-time transport and traffic management and monitoring, producing cleaner vehicles and low-carbon mobility solutions that allow people to walk and bike more freely, platforms to better utilize existing and new forms of shared and ambient mobility, e.g. bikes, buses, and autonomous vehicles.

8 CONCLUSION

The paper concludes that there is visibility of 4IR technologies in public transportation but not all the modes of transport have deployed them, with a promising development of sustainable transportation but calls for interventions for enhancement as the level of private motorized transportation in the city are high. The city is well serviced by public transportation, as different areas are serviced by different modes and some modes and systems services the whole city. Further, there is a need to formally integrate these available modes of public transportation to provide seamless travelling across the city, and with proper understanding of 4IR technologies and proper analysis it is a possibility. Consequenlty, the city is not very far to have a smart sustainable public transportation as critical initiatives need to be ventured. Looking at the technological innovations used by other transport systems in the city such as Rea Vaya system, Ubers/taxify and Gautrain system, there is a possibility of enhancement for other modes or systems of public transportation. The intervention of the 4IR at present could be looked at and be undermined by many but it could prove to be the answer for challenges faced in transportation as it offer unmatched technological innovations that has never existed before.

The paper recommends that there should be exploitation of 4IR technologies which will bring integrated intra- and inter-urban public transport systems, reducing the need for private vehicles, real-time transport and traffic management and monitoring, cleaner vehicles and low-carbon mobility solutions that allow people to walk and bike more freely, platforms to better utilize existing and new forms of shared and ambient mobility, e.g. bikes, buses, and autonomous vehicles. The benifits of technology and advantages they bring to transportation include; smart transportation is safer: by combining machine learning with IoT and 5G, autonomous transportation systems (both in vehicles and in stationary infrastructure such as intersections) have proven to reduce the “human factor” in accidents. Computers don’t get distracted or fatigued or emotional; smart transportation is better managed: data collection is an important key to responsible public management of infrastructure. Smart transportation not only provides detailed data points for every aspect of the transportation system, but allows administrators to better monitor operations, track maintenance needs, and identify key sources of problems that need to be fixed; smart transportation is more efficient: with better management comes more efficient use. Quality data can help to pinpoint areas where efficiency can be improved. Maybe a slight adjustment in train schedules would provide for better fill rates, or, perhaps bus routes would better serve the community if stops were allocated differently; smart transportation is cost effective because smart transportation makes better use of the resources available, it can cut down costs thanks to preventative maintenance, lower energy consumption, and fewer resources used towards accidents. Cost savings can also be gained by riders when inexpensive public transit is efficient enough to compete with private vehicle ownership; smart transportation provides rapid insights: city traffic management centers (TMCs) can get rapid visibility and notifications for trouble spots or city-wide issues affecting congestion on city streets, public safety and emergency response systems, in order to take action or communicate more effectively with other agencies and emergency responders (European Commision, 2021).

9 REFERENCES

Baloyi, M.M. (2013). The Taxi Recapitalisation Policy: is it a hollow dream?. Journal of Public Administration, 48(2), pp.342-352.

Black,W.R. (1997). North American transportation: perspectives on research needs and sustainable transportation. Journal of Transport Geography 5, 12-19.

DIGI. (2020). An introduction to Smart Transportation: Benefits and exmples. Available from: https://www.digi.com/blog/post/introduction-to-smart-transportation-benefits (Access 27 July 2022).

European Commision. (2021). Mobility and Transport: Mobility strategy. A fundamental transport transformation: Commission presents its plan for green, smart and affordable mobility. Available from: https://transport.ec.europa.eu/transport-themes/mobility-strategy_en (Access 27 July 2022).

Litman, T. and Burwell, D. (2006). Issues in sustainable transportation international. Journal of Global Environment Issues. Vol 6,No. 4,pp.331-347.

Marwala, T. (2020). Urban Planning in the fourth industrial age. UJ. Available from: https://www.uj.ac.za/newandevents/Pages/Urban-planning-in-the-fourth-industrial-age.aspx (Access 27 July 2022).

Mbatha, S.G., Gumbo, T., Oniya, O. and Moyo, T. (2021) . ICT Usage to Improve Efficiency in the City of Johannesburg Public Transportation System. In CITIES 20.50–Creating Habitats for the 3rd Millennium: Smart–Sustainable–Climate Neutral. Proceedings of REAL CORP 2021, 26th International Conference on Urban Development, Regional Planning and Information Society (pp. 403-414). CORP–Competence Center of Urban and Regional Planning.

Siyongwana, P.Q. and Binza, M.S. (2012). Challenges facing the transformation of the public transport system in Nelson Mandela Bay, South Africa: history in the making. Journal for Contemporary History, 37(1), pp.191-202.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

The World Bank. (2022). Sustainable Mobility: Helping countries develop concrete, locally relevant solutions. Available from: https://www.worldbank.org/en/results/2020/11/11/the-global-roadmap-of-action-toward-sustainable-mobility (Access 30 July 2022).

US Department of Transportation. (2009). Manual on Uniform Traffic Control Devices; for Streets and Highways. US Department of Transportation, Federal Highway Administration..

World Commission on Environment and Development. (1987).Our Common Future. Brundtland Report. Oxford University Press, Oxford.

🏆 *reviewed paper*

The Contribution of Public Spaces to Climate Change Adaptation in Austrian Cities

Roswitha Weichselbaumer, Doris Damyanovic, Florian Reinwald

(DI Roswitha Weichselbaumer, BOKU Vienna, roswitha.weichselbaumer@boku.ac.at)
(Assoc.Prof. DI Dr. Doris Damyanovic, BOKU Vienna, doris.damyanovic@boku.ac.at)
(DI Dr. Florian Reinwald, BOKU Vienna, florian.reinwald@boku.ac.at)

1 ABSTRACT

Cities and urban areas are particularly affected by the impacts of climate change, especially by rising temperatures and more frequent and heavier rainfall events. Adapting spatial development to the consequences of climate change is being increasingly anchored as a goal in Austrian and European policies and planning strategies. Larger cities are active in setting strategic climate change adaptation (CCA) goals and implementing measures at local scale. Urban green and blue infrastructure (UGBI) and their ecosystem services (ESS) are one of the most effective measures for coping with the consequences of climate change. Urban ecosystems are essential for the urban climate and urban residents due to their regulating (e.g. reduction of the urban heat island effect), supporting (e.g. increase in biodiversity), provisioning (e.g. water filtration) and socio-cultural (e.g. benefits for health, well-being, recreation) functions.

In built-up areas, public space is one of the most important spatial resource for implementing CCA measures and especially UGBI. While steering mechanisms on private properties often fail due to lack of authorisation, instruments or legal regulations, the planning and design of public space is the direct responsibility of cities as local planning authorities. However, in public space, CCA measures and UGBI have to compete with other demands and interests, such as recreation, social interaction and communication, mobility or energy production. As cities grow and densify, pressure on public space increases. Therefore, CCA and CCA measures – both for private and public spaces – need to be mainstreamed into policies at all levels and subsequently integrated into formal planning instruments and planning processes.

Our paper investigates the horizontal and vertical integration of CCA, and especially CCA in public space (streets, squares and parks), into Austrian planning-related policies on national, federal state and municipal level and critically reflects on the mechanisms for implementation in planning practice. The research is based on i) a comprehensive analysis of policy documents of four Austrian federal states (Vienna, Styria, Salzburg and Upper Austria) and cities (Vienna, Graz, Salzburg, Wels), and ii) expert interviews with members of federal state and municipal planning administrations. The policy documents include CCA strategies that have an impact on planning and explicit spatial development strategies. The results show a emerging manifestation of CCA in policy documents, though not yet consistently at all levels and in all municipalities. Measures for CCA in public space are mainly anchored at municipal level, as cities already operate actively out of a given urgency. Despite the integration of CCA measures into the strategic planning level, our research shows that implementation still faces obstacles in planning practice. Our study highlights the importance of political agenda setting for the realization of CCA measures in public space and discusses success factors and implementation gaps.

Keywords: planning instruments, public space, policies, climate change, green infrastructure

2 INTRODUCTION

Changes in temperature and precipitation patterns and their direct and indirect spatial impacts are the key challenges of climate change adaptation for cities and urban areas (Carter et. al. 2015). Public spaces need to be adapted to heat stress, heavy rainfall events, and increasing and prolonged periods of drought. (CCCA 2019).

2.1 Changes in climate signals and impacts on Austrian cities

Austrian cities are affected differently by the impacts of climate change, depending on their climate zone and physical and spatial structure. However, a similar trend can be observed in all of them.

In general, Austrian cities are affected more by climate change-induced temperature increases than rural municipalities. Compared to rural areas, the higher degree of sealed surface, the higher building density and the lower proportion of vegetation elements in cities result in more solar radiation being absorbed and stored and less thermal radiation being released into the atmosphere. The heat storage in buildings and surfaces

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

during the day and the insufficient temperature reliese at night lead to urban heat islands (UHI): higher temperatures in cities than in the surrounding rural areas (Oke 1982, MA22 2015).

A comparison of temperature development in Austria in the periods 1969-1990, 1971-2000 and 1981-2010 shows a significant increase in heat days (days with a temperature above 30°C) and a similar picture for the cities of Vienna and Salzburg. In Vienna, the number of heat days increased from an average of 9.6 in 1996-1990 to 11.5 in 1971-2000 and 15.2 in 1981-2010 (record number of heat days: 42 in 2015). A similar picture can be seen in the City of Salzburg, where the number of heat days increased from an average of 5.8 in the period 1969-1990 to 8.0 and up to 10.4 in the period 1981-2010 (record number of heat days: 40 in 2015). In Graz, the number of heat days rose from an average of 3.4 to 6.6 and up to 11.5 (record number of heat days: 41 in 2003). No data is available for the city of Wels. In the nearby city of Linz, however, a doubling of the heat days can be observed over the same periods (ZAMG 2012). This trend has intensified again in the last ten years: Vienna recorded an average of 20.1 heat days, Salzburg 12, Graz 16.7, and Linz 15 (ZAMG 2021).

Rising temperatures in urban ares cause health problems (Patz et. al. 2005) and ecological consequences, increase energy and water consumption (Santamouris 2020) and exacerbate other environmental burdens such as air pollution (Sarrat et. al. 2006). Heat stress in public spaces can lead to health risks for humans and other species and reduce the quality of stay and frequency of use, negatively affecting the quality of life of urban residents (Sharifi & Boland 2017).

Changing precipitation patterns also affect public spaces. On the one hand, the increasing intensity of extreme rainfall combined with a high degree of sealed surfaces on streets and squares increases the inflow into the sewer system, which can lead to sewer overflows and flooding (Willems et. al. 2012). On the other hand, more frequent and longer dry periods have a negative impact on the vegetation – especially trees – along streets and squares (Jentsch & Beierkuhnlein 2008, Allen et. al 2010).

Auer et al. (2005) carried out a historical study for the Alpine region and Austria and recorded strong fluctuations in precipitation since 1800. The last decades show smaller fluctuations in annual precipitation totals, but regionally specific, partially opposing precipitation trends. The northwest of Austria was characterized by an increase, the south by a decrease in annual precipitation (ZAMG o.J). In general, however, the higher air temperature as a result of climate change leads to a higher evaporation rate and thus potentially to an increase in precipitation (Blöschl et. al. 2018). For Austria, it can be assumed that with the same annual precipitation total, there will be an increase in small-scale and large-scale rainfall extremes with shifts between winter and summer. Both processes together, i.e. the rise in precipitation intensity due to rising temperatures, and more frequent heavy rainfalls, lead to an increase in damage-causing extreme events (Chimani 2016).

At the same time, the drought frequency in the Alpine region is increasing, driven by a higher atmospheric evaporative demand due to rising temperatures (Trnka et al. 2016). Austrian cities are affected differently. In particular, the north-east of Austria, including Vienna, is traditionally a region of low precipitation and increasingly suffers from a negative water balance (potential evapotranspiration is higher than the annual precipitation) (Reniu 2018). The urban region of Graz is also strongly affected by drought (ibid).

Temperature and precipitation changes are expected to continue – depending on the underlying greenhouse gas emission scenarios. These changes have massive impact on urban public space. Therefore, measures to adapt to heat and, simultaneously regulate stormwater (improving water retention while maximising water available to plants) are urgently needed to achieve the necessary adaptation responses.

2.2 Urban green and blue infrastructure as an effective adaption measure

Several adaptation measures exist to counteract heat stress in cities and to deal with heavy rainfall events and droughts (Stanton-Geddes et al. 2020, de Wit et al. 2020, Oswald et al. 2020). One promising measure is to increase the share of urban green and blue infrastructure (UGBI). Numerous research projects have shown the various ecosystem services UGBI provides. Regulating services like shading, evaporation and evapotranspiration (water released to the atmosphere via plants and soil) lower air temperature and reduce heat loads in public spaces. Unsealed and greened areas support stormwater runoff. In addition to the benefits that can moderate the urban climate, UGBI such as trees, shrubs, green roofs or facades, streams or

ponds, provides other benefits: it promotes physical and mental health of urban residents or contributes to urban biodiversity (MEA 2005, TEEB 2010, Grunewald & Bastian 2013).

Climate change, on the otheer hand, also poses challenges for urban green spaces and UGBI (Alizadeh & Hitchmough 2019) by threatening the water supply. Higher temperatures lead to an increase in evapotranspiration and higher water demand. The trend toward more days with medium and high rainfall and fewer days with low to medium rainfall (Chimani et al. 2016) leads to reduced water availability for plants even if the total annual rainfall remains constant.

2.3 Spatial and technical measures

In addition to UGBI, technical and structural-spatial measures support the adaptation of public spaces. These include, for example, technical shading elements in places where tree plantings are not possible, or light-colored surface materials. The albedo (a measure of the reflectivity of surfaces), the thermal capacity (a measure of thermal storage capacity) or the runoff coefficient (ratio of the amount of runoff to precipitation received) of surface materials are decisive for temperature development or stormwater runoff (BBSR 2015, EPA 2008).

2.4 Challenges in the implementation of climate change adaptation measures in public spaces

Urban public spaces are potential "carriers" of adaptation measures by providing space for implementation. Numerous Austrian and European cities anchor the adaptation of public spaces to climate change as a strategic planning goal in policy documents, conduct pilot projects or develop new strategies and measures. Compared to private properties, cities have the ability to act in public space as it is (mostly) owned by them. However, despite their direct influence, cities face challenges in implementing adaptation measures. For example, public space is sealed to varying degrees depending on its size and use, or only accessible for certain measures (Figure 4). Furthermore, different functional and use demands collide in public space. They have to combine UGBI and mobility, provide spatial structures for stay and movement, serve social exchange as well as energy production (Becker 2014). These competing demands have to be negotiated and do not always favour CCA measures.

Although CCA, and especially CCA in public space, is increasingly anchored in policy documents, comprehensive implementation in planning practice often fails at the local level. It is unclear whether and to what extent goals and measures for CCA in public space are consistently anchored in CCA and spatial development strategies at all levels (from national to municipal) and eventually integrated into formal planning instruments and planning processes. Our paper addresses this gap and poses the following research questions: What goals and measures for CCA or CCA in public space do Austrian federal states and cities formulate in policy documents? What mandate do they thereby formulate for planning practice? Where are there implementation gaps?

3 MATERIAL AND METHOD

As outlined above, the aim of this paper is to analyse how CCA, and especially CCA of urban public spaces, is addressed in Austrian planning-related policies and to critically reflect the implementation process in planning practice. The data collection included two steps. First, we conducted a comparative content analysis of 23 policy documents (CCA strategies which have an impact on planning and explicit spatial development strategies. We took four Austrian federal states (Vienna, Styria, Salzburg and Upper Austria) and cities (Vienna, Graz, Salzburg and Wels) as an example) (Table 1). Vienna represents a special case, as it is both a federal state and a municipality. We also divided the Viennese documents into federal state and municipal documents, as they are comparable to the other examples at the respective planning levels. Following the policy cycle by Knoepfel et al. (2011), the subject of analysis was political agenda setting, i.e. the manifestation of CCA on the agenda of political and planning decision-makers. As policies we define "a series of intentionally coherent decisions or activities taken or carried out by different public […] actors […] with a view to resolving […] a problem that is politically defined as collective in nature" (Knoepfel et al. 2011, p. 24). Policies can therefore be understood as the content-related programming of political initiatives, which are expressed in goals and measures formulated in policy documents. We analysed these goals and measures as they define requirements for political and planning action and (nominal) spatial planning instruments. In a second step, we conducted interviews with 15 experts within administration of the four

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

federal states and cities to discuss the integration of CCA goals and measures into planning instruments and planning practice. We analysed the policy documents as well as the interviews by using the method of qualitative content analysis (Mayring 2019, Kuckartz 2016, Schreier 2013, Gläser and Laudel 2010) and systematized and interpreted the relevant content and statements according to inductively developed analysis categories. The analysis was carried out horizontally (comparison of the four federal states and cities among each other) and vertically (comparison at different planning levels – from national to federal state to municipal). The content of our contribution focuses on goals and measures that can be influenced by spatial planning. Also, we focused on the most important public spaces that are (usually) owned by cities, namely streets, squares and parks. Semi-public or semi-private spaces, such as allotments or green spaces of residential buildings, can also implement CCA measures, but are not within a city's direct spehre of influence.

LEVEL	FEDERAL STATE/CITY	NAME OF POLICY DOCUMENTS AND YEAR
National	Austria	• Regierungsprogramm [Governments Agreement] (2020) • Österreichische Strategie zur Anpassung an den Klimawandel [Austrian Strategy for Adaptation to Climate Change] (2017) • Österreichisches Raumentwicklungskonzept [Austrian Spatial Development Concept] (2021)
Federal state	Vienna	• Regierungsübereinkommen [Governments Agreement] (2020) • Smart (Klima) City Wien Rahmenstrategie [Smart (Climate) City Strategy Vienna] (2022) • Klimafahrplan [Climate Roadmap] (2020)
City	Vienna	• Stadtentwicklungsplan [Urban Development Plan 2025] (2014) • Fachkonzept "Grün- und Freiraum" [Thematic Concept "Green and Open Spaces"] (2014) • Fachkonzept „Öffentlicher Raum" [Thematic Concept "Public Space"] (2014)
Federal state	Styria	• Regierungsübereinkommen [Governments Agreement] (2019) • Klimawandelanpassungsstrategie Steiermark [Climate Change Adaptation Strategy Styria] (2015) • Landesentwicklungsleitbild [Provincial Development Concept] (2013)
City	Graz	• Regierungsübereinkommen [Governments Agreement] (2021) • Grazer Klimawandelanpassung Aktionsplan [Climate Change Adaption Action Plan] (2022) • Stadtentwicklungskonzept 4.0 [Urban Development Concept] 4.0 (2020)
Federal state	Salzburg	• Regierungsübereinkommen [Governments Agreement] (2018) • Sazburger Landesentwicklungsprogramm [Salzburg Land Development Programme] (2021) • Strategie zur Anpassung an den Klimawandel Salzburg [Climate Change Adaptation Strategy Salzburg] (2017)
City	Salzburg	• Regierungsübereinkommen [Governments Agreement] (2019) • Initiative Smart City Salzburg [Smart City Salzburg Initiative] (2019) • Räumliches Entwicklungskonzept [Spatial Development Concept] (2007) (in revision)
Federal state	Upper Austria	• Regierungsübereinkommen [Governments Agreement] (2021) • Oberösterreichische Klimawandelanpassungsstrategie [Upper Austrian Climate Change Adaptation Strategy] (2013) • Oberösterreichische Raumordnungsstrategie [Upper Austrian Spatial Development Strategy] (2021)
City	Wels	• Örtliches Entwicklungskonzept [Local Development Concept] (2015) • Stadtregionale Strategie der Stadt Wels [City-regional Strategy Wels] (2016)

Table 1: Overview of analysed policy documents.

4 RESULTS

In the following section, we present how CCA manifests on the political angenda. First, we show whether and how CCA in general, and CCA in public space using UGBI in particular, is reflected in policy documents on different levels. Second, we illustrate what measures for CCA in public space are mentioned and set as mandates for political and planning action.

4.1 Agenda setting – analysis of policy goals on CCA and CCA in public space

With the ratification of the Paris Agreement in 2016, Austria committed to plan, implement and monitor measures to adapt to the impacts of climate change (UNFCCC 2015 – Paris Agreement Article 7 (9)). This mandate for Austrian policy and administration is reinforced by the adoption of the European Climate Adaptation Strategies (EC 2013, 2021) and the announcement of the European Green Deal (EC, 2019). Like most European countries, Austria has passed a national adaptation strategy accompanied by an action plan for implementation (BMNT 2017). The strategy identifies landscape-, urban- and spatial planning as key actors in CCA and names the climate-resilient design of public green and open spaces as well as the protection and expansion of UGBI as central goals and measures (BMNT 2017). The recently revised Austrian Spatial Development Concept includes the strategic goal of adapting spatial structures to climate change and aims at protecting and expanding green networks and strengthening their climate-related functions (ÖROK 2021). The concept emphasizes the importance of green and blue infrastructure and claims

that it should be given the same value as grey infrastructure. As a consequence of the (supra)national goals, adapting urban areas and public spaces to the impacts of climate change by using UGBI becomes part of the federal state and municipal agenda and is reflected in planning policies.

4.1.1 The overall goal of climate change adaption reflected in planning policies

The policy analysis reveals that the general need for adaptation to climate change is largely on the political agenda and has been incorporated into a majority of the policy documents on federal state and municipal level. All four federal states (Vienna, Styria, Salzburg and Upper Austria) and two cities (Vienna and Graz) directly address climate change adaptation as a future policy and/or planning task (Figure 1). Adaptation to climate change is strongly represented in the policy documents of the City of Vienna, the federal state of Styria and the City of Graz and less forcefully in the documents of the federal states of Salzburg and Upper Austria. In contrast, the planning goals of the City of Salzburg and the City of Wels refer to CCA only indirectly via planning principles that are not directly assigned to CCA but have an influence on it, such as inwards development, active land policy, sustainable land use or the protection of green spaces and natural assets. An analysis of the vertical integration shows that the principal goal of CCA is more frequently anchored in policy documents at federal state than at municipal level. While in the City of Vienna, the federal state of Styria and the City of Graz, the goal of CCA is consistently addressed at both, the federal state and municipal level, in Salzburg and Upper Austria the topic has so far only been taken up in policy documents at the federal state level. However, outdated planning strategies (City of Salzburg and City of Wels, planning strategies between 2007 and 2016) that are currently being revised, may be a reason for the lack of mainstreaming (Table 1).

Compared to the overall goal of climate change adaptation, CCA of public spaces is less prominent on the political agenda. While CCA generally manifests itself more frequently at federal state level, specific planning goals for adapting public spaces to the impacts of climate change tend to be formulated at municipal level. This pattern reflects the hierarchical distribution of competencies in the Austrian spatial planning system, where the most detailed spatial goals and measures are formulated at the lowest planning level. Direct references to CCA in public space are more prevalent in recently designed or updated policy documents, while earlier ones include indirect references. The City of Salzburg and the City of Wels set themselves the strategic goals of “creating green corridors", which are not directly formulated for CCA but address adaptation services and include public spaces. The policy documents of the City of Vienna, the City of Graz (municipal level), as well as the Salzburg Strategy for Adaptation to Climate Change and the Upper Austrian Spatial Planning Strategy (federal state level) include explicit goals for public spaces, as they will have to make a central contribution to CCA in urban areas. All of these documents highlight the use of UGBI as one of the key strategies to adapt public spaces to the impacts of climate change.

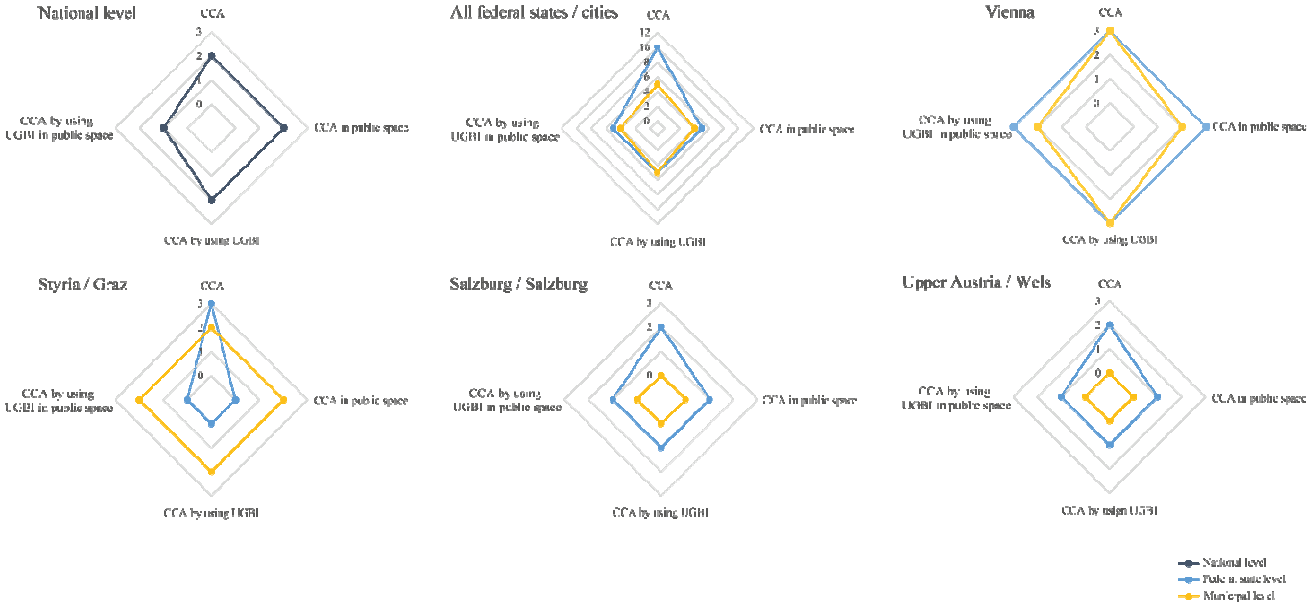


Fig. 1: Overarching goals on climate change adaptation (CCA), CCA in public space and CCA by using urban green and blue infrastructure (UGBI). Goals explicitly mentioned in the policy documents and strategies, at national level, as well as combined and individually for all four case studies at federal state and municipal level. Number of documents with explicit references.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

4.1.2 Policy goals related to CCA in public space and the use of UGBI

More specifically, the predominant goals formulated in the context of CCA, public space and UGBI are: the protection and expansion of public green and open spaces, climate-resilient design, interconnection and creation of public green and open space networks, increased use of green and blue infrastructure in public spaces, a fair provision of public green and open spaces, quality enhancement and the improvement of accessibility and availability (Figure 2). These goals are represented on both, federal state and municipal level, and illustrate three main approaches: i) safeguarding public green and open spaces as elements with positive climate impact per se, ii) implementing CCA measures in public green and open spaces or implementing a climate-resilient design, and iii) ensuring the social and spatial availability, accessibility and usability of climate-effective public green and open spaces.

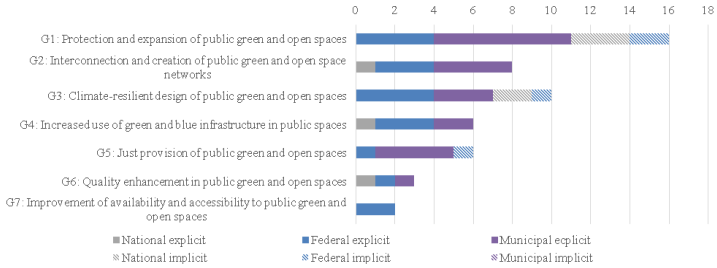


Fig. 2: Objectives related to climate change adaptation (CCA), urban green and blue infrastructure (UGBI) and public space mentioned in policy documents. Number of documents with explicit or implicit references.

4.2 CCA measures for public spaces mentioned in the policies

In addition to setting goals, the policy documents address CCA measures and thus define political and planning tasks. In relation to the objectives identified in 4.1.2, the measures can be divided into two broad categories: i.) land use management to protect and expand public green and open spaces per se and to regulate their spatial distribution, and ii.) measures for climate-sensitive design of public green and open spaces (Figure 3). The two categories address different spatial scales and planning levels, planning authorities and actors and require different steering instruments and mechanisms. The measures can be spatially applied in different types of public spaces (Figure 4).

4.2.1 Land use management

Land use management (i) is the most frequently mentioned measure related to public space and CCA. It serves to maintain and expand public space as resource to establish cold- and fresh air corridors, retention areas and vegetation elements providing ecosystem services. Spatial and urban planning are addressed as responsible stakeholders. Land use management supports the goals of protecting and expanding climate-effective public green and open spaces (G1), linking them to form continuous networks (G2), distributing them socially and spatially (G5) and improving their availability and accessibility (G7). The measure is explicitly included in the policy documents of all four fedederal states and cities – with exception of those of the City of Wels, in which land use management is also addressed, but not (yet) under the objective of CCA. Another measure closely related to land use management is the reduction of surface sealing. It is being pushed by all four federal states and cities – although not always explicitly under the goal of CCA.

4.2.2 Climate-sensitive design of public green and open spaces

In addition to safeguarding public spaces, the policy documents address the implementation of CCA measures in public spaces and their climate-resiliente designs (G3). The identified key measures are: a.) the use of green infrastructure (GI) (G4), b.) the prevention of soil sealing or unsealing surfaces, c.) rainwater management, d.) increasing the capcities for soil infiltration e.) the use of blue infrastructure, and f.) increasing albedo (Figure 3). Urban planning, green and open space planning and landscape architecture are addressed as actors in the implementation of these measures.

The use of urban green infrastructure (UGI) is a cost-efficient and particularly effective CCA measure (Pfoser et al. 2013). Vegetation elements in public spaces reduce heat stress through shading and evapotranspiration and decrease stormwater runoff by absorbing and capturing rainwater (Grunewald et al. 2013, BBSR 2015). The use of green infrastructure in public spaces is anchored as a key measure in policy documents on national level and very prominently in policy documents of the City of Vienna and the City of

Graz. Documents of the federal state of Salzburg implicitly refer to it. Specific UGI elements mentioned are trees (protection of existing trees and new plantings), followed by shrubs, mobile greening and façade greening on adjacent buildings. The policy documents also emphasize the conditions for vegetation elements to develop properly, such as choosing appropriate tree species, providing sufficient soil volume, tree pits or sufficient water supply.

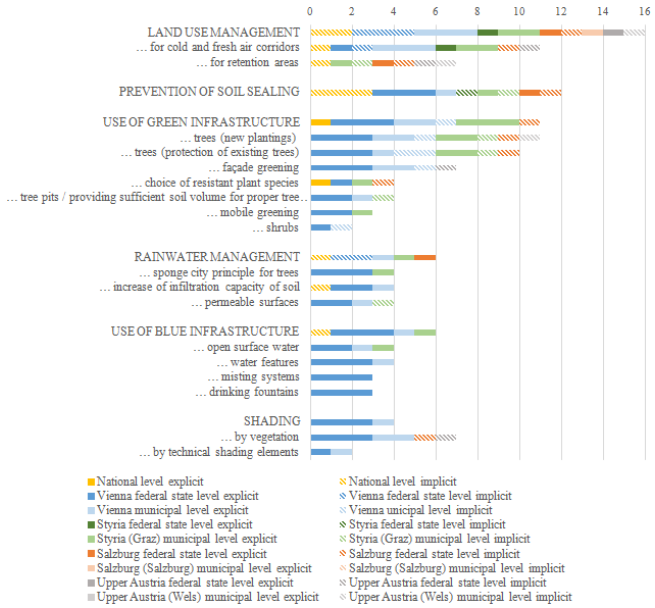


Fig. 3: Measures for the climate-resilient design of public space mentioned in policy documents. Number of documents with explicit or implicit references.

A high degree of sealed surfaces – as it is common in public spaces – discharges rainwater immediately into the sewage system, which can lead to flooding of streets and squares (Fini et al. 2017). The measure of unsealing surfaces or preventing soil sealing in the first place is therefore firmly anchored in policy documents. In general, preventing soil sealing is a fundamental principle of national, provincial, and municipal planning decisions and incorporated in many planning instruments and legislations. In the context of CCA and as a measure of adapting public spaces, it is especially mentioned in the policy documents of the City of Vienna and the City of Graz. Closely related to limiting the degree of soil sealing, but less prominent in the policy documents, are measures of rainwater management. Permeable surfaces or specific elements for rainwater management (e.g. infiltration beds or soil filters) can be used for this purpose (BBSR 2015, Grimm 2018). Rainwater management measures are explicitly anchored in the policy documents of the City of Vienna, the City of Graz and in Salzburg's Land Development Program. Policy documents at national level also include rainwater management measures – but not explicitly in connection with public space. Ideally, rainwater management not only helps to reduce stormwater runoff, but with proper planning makes water available to plants and provides them with water even during dry periods. The sponge city principle for trees, which temporarily stores water on site by infiltrating it into the root zone (Grimm 2018), is an example of such an element. Its implication is anchored in the policy documents of the City of Vienna and the City of Graz.

Water elements in various forms – for play, sensory experience, cooling down or drinking – are central measures for improving the quality of public spaces during heat waves (Almaaitah 2021). The creation of water bodies with open water surfaces, misting systems, drinking fountains or water features is clearly on the political and planning agenda on a national level (implicitly) and on municipal level especially in the City of Vienna and the City of Graz (explicitly).

The ability of materials to reflect sunlight – the so-called albedo – influences how strongly surfaces heat up (Zuvel-Aloise et al 2013). Darker surfaces tend to absorb more radiation and therefore store and re-emit higher temperatures. Increasing the albedo by choosing surface materials of lighter color is considered an important measure for reducing heat load in public open spaces. This measure is explicitly and implicitly promoted in the policy documents of the City of Vienna.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

In addition, the simple and effective measure of shading to regulate temperatures in urban spaces was repeatedly mentioned in policy documents (City of Vienna and federal states of Salzburg and Upper Austria). In particular, shading by vegetation is emphasized. Technical shading elements like pergolas are addressed in the policies of the city of Vienna.

Fig. 4: Measures for the climate-resilient design of public space according to their different spatial implementation options.

The mentioned measures express approaches to face the "collective problem" (Knoepfel et. al. 2011) of climate change and its impact on public space. However, their implementation in planning practice encounters obstacles, which are discussed in the next section.

5 DISCUSSION

The comparative policy analysis confirms that climate change adaptation is largely on the political agenda of the four federal states and cities analysed. CCA is strongly anchored as a central task of spatial planning and development – especially at federal state level. At municipal level, policies more frequently include concrete measures for CCA in public space. In general, it appears that recently published or revised policy documents have incorporated CCA, while the topic is mostly absent in the older ones. Vertical integration – i.e. mainstreaming CCA from national to municipal level – is therefore only evident in two of the four federal states and cities (Vienna, Styria and Graz). The policy documents of Salzburg and Upper Austria so far include only indirect goals and measures dealing with adaptation services. However, this can be attributed to the age of the documents. Especially local development concepts have long revision periods. Salzburg (actual concept from 2007) and Wels (actual concept from 2015) are currently revising their concepts and are going to elaborate CCA as central topics. The City of Salzburg is intensively dealing with the challenges of climate change in the revision and has analysed the current and future climate development as well as the concrete impacts in detail (Stadt Salzburg 2021). The City of Vienna recently evaluated its urban development concept published in 2014 and is preparing a revision. The evaluation concluded that CCA is a top priority and should be given greater consideration in the new concept (MA18 2020).

These developments show that climate change adaptation is currently experiencing high momentum in the field of spatial planning and development. On the one hand, this is due to the increasing awareness of climatic changes and the growing affectedness, and on the other hand, to the integration of the topic into higher-level policies and guidlines. The expert interviews discussed in the following section capture current developments and contexts that are not (yet) included in the policy documents and highlight implementation gaps in planning practice. In addition, the following section compares the results of the policy analysis with scientific literature.

5.1 Awareness of changes in climate signals to develop strategies and measures

Before strategies and measures can be developed, planning authorities need to identify and analyse changing climate signals and their spatial impacts on local level (Jiricka-Pürrer et al. 2021). The policy analysis as well as the interviewees confirm that CCA has “arrived” in Austrian spatial planning and development, since federal states and cities increasingly deal with changes in climate conditions and conduct at least exposure and in some cases vulnerability analysis. Larger cities have more opportunities to gain this knowledge due to their financial, personnel and technical capacities, while smaller cities mostly still lack reliable information on climate change factors and their impacts on local scale or do not have the capacities to process it and make resulting decision (Schindelegger et al. 2021, Kruse & Pütz 2014).

5.2 Vertical integration - from social aspiration to concrete implementation

As political agenda-setting does not only take place in formal processes, but also in socio-political discourses, the interviewees described how climate change adaptation has been established as an issue in spatial planning and development. In larger cities, the interviewees state, the discussion has been going on for about 10 years – originally under the topic of sustainable development and later as part of the smart city discourse. Other cities have initiated adaptation processes because they needed to respond to urgent risks from natural hazards or climate change impacts – such as sewer flooding during intensive rainfall events. In Graz, a city affected by air pollution, awareness of urban climate issues was raised much earlier, as keeping ventilation corridors open has been planning practice for many decades. In the last three to four years, CCA

has become a central issue in all four cities and is increasingly pushed politically. Growing pressure from civil society and the media is also responsible for putting CCA on the political agenda.

The (partial lack of) relevance or explicitness of overarching strategies were mentioned as challenges for vertical integration. Although spatial and urban planning are addressed as a key actors, the strategies usually lack a clear designation of competencies and responsibilities. Also, the overarching concepts are often too strategic and do not propose concrete measures that can be implemented directly at municipal level.

Other barriers to vertical integration of CCA are the lack of consistent guidelines and, most importantly, the lack of legally binding instruments. However, according to the interviewees, the situation is different when it comes to adapting public spaces to climate change. Participants emphasized that cities can mostly manage the implementation of adaptation measures themselves. They are the owners of the public space as well as the financiers who pay for the measures and the developers who implement them. Interviewees see challenges in the need to change internal standards and develop new comprehensive solutions.

5.3 Horizontal integration - differences in adaptation necessary

A horizontal comparison of policies across the four federal states and cities reveals an inhomogeneous picture in the anchoring of CCA and especially CCA in public space. The interviewees underpin this finding. The acceptance of climate change adaptation measures in public space within politics and administration varies. It ranges from positions that support climate change adaptation and are positive about increasing its political relevance, to a clear lack of political support. The fact that political will and the setting of overarching political goals are necessary to achieve progress in administrative action is mentioned by all respondents as an important and necessary basis.

According to the interviewees, a particular challenge arises from the combination of the affectedness of cities versus rural municipalities and the distribution of planning competencies in Austria. There exist only a few large cities in Austria. 71 Austrian municipalities count more than 10,000 inhabitants and are officially classified as cities. However, only six of them count more than 100,000 inhabitants (Vienna, Graz, Linz, Salzburg, Innsbruck and Klagenfurt (from 2022)). Since larger cities are particularly affected by the UHI effect, but there is only a small number of them per federal state, they are mostly left to their own to develop adaptation strategies and measures. "Since we are the only big city, there is a lack of strategies or guidelines at federal state level" (Interview 4). Conversely, employees of the administration at federal state level emphasize that, in line with the hierarchical structure of the Austrian planning system, the freedom of action of cities and municipalities should not be restricted by the federal states.

The impact of climate change varies across regions. In Austria there are four climate zones (Central European Transitional Climate, Pannonian Climate, Illyrian Climate and Alpine Climate) that expose cities to different climatic challenges (APCC 2014). Specific local climatic conditions, as well as different built-up spatial structures, also cause the four analysed cities studied to deal with urban climate to varying degrees. Authors (Birkmann et al. 2017, Juhola & Westerhoff 2011) emphasize the need to tailor strategies and measures to diverse exposures and vulnerabilities. Similarly, different building traditions require different measures.

5.4 Adaptation of public spaces as a major task

Newly released policy documents and strategies identify public space – streets, squares and parks – as important places for implementing adaptation measures. Climate-resilient public spaces are essential structural and spatial measures to realize climate-resilient cities (Damyanovic et al. 2021). Respondents from urban planning departments confirm that implementation in public space, i.e. within cities`own sphere of influence, is comparatively easy. The type of measures and their implementation differs between the urban stock and urban expansion areas. In built-up areas, it is mainly existing buildings are adapted, while in urban expansion areas there is more potential for designing and introducing new measures. In development areas, standards are increasingly changing and new construction methods are evolving. "New streets are now being designed 1.5 times wider than they used to be" (IP 2) to accommodate green infrastructure and rainwater management measures.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

5.5 Securing public green spaces and controlling land use

Protecting public green and open spaces by restricting land uses is a strategy mentioned by all cities. Large-scale measures like the protection of (public) green and open spaces as cold air corridors and retention areas for flood protection are usually achieved through regulations in local development concepts and zoning plans.

Increasingly, small-scale regulations – such as the orientation of roads or the design of road cross-sections – are being considered in zoning plans under the aspect of climate change adaptation (e.g., N-S oriented roads are more exposed to the sun; wider roads allow for more UGBI).

5.6 Redesign of streets and squares

Redesigning existing streets and equipping new streets with various adaptation measures are strategies pursued by all cities analysed. Differences exist in the level of detail of the implementation process: some cities conduct detailed exposition analyses to select locations, while others focus more on the quantity of implemented measures. "If we plant trees, we achieve a cooling effect through shading. No one will question this positive effect" (IP 2) vs. "We have to take a close look in order to set priorities" (IP 3). The four analysed cities implement numerous measures and pilot projects in streets and squares and partially evaluate their effects – either through monitoring (e.g. in Graz) or through specific evaluations like the "Climate Fit Roads" program in Vienna (Damyanovic et al. 2021).

5.7 Trees as particularly effective measures

The interviews confirmed that trees are one of the most cost-effective and efficient adaptation measures, especially in public space. However, the necessary changes to the streetscape and the spatial distribution to support urban green infrastructure is still a controversial discussion in planning practice: "Tree planting is important and should not be under discussion. But it is still being discussed. Always you and your trees, they say" (IP 1). The number of trees is questioned in the same way: "We should aim for a closed canopy, but..." or: "I would like to plan one parking lot for parallel parkers, maximum two for cross parkers, to achieve a distance of 5-6 m between two trees, so that the trees can grow to form a closed canopy cover" (IP 2).

5.8 Multiple demands on public space as a challenge

The context of climate change adaptation emphasizes that public green and open spaces in urban areas must serve multiple functions and uses. They have to combine green and blue infrastructure, act as natural air conditions and absorb water like sponges during heavy rainfall events. At the same time, they have to provide urban dwellers with high quality recreational spaces that, in the best case, are networked, easily accessible and equitably distributed. Public green and open spaces are places for exercise, everyday life activities, contemplation and social interaction (Gehl 2010). In terms of climate mitigation, public spaces must be places for smart energy production and provide spatial structures for climate-friendly mobility. This leads to a conflict of competing demands and requirements for public green and open space, which is becoming increasingly urgent due to growing urbanization and competition for land (Carter 2011).

In recent years, research interest in creating synergies between different function and uses in public green and open spaces has increased. Scientific literature and planning practice use different terms to address the coordination of multiple requirements. The German discussion refers to "multiple occupancy of spaces" or "multidimensional spaces" (Stokman et al. 2013, Kind et al. 2019). A commonly used term is "multifunctionality", which is prone to various definitions and interpretations. In space-time analyses, multifunctionality is used to express the occurrence of more than one activity in the same place and/or at the same time (Batty et al. 2004, Zivkovic et al. 2019). In urban planning and design, it refers to the overlapping of several uses in one place (Zivkovic et al. 2019). In green infrastructure planning, multifunctionality is associated with the multiple functions (economic, ecologic and social) and ecosystem services (regulating, provisioning, socio-cultural) that green and open spaces provide (Pauleit et al. 2014) to humans and the environment. Becker (2014) uses the term "multicoding" to emphasize the overlap of demands and ideas (codes) actors attach to urban public spaces according to their individual values and subject-specific perspectives. He intentionally does not speak of "functions", as they are "abstract and objective" but rather identifies actors and their interests that meet in public green and open space and need to be negotiated.

According to Becker's actor-centered concept (Becker 2014), multicoding requires an integrative and interdisciplinary planning approach, that is not yet common in municipal planning practice. Due to the sectoral planning logic in Austria, planning disciplines mostly operate within their own sphere of responsibility, while integrated planning processes are just being tested in cities and pilot projects (Juschten et al. 2021). The sectoral approach is also prevalent in the analysed climate change adaptation strategies, which specify sectoral fields of action.

Integrated and interdisciplinary planning requires appropriate institutional and administrative structures and needs personnel and financial resources (Schuchardt et al. 2020). Authors see a comprehensive understanding of green and open spaces and their multiple functions and services as a necessary prerequisite for designing and planning multifunctional spaces. Fluhrer et al. (2021) consider the ecosystem services approach, which emphasizes the multiple benefits of green infrastructure, helpful in developing a more holistic understanding. Hansen et al. (2019) call for a development of typologies and guidelines for planning and designing multifunctional green and open spaces, as well as systematic assessments in baseline surveys and evaluations that take into account the social, ecological and economic dimensions.

6 CONCLUSION

The first Austrian strategy for adapting to climate change was published ten years ago (BMFLUW 2012a and b). At that time, Austria was one of the first countries in the European Union to develop an action plan for implementation. The strategy identifies spatial planning and development, landscape- and urban planning as well as cities as drivers of adaptation. In particular, the protection and expansion of public spaces and urban green and blue infrastructure is mentioned as one of the key goals and strategies for adapting cities and urban areas. After more than ten years in which adaptation to climate change has been established as a second pillar alongside climate mitigation in climate policy, a lot has happened in the field of spatial planning and development. The policy analysis shows that CCA, and especially CCA in public spaces, is largely mainstreamed in policy documents that influence spatial development. Socially and (and partly also politically), maintaining quality of life in urban areas is closely linked to climate change adaptation measures. All four analysed federal states and cities have recognized climate change as a challenge for the development of public space. Heat, drought and heavy rainfall events are the direct consequences of climate change – with varying degrees of severity and spatial impact – and affect public space. The results underline that public space – especially in built up areas – is one of the last spatial reserves for adaptation and therefore represents a key field of action in all cities (Battisti & Santucci 2020, Matos & Costa 2018). When it comes to concrete implementation of adaptation measures in public space, it is mostly up to the cities to become active themselves.

6.1 Paper is patient – comprehensive implementation is still a long way to go

Strategies alone cannot achieve effective adaptation. Several Austrian cities have launched pilot projects to adapt public spaces and streets. However, a comprehensive implementation of adaptation measures is necessary to meet the challenges of climate change. Research and administration are asked to translate the experience from these pilot projects into standards to enable comprehensive implementation. In the future, public space will have to fulfill a variety of functions and uses. Becker's approach of multicoding (Becker 2014) raises awareness of the multiple actors and interests that claim public space. According to Becker, renegotiating the distribution of public space is a task that can only be implemented in an interdisciplinary and integrated manner. All sectors are called upon to contribute and work together to examine how public space can be used effectively and efficiently to achieve all goals.

6.2 The potential of urban green and blue infrastructure to create multifunctional public spaces

Public space must become more functionally efficient while withstanding the impacts of climate change and being a place to implement adaptation measures. The use of green and blue infrastructure creates synergy effects and supports multiple functions and uses in public space. While in Austrian cities every single tree planting was discussed intensively and dismissed because of the loss of parking lots for a long time, it is now taken for granted to plant trees in public spaces and to implement climate-resilient elements. Urban green and blue infrastructure provides a variety of ecosystem services and is – especially when synergy effects are taken into account – economically more efficient than monofunctional technical solutions.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

7 ACKNOWLEDGEMENT

The research was conducted as part of the project “Climate Proofing of (Urban) Planning Instruments” in cooperation with TU Vienna, Research Unit for Land Policy and Land Management, Institute of Spatial Planning, funded by the Austrian Climate Research Program and conducted within the program “ACRP – 12th Call” (KR19AC0K17599).

8 REFERENCES

ALLEN, Craig D.; MACALADY, Alison K.; CHENCHOUNI, Haroun; BACHELET, Dominique; MCDOWELL, Nate; VENNETIER, Michel et al.: A global overview of drought and heat-induced tree mortality reveals emerging climate change risks for forests. In: Forest Ecology and Management 259 (4), pp. 660–684, 2010.

ALMAAITAH, Tamer; APPLEBY, Madison; ROSENBLAT, Howard; DRAKE, Jennifer; JOKSIMOVIC, Darko: The potential of Blue-Green infrastructure as a climate change adaptation strategy: a systematic literature review. In: Blue-Green Systems 3 (1), pp. 223–248, 2021.

ALIZADEH, Behdad; HITCHMOUGH, James: A review of urban landscape adaptation to the challenge of climate change. In: IJCCSM, 11 (2), 2019.

APCC – Austrian Panel on Climate Change: Österreichischer Sachstandsbericht 2014. Vienna, 2014. Online: https://ccca.ac.at/wissenstransfer/apcc/aar14

AUER, Ingeborg; BÖHM, Reinhard; JURKOVIĆ, Anita; ORLIK, Alexander; POTZMANN, Roland; SCHÖNER, Wolfgang et al.: A new instrumental precipitation dataset for the greater alpine region for the period 1800–2002. In: International Journal of Climatology, 25, pp. 139-155. 2005.

BATTY, Michael; BESUSSI, Elena; MAAT, Kees; HARTS, Jan Jaap: Representing Multifunctional Cities: Density and Diversity in Space and Time. In: Built Environment, 30 (4), pp. 324–337, 2004.

BATTISTI, Alessandra; SANTUCCI, Daniele: Activating Public Space: An Approach for Climate Change Mitigation. Technische Universität München, Fakultät für Architektur. München, 2020.

BBSR – Bundesinstitut für Bau-, Stadt- und Raumforschung, eds.: Überflutungs- und Hitzevorsorge durch die Stadtentwicklung. Strategien und Maßnahmen zum Regenwassermanagement gegen urbane Sturzfluten und überhitzte Städte. Bonn, BBSR, 2015.

BECKER, Carlo: Mehrdimensionale Stadt – mehrdimensionale Freiräume. In: Raumplanung, 172, pp. 27-33, 2014.

BIRKMANN, Jan; GREIVING, Stefan; SERDECZNY, Olivia: Das Assessment von Vulnerabilitäten, Risiken und Unsicherheiten. In: SCHUCK-ZÖLLER, Susanne; JACOB, Daniela; BRASSEUR, Guy. Klimawandel in Deutschland. Berlin; Heidelberg, Springer, pp. 267–276, 2017.

BLÖSCHL, Günter; BLASCHKE, Alfred Paul; HASLINGER, Klaus; HOFSTÄTTER, Michael; PARAJKA, Juraj; SALINAS, José; SCHÖNER, Wolfgang: Auswirkungen der Klimaänderung auf Österreichs Wasserwirtschaft – ein aktualisierter Statusbericht. In: Österr Wasser- und Abfallw 70 (9-10), S. 462–473, 2018.

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft: Die österreichische Strategie zur Anpassung an den Klimawandel. Teil 1. Wien, 2012a.

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft: Die österreichische Strategie zur Anpassung an den Klimawandel. Teil 2 – Aktionsplan. Handlungsempfehlungen für die Umsetzung. Wien, 2012b.

BMNT – Bundesministerium für Nachhaltigkeit und Tourismus: The Austrian strategy for adaptation to climate change. Vienna, 2017.

CARTER, Jeremy: Climate change adaptation in European cities. In: Current Opinion in Environmental Sustainability, 3 (3), pp. 193-198, 2011.

CARTER Jeremy; CAVAN, Gina; CONNELLY, Angela; GUY, Simon; HANDLEY, John; KAZMIERCZAK, Aleksandra: Climate change and the city. Building capacity for urban adaptation. In: Progress in Planning, 95, pp. 1–66. 2015.

CCCA – Climate Change Center Austria: Klimastatusbericht Österreich 2019. 2019

CHIMANI, Barbara, HEINRICH, Georg, HOFSTÄTTER, Michael, KERSCHBAUMER, Markus, KIENBERGER, Stefan, LEUPRECHT, Armin et al.: ÖKS15 – Klimaszenarien für Österreich. Daten, Methoden und Klimaanalyse. Projektendbericht. Vienna, ZAMG, 2016.

DAMYANOVIC, Doris; GRIMM, Karl; REISINGER, Philipp; GABOR, Anna; REINWALD, Florian: Nachhaltige klimafitte urbane Plätze und Straßen, Klimafitte Elemente – Katalog. Wien, 2021.

DE WIT, Rosemarie; KAINZ, Astrid; GOLER, Robert; ZUVELA-ALOISE, Maja, HAHN, Claudia; ZUCCARO, Giulio et al.: Supporting climate proof planning with CLARITY's climate service and modelling of climate adaptation strategies – the Linz use-case. In: Urban Climate, 34, no. 100675. 2020.

EPA – U.S. Environmental Protection Agency. Reducing Urban Heat Islands: Compendium of Strategies, Urban Heat Island Basics. U.S. Environmental Protection Agency’s Office of Atmospheric Programs. 2008.

EC – European Commission: European Strategy on Adaptation to Climate Change: COM(2019) 640. Brussels, European Commission, 2013.

EC – European Commission: The European Green Deal: COM(2019) 640. Brussels, European Commission, 2019.

EC – European Commission: New EU Strategy on Climate Adaptation: COM/2021/82. Brussels, European Commission, 2021.

FINI, Alessio; FRANGI, Piero; MORI, Jacopo; DONZELLI, D.; FERRINI, Francesco: Nature based solutions to mitigate soil sealing in urban areas: Results from a 4-year study comparing permeable, porous, and impermeable pavements. In: Environmental Research, 156, pp. 443–454, 2017.

FLUHRER, Tanja; CHAPA, Fernando; HACK, Jochen: A Methodology for Assessing the Implementation Potential for Retrofitted and Multifunctional Urban Green Infrastructure in Public Areas of the Global South. In: Sustainability 13 (1), 2021.

GEHL, Jan: Cities for People. Washington, Island Press, 2020.

GLÄSER, Jochen; LAUDEL, Grit: Experteninterviews und qualitative Inhaltsanalyse als Instrumente konstruierender Untersu¬chungen. Wiesbaden, VS Verlag für Sozialwissenschaften, 2010.

GRIMM, Karl: Stadt Salzburg – Studie Regenwassermanagement. Grundlagen, Maßnahmen und Empfehlungen. Salzburg, Stadt Salzburg, Amt für Stadtplanung und Verkehr, 2018.
GRUNEWALD, Karsten; BASTIAN, Olaf: Ökosystemdienstleistungen: Konzept, Methoden und Fallbeispiele. Berlin, Springer Spektrum, 2013.
HANSEN, Rieke; OLAFSSON, Anton; VAN DER JAGT, Alexander; RALL, Emily; PAULEIT, Stephan (2019): Planning multifunctional green infrastructure for compact cities: What is the state of practice? In: Ecological Indicators 96 (3), pp. 99–110, 2019.
JENTSCH, Anke; BEIERKUHNLEIN, Carl: Research frontiers in climate change: Effects of extreme meteorological events on ecosystems. In: Comptes Rendus Geoscience 340 (9-10), pp. 621–628, 2008.
JIRICKA-PÜRRER, Alexandra, REINWALD, Florian, WEICHSELBAUMER, Roswitha; JUSCHTEN, Maria: Endbericht zur Studie CLIP-OST Climate Proofing – Ostregion: Check der Planungssysteme im Burgenland, in Niederösterreich und in Wien zur besseren Bewältigung der Klimawandelfolgen. Wien, PGO, 2021.
JUHOLA, Sirkku; WESTERHOFF, Lisa: Challenges of adaptation to climate change across multiple scales: a case study of network governance in two European countries. In: Environmental Science & Policy 14 (3), pp. 239–247, 2011.
JUSCHTEN, Maria; REINWALD, Florian; WEICHSELBAUMER, Roswitha; JIRICKA-PÜRRER, Alexandra: Developing an Integrative Theoretical Framework for Climate Proofing Spatial Planning across Sectors, Policy Levels, and Planning Areas. In: Land 2021, 10, 772, 2021.
KIND, Christian; KAISER, Theresa, RIESE, Miriam; BUBECK, Philip, MÜGGENBURG, Eva; THIEKEN, Annegret; SCHÜLLER, Lynn; FLEISCHMANN, Regina: Vorsorge gegen Starkregenereignisse und Maßnahmen zur wassersensiblen Stadtentwicklung – Analyse des Standes der Starkregenvorsorge in Deutschland und Ableitung zukünftigen Handlungsbedarfs. Dessau-Roßlau, Umweltbundesamt, 2019.
KNOEPFEL, Peter; LARRUE, Corinne; VARONE, Frederic; HILL, Michael: Public policy analysis. Bristol, Policy Press, 2011.
KRUSE, Sylvia; PÜTZ, Marco: Adaptive Capacities of Spatial Planning in the Context of Climate Change in the European Alps. In: European Planning Studies 22 (12), pp. 2620–2638, 2014.
KUCKARTZ, Udo: Qualitative Inhaltsanalyse. Methoden, Pra¬xis, Computerunterstützung. Weinheim, Beltz Juventa, 2016.
MAYRING, Philipp: Qualitative Inhaltsanalyse – Abgrenzungen, Spielarten, Weiterentwicklungen. In: Forum Qualitative Sozialforschung, 20 (3), 2019.
MA 18 - Stadtentwicklung und Stadtplanung: POSITIONSBESTIMMUNG: DER STEP 2025 AUS HEUTIGER SICHT, Aktuelle Einblicke und Ausblicke, 2020.
MA 22 – Naturschutz: Urban Heat Island – Strategieplan Wien. 2015.
MATOS, Silva, Maria; COSTA, João Pedro: Urban Floods and Climate Change Adaptation: The Potential of Public Space Design When Accommodating Natural Processes. In: Water 10, no. 2, 180, 2018.
MEA – Millennium Ecosystem Assessment: Ecosystems and Human Well-being: Synthesis. 2005 Online: http://www.millenniumassessment.org/documents/document.356.aspx.pdf
OKE, Tim: The energetic basis of the urban heat island. In: Quarterly Journal of the Royal Meteorological Society, 108 (1982), pp. 1-24, 1982.
OSWALD, Sandro M.; HOLLOSI, Brigitta; ŽUVELA-ALOISE, Maja; SEE, Linda; GUGGENBERGER, Stefan; HAFNER, Wolfgang et al.: Using urban climate modelling and improved land use classifications to support climate change adaptation in urban environments: A case study for the city of Klagenfurt, Austria. In: Urban Climate, 31 (4), no. 100582. 2020.
ÖROK - Österreichische Raumordnungskonferenz: ÖREK 2030, Österreichisches Raumentwicklungskonzept, Raum für Wandel. Vienna, ÖROK, 2021.
PATZ, Jonathan; CAMPBELL-LENDRUM, Diarmid; HOLLOWAY, Tracey; FOLEY, Jonathan: Impact of regional climate change on human health. In: Nature 438 (7066), pp. 310–317, 2005.
PAULEIT, Stephan; LIU, Li; AHERN, Jack; KAZMIERCZAK, Aleksandra: Multifunctional Green Infrastructure Planning to Promote Ecological Services in the City. In: NIEMELÄ, Jari; BREUSTE, Jürgen; ELMQVIST, Thomas; GUNTENSPERGEN Glenn, MCINTYRE Nancy, eds.: Urban ecology. Patterns, processes, and applications. Reprinted with corrections. Oxford, Oxford University Press, pp. 272–285, 2014.
PFOSER, Nicole; JENNER, Nathalie; HENRICH, Johanna; HEUSINGER, Jannik; WEBER, Stephan; SCHREINER, Johannes; UNTEN KANASHIRO, Carlos: Gebäude Begrünung Energie - Potenziale und Wechselwirkungen. Darmstadt, TU Darmstadt, 2013.
RANNOW, Sven; LOIBL, Wolfgang; GREIVING, Stefan; GRUEHN, Dietwald; MEYER, Burghard: Potential impacts of climate change in Germany—Identifying regional priorities for adaptation activities in spatial planning. In: Landscape and Urban Planning, 98 (3-4), pp. 160–171, 2010.
RENIU, Maria: Evapotranspiration projections in Austria under different climate change scenarios. Diplomarbeit / Masterarbeit - Institut für Meteorologie (BOKU-Met), BOKU-Universität für Bodenkultur, 2018.
SCHINDELEGGER, Arthur; WEICHSELBAUMER, Roswitha; DAMYANOVIC, Doris; REINWALD, Florian: „Climate Proofing" – Ein Framework zur Integration der Klimawandelanpassung in die Raumplanung. Der Öffentliche Sektor - The Public Sector, 47 (2), pp. 9-25, 2021.
SARRAT, Claire; LEMONSU, Aude; MASSON, Valéry; GUIDELIA, Daniel: Impact of urban heat island on regional atmospheric pollution. In: Atmospheric Environment 40 (10), pp. 1743–1758, 2006.
SANTAMOURIS, Mattheos: Recent progress on urban overheating and heat island research. Integrated assessment of the energy, environmental, vulnerability and health impact. Synergies with the global climate change. In: Energy and Buildings 207, 109482, 2020.
SCHREIER, Margit: Qualitative content ana¬lysis in practice. London, Sage, 2012.
SCHUCHARDT, Marion; KYRIAKOPOULOS, Fee; FRANZKOWIAK, Nina; BEYER, Alissa; STRICKLER, Roman; GEHRKE, Brigitte et al.: Bremer Straße 2030. Strategische Ansätze zur Entwicklung des Nahraums Bremer Straße als sozial-ökologisch-pädagogisches Stadtgefüge. Berlin, Stadt Bremen Stadtentwicklungsamt, 2020.
SCHUCK-ZÖLLER, Susanne; JACOB, Daniela; BRASSEUR, Guy: Klimawandel in Deutschland. Berlin; Heidelberg, Springer, 2017.

SHARIFI, Ehsan.; BOLAND, John: Heat resilience in public space and its applications in healthy and low carbon cities. In: Procedia Engineering 180, pp. 944–954, 2017.
STADT SALZBURG, MA 5/03 – Amt für Stadtplanung und Verkehr: Grundlagenbericht zum neuen Räumlichen Entwicklungskonzept der Stadt Salzburg, 2021.
STANTON-GEDDES, Zuzana; SIMPSON, Alanna; ELLMAUER-KLAMBAUER, Anita; DENGLER, Solene; STAUDINGER, Michael; ZUVELA-ALOISE, Maja et.al.: Analysis of Heat Waves and Urban Heat Island Effects in Central European Cities and Implications for Urban Planning. Washington D.C., World Bank Group, 2020.
STOKMAN, Antje, DEISTER, Lisa, DIETERLE, Jan: Internationale Ansätze und Referenzprojekte zu Klimaanpassungsstrategien der Überflutungs- und Trockenheitsvorsorge verschiedener Siedlungstypen im Klimawandel Stuttgart. Expertise im Rahmen des ExWoSt-Forschungsprogramms „Klimaanpassungsstrategien zu Überflutungsvorsorge verschiedener Siedlungstypen.“. Stuttgart, 2013.
TEEB – The Economics of Ecosystems and Biodiversity: The Economics of Ecosystems and Biodiversity: Ecological and Economic Foundations. London and Washington, Earthscan, 2010.
TRNKA, Miroslav; BALEK, Jan; ŠTĚPÁNEK, Petr; ZAHRADNÍČEK, Pavel and others: Drought trends over part of Central Europe between 1961 and 2014. Clim Res 70:143-160. 2019. https://doi.org/10.3354/cr01420
UNFCCC – United Nations Framework Convention on Climate Change: Adoption of the Paris Agreement: 21st Conference of the Parties. Paris, UN, 2015.
WILLEMS, Patrick; ARNBJERG-NIELSEN, Karsten; OLSSON, Jonas; NGUYEN, Van-Thanh-Van: Climate change impact assessment on urban rainfall extremes and urban drainage: Methods and shortcomings. In: Atmospheric Research 103, pp. 106–118, 2012.
ZAMG – Zentralanstalt für Meteorologie und Geodynamik: Sommer: Hitzetage werden immer häufiger. 2012. Online: https://www.zamg.ac.at/cms/de/klima/news/hitzetage-werden-immer-haeufiger
ZAMG – Zentralanstalt für Meteorologie und Geodynamik: Sommer 2021: sehr warm und teils nass, teils trocken. 2021. Online: https://www.zamg.ac.at/cms/de/klima/news/sommer-2021-sehr-warm-und-teils-nass-teils-trocken
ZAMG – Zentralanstalt für Meteorologie und Geodynamik: Informationsportal Klimawandel: Niederschlag. o.J.. Online: https://www.zamg.ac.at/cms/de/klima/informationsportal-klimawandel/klimavergangenheit/neoklima/niederschlag
ZIVKOVIC, Jelena; LALOVIC, Ksenija; MILOJEVIC, Milica; NIKEZIC, Ana: Multifunctional public open spaces for sustainable cities: Concept and application. In: Facta Univ Arch Civ Enge, 17 (2), pp. 205–219, 2019.
ZUVELA-ALOISE, Maja et al.: FOCUS-I – Future Of Climatic Urban heat Stress Impacts. 2013. Online: https://www.klimafonds.gv.at/wp-content/uploads/sites/16/03032015FOCUSZuvela-AloiseEBACRP2B060373.pdf.

🏆 *reviewed paper*

The Effect of Active Travel on Sustainable Transport Planning: Empirical Evidence from Selected European and African Countries

Oluwayemi-Oniya Aderibigbe, Trynos Gumbo

(Dr. Ouwayemi-Oniya Aderibigbe, Dept. of Urban and Regional Planning, University of Johannesburg. Cnr Siemert & Beit Streets, Doornfontein 0184 Johannesburg, South Africa, oboniya@uj.ac..za)
(Prof Trynos Gumbo, Dept. of Urban and Regional Planning, University of Johannesburg. Cnr Siemert & Beit Streets, Doornfontein 0184 Johannesburg, South Africa, tgumbo@uj.ac.za)

1 ABSTRACT

In recent times, people have been advocating the adoption of active travel such as walking and cycling due to its benefits to the health of human beings and the overall quality of the urban environment. Urban transport, being one of the major challenges to sustainable development, remains the fastest-growing source of carbon emission in major cities of the world, and as a result, there is a need to adopt methods aimed at reducing over-reliance on vehicles, being the major contributor to carbon emission in our environment. Although various scholars have contrasting views on the role of active travel in sustainable planning, it is believed to be beneficial to improve health without necessarily make a significant impact on the economy and built environment. Consequently, this study reviewed literature on active travel use in the developed and developing countries of the world and its impact on sustainable urban transport planning and development. The study adopted the Prisma approach by extracting relevant information from peer-reviewed journal articles and proceedings. Findings from this study revealed that active travel reduces environmental health damage such as global warming as well as air and noise pollution caused by increased reliance on vehicles, and variations exist in the use of active mode in both the developed and developing countries of the world. The study recommends that stakeholders in the transport sector, as well as the government in the developing countries, should provide relevant transport infrastructures that promote and support active travel use in order to achieve sustainable transport growth and development.

Keywords: Transportation, Sustainability, Planning, Urban Transport, Active Travel

2 INTRODUCTION

How we plan, design and manage our built environment, including our public spaces and transport systems, significantly impacts our overall health and wellbeing (Wen, Rissel & Fu 2013). According to the United State Department of Health and Human Services (2020), Active transportation (AT), such as walking, cycling or using public transit as a means of transport offers an opportunity to move closer to reaching Healthy People 2020 objectives of increasing physical activity and "reducing the proportion of people who are considered 'obese'. Several studies (Roberts, Mandic, Fryer, Brachman & Ray 2019; Wen, Rissel, & Fu 2013;) have been carried out on active travel in relation to healthy living, however little or no discussion has taken place on the impact of active travel/public transport on sustainable transport planning.

According to the World Bank (2021), road planning and design that place much emphasis on motorised vehicles such as private vehicles have detrimentally impacted air quality, greenhouse gas emissions (GHGs), road injuries and fatalities, congestion, and equity. These problems will only be exacerbated unless a meaningful shift to sustainable transport is encouraged by governments and relevant stakeholders in the transport sector. Active mobility or travel refers to walking, cycling, wheelchair users or other light device users, and other modes such as scooters and e-bikes. This form of travel provides the lowest emissions of all forms of transport and it equips people with active lives that bring health, social, and economic benefits. However, walkers and cyclists are the most vulnerable to road injuries, given the lack of safe infrastructure and speed management protecting them from motor vehicles. While some countries have already committed to vision zero and follow a safe system approach to their road infrastructure planning and design, car-centric practices continue to take the lead in most countries (Welle et al 2018).

Environmentalists have long touted the benefits of carpooling and utilising active travel/public transport to reduce greenhouse gas emissions and slow the effects of climate change. By utilising high-occupancy vehicles (HOVs), more people can be transported to the same place in one vehicle, against individuals driving themselves. The additional social benefits of increased active transport and reduced motor vehicle use include: transport benefits of reduced congestion, car space requirements and costs; environmental benefits of reduced air, noise, and visual pollution; energy use reductions through fewer cars, lower fossil

fuel use and greenhouse gas emissions. Moreover, communities are further strengthened through increased social interactions on the streets and within neighbourhoods. Despite the benefits associated with active travel, especially in the area of ensuring sustainable planning, it has been realised that some countries are yet to adopt and embrace this mode of transport. Hence, the main pursuit of this study is to examine the impact of active travel adoption and use on sustainable planning and development.

This paper starts by presenting a general overview of active travel, it goes on to examine the role of active travel in sustainable planning and ends by comparing active travel use in some selected developed and developing countries.

3 CONCEPTUAL SYNOPSIS

3.1 General overview of Active travel and Transport Development: Concept of Sustainability

As cities grew in the 20th century, expanded transportation networks furthered urban development but also created a series of challenges towards achieving transport sustainability. The rise in urbanisation, standard of living and rapid economic development have led to the growth and progress in the development of urban and intercity transportation systems. Based on this, the majority of the urban centres have been experiencing diverse transportation problems ranging from traffic congestion, accidents, inadequate transport infrastructure and poor maintenance policies from governments and stakeholders. Due to this, it is pivotal that relevant stakeholders in the transport sector adopt measures aimed at ensuring environmental sustainability. This can be achieved by exploring measures aimed at curbing the menace associated with transportation management in major cities of the world.

Transport systems have a crucial role to play in the development and growth of cities thus making human settlements inclusive; safe, resilient and sustainable (Gumbo et al 2022). One of the targets of the sustainable development goals calls for strengthening efforts to provide access to safe, affordable, accessible and sustainable transport systems for all. It also underlines the need to pay special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons. Globally, the trend in traffic volume is well known, as it has been on the rise for decades. Also, mobility demand has been rising due to increased car ownership in both the developed and developing countries of the world. Andrzej (2002) asserted that the consequential effect of this is seen in traffic congestion in major cities of the world. This has resulted in the loss of cities' attractiveness through tailbacks, noise pollution and exhaust fumes (air pollution). Sustainable urban transport systems require alternatives to the use of private cars that are competitive in terms of convenience and flexibility as well as cost (Dumba et al 2017). Based on this, the enlargement of existing transport infrastructures may not be the solution to the ever-growing traffic problems, thus the need to adopt alternatives, among them the use of active travel.

In a report by the Organisation for Economic Cooperation and Development (OECD). (2018), there is a need to generate alternatives to the use of private cars that are competitive in terms of convenience and flexibility as well as cost to achieve a sustainable urban transport system. One of the ways of discouraging over-reliance on private automobiles is to create an integrated urban transport system by incorporating non-motorised travel such as cycling and walking. Such sustainable transport planning and development would reduce over-dependence and reliance on roads. Chin and Foong (2005) defined sustainable development as one that meets the needs of the present generation without compromising the ability of future generations to meet their own needs. Sustainable transport refers to transport that is sustainable in terms of social, environmental and climate impacts. It aims at a proper balance between current and future environmental, social and economic qualities. Sustainable transport is a key element in the development of sustainable cities (Gumbo and Moyo 2020). A city with sustainable transport should be a city that promotes integrated planning between transport and land use to reduce the need for travel, maximise the utility and value of space, and enhance the efficiency of energy use and the city's liveability (Toan 2018).

3.2 Active Travel Concept

Song et al (2013) defined active travel as any walking and cycling in which people engage for their respective trips. It is widely recognised that active travel (walking and cycling) helps to mitigate the adverse effects of auto-dependent and physically inactive lifestyles as well as traffic congestion, air pollution, and health problems (Brand and Boardman, 2008; Ogilvie et al, 2010; Pratt et al, 2000). Generally, countries that

promote and enhance active mobility contribute to economic and social justice in their territories. Investing in walking and cycling is a policy that responds to the needs and journeys of the poor that can change the livelihoods of the most vulnerable. In addition to improving the urban experience of people that generally cannot afford motorised private transportation, active mobility projects can unlock the health, environmental, and economic benefits of low-carbon lifestyles among the poorest residents. Moreover, making active modes of transportation safer and more efficient rather than a burdensome necessity can lead to mode share retention and future prevention of modal shift to private motor vehicles.

3.3 Benefits of Active Travel

The role of active travel is significant in the lives of people and the community and leads to reduction in the emission of harmful gaseous substances into the environment: Cities contributes more than 60 per cent of the world's GHG emissions and approximately one-third of these emissions stem from urban transport. A recent study that observed 3,800 people across seven European cities, showed that small changes in a person's transport habits can significantly cut their carbon footprint. The study concluded that if people switch just one trip per day from driving to cycling, they will reduce their carbon footprint by 67 per cent, about 0.5 tons per year (World Bank 2021).

In a similar study by Mason et al (2015), a high modal shift scenario modelled by the Institute for Transportation and Development Policy (ITDP) found that if urban passengers' use of bikes and e-bikes were to increase to 11 percent by 2030 and 14 percent in 2050, energy use and carbon emissions for urban transport would be reduced by seven percent in 2030 and 11 percent in 2050. Under this scenario, the high uptake of cycling and e-bike use would save the world a total of USD 6 trillion between 2015 and 2030, and USD 24 trillion between 2015 and 2050. The enabling factor behind the feasibility of such striking changes in travel behaviour lie in the fact that most trips made in urban areas are under ten kilometers, a distance easily cycled, especially when safe infrastructure is present. Also, the provision of more pedestrian walkways to support and encourage active travel will reduce air pollution in urban centres. For instance, Burgen, (2018) posited that city centres in Spain have been pedestrianised since 1999 and this has resulted in a 70 percent decrease in carbon dioxide emissions.

Apart from the reduction in emission of harmful gaseous substance to the environment, The benefits to health are also abundant with greater rates of cycling and walking. It has been noted that insufficient physical activity is one of the leading risk factor for noncommunicable disease. Around 3.2 million deaths per year, are related to physical inactivity (World Health Organization, (WHO) 2020). Essel and Spadaro (2020) further reiterated that active travel offers one way to mitigate some of these deaths. From the study it was discovered that scaling up sustainable mobility, such as safe cycling and walking, could save up to 5,500 premature deaths with improvements to air quality and an additional 33,000 lives from increased physical activity over a 35-year period, for a total of USD15 billion from averted healthcare costs.

According to Volker and Handy (2021), Active travel has also been found to promote economic development. This is evident in its positive impact which supports investment in bicycle and pedestrian infrastructure in local retail and food service businesses. It was asserted that most of the active mobility infrastructure had positive economic effects. Indicators such as retail or food sales, employment, and customer spending increased and that adding bicycle and pedestrian facilities encouraged more visitors by bike or on foot. The economic benefits of cycling and walking have also been realised in new industries, namely that of green tourism. Under this umbrella, bicycle tourism has long been one of its more popular forms. In Europe and the United States, bicycle tourism has had immense economic impact to the tune of USD 96.7 billion and 44 billion euros annually (Adventure Cycling Association 2017).

Improving active mobility in cities and other communities can also reap social benefits of social cohesion, perceptions of security, and liveability. Travelling on foot or by bike along with others is believed to promote feelings of positive fulfilment (McIlvenny, 2015). After the pedestrianiaation of Istanbul's historic peninsula, a survey revealed that 68 percent of pedestrian respondents felt more comfortable being in that area than previously, and that 66 percent reported spending more time in the area. The lockdowns brought by the COVID-19 pandemic had serious impacts on people's physical and mental health. Active mobility modes increase opportunities for social interaction between diverse members of the community, which can broaden people's ability to engage with difference and, in turn, positively impact social cohesion.33 Ultimately, people's physical, mental, social, and economic health will benefit from the ability to move in safe

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

environments. Active travel makes cities and human settlements inclusive, safe, resilient, and sustainable. Safe, inclusive, and sustainable cities require safe, inclusive, and sustainable streets. Improved safety for pedestrians and cyclists will be necessary to meet the road safety target to halve road traffic deaths. Providing safe public spaces that are accessible to all entails making cities bicycle- and walking-friendly (Risimati et al 20210. Safe, comprehensive active mobility networks when coupled with speed management will raise equal opportunities for city dwellers. Overall, Active travel not only promotes individual wellbeing but also promotes the growth of the environment and community at large.

3.4 The Place of Active Travel in Sustainable Transportation Systems

According to the International Energy Agency, greenhouse gas emissions from the transport sector are expected to increase by 120% from 2000 to 2050 (ITDP, 2015 in Tonnesen, Knapskog, Uteng & Oksenholt 2020). In response to this, a mobility shift, away from private car use and towards higher shares of walking and cycling has been routinely mentioned and to some extent adopted at different levels of governance. However, there is a need for substantial change or shift to making the non-motorised transport seamless to use. In the United States, children and adolescents from low-income or historically disadvantaged minority families experience more transportation obstacles, which not only profoundly restrict their access to basic needs, but also create a perpetual impoverished entrapment that limits their upward mobility. The benefits of strengthening active travel through improved access are diverse and multiple. From the climate perspective, reduced car use would likely reduce the carbon footprint, as more travellers will adopt the use of active travel in combination with climate-friendly modes of transport. In furtherance to this, reduction in private car use holds the potential to reduce other negative externalities relating to congestion, traffic accidents, local air and noise pollution.

In a study by Ostergaard et al (2013), active travel in combination with public transport will positively affect public health in comparison to door-to-door travel in private cars, as it helps to achieve healthy living through exercise and to reduce the obesity rate among people. Belcher, Berrigan, Dodd, Emken, Chou and Spruijt-Metz (2010) further reiterated that youth that use active travel have better cardiorespiratory and muscular fitness, increased energy expenditure, more favourable body composition and less weight gain compared to youth that do not engage in active travel. Overall active travel can help in both physical health development of people and environmental development of communities through the reduction of both air and noise pollution. For active transport to help achieve sustainable development, Cascajo, Lopez, Herrero, and Monzon (2019) posited that travellers tend to select the transport mode which they perceive to be the most attractive. Hence, a simple derivative to support sustainable transport goals is that land use and transport systems should be developed to make walking, cycling and public transport use attractive and simultaneously provide competitive advantages over private cars. Given that mode choice is not static and gets influenced by changes in service quality for each mode, the dynamic of choice and its interlocking with access, egress and transfer (AET) needs an in-depth scanning of policies. Though previous studies have highlighted that use of active travel increases when services and facilities are improved (Kjørstad & Nordheim, 2005 cited in Tonnesen, Knapskog, Uteng & Oksenholt 2020 ; Naess 2012), isolated measures directed at different transport modes are usually not sufficient to affect a major modal shift in urban areas. To make a dent in the current car-based mobility structures, it is expedient to adopt an integrated approach which can monitor and plan for the entirety of modes (car, public transport, bicycling, bike-sharing, e-scooters and walking) as one interconnected unit and consider the commute time as well from point of entry and stops (walking) to the next interchange (bus, rail station) etc which should not be too long in order to retain consumers and encourage active travel.

4 METHODOLOGY

The study adopted the Prisma approach in reporting the reviews on the use of active travel in both the developed and the developing countries. Information from this study was derived from the most recent academic literature on the subject matter, and was complemented by presenting and reporting the case studies from some selected countries in Europe and Africa. In this way, the case studies provided a fundamental source of information in defining the methodology and then its main application testbeds. The proposed multilayer approach was aimed at understanding the impact of active travel in the operation of a sustainable transport system.

5 FINDINGS (EXPERIENCE FROM EUROPE, SOUTH AFRICA AND NIGERIA)

This chapter presents information on active travel, its use and applicability in some selected countries in both the developed and developing countries.

5.1 Active Travel in the Developed Countries of the world: Case study from selected European Countries

Recently, many Western industrialized countries have encouraged and adopted walking and cycling because active travel increases daily physical activity, hence reducing obesity and other chronic diseases (Buehler et al, 2011). It is widely recognised that several countries already have a high share of active mode use in Europe, some of these include the Netherlands, Denmark, and Germany (Pucher and Buehler, 2008). In the Netherlands, the active mode share in terms of trip frequency was 44% in 2017 and more than half of these were cycling trips (CBS, 2018). Pucher and Buehler (2008) make a distinction between the cycling rich countries and other countries where cycling is uncommon, such as the USA, Canada, and the UK. From the study, it was discovered that even though more kilometers are cycled in the Netherlands, the fatality and accident rates are much lower compared to the cycling poor countries, indicating a very safe cycling environment. This is due to government policies that support active travel mode by providing a safe and enabling environment to encourage and support the use of non-motorised transport in the country.

In another study, Fishman (2016) identifies the Dutch mature and complete cycling infrastructure as the main contributor to the safe environment. Furthermore, Fishman (2016) stresses that in the Netherlands the cycling population is much more diverse in terms of socio-demographic compared to other countries. Women are known to cycle more than men (Heinen et al., 2010) and also elderly people are active bicycle users (Fishman, 2016). The study of Fishman (2016) identifies that there is a knowledge gap concerning active mode choice from countries like the Netherlands, that have mature infrastructure, are safe, and where cyclists' demographics are diverse. This would enable the possibility to make a comparison of relevant determinants for active mode choice between cycling rich and cycling poor countries. Furthermore, when investigating active mode choice in the Netherlands there is no need to oversample the cycling population, because a representative sample of the population suffices to ensure a large enough sample of cyclists. From the study, it was argued that the Dutch are 'blind to cycling', meaning that cycling is such an ordinary activity that it has not been warranted much attention, both by practitioners and researchers. Only recently this has started to change. Dutch transport planning models, such as LMS (Rijkswaterstaat, 2018), are used by governmental authorities to assess the impact of policies. These models are tailored to the car and public transport.

In line with Fishman's (2016) argument, the active modes have not received much attention. Walking and cycling are combined into 'slow modes' and often evaluated as 'rest-category' (De Jong et al., 2007). Ton et al, (2019), in a study asserted that the use of active travel goes beyond policies, the study identified six characteristics and determinants of active mode choice; they include, individual characteristics, household characteristics, trip characteristics, built environment, season and weather characteristics, and work conditions. Several studies (Central Bureau of Statistics, 2014; Harms et al, 2013; Fishman et al, 2015) have been conducted on active travel in the Netherlands using data collected by the Dutch National Travel Survey. Harms et al (2013), opined that even though the overall cycling shares have been relatively stable at around 27% for over decades cycling distances have increased by 14%. It was further reported that half of all trips made by those aged 18 years and above are by bicycle. However, almost all of the 14% growth in the distance cycled is due to those aged 50 years or more. Another trend which was reported in the study of Harms et al (2013) is a reduction in car use by those aged 18–30. Consistent with evidence from Delbosc and Currie (2013), women have a higher share of cycling as a proportion of all trips but men cycle greater distances. In another study by Scheepers et al, (2013), on exclusively short trips (under 7.5 km) using NTS data collected between 2004–2009. Walking and cycling mode share is analysed together in comparison to car use for different trip purposes (i.e. shopping, commuting, chauffeuring, and sports). It was found that for trips under 7.5 km, 44% are made by car, regardless of trip purpose. Bicycle use was highest for commuting (47%), falling to 35% for both chauffeuring and shopping. Walking was highest for chauffeuring, accounting for 21% of trips, reducing to 9% for commuting. Trip durations were found to be similar, on average, between car, bicycle and foot (around 10 minutes) although distance travelled varies from 3.3 km for cars, 2.1 km for cycling and 0.8 km for walking.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

In Germany, Policies aimed at promoting sustainable transport have been implemented. These includes restrictions on car use, provision of high-quality, attractively priced, well- coordinated public transport services as a viable alternative to the car for many trips, especially in large cities. Thirdly, the provision of transport infrastructure to promote and encourage non-motorized travel has been vastly improved to increase the safety and convenience of walking and cycling. According to Buehler and Pucher (2009), German governments at all levels have influenced travel behavior through a series of policies enacted over decades. These includes Pricing, restrictions, and mandated technological improvements aimed at reducing the harmful impacts of car use. In addition to this, there has been integration of public transportation at the metropolitan and national levels which provide a viable alternative to the car. Apart from these, there has been improvement in the land use-planning, this is done by implementing regional land planning policies aimed at encouraging compact, mixed-use development, thus keep trip distances short and feasible for walking or cycling.

German cities have greatly improved non-motorised transport infrastructure used by pedestrians and bicyclists (BMVBS, 2002). For example, free zones that cover much of the city centre and wide sidewalks on both sides of every street for pedestrians. Other pedestrian friendly design features include pedestrian refuge islands for crossing wide streets, clearly marked zebra crosswalks, often raised and with special lighting for visibility; and pedestrian-activated crossing signals (Pucher and Dijkstra, 2003). Also, all residential and commercial developments have sidewalks for pedestrians, and many feature separate bike paths and extensive parking for cyclists. The bicycling and walking networks in virtually all German cities include numerous off-street short cut connections for cyclists and pedestrians to enable them to take the most direct possible route from origin to destination. The result of such a wide range of facilities is a complete, integrated system of bicycling and walking routes that permit cyclists and pedestrians to move either on completely separate paths and lanes or on lightly travelled, traffic-calmed residential streets without competing with cars on the road (Pucher and Buehler, 2008). The resultant effect is reduction in traffic congestion as there will be fewer vehicles on the road, accident reduction and an environment free from pollution arising from excessive car reliance. Overall, it can be asserted from these studies that the use of active travel is being embraced as a mode choice in Europe as majority of the respondents engage in the use of non-motorised transport (walking/cycling) for majority of their trips.

5.2 Active Travel in the Developing Countries of the world: Case study from selected African Countries

Walking is the most important mode of transport in the “Global South. ” Depending on the location, the mode accounts for between 33 and 90% of trips. Despite its importance and the notion that walking is available to all, there are vast parts of the population that cannot use the mode, as infrastructure is not conducive (Vanderschuren, et al, 2022). NMT in Africa is not driven by the type of benefits that have been identified by Litman (2012). The burden that the urban poor have to carry in Africa is not only economic. They also carry a road safety burden. Traffic accident rates are very high, nearly 30-40 times those in the European Union (Sub-Saharan Africa Transport Policy Program (SAATP) 2005). In 2002, global road traffic injuries accounted for 2.1% of all deaths, making them one of the leading causes of death. Most of those killed or injured, due to road crashes globally, are pedestrians in developing countries. They are also breadwinners for their families. In addition to these deaths, an estimated 20 million to 50 million people are injured in road crashes each year (Vanderschuren, 2006).

A recent analysis of the South African Household Travel Survey (2013) revealed that approximately 75% (also representative of Cape Town) of inhabitants require special consideration in planning, designing, and implementing of transport infrastructure. That percentage includes children, females, and persons with disabilities. From the study, it was discovered that there is an overwhelming lack of support of walking and cycling in most African cities. Many countries and cities in the region do not include the active travel modes in plans and, where infrastructure is provided, implementation is often not fit for purpose. In many instances, this is further compounded by a lack of supply of suitable infrastructures that supports active mobility, with a failing or weak bicycle industry notably lacking in official government support.

From a transportation perspective, Kershaw and Forer (2010) opined that users make mode choices based on a variety of factors. They include economic, or service driven ones, based on individual roles, habits and interests or age, income, life cycle, gender and ability. As transport involves the human movement from one

place or neighbourhood to another, the power dynamics that flow from race, gender, class, and other systems of subjugation or privilege will, generally, transcend the boundaries of any given space, place or neighbourhood. Analysis reflects different mobility patterns for males and females and suggests that harassment experiences have a significant effect on user choices (Vanderschuren, et al, 2019). From the experience of developing countries on the use of active mobility, it was discovered that even though the residents make use of some active mode (walking), it is not as a result of the benefits derives from its use, but rather because of the low income being generated by households which often deprives them of using the motorised mode of transport. In addition to this, the governments do not make provision for transport infrastructures which support active travel when designing and formulating transport policies.

5.3 Active Travel in the Transitional Countries: Case study of Armenia

World Economic Situation and Prospects (WESP) classified all countries of the world into one of three broad categories: developed economies, economies in transition and developing economies. The basis for the classification is to reflect basic economic country conditions. Several countries (in particular the economies in transition) have characteristics that could place them in more than one category; however, for purposes of analysis, the groupings have been made mutually exclusive. Within each broad category, some subgroups are defined based either on geographical location such as the subgroup of "major developed economies", which is based on the membership of the Group of Seven. Geographical regions for developing economies are as follows: Africa, East Asia, South Asia, Western Asia, and Latin America and the Caribbean. As defined by WESP (2014), countries in transition include Ukraine, Albania, Serbia, Belarus, Armenia among others. Based on this, it is pivotal to examine the use of non-motorised transport in these countries to know its impact on their mobility and development.

For the purpose of our study, we examined active travel use in Armenia, a country in transition. Being a landlocked country, Armenia has an economy that depends on transport and cross-border access. However, Armenia's location presents a significant problem for the transport sector due to the few international borders and poor climatic condition which has impeded the growth in the transport sector. These problems result in high transport costs, particularly for traded goods, and expensive infrastructure development and maintenance. Armenia has a few railway lines and an extensive road network. While car ownership has been growing steadily in recent years, it is still relatively low. Public transport plays a critical role, especially in cities. Armenia's urban transport system faces several problems among which are the declining use of public transport, a lack of pedestrian safety and traffic congestion (Asian Development bank, ADB 2011). The demand for public transport has changed dramatically in recent years with the introduction of minibuses and a decline in large bus, trolleybus, and metro services. But little attention has been paid to the use of active travel/ non-motorised transport in the country.

6 PLANNING AND DESIGNING ACTIVE MOBILITY – RECOMMENDATIONS

Across the globe, many cities in the developed countries have high rates of cycling and walking. This is as a result of good policy and investment in transport infrastructures that support active travel, but for others, especially in the developing countries, it may be attributed to a lack of public transit or the high expense of driving. According to the World Bank (2021), cities in the United States, such as Portland, Minneapolis, and Washington, D.C., have grown their cycling rates. For example, Portland has seen a 374 per cent increase in the bicycle commuters between 2000 and 2017, largely attributable to its 385 miles of bikeways.3 The city also has the highest number of bike commuters in the United States, which in 2014 peaked at 7.2 per cent. In middle-income countries such as Colombia, the city of Bogota has grown its rates of cycling from 0.58 per cent in 1996 to 9.1 per cent in 2017 through the development of its bike network (Rosas-Satizábal & Rodriguez-Valencia 2019).

To encourage and support the use of non-motorised transport, there is a need for the provision of an infrastructure policy that protects pedestrians and cyclists to make active mobility safer for existing users and more attractive to potential new users. City dwellers should be able to walk or cycle across their city via safe, convenient, and comfortable routes, free from traffic-related dangers and stress, regardless of their age, gender, and abilities. Infrastructure planning and design, along with other policies like traffic enforcement, need to protect people from collisions with motor vehicles. These measures include separated facilities like sidewalks and cycle tracks, and speed management with reduced speed limits, traffic calming, and safe

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

intersections. Infrastructure planning and design for active mobility should contribute to the articulation of networks that connect places and neighbourhoods in a city. Car-centric planning led to city- and country-wide networks that allow motorists to reach most places in most cities around the world. Likewise, a paradigm shift that prioritises active transport should lead to repurposing street networks to safely and conveniently connect most origins and destinations for people that walk or cycle. The following are some of the most important components of neighbourhood walkability: walkways; crosswalks; visually active frontage; physically permeable frontage; shade and shelter; small blocks; prioritised connectivity; complementary uses; access to local services; driveway density; and roadway area. SLOCAT (2021), also reiterated that to support active travel, pedestrian networks should be designed to be:

(1) Continuous and connected: pedestrians must be able to enjoy multiple continuous, well-linked routes that reach key destinations.

(2) Accessible and comfortable: streets must offer universal access to users from all walks of life and must provide enough capacity for people to walk comfortably next to someone else.

(3) Safe: streets must always guarantee personal and traffic safety through well-lit, obstruction-free, and accessible spaces, as well as short, direct, and visible pathways at intersections.

(4) Relevant to context: networks must adapt to the scale, character, identity, topography, and green elements of the streets.

7 CONCLUSION

The study revealed that the benefits derived from the use of active travel outweigh the disadvantages. While a majority of cities in the developed countries such as Europe (the Netherlands among others) have policies that support and encourage active mobility, the reverse is the case in many of the developing countries. South Africa being a case study in the developing country, it was discovered that the residents adopted active mode of transport as a result of the low-income generation which does not allow them to have access to private automobiles or access public transport such as the train. The built environment does not support the use of active travel as the government contributes little investment in active travel. In view of this, governments and relevant stakeholders should invest in the provision of relevant infrastructures that support and encourage active mobility in both the developed and developing countries of the world.

8 REFERENCES

Adventure Cycling Association (2017). “Bicycle Tourism 101. https://www.adventurecycling.org/advocacy/ building-bike-tourism/bicycle-tourism-101/

Andrzej, A. (2002). Intelligent Integrated Transport system. 565-570

Asian Development Bank (ADB) (2011). Armenia Transport Outlook. Transport Sector Master Plan,https://www.adb.org/sites/default/files/publication/28298/armenia-transport-outlook.

Belcher, B.R., Berrigan, D., Dodd, K.W., Emken, B.A., Chou, C.P. & Spruijt-Metz, D (2010). Physical activity in US youth: Impact of race/ethnicity, age, gender, and weight status. Med. Sci. Sports Exerc. 42, 2211–2221.

BMVBS (2000) Urban development and urban policy in Germany. German Federal Ministry of Transportation and Urban Development, Bundesamt fuer Bauwesen und Raumordnung, Bonn.

Brand C, Boardman B, 2008, “Taming of the few—the unequal contribution of greenhouse gas emissions from personal travel in the UK. Energy Policy 36, 224–238

Buehler, R., Pucher, J., Merom, D. & Bauman, A. (2011). Active Travel in Germany and the US.: Contributions of Daily Walking and Cycling to Physical Activity. American Journal of Preventive Medicine, 41(3), 241-250.

Buehler, R. & Pucher, J. (2009). Sustainable Transport that works: Lessons from Germany. World Transport Policy & Practice, 15,(1), 13-46

Burgen, S. (2018). For Me, This Is Paradise: Life in the Spanish City That Banned Cars.” The Guardian, September 18, 2018, sec. Cities. https://www.theguardian.com/cities/2018/sep/18/paradise-life-spanish-city- banned-cars-pontevedra

Cascajo, R., Lopez, E., Hererro, F. & Monzon A. (2019). Users’ perception of transfers in multimodal urban trips: A qualitative study. International Journal of Sustainable Transportation. 13(6), 393-406.

CBS, (2018). Personenmobiliteit in Nederland; vervoerwijzen en motieven; regio's. Retrieved August 08, 2018, from Statline: < https://opendata.cbs.nl/ statline/#/ CBS/nl/dataset/83500ned/table?ts=1533718250585 > (in Dutch)

Central Bureau of Statistics, (2014) Research Travel in Netherlands (OViN). In: Central Bureau of Statistics, editor. The Netherlands: Central Bureau of Statistics.

Chin, H.C. & Foong, K.W (2005). Issues in transportation planning - the Singapore experience. WIT Transactions on State of the Art in Science and Engineering, vol. 22, 127-158.

CIVITAS. (2017). Walking, Cycling and Congestion: 15 Quick Facts for Cities.” https://civitas.eu/resources/ walking-cycling-and-congestion-15-quick-facts-for-cities.

Delbosc A. & Currie, G. (2013) Causes of Youth Licensing Decline: A Synthesis of Evidence. Transport Reviews 33: 271–290.

De Jong, G., Daly, A., Pieters, M., Miller, S., Plasmeijer, R., & Hofman, F. (2007). Uncertainty in traffic forecasts: Literature review and New results for the Netherlands. Transportation, 375–395.

Dumba S, Vassileva LD, and Gumbo T, (2017) Methodological issues in modelling signalised intersection capacity under informal public transport operations: Case study, Harare, Zimbabwe, Transportation Research Procedia, 25, 4895-4919, https://doi.org/10.1016/j.trpro.2017.05.367

Essel, D., & Spadaro, J.V. (2020). Health and economic impacts of transport interventions in Accra, Ghana. Geneva: World Health Organization; 2020. https://www.who.int/publications-detail-redirect/9789240017306

Fishman, E. (2016). Cycling as transport. Transport Reviews. 1–8.

Fishman, E., Bocker, L. & Helbich, M. (2015). Adults Active Travel in the Netherlands: An Analysis of Its Contribution to Physical Activity Requirements. Plos One, 10(4): e0121871. doi:10.1371/journal.pone.0121871.

Gumbo Trynos and Moyo Thembani (2020) Exploring the Interoperability of Public Transport Systems for Sustainable Mobility in Developing Cities: Lessons from Johannesburg Metropolitan City, South Africa, Sustainability, 12, 5875; 1-16; https://doi:10.3390/su12155875.

Gumbo Trynos; Moyo Thembani; Ndwandwe Bongumusa; Risimati Brightnes; Mbatha Siphiwe (2022) Urban Public Transport Systems Innovations in the Era of the Fourth Industrial Revolution: Perspectives, Reflections and Conjectures, Springer Nature Switzerland AG, https://link.springer.com/book/10.1007/9783030987176.

Heinen, E., Van Wee, B., Maat, K., (2010). Commuting by bicycle: An overview of the literature. Transport Reviews. 59–96.

Kershaw, P. & Forer, B. (2010). Selection of area-level variables from administrative data: an intersectional approach to the study of place and child development. Health Place 16, 500–511. doi: 10.1016/j.healthplace.2009. 12.008

Litman, T. (2012), Evaluating Non-Motorized Transportation Benefits and Costs, Victoria Transport Policy Institute.

Mason, J., Fulton, L., & McDonald, Z. (2015). A Global High Shift Cycling Scenario: The Potential for Dramatically Increasing Bicycle and e-Bike Use in Cities around the World, with Estimated Energy, CO2, and Cost Impacts." Institute for Transportation & Development Policy and University of California Davis. https://itdpdotorg.wpengine.com/wp-content/uploads/2015/11/A-Global-High-Shift-Cycling-Scenario_ Nov-2015.pdf.

McIlvenny, P. (2015). The Joy of Biking Together: Sharing Everyday Experiences of Vélomobility, Mobilities, 10:1, 55-82. https://www.tandfonline.com/doi/abs/10.1080/17450101.2013.844950

Naess, P. (2012). Urban form and Travel Behaviour: Experience from a Nordic Context. Journal of Transport and Land Use, 5(2), 21-45.

Ogilvie D, Mitchell R, Mutrie N, Petticrew M, & Platt S, (2010). Shoe leather epidemiology: active travel and transport infrastructure in the urban landscape. International Journal of Behavioral Nutrition and Physical Activity, 7: 43

Organisation for Economic Coperation and Development OECD, (2018). Integrating urban public transport systems and cycling. Summary and Conclusions of the International Transport Forum (ITF) roundtable on integrated and sustainable urban transport held in Tokyo, between 24-25 April 2017.

Ostergaard, L., Kolle, E., Steene-Johannessen, Anderssen, S.A. & Andersen, L.B. (2013). Cross sectional analysis of the association between mode of school transportation and physical fitness in children and adolescents. Int. . Behav. Nutr. Phys. 10, 91.

Pucher, J., & Buehler, R. (2008). Making cycling irresistible: Lessons from The Netherlands, Denmark and Germany. Transport Reviews. 495–528.

Pucher, J. & Dijkstra, L. (2003) Promoting safe walking and cycling to improve public health: Lessons from the Netherlands and Germany. American Journal of Public Health 93.

Pratt M, Macera C A, Wang G, (2000). "Higher direct medical costs associated with physical inactivity. Physician Sports Medicine. 28, (10) 63–70

Rijkswaterstaat, (2018) . Nederlands Regionaal Model (NRM) en Landelijk Model Systeem (LMS). Retrieved from Rijkswaterstaat: < https://www rijkswaterstaat.nl/wegen/wegbeheer/aanleg-wegen/nederlands-regionaal-model-nrm-en-landelijk-model-systeem-lms.aspx

Risimati Brightnes, Gumbo Trynos and Chakwizira James (2021) Spatial Integration of Non-Motorised Transport and Urban Public Transport Infrastructure: A Case of Johannesburg, Sustainability, 13, 11461; 1-17, https://www.mdpi.com/2071-1050/13/20/11461

Robert, J.D., Mandic, S., Fryer, C.S., & Brachman, M.L. & Ray, R. (2019). Between Privilege and Oppression: An intersectional analysis of Active Transportation Experiences among Washington D.C. area youths. International Journal of Environmental Research and Public Health. 16 (1313).

Rosas-Satizábal, D. & Rodriguez-Valencia, A. (2019). Factors and policies explaining the emergence of the bicycle commuter in Bogotá, Case Studies on Transport Policy, 7, (1), 138-149. https://doi.org/10.1016/j.cstp.2018.12.007.

Sub-Saharan Africa Transport Policy Program (SSATP, 2005), Non-Motorized Transport in African Cities, Lessons from Experience in Kenya and Tanzania, SSATP Working Paper No. 80.

Scheepers, E., Wendel-Vos W., Van Kempen, E., Panis, L.I., Maas J., & Stipdonk H. (2013) Personal and Environmental Characteristics Associated with Choice of Active Transport Modes versus Car Use for Different Trip Purposes of Trips up to 7.5 Kilometers in The Netherlands. PLoS ONE 8: e73105. doi: 10.1371

SLOCAT, (2021). Transport and Climate Change Global Status Report 2nd Edition. Section 3.3: Walking and cycling. https://tcc-gsr.com/responses-to-policies/walking-and-cycling.

Song, Y., Preston, J.M. & Brand, C. (2013). What explains Active Travel Behaviour: Evidences from Case Studies in the UK. Environment and Planning A, 45, 2980-2998. doi:10.1068/a4669

Statistics South Africa (STATSSA) (2013). National Household Travel Survey (SANHTS), 2013. Version 1. Pretoria: Statistics South Africa [producer], 2014. Cape Town: DataFirst [distributor], 2014.

Toan, T.D. (2018). Managing traffic congestion in a city: A study of Singapore's experiences. Proceeding International Conference on Sustainability in Civil Engineering, in Vietnam

Ton, D., Duives, D.C., Cats, O., Hoogendoorn-Lanser, S. & Hoogendoorn, S.P. (2019). Cycling or Walking? Determinants of Mode Choice in Netherlands. Transportation Research Part A. 123, 7-23.

Tønnesen, A., Knapskog, N., Uteng, T.P., & Oksenholt, K.V. (2020). The integration of active travel and public transport in Norwegian policy packages: A study on 'access, egress and transfer' and their positioning in two multilevel contractual agreements, Research in Transportation Business & Management, https://doi.org/10.1016/j.rtbm.2020.100546

UN Habitat. (2013). Streets as Public Spaces and Drivers of Urban Prosperity. https://unhabitat.org/streets-as- public-spaces-and-drivers-of-urban-prosperity
Vanderschuren, M.J.W.A (2006), Intelligent Transport Systems in South Africa, Impact Assessment through Microscopic Simulation in the South African Context, TRAIL Thesis Series T2006/4, Book, ISBN number.
Vanderschuren, M., Newlands, A. & Wheeldon, A. (2022). Improving Non-motorized Transportation Provision in a Socially Inclusive Way- The case of Cape Town. Frontiers Sustainable Cities 4:775339. doi: 10.3389/frsc.2022.775339
Volker, J., & Handy, S. (2021). Economic Impacts on Local Businesses of Investments in Bicycle and Pedestrian Infrastructure: A Review of the Evidence." Transport Reviews 41 (4): 401–31. https://doi.org/10. 1080/01441647.2021.1912849
Welle, B., et al. (2018). Sustainable & Safe: A Vision and Guidance for Zero Road Deaths. World Resources Institute: Washington DC. https://www.wri.org/research/sustainable-and-safe-vision-and-guidance-zero- road-deaths
Wen, L.M., Rissel, C. & Fu, H. (2013). The effect of Active transport, Transport systems and Urban Designs on Population health. Journal of Environmental and Public Health, Volume 2013.
World Bank (2021). Investing for momentum in Active mobility. Discussion Paper on Transport Decarbonization Investment.
World Economic Situation and Prospects (WESP) (2014). Country Classification. https://www.un.org/en/development/desa/policy/wesp/wesp_current/2014wesp_country_classification.
World Health Organization (WHO). (2020). "Physical Activity." https://www.who.int/news-room/fact-sheets/detail/physical-activity

🏆 *reviewed paper*

The Effect of Digital Media in Reviving Urban Public Spaces

Nesma Magued , Hassan Abdel-Salam , Asmaa Elsayed Hasan

(Demonstrator Nesma Magued, Department of Architecture, Faculty of Engineering, Alexandria University, Egypt, nesmamagued@alexu.edu.eg)
(Professor Hassan Abdel-Salam, Department of Architecture, Faculty of Engineering, Alexandria University, Egypt, hasalam@alexu.edu.eg)
(Lecturer Asmaa Elsayed Hasan, Department of Architecture, Faculty of Engineering, Alexandria University, Egypt, asmaa.elsayed@alexu.edu.eg)

1 ABSTRACT

Urban public spaces have always been valued by city residents and experts. Pioneers and critics have managed to develop several evaluation parameters that indicate space efficiency and success.

Unfortunately, a new social trend is emerging, pushing the public towards virtual life. People's over reliance on media is unprecedented. Public spaces' importance is decreasing, they are becoming more deserted than ever. Urbanisation has pushed this phenomenon to its extreme. However, what is regarded as a massive defeat and a huge promoter of public space abandonment, can be interpreted differently. Digital media can be utilised in public domain revitalisation.

The study focuses on public space assessment, using nine qualities retrieved from the literature review, followed by a proposal of prospects for reviving the common realm using media tools. This was accredited by the case study of a neighborhood park in Smouha, Alexandria. A questionnaire was used in order to determine the effect of several media interventions' suggestions on qualities of success of the park, and how far they can reestablish the lost spaces. This research aims to reach a clear conclusion about the effect of media use in public involvement and on space qualities to reach specific recommendations for public space improvement.

Keywords: Qualities of Success, Digital Media, Smart Urban Spaces, Assessment, Public Involvement

2 INTRODUCTION

"There is more than the eye can see, more than the ear can hear, a setting or a view waiting to be explored." (Lynch, 1960, p. 1).

This is how Kevin Lynch defines the public domain as a place beyond what is tangible, an eternal piece of art, that can persist and have an impact. He continues to describe it as a large stage, where the public is part of the show, they can never be only spectators. Hence, a major aspect of the public space only appears when it is put into relation with its users and their interactions. This interrelation needs to be regulated by some sort of benchmarks, representing what the public could look for in their shared domain, to be applied to public spaces as the main assessing factors that determine the positivity of people-space relation. Relying on some of the pioneers' studies, these benchmarks, representing the qualities of success of public spaces are: visual qualities, inclusiveness, access and linkage, protection, user centred approach applied, activities and functionality, comfort, enjoyment, livability and vitality and finally communal qualities. Further explanation is given in the literature review.

People perceive public spaces in different ways related to cultural backgrounds, gender, preferences, history and social stage. All these factors affect behavioural patterns in many ways that cannot be computed or predicted. Then, those behaviours spread and shape the public space all over again.

This explains the fact beneath the changing image of public spaces due to public behavioural changes occurring from one decade to another. Especially when there is a certain life deviating event or promoter. Recently, and due to the excessive technological achievements, people are depending more and more on digital media, allowing their life to be more virtual than real.

Back in 1998, Rob White was able to anticipate a certain behaviour in his book Public spaces for young people (White, 1998). He mentions the appearance of a considerable debate about the fact of the presence of youngsters in public spaces and their involvement in various activities. He also detects anti-social behaviour among young people, that is easily perceived by individuals they deal with such as shop-keepers and older generations. Back then, technology was taking significantly large steps, with the growing number of computers and mobile phones ownership, as well as the internet availability to the public that started in 1991.

At this time, probably the addiction was not yet in question, but the willingness of adolescents to escape from their lives to screens was certainly threatening.

In addition, in his publication Public space for a changing public life Gehl, (2007) wonders about the potentiality of the digital and virtual world to substitute the direct contact between human-beings, and if the deserted public realm can be considered as an acceptable consequence for these challenges.

This addiction to social media has reached the physical, mental and social lives of human beings and it has even affected the urbanised environments in ways that could never be imagined, and never be restored. Some public behaviours are even recently appearing due to the crowd orientation.

Houghton describes some terminologies as being the new trendy behaviours not by choice, but as a consequence of suffering from media addiction (Houghton, 2010).

These behaviours include: Hyper-coordination; copresence and distant focus; mobile phones for perception of security; productive use of transition or travel time; constant connection of work and contact; and public dance or choreography of the mobile phone.

In order to understand the effect of media overreliance better in daily community life and in the living environments, a correlation is made between the long established qualities of the public spaces in which people spend most of their time, and how they are affected by the addictive behaviour of the crowd, or its resultant trait changes as shown in table 1.

Digital Addiction	Visual Qualities	Inclusiveness	Access and Linkage	Protection	User Centere	Activities an Functionali	Comfort	Enjoymen	Livability an Vitality	Communal qualities
Hyper-coordination						●				
Co-presence and Distant Focus	●				●	●			●	
Mobilephones for Perception of Security					●				●	
Productive Use of Transition or Travel time	●				●	●	●	●	●	
Constant Connection of Work and Contact					●		●	●	●	
Public Dance or Choreography of the Mobile Phone	●				●	●				
Weight of effect	Moderate	slight		slight	Large	Large	Moderate	Moderate	Large	slight

Table 1: The effect of digital addiction and its accompanying personality traits on the qualities of success of public spaces.

It seems that large configurations and changes in the human perception, priorities, needs and interests have occurred, only to leave the well designed public spaces with an extra challenge in terms of people participation. This is mainly reflected in the user centred features in public spaces, their offered comfort, and livability and vitality. Those are the most affected qualities by this behavioural disorder. However, all other qualities seem to be affected as well. In consequence, public spaces have lost their roles and significance, and regrettably their contribution to society could never be filled with any substitutions. Urban spaces can suffer from the affiliates of this mainstream, leading to major changes in the known social pattern and threatening the long established qualities of the public realm.

This aversion towards the public realm obligates a fast and effective intervention. Using media tools is considered to be the ultimate solution for people's involvement in public spaces. Since the main challenge relies on people overreliance on technology, the solution can lie in using this specific tool, as an attraction to people towards public spaces, and exploiting it in creating significant engagement in public spaces. This is accredited by an empirical study for a neighbourhood park in Alexandria, Egypt, to determine the degree of impact of media tools application in the public domain and in the amelioration of public space assessment and qualities of success.

3 LITERATURE REVIEW

3.1 Public space qualities of success

Since a poorly designed public space is never able to accomplish its roles. a theoretical review has been done in order to achieve a better understanding of public spaces qualities that are key elements to the success of the common domain .

Architects and urban planning pioneers suggested over the years various parameters that can be used to assess public spaces. These assets were skimmed through and sorted to attain a coherent set of qualities that can be defined as qualities of success for public space. Each quality was mentioned by several studies, using various terms that reflect the same value. Table 2 shows the qualities of success of public spaces, and their related sub-qualities, used to measure and assess the space value.

Qualities				Linkage						Functionality										Vitality				Qualities	
Artistic	Degree of Attractiveness	Degree of Legibility	Distinctiveness	Proximity and Accessibility Degree	Coexistence Ratio	Protection Against Traffic and Accidents	Protection Against Crime and Violence	Protection Against Unpleasant Sense Experiences	Protection from the Environmental Conditions	For People	Respect Human Scale	Functional Space	Various Activities	Efficiency and Quality Level	Possibilities for Walking	Possibilities for Standing and Staying	Possibilities for Sitting	Possibilities to See	Possibilities for Hearing and Talking	Possibilities for Playing and Unwinding	Scale	Possibilities for Enjoying Positive Aspects or Climate	Aesthetic Qualities	Positive Sense Experiences	Healthiness	Sustainability	Sociability	Cleanliness	Affecting Cultural Heritage	Affecting City Policy

Table 2: Classification of open space qualities and their sub-qualities.

The characteristics of open space qualities can be elaborated as follows:

- Visual qualities: Visual qualities can be applied at four consecutive scales. Starting with the aesthetics of public spaces mentioned by Sitte as the artwork (Sitte, 1889), Jacobs expresses the importance of the senses, especially sight (Jacobs, 1961), as well as McCormack, Rock, Toohey and Hignell (McCormack, Rock, Toohey, & Hignell, 2010), Gehl (Gehl & Svarre, 2013), Mehan (Mehan, 2016) and Van Hecke and his colleagues (Van Hecke et al., 2018).

This is followed by the attractiveness of public realm. Authors who mentioning this particular scale of visual qualities are Carmona, de Magalhães and Hammond (Carmona, De Magalhaes, & Hammond, 2008) Gehl (Gehl, 2007), and finally Zagroba (Zagroba, 2016).

Imagebility and legibility are considered as core attributes in visual qualities. They are explored and explained by Lynch as legibility and mental images (Lynch, 1960) and in Project for Public Spaces (PPS., 2009).

Finally the identity scale is introduced by Lynch (Lynch, 1960), as well as Carmona, de Magalhães and Hammond (Carmona et al., 2008) -who uses the term distinctiveness-, as well as Balabanides and Philippou (Balabanides & Philippou, 2015).

This process was repeated to reach a coherent set of qualities and sub-qualities as showed in the previous table. Each quality classification is mentioned briefly, relying on the references that accredit it.

- Inclusiveness, Access and Linkage: This quality is subdivided into two scales, the first one is the proximity, accessibility and linkage degree (Carmona et al., 2008; Lynch, 1960; McCormack et al., 2010; PPS., 2009; Sitte, 1889; Zagroba, 2016).

As for inclusiveness, it is mentioned by several references including: (Balabanides & Philippou, 2015; Carmona et al., 2008; Gehl & Svarre, 2013; Jacobs, 1961; Marcus & Wischemann, 1990).

- Safety: It is a quality that can be described as crucial for the public realm (Carmona et al., 2008; Davis, 1990; Jacobs, 1961; Lynch, 1960; McCormack et al., 2010; Newman, 1972). Gehl (Gehl & Svarre, 2013) actually talks about the safety sub-qualities. Balabanides and Philippou and Van Hecke and his colleagues all insist on the fact that safety and security are at the core of public spaces success (Balabanides & Philippou, 2015; Van Hecke et al., 2018).

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

- User Centred approach: User centered theories were evolutionary at their time. Creating a space that focuses on human needs and dimensions raised public spaces' value to another level (Alexander, 1977; Gehl & Svarre, 2013; Sitte, 1889). Other researchers focus on another level of user centred approach which is respecting human scale and dimensions in all designs (Balabanides & Philippou, 2015; Gehl, 1987).
- Activities and functionality: Public spaces can be defined as containers that embrace public activities and functions dedicated to the city residents; hence, the functionality and activities held within the public realm, and their efficiency determine the space success. The first scale of this quality is space functionality (Carmona et al., 2008; Corbusier, 1927; Gehl & Svarre, 2013; Mehan, 2016), assisted by the space activities (Balabanides & Philippou, 2015; Gehl & Svarre, 2013; Lynch, 1960; McCormack et al., 2010; PPS., 2009; Van Hecke et al., 2018).

Ultimately it is reaching the efficiency and maintenance scale of functionality (Balabanides & Philippou, 2015; Carmona et al., 2008; Lynch, 1960; McCormack et al., 2010; Van Hecke et al., 2018).

- Comfort: This can be seen as another key element in the public spaces including thermal and environmental comfort (Bosselmann et al., 1984; Carmona et al., 2008; Peng, Feng, & Timmermans, 2019; PPS., 2009). Gehl and Svarre describe several comfort indicators which are used as sub-qualities (Gehl & Svarre, 2013).
- Enjoyment: Its basic categories are reflected in Gehl's studies as the concept of enjoyment (Gehl & Svarre, 2013); it is mentioned additionally in various sources (Mehan, 2016) and others.
- Liveability and Vitality: Together, they form the eighth value. Enjoyment is upgraded into vitality. mentioned as healthy environments and cleanliness which consist of two sub-qualities (Balabanides & Philippou, 2015; Carmona et al., 2008; Gehl, 2007). Sustainability is suggested by Gehl (Gehl, 2007). in addition to liveability and sociability qualities (Balabanides & Philippou, 2015; Gehl & Svarre, 2013; Jacobs, 1961; PPS., 2009).
- Communal qualities: At long last, communal qualities form an important approach to public space evaluation. How the public domain affects the cultural identity of society and preserves its cultural heritage; this is the main focus of Zagroba (Zagroba, 2016),adding the management policy and rules accredited by Linde Van Hecke and her colleagues (Van Hecke et al., 2018).

These qualities work complementary to reach greater success for public spaces. Their cooperation ensures better environments and excellent results.

3.2 Benefits of introducing digital media into public spaces

Having a digitalised public urban space has as its main goal the enhancement of space liveability and sociability. This happens by increasing its aesthetics, its accessibility, its level of security, along with its user friendliness, its offered activities and its comfort in order to maintain satisfaction of individuals and in turn increase communal partnership. Digital media and internet use have a great impact on improving the quality of life of individuals. As Ali, Alam, Taylor and Rafiq state this happens by enhancing physical and psychological well-being, promoting self-esteem and facilitating social relationships (Ali, Alam, Taylor, & Rafiq, 2020).

Radwan and Morsi (Radwan & Morsy, 2018) conducted a comparison between a typical public space and a smart public space reaching the following conclusion. Addressing the accessibility aspect of the public realm, a digitalised space is more accessible since it offers digital accessibility, whereby users can access the space virtually, obtaining all sorts of data they need to know and maybe encouraging them to actually visit the place.

Visually speaking, a space using digital media can have the same appealing look than the ordinary space. in addition to beauty, with some added features such as virtual reality and other smart features. Eco-friendliness is a must nowadays, and smart tools make it more applicable and independent of state government. Sociability and inclusiveness are key qualities in public spaces, and must be present whether the space is digitalised or not.

As for management, smart technologies offer a collaborative approach wherebu people can exercise their partnership. Event coordination becomes easier when applying new technologies. User feedback can be

much faster and on the spot, and eventually more frequent than the manual one. And finally, users are allowed to interact with their occupied space to a great extent and in an evolving manner.

This was further documented by the study of digital media tools interventions in public spaces and how they affect each of the nine quality, finally reaching the same conclusion. A digital media tool implementation is always a gain for the public space. Various tools of media can affect the nine qualities of success of public space differently, but at the same time ensure more people involvement, especially people who are suffering from media overreliance. Those will be definitely interested in the renovations of their public domain to suit their interests and emerging needs.

4 METHODOLOGY

The aim of this research is to introduce a new perspective where digital media should be seen not as a harmful tool, but rather as a cooperative feature in the revival of existing urban spaces and public involvement stimulation. This will be achieved by studying the urban public spaces, their overall quality and prospect for revitalisation.

The research is focusing on optimising the public realm by using smart features that are aligned with the enormous current technological development, in addition to taking advantage of the digital media and people addiction and overreliance, turning it into a privilege. And finally, the research is dealing with digital appliances as an attraction to the physical world for all generations, so that they can engage in different social activities revitalising the urban spaces and their significance.

This paper adopts an inductive methodology. It includes a literature review with attention to the public space values and qualities of success, their recess due to overreliance of the public on digital media. This also includes the restoration of the role and importance of public urban space through retrofitting it to a digital era, where tools of digital media are used in public spaces to attract more users, engage them into the public domain and evaluate their experience for future improvement. This is followed by a questionnaire based survey to: (1) determine the users identity and scale of dependence on digital media and their interest into visiting open public spaces; (2) define their perception of the space qualities and success ratio at its initial stage; and finally (3) suggest a set of theoretical interventions -which are suggested but not actually applied in the park due to several limitations- that utilize digital tools in the public space and examine the users' reaction to them. Thus, combining the theoretical findings with the users' perception of the suggested interventions will help in defining a clear assessment process that can be generalised in order to reach a set of recommendations that leads to a better, more adapted urban environment, matches the public needs and their interests, and is capable of attracting and engaging people into social life and a balanced society.

A methodology diagram is shown in figure 1.

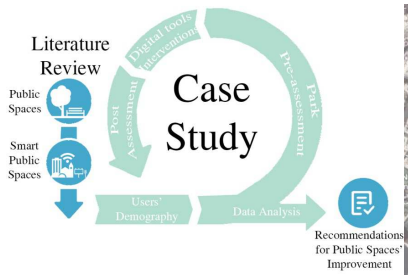


Fig. 1 (left): Methodology Diagram. Fig. 2: (middle) map of the chosen site of the Smouha Neighbourhood Park and its surroundings, Fig. 3: (right) the park space and definers.

5 CASE STUDY

5.1 Settings: neighbourhood park in Smouha, Alexandria

The paper focuses on a neighbourhood park as a case study of the impact of digital media implementation into public spaces. The neighbourhood park in Smouha, Alexandria was chosen. The park is located in the middle of a high income neighbourhood in Smouha at the centre of the city.

The park is at the centre of a non gated compound known as "The Golden Square".

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

It is surrounded by a number of educational facilities, such as the Faculty of Nursing, Faculty of Economic Studies and Political Science, Mohamed Zahran Experimental School and a couple of smaller schools. Student housing is also nearby, for foreign students. The Mubarak Sports Club and Antoniadis' Garden are also considered as major magnets for the whole setting; not to neglect the existing well known hyper markets.

In addition, several medical facilities exist in the region. Thr Al Salama Hospital also known as Al Andaluseya Hospital, and the medical complex are considered to be only streets away from the designated park. These significant surroundings are indicated in figure 2, while figure 3 shows a perspective of the park.

In the last decade, the site was known to be a great attraction for commercial activities. Lots of restaurants and cafes were built to draw more youth to spend extra time there in social and common activities.

Nonetheless, the overall activity index in the context does not rise to the offered amenities. The outdoor activities, and park liveability seem to be in question day after day.

5.2 Data collection and analysis

An online survey dedicated to the park users was undertaken at the end of April 2022, it reached people who are generally engaged in the park or periodically pass by it. The residents in the adjacent apartments, were also encouraged to take part in the questionnaire in order to make their voice heard in terms of how they assess the park's existing situation and, more importantly, how they evaluate the proposed interventions in it.

The questionnaire was undertaken to determine the park's overall existing qualities' status, and to suggest interventions using digital media technologies and to explore the impact of digital media use in the public domain. The survey was divided into four sections. Section 1 was used to categorise the users and participants into groups according to their gender, age range, highest educational degree obtained, city residency, dependency on digital media, frequency of their visit to the park, duration of their stay, preferred timing of the visit and pattern of the visit whether alone or in groups. Section 2 was dedicated to assess the park qualities in its initial status and current situation. Questions about the nine qualities of success of public spaces reached in the literature review were included. Each quality had a set of sub-qualities -a result of the theoretical study as well, dividing each quality into a variety of scales (from two to six sub-qualities). They were submitted to the participants to check whether they find them present in the park. Section 3 introduced four park interventions to the users -adaptive lighting system, mobile application, public art interactive screen and media facades-, who were asked to assess the qualities of the space all-over again taking into consideration the impact of the suggested interventions on the public space setting.

The analysis began with a descriptive analysis of the participants in the questionnaire to be linked afterwards to various perception of quality evolvement. Then an analysis of the sub-qualities offered by the space at its initial state and the evaluation of its qualities before any intervention was made. Afterwards, the suggested implementations and interventions were analysed, followed by the qualities' assessment after the use of digital media.

Finally, a comparison was made between the qualities achieved before and after, qualities were ordered according to the degree the media tools impacted on each of them. Furthermore some filters were added to identify how different user groups perceived the impacted qualities.

6 RESULTS AND DISCUSSION

6.1 Demography of the sample

The online questionnaire investigated a sample of 66 users of Smouha's Neighborhood Park. Regarding the limitation of data related to the total park's users' count, this sample is considered to be the largest reached users' set. More than half of the participants, 37 users to be exact (56.06%) are between seventeen and thirty years old making up the majority of the participants from the young adults. Male participants are slightly exceeding female participants by 8 users. The ratio is (56.06%) males to (43.94%) females.

Since young adults were the majority of the participants, (66.67%) they state to have a bachelor's degree. Concerning the participants' dependence on digital media, which is a major personality aspect affecting the assessment of the park, all participants state having some sort of dependence on digital media, varying from

large, average and low dependence, the majority having average dependence (60.61%). (95.45%) of the sample are residents in Alexandria.

As for the information dealing with users' relation with the designated public park, the preferred timing for users to visit the park is not clear. Most of the participants (40.91%) mention visiting it equally by daytime and nighttime. As for the visit pattern whether alone or in groups, no specific pattern is identified, given the fact that (53.03%) of users practice both patterns. The frequency of the visit is a major characteristic. Users with the least visiting ratio -less than once a month- are at the top of the list with (33.33%) of participants. While the duration of the stay indicate that most of the park's users (63.64%) are not active users, they are only passing by the park on their way not actually spending time engaging in the park's activities. The previous numbers indicate a distinctive mass behaviour that encourages people, especially the residents nearby public spaces. to neglect the common domain and subside from it for their daily routines and life pattern. Whether this is due to a deficiency in the quality of the space, or a negative trend in public behaviour following the overreliance on digital media, the problem remains a fact and a challenge to the existing public setting which is transforming into a lost space.

6.2 Users' perception of park qualities before digital media tools implementation

Following the demographic assessment, the participants proceeded in the questionnaire to identify how they evaluate each quality of success in the park. Sub-qualities from the literature review were introduced as a checklist to mark whenever each one is present. Hence every quality is defined by its own parameters, which therefore are used to assess the overall quality score and how far it is present in the existing park situation. This section is focusing on each quality segregation and the sub-qualities evaluation.

When assessing visual qualities, the degree of legibility of the park takes the lead with 26 votes. The distinctiveness has the least points, only 12 participants say the park is distinctive.

Inclusiveness, access and linkage defined in proximity and accessibility qualities exceed the coexistence value, 46 to 22 points consequently.

As for protection, it seems that the park is highly protected against traffic and accidents, 36 participants affirm they felt secure from vehicles' movement. While the protection against climate conditions is not a clear priority in the design, only 6 users assume they are protected against environmental aspects.

The user centred approach evaluation concludes that the proportion of both sub-qualities is three-quarters to one quarter, with human scale standing out as a major aspect of the park design.

In activities and functionality assessment, more than half of the users (28 user) admit that various activities are offered at the park. On the other hand only 13 participants vote for the functionality of the space.

Comfort can be referred to a lot of factors, including walkability which is the most distinctive possibility at the park, with 43 participants votes. The least common one (12 votes) is the ability of the users to play and unwind.

Assessing enjoyment, scale and the sense of enclosure are definitely impactful in terms of people enjoyment. 23 participants say that they enjoy the park thanks to its ambiance. Only 4 participants mention that they enjoy their experience and activity in the park.

As for liveability and vitality, 31 users assume that the park has an effective role in nature preservation and sustainability. 13 participants vote for the park's cleanliness, which can indicate a certain deficiency in the maintenance of the park.

Finally, communal qualities is reflected in the interesting fact that the park visitors see the public space as a reflection of the city policy and interest in open spaces, and the value of their involvement in the decision making process. 25 participants vote for the park being an active sector of the city policy. As for the least scoring sub-quality, only four users mention the park as having a cultural and historical heritage to communicate.

The following pie charts (figure 4) show each quality division, and points reached for every sub-quality :

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Fig. 4: Pie charts showing the public perception for sub-qualities presence at the initial park status.

6.3 Selected tools and their implementation

A set of digital tools were selected according to the preceeding studies comparing different media technology applications and their effect on the public space where they are implemented. Hence, the four most impactful tools were introduced to the survey's participants as suggestions for implementation to assure the greatest possible impact on the park's quality. The four tools were theoretically proposed to the public, with relevant illustrations and descriptions, but without their actual implementation due to several limitations.

The four tools are adaptive lighting system, mobile application, public art interactive screen and media facades.

Interventions can be described as follows:

Intervention 1: Adaptive lighting system, varying between the ground spots and the light fixtures, both responding to public presence by becoming more warm in colour. This is in addition to the lit seats at the centre of the park, and the lighting fixtures for the plants and trees.

Intervention 2: Mobile application that is downloadable and shows its user whenever there is an event occurring in the park. The application also can be connected to the public screen to show information about the park and its entourage. In addition to this, the user can select a certain music instrument to play when he/she comes by the light fixtures. Hence more people will be moving around experimenting different sounds and interacting with other application users.

Intervention 3: Interactive public screens are installed at the centre of the park, inviting users to spend time there experimenting and making public art and drawings that will be projected on the building's facade behind the screens.

Intervention 4: A video mapping technology facade, where the drawings are projected on the screens, making the space more intimate and personal to each of the users, who can easily feel ownership and see his/her own effect and contribution.

The following figures (figure 5-8) show the suggested interventions.

Fig. 5: (left) interventions 1 and 2, Fig. 6: (right) intervention 1.

Fig. 7: (left) interventions 1,2,3 and 4, Fig. 8: (right) intervention 1 and 2.

6.4 Users' perception of park qualities after digital media tools implementation

Participants in the survey were asked to re-assess the space qualities -after going through the illustrations and suggestions of interventions- following the same preceeding process of the sub-qualities evaluation in terms of the suggested media interventions. Thus, the assessment remains theoretical, and not evidence based, however it closely interprets and anticipates the public's reaction to media interventions. Qualities were identified and evaluated to reach the following conclusions:

Visual qualities are greatly affected by the proposed interventions. Sub-qualities are differently affected, to the extent that they varied in order. Distinctiveness and attractiveness are major impacts of the interventions, from being last two before the media tools implementations, to scoring 30 points each after interventions. This was followed by artistic values, then by the degree of legibility which actually decreases after the intervention.

Inclusiveness increases, with no distinctive transformation in sub-qualities proportions. Proximity and accessibility are till at the top with nearly two third of the participants votes.

Protection is also affected as a total value, not on the scale of sub-qualities proportions. However the least scoring qualities from the initial stage rise up to represent about (50%) of total votes for the quality. Still, the traffic protection is at the top of the parameters with 42 points. Climate protection is last with only nine votes.

The user centred approach witnessed a major improvement, specifically in its dedication for people needs and interest. Still it comes second with 34 participants' votes against 40 for respecting human scale.

Activities and functionality show a general increase. Functionality improves greatly, to move from last to second position, almost first with the activities availability with only one vote difference. Efficiency and quality come last with 19 votes.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Regarding comfort, lots of new possibilities emerge. Still the walkability is at the top, with 52 points. Standing and staying increase to score second of the group with 37 points. Then, there is the ability to see around, very close to the sitting facilities that are added by the proposal to reach 32 points after only scoring 17 points. Hearing and talking come next, and finally the possibility to play and unwind, which remains last. However it increases by 9 votes.

Enjoyment improves while maintaining the same hierarchy. Nonetheless, the enjoyment of positive aspects and positive sense of experience are subjected to the greatest increase, scoring 23 and 22 points which is approximately (20%) of the quality each, when they were only (7%) and (14%).

As for liveability and vitality, sustainability decreases, healthiness and sociability rise to score first and second with 40 and 31 points. Afterwards, there is sustainability. And finally cleanliness which increases considerably indicating that having this sort of projects implemented in public spaces will definitely mean more maintenance and responsibility from both sides, decision makers and users.

Last but not least is the communal value. Still maintaining their approximate proportions, the participation of the park in city policy reaches 38 points, followed by its social value (26 points), and afterwards the cultural and historical impact with 8 points. Charts are shown in the next figure (figure 9).

Fig. 9: Pie charts showing the public perception for sub-qualities presence after the suggested digital media interventions.

Sub-qualities are subjected to major changes reflected in the large improvement when comparing their scored points before and after the media interventions. Some sub-qualities are more impacted, nonetheless no category shows a decrease in its attained points.

6.5 Comparing the park status before and after the experiment

An analysis was undertaken to compare each quality score of points -whenever a sub-quality is achieved a point is added to the overall quality score- before and after the suggested digital media interventions. However the score of the qualities are not to be compared to each other as it depends greatly on the number of factors and sub-qualities for each one which varies from two to six sub-qualities.

What can be viewed in proportion to each other is the score of each quality before and after the digital tools interventions and how much it improved.

Visual qualities has improved from 74 points to reach 107 points after the media interventions, which means the visual values are (45%) more present. Inclusiveness, access and linkage begun with 68 points. then has increased by (19%) to achieve 82 points after implementation. Protection has risen from 63 points to 85

points. A total of an increase of (35%). User centred approach scored 44 points before and 74 points after, with an impressive jump of (68%). Activities and functionality had 59 points, then they have escalated to 90 points improving by (53%) of the total quality. Comfort has made it from 155 points to 203 total points with (31%) additional points. Enjoyment begun with 57 and has reached 113. Digital media has succeeded in raising the enjoyment state by (98%) which is a huge impact factor. Liveability and vitality have been transformed from 87 points to 124 points, with (43%) more quality evidence. Communal qualities had 44 points and have reached 72 point after media involvement. (64%) of the quality has developed thanks to the innovated interventions. The results are shown in figure 10.

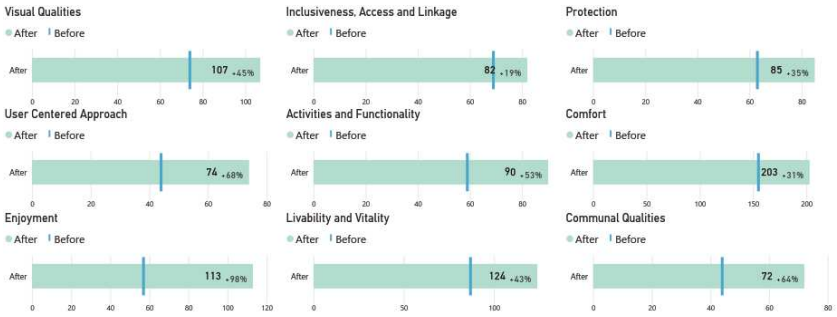


Fig. 10: Indicating each quality total points before and after the digital media tools implementation, as well as the added percentage due to media interventions.

According to the previous analysis, it is undisputable that -when confronted by the digital media tool implementation into the public space- all qualities improve greatly, showing more impact on some sub-qualities than others, however always reaching the same conclusion. Digital tools succeed in attracting more people into the public space and engaging them within, creating new interrelations between users and the space, which ensures the memorable, enjoyable experience in the open space.

6.6 Impacted qualities scale

Depending on the previous findings, the next step is to analyse the relation of qualities growth -putting the participants total number and each quality ranking in the equation-, in order to determine the most and least affected qualities by the interventions suggested. This will definitely lead to better decision making for future implementation of media tools into different public spaces.

The space respect for user centred approach is the lead quality with (22.7%) more configuration of the quality from the initial stage to the proposed one, respecting the total amount of increase possibility. Followed by enjoyment and communal qualities which both score (21.2%) improvement when taking the digital tools into consideration.

Activities and functionality come third with (15.7%) difference. Afterwards come liveability and vitality of the park (14.0%). Visual qualities come next (12.5%), more aesthetics are achieved. Comfort evolves closely, with (12.1%). Inclusiveness access and linkage score (10.6%) more points. And finally, protection with (8.3%) additional weight after media implementation.

The qualities order generally reflects the users perception of the improvement of each quality from its initial stage which was the park state, to the final stage after the suggestion of the implementation of all media tools, the interactive lighting, the mobile application, the interactive art screens and the media facade on buildings in front of the park, taking into consideration the total number of survey's participants, and each quality sub-qualities number.

The next graph (figure 11) represents the impact factor on each quality (how much it has improved from the initial stage, to the final stage with the suggested tool use).

People seem to acknowledge more the fact that integrating technology into their public spaces will definitely increase how it is dedicated to them and reacts to their needs and aspirations, their enjoyment in the park, and how well they feel influential and heard, simply by being in the public realm and how they sense ownership and pride when they spend time there.

In parallel, they seem to appreciate the effect of media implementations but not exceeding protection measurements in public spaces. However, the least impacted quality is still accredited as being positively affected by media tools interventions.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

These were the results of the whole sample of survey's participants. The next analysis shows a comparison between certain groups leading to a better understanding of each groups' needs and interests.

6.6.1 Analysis of impact according to user's dependence on digital media

When applying the rank order of qualities to certain groups, interesting facts and orientations became clear.

One of the most important filters is the degree of dependency of the users on digital media. Since the main problem definition was related to media overreliance, it is anticipated that the solutions offered will have more impact on people who actually suffer from media addiction and depend on media tools greatly.

The results of this comparison are shown in the next graphs (figure 12).

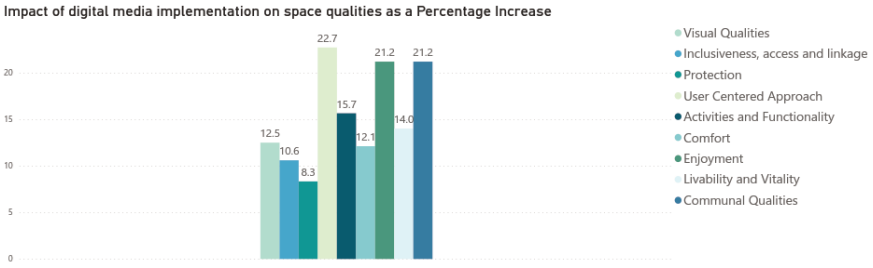


Fig. 11: Chart showing the impact percentage of digital media implementations on each quality.

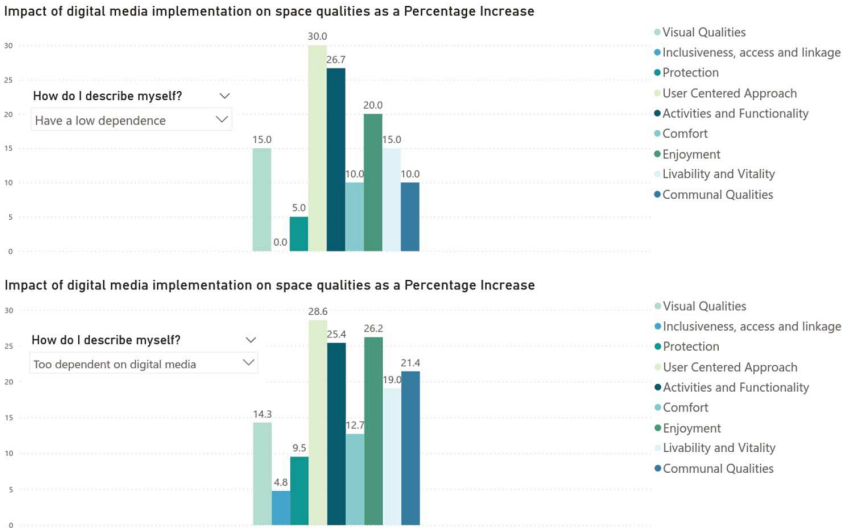


Fig. 12: Graphs comparing the impact of media implementation on qualities of success for both groups, the one with the least dependency on digital media, and the one with the highest dependency on media.

Most of the qualities improvements are more significant for the group with major media overreliance. Visual qualities, user centred approach and activities and functionality are the qualities which achieve better scores of people with low dependence on media. The fascinating fact is that inclusiveness, access and linkage evolvement seem to be have no significant weight for people with the least addiction rates.

Hence, while the highest improvement factor is identified by the low dependent on digital media group, the overall assessment of the qualities' evolvement is greater for the highly dependent on digital media group, which was anticipated.

6.6.2 Analysis of impact according to user's frequency and duration of visit to the park

The next applied filters are consecutively the frequency of the users' visits to the park and the duration of their stay. The selected groups are the ones with the highest frequency and the ones with the highest duration of visit respectively, since these are the groups that recorded meaningful findings. It is a necessity to mention that when reviewing the groups with the lowest frequency and duration of stay, a similar and close result to the overall impact of digital media on space qualities was registered. Hence, came the necessity of exploring the impact on space qualities according to the opposite groups, and the results were astonishing, as shown in the next graphs (figure 13, 14).

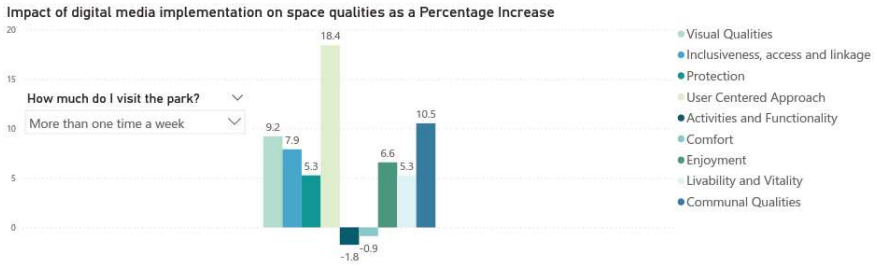


Fig. 13 Showing the impact of digital media on space qualities according to people visiting the park for more than once a week.

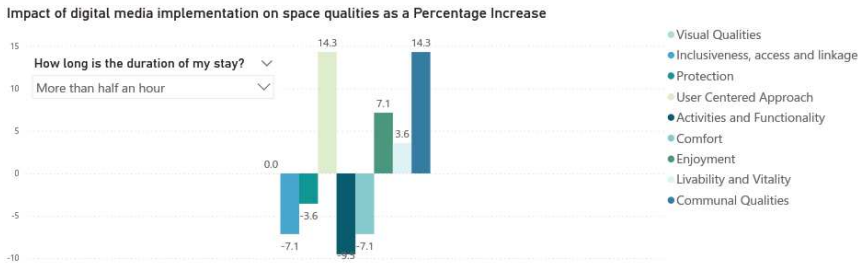


Fig. 14 Showing the impact of digital media on space qualities according to people visiting the park for more than half an hour.

It seems that users with the highest frequency of visits, and the highest duration of stay have a certain resistance to the change suggested in their beloved public space. Qualities such as activities and functionality and comfort have scored lower grades after the interventions according to both groups. This is in addition to inclusiveness, access and linkage and protection, which both witnesse a remarkable decrease after the media interventions according to the group with the highest duration of stay in the park. Visual qualities seem to remain constant according to this same group too.

7 CONCLUSION AND RECOMMENDATIONS

Public spaces will definitely remain a core element to each society. However, the innovative public behaviour that leans towards media overdependence has shown great impact on personality traits and consequently on their behaviour towards the public realm. Public spaces are becoming more deserted than ever with this tendency to overcompensate physical and concrete interactions with virtual ones.

This does not have to be the case since digital media can be used in both ways, as a harmful tool causing people isolation and introversion as well as being used as a space revitalisation enhancer. The research case study affirms the credibility of media tools' use in order to improve public space attraction and people's engagement in it.

According to the findings, qualities assessed for Smouha's neighbourhood park before media interventions greatly improve to reach new benchmarks of the space qualities when suggesting the four media interventions (interactive lighting, mobile application, interactive art screen and media facade).

When ordering the qualities depending on the participants perception of how they were promoted, the reached conclusion is that the user centred approach of the public space comes first as being the most affected by the digital implementation. Public enjoyment alongside with the space's communal value come second. Then there is the space's activity and functionality impact, followed by its liveability and vitality. Visual qualities have improved considerably too, taking the fifth place. Comfort comes next. Inclusiveness, access and linkage also are enhanced but slightly less than the preceeding qualities. And finally there is the protection evolvement.

People with the highest media dependence seem to benefit more from the implementation suggested, since they record better rates of qualities' improvement. People with less dependence assume that qualities will be affected less by those interventions, even the media tools effect on inclusiveness, access and linkage quality may not be significant at all according to them.

Additionally, when taking the regular visitors as the filtering group, it seems like they have some resistance to the change, which appears in some of the qualities regression rather than improvement. Casual visitors on the other hand show different results, they seem to be more willing to visit and spend time at the park. Based on novelty, this might be a short term effect of the media installations, that deffinitely cannot compensate the

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

actual users who seem to be resentful of the suggested interventions. Though, the questionnaires' participants acknowledge the effect of media tools not only on their willingness to visit the park more often - which could be a short term consequence of the innovative offered experience- but mainly on all park's qualities. They record an improvement in the park's visual qualities, its attractiveness,access and inclusiveness, its safety measurements, its dedication for users, the activities held inside, people's enjoyment within, its livability and its communal effect. Hence, since the overall quality of the park is anticipated to improve with these installations, affirmatively media have positive long lasting effects concerning people's attraction and engagement. This could be accredited by a concrete assessment after the in-site implementation of the media tools, and their integration into the park's life for a year or more to investigate longer terms' impacts.

Interestingly, by exploring the participants needs, it is clear that the listed missing elements and problems in Smouha's park, are ones that could be easily addressed by the use of media, whether with the suggested interventions or similar ones, since most of the park users are highly dependent and attached to media technologies. Which is the case for most of the public nowadays, and can be generalised as a major prospect for public spaces revitalisation. Media involvement in the design can definitely guarantee more people attraction and consequently their engagement in the offered renovated public realm.

At the end, this study offers new prospects for further research on public spaces needs and capabilities. Alongside with these findings, a clear understanding of the degree and significance of urgency and priorities can be reached. Merging field surveys to determine the weak qualities in the public space, with the anticipation of the impact of specific media tools on each quality, will ensure the revitalisation of those public domains. The assessment of the affected qualities is crucial in helping the decision makers setting-up action plans, devise budgets and establish effective phases for implementations, finally leading to a remarkable public space development process.

8 REFERENCES

Alexander, C. (1977). A pattern language: towns, buildings, construction: Oxford university press.

Ali, M. A., Alam, K., Taylor, B., & Rafiq, S. (2020). Does digital inclusion affect quality of life? Evidence from Australian household panel data. Telematics and Informatics, 51, 101405.

Balabanides, A., & Philippou, P. (2015). Human Activities comprise the success to reach quality of open public spaces.

Bosselmann, P., Flores, J., Gray, W., Priestley, T., Anderson, R., Arens, E., . . . Kim, J.-J. (1984). Sun, Wind, and Comfort A Study of Open Spaces and Sidewalks in Four Downtown Areas.

Carmona, M., De Magalhaes, C., & Hammond, L. (2008). Public space: the management dimension: Routledge.

Corbusier, L. (1927). Towards a New Architecture (London, Archi. London ,England: tectural Press.

Davis, M. (1990). City of Quartz: Excavating the Future in Los Angeles. New York: Verso Books.

Gehl, J. (1987). Life between buildings (Vol. 23): New York: Van Nostrand Reinhold.

Gehl, J. (2007). Public spaces for a changing public life. Open space: People space, 2, 3-11.

Gehl, J., & Svarre, B. (2013). How to study public life (Vol. 2): Springer.

Houghton, K. (2010). Augmenting public urban spaces: the impact of the digital future on the design of public urban spaces. Paper presented at the Utopia 2010 PIA Queensland State Planning Conference.

Jacobs, J. (1961). The Death and Life of Great American Cities. New York: Random House.

Lynch, K. (1960). The Image of the City. Cambridge, Massachusetts, and London, England: M.I.T. press.

Marcus, C. C., & Wischemann, T. (1990). Campus Outdoor Spaces. People Places, Design Guidelines for Urban Open Space. Edited by Clare Cooper Marcus and Carolyn Francis. New York, USA: Van Nostrand Reinhold, New York, USA.

McCormack, G. R., Rock, M., Toohey, A. M., & Hignell, D. (2010). Characteristics of urban parks associated with park use and physical activity: A review of qualitative research. Health & place, 16(4), 712-726.

Mehan, A. (2016). Investigating the role of historical public squares on promotion of citizens' quality of life. Procedia Engineering, 161, 1768-1773.

Newman, O. (1972). Defensible space: Macmillan New York.

Peng, Y., Feng, T., & Timmermans, H. (2019). A path analysis of outdoor comfort in urban public spaces. Building and Environment, 148, 459-467.

PPS., P. f. P. S. (2009). What makes a successful place? Retrieved from https://www.pps.org/article/grplacefeat

Radwan, A. H., & Morsy, A. A. G. (2018). Smart Urban Public Spaces-Towards a Better City Life. Paper presented at the Forthcoming, Proceedings of CPUD '18 Conference, organized by DAKAM (Eastern Mediterranean Academic Research Center).

Sitte, C. (1889). The Art of Building Cities (transl. by Stewart, C.). Germany: Connecticut: Hyperion Press.

Van Hecke, L., Ghekiere, A., Veitch, J., Van Dyck, D., Van Cauwenberg, J., Clarys, P., & Deforche, B. (2018). Public open space characteristics influencing adolescents' use and physical activity: A systematic literature review of qualitative and quantitative studies. Health & place, 51, 158-173.

White, R. (1998). Public Spaces for Young People: A Guide to Creative Projects & Positive Strategies: ERIC.

Zagroba, M. (2016). Issues of the revitalization of historic centres in small towns in Warmia. Procedia Engineering, 161, 221-225.

🏆 *reviewed paper*

The Influence of Built Environment Characteristics on the Occurrence of Crime in Neighbourhoods of Amsterdam: A Geographically Weighted Regression Analysis

Gamze Dane, Stephan Leeuw, Dena Kasraian, Aloys Borgers

(Dr. Gamze Dane, Department of the Built Environment, Eindhoven University of Technology, 5612 AZ, Eindhoven, The Netherlands, g.z.dane@tue.nl)
(MSc. Stephan Leeuw, Department of the Built Environment, Eindhoven University of Technology, 5612 AZ, Eindhoven, The Netherlands, stephanaleeuw@gmail.com)
(Dr. Dena Kasraian, Department of the Built Environment, Eindhoven University of Technology, 5612 AZ, Eindhoven, The Netherlands, d.kasraian@tue.nl)
(MSc. Aloys Borgers, Department of the Built Environment, Eindhoven University of Technology, 5612 AZ, Eindhoven, The Netherlands, a.w.j.Borgers@tue.nl)

1 ABSTRACT

Crime in neighbourhoods has a significant impact on the quality of life and safety of the residents. There are theories that suggest the relation between the built environment characteristics and the occurrence of crime. These theories suggest that designing the built environment in a particular way could reduce the number of criminal activities, the fear of crime and the victimisation of residents and legitimate users of the area. However, there is little empirical research on this topic.

In recent years, the amount of open and spatial data has increased which enables to test these theories empirically. This current study aims to understand the influence better of built environment characteristics on the amount of crime in the neighbourhoods in Amsterdam by using open and spatial data. In this study, firstly existing theories on the relation between crime and built environment characteristics (i.e. land use, street layout, the existence of parking amenities, the existence of greenspace, the existence of street lighting) were discussed. Later, the influence of selected built environment characteristics on the amount of crime in Amsterdam neighbourhoods was empirically tested. Data regarding crimes was obtained from the Dutch police department. It provides crime rates per crime type (burglary, vandalism, violent crimes, drugs and nuisance, and theft) and per neighbourhood. The data regarding built environment characteristics were gathered from Open Street Map and Amsterdam open data, and they were processed for further analysis.

In order to look into the relation between the occurrence of crime in neighbourhoods of Amsterdam and the built environment characteristics, firstly an exploratory regression analysis was performed on the different crime types, and then a geographically weighted regression analysis was conducted to identify local variations. The results show that different types of crime were influenced by different characteristics of the built environment. Moreover, variations in the neighbourhoods were observed. One of the findings of this research is that tourist attractions strongly correlate with the amount of crime. Another interesting finding is that mixed land-use is negatively correlated with the amount of crime. In general, it can be concluded that the built environment does have an influence on the occurrence of crime and that this influence differs among crime types. Moreover, different characteristics of the built environment influence different types of crime. The results of this study provide insights for policy recommendations both for necessary data and urban design with respect to crime prevention.

Keywords: geographically weighted regression, environmental criminology, crime prevention through environmental design (CPTED), geographical information systems (GIS), urban planning

2 INTRODUCTION

The relation between crime and the built environment has been researched relatively little. However, research that has been done reports that designing the built environment in a particular way could reduce the number of criminal activities, the fear of crime and victimisation of residents and legitimate users of the area. In 1961, Jacobs postulated in The Death and Life of Great American cities [1], that the urban environment could affect the behaviour of users in the area, especially that land-use diversity and a high pedestrian activity influence the perception of safety positively. Subsequently, Newman (1972) developed the defensible space theory in the early 1970s [2]. The defensible space theory is characterised by low urban density with high proportions of residential areas with limited access to strangers. Also, in 1971, Jeffery introduced the term Crime Prevention Through Environmental Design (CPTED) [3]. All these contributions were aimed to reduce crime by shaping the built environment.

This current study aims to understand empirically which characteristics of the built environment, socio-demographics and socio-economics have influence on crime numbers of different types of crimes in the neighbourhoods of Amsterdam. In this research, the following types of crime are considered: burglary, vandalism, violent crimes, drugs and nuisance related crimes and theft. Moreover, all crimes combined were analysed. The unit of analysis was selected as the neighbourhoods of Amsterdam.

This paper is organised as follows: First literature on the relation between the built environment and crime is presented. Then, methodology and data is introduced. Following that, analyses are conducted and noticeable results per crime type are discussed. The paper concludes with a discussion of findings and suggestions for policy makers.

3 LITERATURE REVIEW

Jane Jacobs was one of the first who established a relation between the physical environment and crime. Jacobs (1961) argued that crime occurs when residents feel isolated and anonymous, and when they believe that they have no stake in their neighbourhood [1]. Jacobs proposed four conditions of urban design: (I) mixed land-uses to stimulate pedestrian activity on the streets and parks; (II) districts should be divided into small blocks with frequent corners and interconnecting streets; (III) diversity of old and new buildings to ensure diversity of enterprises; (IV) a sufficient population density to stimulate activity among residents [4]. The four conditions all contribute to ‘’eyes on the street’’ which is the term Jacobs introduced for informal surveillance.

Oscar Newman (1972), an architect and urban designer, developed the defensible space theory in the early 1970s [2]. According to Donnelly (2010) [4], the defensible space theory has four key concepts: territoriality, surveillance, image and milieu. ‘’The four elements of defensible space can translate the latent territoriality and sense of community of residents into a responsibility to secure and maintain a safe, productive and well-maintained neighbourhood’’ (Cozens, 2008) [5]. Newman (1972) also argued that high-rise buildings and high urban density results in anonymity which in turn has an influence on the occurrence of crime [2].

The contributions of Jacobs (1961) and Newman (1972) formed the basis of what is now known as crime prevention through environmental design (CPTED) [1-2]. CPTED is considered to be mostly a ‘natural’ strategy in preventing crime which implies that it is not labour intensive. Fennelly & Crowe (2013) state that there are four principles of CPTED: (I) territoriality, (II) surveillance, (III) access control and (IV) image and maintenance. Territoriality is aimed at the demarcation of public and private space [6]. Natural surveillance is involved in creating more ‘’eyes on the street’’. The third principle, access control, relates to controlling the people in areas where they should not be. Finally, the principle of maintenance and image, concerned with appearance of the area can be related to the broken window theory by Kelling & Wilson (1982) [7]. The theory describes how one broken window (which is not repaired immediately) could lead to a signal that no one cares about the neighbourhood, and thus that breaking more windows will cost nothing. The theory is not only concerned with the physical deterioration of the neighbourhood, but also the social ties. While not repairing a broken window sends a message about the area, it also sends a message about the residents, as they did not repair the window.

Below the relevant characteristics of the built environment that have been researched in relation to crime prevention, are discussed.

3.1 Land use

Jacobs (1961) mentioned the importance of different land uses in an area to improve pedestrian activity and thus increase the natural surveillance (eyes on the street) in the neighborhood [1]. The study by Wuschke & Kinney (2018) concluded that rates of property crimes and violent crimes are most present on residential land uses [8]. However, these types of crime occur disproportionally at a higher rate in areas classified as commercial or recreational.

3.2 Greenspace

According to de Vries, Verheij, Groenewegen, & Spreeuwenberg (2003), greenspace leads to more physical activity such as walking and cycling and therefore the presence of greenspace may have a positive effect on natural surveillance [9]. However, this positive effect on natural surveillance might also be dependent on the time of the day (Weijs-Perrée et al., 2020) [10]. Shepley, Sachs, Sadatsafavi, Fournier, & Peditto (2019)

found in their extensive literature review of 45 quantitative researches that greenspace helps reducing crime [11]. Bogar & Beyer (2016) claimed that the current research body is too small and that there is too much variation among the researches to draw conclusions [12].

3.3 Street lighting

Street lighting is commonly mentioned in studies regarding CPTED, as it increases visibility and therefore also increases the natural surveillance (Gulak, Kun, Koday, & Koday, 2007; Hedayati Marzbali, Abdullah, Ignatius, & Maghsoodi Tilaki, 2016; Hedayati Marzbali, Abdullah, Razak, & Maghsoodi Tilaki, 2012; Lee, Park, & Jung, 2016) [13-16]. Moreover, Lee et al., (2016) found that streetlighting reduces the fear of crime and that it increases pedestrian activity [16].

3.4 Street layout

The design of infrastructure is associated with the access control principle of CPTED. Sohn (2016) found the street density and intersection density to be significantly correlated with residential crime density [17]. Block & Block (1995) found that many, liquor related crimes occur near intersections, especially in grid and diagonal street patterns [18].

Newman (1972) argued that cul de sacs (dead end streets) are the streets where crime occurs the least, as small group of neighbours can survey the area that is accessible from their dwelling (Hillier, 2004) [2,19]. Moreover, Yang (2006) showed that residential burglary occurs most on streets with ‘’through traffic’’ and the least on dead-end streets [20]. This is contrary to the argument of Jacobs’ (1961), which stated that areas should be well connected in order to create a more vibrant area where informal surveillance acts as a mechanism against crime [1].

3.5 Parking

Limited (public) parking places is believed to have a positive effect on access control, and furthermore, the fewer cars that are parked, the fewer the opportunities for car related crimes. Moreover, Bennet & Wright (1984), found that burglars look for parked vehicles in the immediate area next to their target as a sign of occupancy [21]. By limiting the number of parking places, it is more likely that they are occupied, and therefore, a higher percentage of the parking places is occupied.

3.6 Housing

“Scholars have long known that home-owners and long-term residents have a greater incentive to protect their local area and might be willing to take more risk in so doing’’ (Felson, 2018) [22]. Hence it could be argued that the number of rented (or owned) homes is of importance in this research.

Vacancy is often mentioned as a determinant of the image and maintenance principle of CPTED. The study conducted by Fuentes & Hernandez (2014) regarding property crime and vacancy, found that for every point increase in vacancy, the number of property crime rose by .84% [23]. Moreover, Cui & Walsh (2015) found that violent crime increased by 19% in the immediate area once a foreclosed home became vacant [24].

Another determinant of crime, in relation to housing, is population density. A high population density is facilitated by high-density housing. Sampson & Groves (1989) found in their study in which they tested the social disorganisation theory that the level of urbanisation is significantly positive correlated with multiple types of crime [25]. They argued that a high level of urbanisation weakens local social structures (decreased social control, weakened local kinship and friend networks). These findings are supported by the finding of Sohn (2016) [17].

3.7 Artworks

According to Fennelly & Crowe (2013) “Art and sculpture are powerful tools in promoting territorial behavior and proprietary concern for space. They attract attention to spaces and help people find their way. One of the greatest values of street art is how it contributes to triangulation, which helps people psychologically connect places, thus increasing perceptions of territoriality and control.’’[6]. However, no empirically research was found in which artworks and cultural heritage symbols are tested against crime.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

3.8 CCTV

The presence of closed circuit television (CCTV) is a mechanical crime prevention method which is aimed at increasing surveillance. Lee, Park, & Jung (2016) argued that the presence of CCTV also provides symbolic barriers that deter criminals and thus CCTV could besides surveillance, also be effective as a mean of access control [16]. Hedayati Marzbali, Abdullah, Ignatius, & Maghsoodi Tilaki (2016) used a similar reasoning [14].

3.9 Tourist attractions

It is generally known that the city of Amsterdam is a tourist intensive city; in 2018 the city was ranked 23rd in the top 100 city destinations by Euromonitor (Geerts, 2018) [26]. Bhati & Pearce (2016) stated that many tourist sites experience vandalism [27]. Moreover, Merrill (2011) stated that cultural heritage monuments/areas are often vandalised with graffiti, which is a textbook example of vandalism [28]. Crime types that occur most due to tourist attractions are vandalism and theft related crimes (Bhati & Pearce, 2016; Jud, 1975) [27,29]. Jud (1975) found that tourism is mainly concerned with property related crimes [29].

3.10 Social disorganisation

Whereas this research is mostly concerned with the physical part of environmental criminology, it is also necessary to include socio-economic and socio-demographic variables as control variables, since crime prevention is a multi-disciplinary and integrated endeavor (United Nations Office on Drugs and Crime, n.d.) [30]. The social disorganisation theory will be used for determining the socio-economic and demographic variables. The social disorganisation theory is considered to be one of the most influential contributions to environmental criminology on the meso-level of analysis, besides the contribution of Jane Jacobs (Wortley & Mazerolle, 2008) [31].

The social disorganisation theory, in short, states that three variables cause social disorganisation. These variables are (I) the physical state of the neighbourhood, (II) the economic status and (III) ethnic heterogeneity. Shaw & McKay (1942) argued that all these three variables contribute to creating social disorganisation, which in turn results in higher crime and delinquency rates in the neighbourhood [32].

The physical state was defined by the population change, vacant and condemned housing and the proximity to industry. Shaw & McKay (1942) argued that high residential mobility makes it difficult to create a social structure in the neighbourhood [32]. Rogerson & Pease (2019) also mentioned that high residential mobility is a challenge for CPTED [33]. Rogerson & Pease (2019) also found that crime in neighbourhood results in motivation to move [33].

Shaw & McKay (1942) argued that ethnic heterogeneity in the population also affects the social structure in the neighbourhood [32]. Ethnic heterogeneity is often solely used as a measure of social disorganisation. Often the heterogeneity index, developed by Blau (1977) is used [34], which is a measure indicating the level of ethnic heterogeneity on a scale from zero to one (Bruinsma, Pauwels, Weerman, & Bernasco, 2013; Davies & Bowers, 2018; Kimpton, Corcoran, & Wickes, 2017; Sampson & Groves, 1989) [25, 35-37].

The literature review revealed that the relation between the built environment and crime has been theorised extensively. Moreover, specific characteristics of the built environment were found to be correlated with crime. In general, these characteristics can be classified into one or more principles of CPTED.

4 MATERIALS AND METHODS

In this section, first the collection of the data and the operationalisation of this data is discussed. Subsequently, the exploratory regression, the ordinary least squares regression and finally the geographically weighted regression analysis are elaborated.

4.1 Data

Data regarding crimes were obtained from the Dutch police department [38]. It provides crime rates per crime type (burglary, vandalism, violent crimes, drugs and nuisance, and theft) and per neighbourhood. In this study, per neighbourhood, the crime density was determined by dividing the number of crimes by the area of the neighbourhood. A square root transformation was performed on the crime density to create a

more normal-like distribution. Logarithmic transformations were not considered due to crime densities of less than one or even zero. The operationalisation of the independent variables is displayed in Table 1.

Variable	Operationalisation	Mean	Min	Max	Std. Dev.	Data source
Cul-de-sac density	# of dead-end streets per square kilometer	21.659	0.000	167.040	23.349	Rijkswaterstaat [39]
Intersection density	# of intersections per square kilometer	146.574	1.363	605.945	79.895	Rijkswaterstaat [39]
Mixed land-use	Heterogeneity index[1]	0.554	0.000	0.915	0.206	PDOK [40]
Percentage of residential land-use	Ratio of land covered by residential land-use	0.521	0.000	1.000	0.295	PDOK[40]
Percentage of retail and catering land-use	Ratio of land covered by retail and catering land-use	0.075	0.000	0.890	1.567	PDOK[40]
Ratio CCTV coverage	Ratio of land covered by CCTV coverage	0.095	0.000	1.000	0.246	Municipality of Amsterdam [41]
Streetlighting density	# of streetlights per square kilometer	2418.775	19.508	6002.020	988.354	Open Data Dutch Government [42]
Artworks	# of public artworks per square kilometer	5.604	0.000	87.823	10.077	Municipality of Amsterdam [41]
Ratio Greenspace	Ratio of land covered by greenspace[2]	0.092	0.000	0.786	0.148	PDOK[40]
Tree density	# of trees per square kilometer	1205.577	0.000	3216.420	613.906	Municipality of Amsterdam [41]
Parking density	# of parking spots per square kilometer	2847.093	0.000	6954.150	1666.157	Municipality of Amsterdam [41]
Population density	# of inhabitants per square kilometer	13045.184	32.000	35855.000	8127.880	Statistics Netherlands [43]
Address density	# of addresses that are present within one kilometer	5746.099	28.000	12417.000	3240.471	Statistics Netherlands [43]
Vacancy rate	percent of vacant dwellings in the neighborhood	7.955	1.000	54.000	7.119	Statistics Netherlands [43]
Tourist attraction density	# of tourist attractions per square kilometer	6.257	0.000	129.599	15.821	Open Data Dutch Government [44]
Ethnic heterogeneity	Blau index [34]	0.642	0.184	0.819	0.115	Statistics Netherlands [43]
Socio-economic status	Sum of z-scores of (I) average real-estate value, (II) share of high educated residents and (III) labor participation.	0.000	-6.535	6.182	2.357	Statistics Netherlands [43,45]
Percentage of rented homes	Percentage of rented homes in the neighborhood.	67.124	3.000	100.000	20.821	Statistics Netherlands [43]

Table 1: Independent variables, their operationalization and descriptive statistics. [1]) Formula heterogeneity index: mixed land-use = (1-∑ki=1 Li2) / ((k-1)/k), Li: ratio land-use type i, k: number of different land-uses. [2]) A 50-meter buffer was created around greenspace outside of the research area, as it is believed that major greenspace areas influence the surrounding neighbourhoods.

4.2 Method

This study aims to understand the influence better of built environment characteristics on the amount of crime in the neighbourhoods in Amsterdam by using open and spatial data. Kubrin & Weitzer (2003) mentioned that researchers that research "social disorganisation" slowly start addressing the problem with aggregation of social data into officially defined areas in space [46]. They argued that this is problematic as these officially defined areas are seldom spatially independent and that crime levels in one neighbourhood influence crime levels in adjacent neighbourhoods. Cahill & Mulligan (2007) argue that one of the problems with global regression models is that possible variations over space are suppressed [47]. Hence, the use of a Geographically Weighted Regression (GWR) analysis is suitable for the aim of this study.

In order to conduct a GWR, the first step of the analysis is an exploratory regression which is aimed to find the most optimal combination of variables while minimising the corrected Akaike's Information Criterion (AIC) for the Ordinary Least Square (OLS) regression model. It was expected that per crime type different variables would be included in the models. The model with the lowest score for AIC, see Akaike (1974), was selected for further analysis [48].

Next, an OLS regression analysis was performed with the variables which were obtained from the exploratory regression. This OLS regression provided coefficients and significance levels of the relevant variables. The residuals of the OLS regression were tested for spatial autocorrelation by using Moran's I. This was done for verification purposes, as clustered residuals might interfere with the effectiveness of the geographically weighted regression. Moreover, it could also indicate that variables are missing which are apparent in areas with overpredictions and underpredictions.

The last step was to conduct a GWR analysis to identify spatial variability in the coefficients. The bandwidth for the fixed kernel was set at three kilometers. The literature suggests a bandwidth of approximately 2400

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

meter [Malczewski & Poetz (2005) & Cahill & Mulligan (2007) [47,49]. Concerning the research area, the minimum bandwidth is approximately 2200, suggesting each neighbourhood has at least one neighbour. Hence, a larger bandwidth was used to ensure that all neighbourhoods have sufficient neighbours. Using a larger bandwidth results in less variability in the results as the model will approach the OLS models.

5 RESULTS

In this section, the results of the analysis are discussed. First, the results from the ordinary least squares regression analysis are discussed. Afterwards, the section continues with the results from GWR per crime type.

5.1 Ordinary Least Squares Regression Results

The results of the exploratory regression analyses and ordinary least squares regression analyses are summarised in Table 2. The variables that came forward at the exploratory regression were included in the OLS regression. Variables without coefficient are variables that did not come forward in the exploratory regression and thus do not improve the model.

Looking at the results of the OLS regression analyses, it can be observed that all variables, except the cul-de-sac density, are included at least once in each model per crime type (burglary, vandalism, violent crimes, drugs and nuisance, theft and the combined model). Moreover, high significance levels can be observed. This is no surprise due to the prior executed exploratory regression which ensures that only relevant variables are included in OLS regression. The results of the OLS regression show global relationships and more generalisable results. In general, the results are in line with the literature, with a few exceptions; such as the greenspace in the burglary model and streetlighting for all models in which it is included. Moreover, CCTV has opposite signs, as was expected, as the literature suggest that CCTV should be effective in decreasing crime.

The most noticeable result of the burglary model is the variable greenspace. In regard to vandalism, streetlighting and artworks having a positive sign is contrary to the findings from the literature. On the other hand, it could be argued that streetlighting and artworks are targets of vandalism, and thus attract vandalism. The other models do not seem to have any notieeable or contradictory findings besides the earlier mentioned CCTV and streetlighting.

Variables	Burglary	Vandalism	Violent Crimes	Drugs and Nuisance	Theft	Combined Crimes
Constant	-.940	-.560	-.369	-.356	2.527**	2.869
Cul-de-sac density	-	-	-	-	-	-
Intersection density	.007***	-	-	.004	-	-
Mixed land-use	1.496**	-	-2.690***	-	-3.250***	-7.424***
Percentage of residential land-use	2.182***	1.131*	-	-	-	-
Percentage of retail and catering land-use	-	7.417***	18.418***	18.443***	26.662***	56.455***
Ratio CCTV	-1.111**	2.004***	2.792***	3.875***	3.230***	5.413***
Streetlighting	-	.00032*	.00042**	.00043*	.002***	.003***
Artworks	.022*	.027**	-	-	-	-
Ratio greenspace	1.911**	-	-	-	-	-
Tree density	-	-	-	-	-	-.001**
Parking density	-	-	.00027**	-.00043***	-	-
Population density	.000204***	.00007***	.00011***	.00005*	.00012***	-
Address density	.000134**	.00024***	.00038***	-	.00048***	.002***
Vacancy rate	.049**	-	.068**	.047*	.104***	-
Tourist attraction density	-	.019*	-	.099***	.146***	.212***
Ethnic heterogeneity	-	4.201***	7.585***	-	-	11.354***
Socio-economic status	-.099*	-	-.256***	-	.397***	.686***
Percentage rented homes	-	-	-	.016*	.032***	.064***
R2-adjusted	.530	.654	.709	0.724	.807	.877
AICc	1796.67	1865.54	2044.70	2120.61	2302.83	2650.37
Max VIF-value	2.670	2.829	3.088	2.088	3.002	2.285

Table 2:Results exploratory and ordinary least squares regression analyses. Note: *** variable significant at the p<0.01 level; ** variable significant at the p<0.05 level; * variable significant at the p<0.10 level; - not included

As a note, the residuals of all models were tested for spatial autocorrelation using Moran's I; the results are displayed in table 3. The residuals of all models were not found to be spatially autocorrelated as the p-value

for all crime types was higher than 0.10. Hence, the residuals were distributed randomly throughout the research area.

Variables	Burglary	Vandalism	Violent Crimes	Drugs and Nuisance	Theft	Total Crimes
Constant	-.940	-.560	-.369	-.356	2.527**	2.869
Cul-de-sac density	-	-	-	-	-	-
Intersection density	.007***	-	-	.004	-	-
Mixed land-use	1.496**	-	-2.690***	-	-3.250***	-7.424***
Percentage of residential land-use	2.182***	1.131*	-	-	-	-
Percentage of retail and catering land-use	-	7.417***	18.418***	18.443***	26.662***	56.455***
Ratio CCTV	-1.111**	2.004***	2.792***	3.875***	3.230***	5.413***
Streetlighting	-	.00032*	.00042**	.00043*	.002***	.003***
Artworks	.022*	.027**	-	-	-	-
Ratio greenspace	1.911*	-	-	-	-	-
Tree density	-	-	-	-	-	-.001**
Parking density	-	-	.00027**	-.00043***	-	-
Population density	.000204***	.00007***	.00011***	.00005*	.00012***	-
Address density	.000134**	.00024***	.00038***	-	.00048***	.002***
Vacancy rate	.049**	-	.068**	.047*	.104***	-
Tourist attraction density	-	.019*	-	.099***	.146***	.212***
Ethnic heterogeneity	-	4.201***	7.585***	-	-	11.354***
Socio-economic status	-.099*	-	-.256***	-	.397***	.686***
Percentage rented homes	-	-	-	.016*	.032***	.064***
R2-adjusted	.530	.654	.709	0.724	.807	.877
AICc	1796.67	1865.54	2044.70	2120.61	2302.83	2650.37
Max VIF-value	2.670	2.829	3.088	2.088	3.002	2.285

	Burglary	Vandalism	Violent Crimes	Drugs and Nuisance	Theft	Combined Crimes
Moran's I 1	0.005360	0.002210	0.000396	0.001985	0.000238	-0.000081
Z-score	1.411898	0.855496	0.520057	0.811449	0.491463	0.433635
P-value	0.157980	0.392277	0.603024	0.417108	0.623099	0.664553

Table 3: Results test for spatial autocorrelation using Moran's I per crime type. Note:1 Bandwidth 3000-meter, Euclidean distance method.

5.2 Results of Geographical Weighted Regression per Crime Type

Per crime type a geographically weighted regression was performed. In this subsection, these analyses and their results are elaborated per crime type.

5.2.1 Burglary

The results of the GWR for the burglary model are displayed in Table 4. The differences in the coefficients and local R-squared values show that there are changing relationships per neighbourhoods. The improvement of the adjusted R-squared value and the AIC shows that taking spatial relationships into account is beneficiary.

	Lowest	Mean	Highest
Intercept	-3.273	-1.115	1.946
Intersection density	0.001	0.007	0.020
Art density	-0.026	0.025	0.105
Ratio CCTV	-5.054	-1.434	0.097
Percentage residential land-use	-3.504	2.327	4.999
Mixed land-use	-5.559	1.147	2.505
Socio-economic status	-0.471	-0.046	0.280
Ratio greenspace	-1.132	1.341	8.127
Population density	0.00005	0.00020	0.00046
Address density	-0.00023	0.00017	0.00037
Vacancy rate	-0.040	0.058	0.158
Local R-squared	0.480	0.548	0.883

Table 4: Results GWR burglary model. R2-adjusted: 0.563; AICc: 1766.98

Looking at the burglary model from the GWR, the most interesting findings are the intersection density and the socio-economic status. The intersection density perfectly follows the empirical results of Sohn (2016) & Yang (2006) [17, 20]. On the other hand, it is contrary to Jacobs' (1961) argument of increased permeability which should decrease crime [1]. Socio-economic status having positive and negative coefficients is also found to be interesting, as it suggests that burglaries should occur the least in areas with a socio-economic status that is close to the mean.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

In Figure 1a, the local R-squared values are displayed. It can easily be observed that the model performs better in peripheral areas of the city, whereas the model performs worse in the city centre. The model performs better in areas with a lower number of burglaries. This implies that the variables explain less variance in the city centre and more in the peripheral areas. The city centre has a relatively large negative coefficient for the intercept (Figure 1b). This could possibly be due to one or more missing variables that could have been added to the regression analysis. This could also explain the lower R-squared values in the city centre, as less variance is found by the model in this specific region. Population density which has the highest standardised coefficient in the OLS regression, seems to have a somewhat random pattern considering the areas with a high number of burglaries in combination with highly populated areas (Figure 1c).

In Figure 1d, the coefficients of the socio-economic status are displayed. As the values for the socio-economic status range between approximately -6 to 6, this in combination with coefficients ranging from approximately -0,5 to 0,3 makes the GWR results relatively difficult to interpret. Neighbourhoods with a poor socio-economic status and also a negative coefficient would experience more burglaries, as multiplying negative values will become positive. On the other hand, neighbourhoods with a high socioeconomic status and also a positive coefficient will also experience more burglaries.

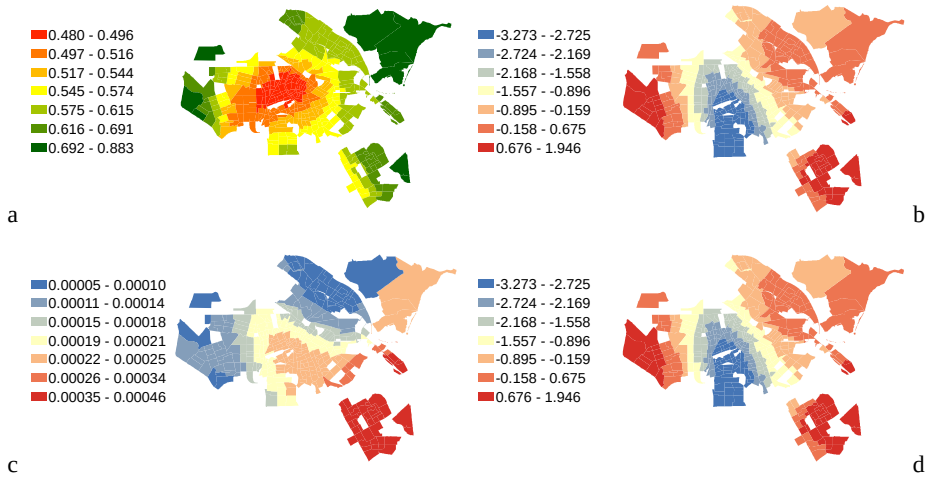


Figure 1: Maps representing results GWR burglary model (a) Local R-squared values; (b) Coefficient intercept burglary model; (c) Coefficient population density burglary model; (d) coefficient socio-economic status.

5.2.2 Vandalism

The results of the vandalism model are displayed in Table 5. It is observed that there are varying relationships. The adjusted R-squared and AICc indicate a significantly better model fit than the OLS regression model. The most interesting finding of the vandalism model is the high positive correlation with tourist attractions, which was initially unexpected. However, the literature suggested that this correlation does make sense (Bhati & Pearce, 2016; Merrill, 2011) [27,28].

	Lowest	Mean	Highest
Intercept	-2.752	0.415	2.519
Art density	-0.067	0.026	0.085
Ratio CCTV	-0.057	2.691	4.086
Ethnic heterogeneity	-0.895	2.705	12.364
Percentage residential land-use	-1.811	1.100	3.442
Percentage retail and catering land-use	-6.147	6.770	15.601
Tourist attraction density	-0.239	0.041	0.443
Streetlighting density	-0.00027	0.00019	0.00074
Population density	-0.000013	0.000083	0.000359
Address density	-0.00104	0.00025	0.00047
Vacancy rate	-0.040	0.058	0.158
Local R-squared	0.415	0.549	0.880

Table 5: Results GWR vandalism model. R2-adjusted: 0.666; AICc: 757.00

It can be observed that the model performs worst in the west area of the city centre, whereas it performs best at the east and north of the city centre. The local R-squared values for areas with many vandalism related crimes, seem to differ (Figure 2a). The intercept is the highest in the city centre, while the peripheral areas have lower coefficients (Figure 2b). Arguably, the intercept might compensate for variables which are not

included but that could have stimulated vandalism, since the local R-squared values are also the lowest near the city centre where vandalism occurs the most. Looking at the coefficients for the address density (figure 2c), it stands out that the southeast region has a negative coefficient. This pattern could be explained as the literature shows that more urbanised areas experience more crime. Unexpectedly, tourist attractions density has the lowest coefficients in the area where most tourist attractions are located (figure 2d). A possible explanation is that the tourist attraction density is much higher in that area and that the model uses a lower coefficient to somehow compensate this by giving tourist intensive areas lower coefficients.

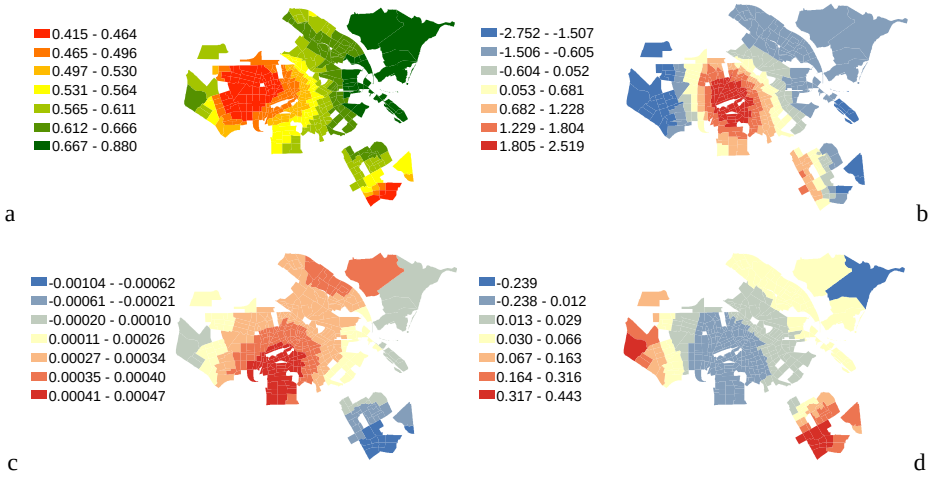


Figure 2: Maps representing results GWR vandalism model (a) Local R-squared values; (b) Coefficient intercept vandalism model; (c) Coefficient address density vandalism model; (d) coefficient tourist attraction density vandalism model.

5.2.3 Violent Crimes

Table 6 shows the results for the violent crimes model. Like the vandalism model, a significant model fit improvement can be observed. The most interesting results of the violent crimes model are that a large number of variables included are perfectly in line with the literature; variables originating from the social disorganisation theory, vacancy, mixed land-use and retail and catering land-use. Looking at the local R-squared values, there are areas in Amsterdam in which 90 percent of the variance can be explained by the GWR model (Figure 3a). A clear division between east and west can be observed; in the east high values are present, whereas the lowest values appear in the west. The city centre where most violent crimes occur, has a R-squared value that is slightly higher than the mean.

	Lowest	Mean	Highest
Intercept	-3.692	0.412	5.238
Parking density	-0.000801	-0.000268	0.00156
Ratio CCTV	-0.426	3.838	6.649
Ethnic heterogeneity	1.182	7.139	11.527
Percentage retail and catering land-use	-0.395	17.054	23.084
Mixed land-use	-6.928	-3.196	2.428
Socio-economic status	-0.565	-0.233	0.188
Streetlighting density	-0.00126	0.00018	0.00159
Population density	-0.00019	0.00011	0.00049
Address density	-0.00060	0.00041	0.00083
Vacancy rate	-0.014	0.081	0.160
Local R-squared	0.617	0.728	0.909

Table 6: Results GWR violent crimes model. R2-adjusted: 0.803; AICc: 412.99

The intercept appears to have the highest coefficient in the southern part of the city, except the south-east region (Figure 3b). The city centre still has a relatively high coefficient whereas the rest of the city has a coefficient of zero or a negative value. The percentage of retail and catering land-use is the highest in the south-east region and the city centre (Figure 3c). The city centre having a relatively high coefficient seems logical, as the city centre experiences most violent crimes and the other variables seem to have less influence in the city centre. Ethnic heterogeneity seems to be influencing violent crimes most in the west, where a high level of ethnic heterogeneity can be observed (Figure 3d). It is interesting that the southeast region, which also has a high level of ethnic heterogeneity, has a relatively low coefficient. Remarkably to see is that ethnic heterogeneity follows a pattern that is similar to that of the local R-squared values. The coefficient for ethnic heterogeneity is the highest in areas where the R-squared is low. Address density has the highest coefficients

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

in a few neighbourhoods in the far west, whereas the city centre also has a relatively high coefficient (Figure 3e). This makes sense as the literature shows that more urbanised areas experience more crime.

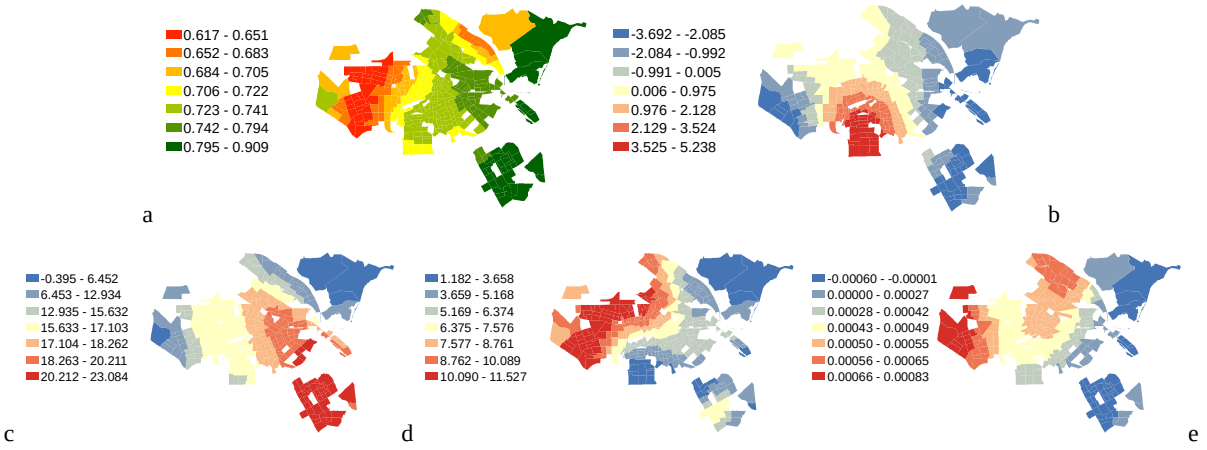


Figure 3: Maps representing results GWR violent crimes model (a) Local R-squared values; (b) Coefficients intercept violent crimes model; (c) Coefficients retail and catering land-use violent crime model; (d) coefficients ethnic heterogeneity violent crimes model; (e) coefficients address density violent crimes model.

5.2.4 Drugs and Nuisance

The GWR results for Drugs and Nuisance related crimes are summarised in Table 7. It is remarkable that there are no signs of improvement by taking spatial relationships into account. Hence, it could be argued that drugs and nuisance related crimes have stationary relationships with the variables included. However, a look at the variables individually shows that varying relationships can be observed.

	Lowest	Mean	Highest
Intercept	-1.653	0.029	2.393
Intersection density	-0.009	0.004	0.012
Parking density	-0.00077	-0.00047	0.00031
Ratio CCTV	0.944	5.138	18.458
Percentage retail and catering land-use	0.705	18.331	31.537
Tourist attraction density	-0.063	0.095	0.267
Streetlighting density	-0.00036	0.0002	0.00122
Population density	-0.000019	0.000065	0.00029
Percentage rented homes	-0.015	0.015	0.049
Vacancy rate	-0.023	0.068	0.118
Local R-squared	0.453	0.721	0.840

Table 7: Results GWR drugs and nuisance model. R2-adjusted: 0.732; AICc: 2137.37

The local R-squared values show that the model explains variance in the south-east region and the city centre the best (Figure 4a). This is preferable as most crimes occur in these areas. The intercept has the highest coefficient in the south-eastern part of the city (Figure 4b). The coefficient of the intercept for the city centre, where most drugs and nuisance related crimes occur, is close to zero. Hence, it could be argued that the variables in the model predict these types of crime well. The tourist attraction density has a relatively low coefficient in the areas where there are more tourist attractions (Figure 4c). Like in the vandalism model, it is expected that this is due to the high number of tourist attractions in the city centre compared to the other areas of the city. A high coefficient would probably result in extreme overpredictions. It is interesting to note that the coefficient for the parking density is negative in the areas where drugs and nuisance related crimes occur most (Figure 4d). A similar pattern as with the violent crimes model can be observed. Arguably, this is due to the fact that these crimes occur most in the city centre where the least parking places are present and thus parking is of less importance. Another remarkable aspect is that in the western part of the city, the coefficient becomes positive, which could be explained by the fact that there are relatively more parking places there, which has a negative influence on the principle of access control from CPTED.

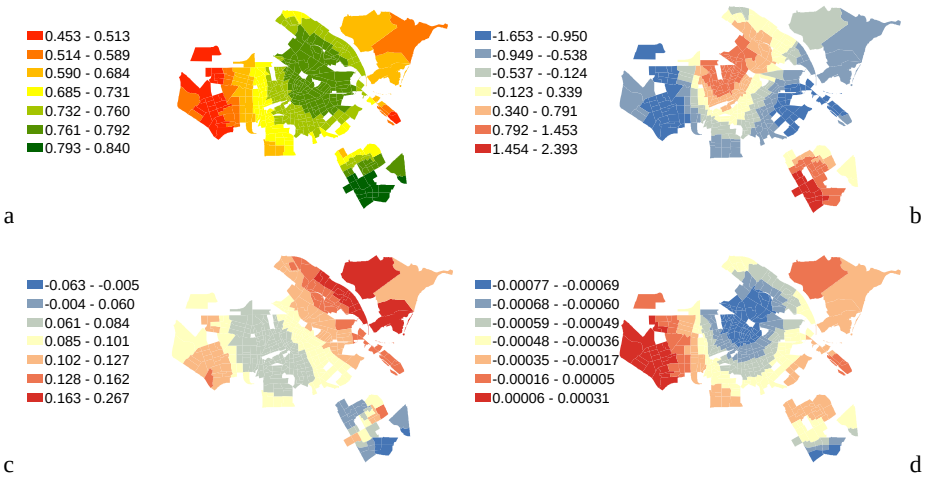


Figure 4: Maps representing results GWR drugs and nuisance model (a) Local R-squared values; (b) Coefficients intercept drugs and nuisance model; (c) Coefficients tourist attraction density drugs and nuisance model; (d) coefficients parking density drugs and nuisance model.

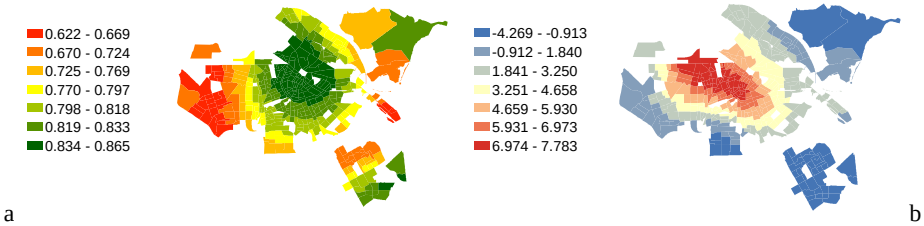
5.2.5 Theft

In Table 8, the coefficients obtained from the GWR for the theft model are displayed. Only a limited improvement can be observed when taking spatial relationships into account. From looking at the local R-squared values it becomes clear that the variance is best explained in neighbourhoods near the city centre (Figure 5a). This makes sense as most theft related crimes occur near the city centre, especially pickpocketing which is generally speaking near tourist attractions.

	Lowest	Mean	Highest
Intercept	-4.269	3.677	7.783
Ratio CCTV	-1.852	4.662	17.415
Percentage retail and catering land-use	3.221	23.616	30.033
Mixed land-use	-7.051	-3.018	3.251
Tourist attraction density	-0.302	0.126	0.278
Socio-economic status	-0.194	0.327	0.762
Streetlighting density	0.000	0.001	0.003
Population density	-0.00017	-0.000096	0.00019
Address density	0.00022	0.00048	0.00120
Percentage rented homes	-0.023	0.018	0.073
Vacancy rate	-0.044	0.147	0.319
Local R-squared	0.622	0.795	0.865

Table 8: Results GWR theft model. R2-adjusted: 0.824; AICc: 2298.92

The intercept has the highest coefficient in the city centre, whereas the peripheral areas of the city have the lowest coefficients (Figure 5b). Taking into consideration that the improvement of the GWR model in comparison to the OLS model is quite poor, it could be argued that theft is stationary, and that the intercept of the GWR acts as a measure of distance to the city centre. Tourist attraction density has surprisingly a relatively low coefficient in the city centre where most tourist attractions are present (Figure 5c). Arguably, this is due to the big differences in the values of the tourist attraction density of the city centre compared to the rest of the city. The highest coefficients for retail and catering land-use can be found in the city centre (Figure 5d). In this area, most land is covered by retail and catering facilities. This implies that the effect of retail and catering facilities is amplified in GWR analysis.



ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

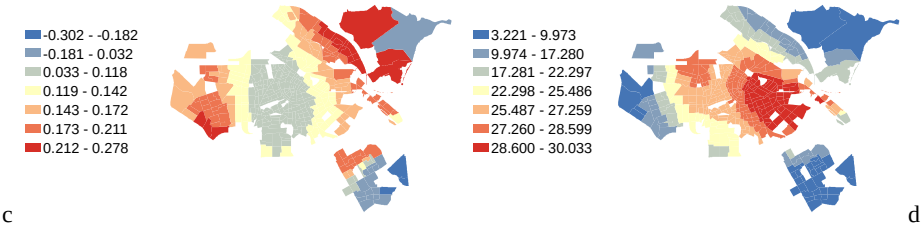


Figure 5: Maps representing results GWR theft model (a) Local R-squared values; (b) Coefficients intercept theft model; (c) Coefficients tourist attraction density theft model; (d) coefficients retail and catering land-use theft model.

5.2.6 Combined Crimes Model

Finally, all crimes combined were analysed. The results are displayed in Table 9. Taking spatial relationships into account was expected to result in a better model fit. Whereas an improvement of approximately .03 in the adjusted R-squared value might seem marginal, it should be noted that the adjusted R-squared of the OLS regression was .877, hence there is less room for improvement. Moreover, the AICc is more than 2000 lower than the OLS regression model.

	Lowest	Mean	Highest
Intercept	-2.621	6.734408	17.414023
Tree density	-0.003	-0.001	0.003
Ratio CCTV	0.658	7.357	21.990
Ethnic heterogeneity	0.016	8.443	17.185
Percentage retail and catering land-use	22.614	55.477	64.419
Mixed land-use	-12.564	-7.541	1.610
Tourist attraction density	-0.478	0.194	0.891
Socio-economic status	-0.245	0.553	1.083
Streetlighting density	0.0013	0.0026	0.0046
Address density	0.0011	0.0016	0.0036
Percentage rented homes	0.006	0.042	0.126
Local R-squared	0.799	0.864	0.942

Table 9: Results GWR combined crimes model. R2-adjusted: 0.916; AICc: 555.92

As can be seen, the areas with highest crime rates also have a higher local R-squared value (Figure 6a). It is preferable that the R-squared is highest in areas with the highest crime rates, as the upmost part of the total crimes are explained by the model.

The intercept appears to have the highest coefficient in the city centre, where relatively many crimes occur (Figure 6b). Arguably, the intercept compensates for variables which are not included in the models. A coefficient for the intercept of approximately 15, in combination with the square root transformation suggests that the intercept compensates for more than 200 crimes per square kilometer per year in those areas. Mixed land-use has the highest coefficients in the east of Amsterdam; towards the west the coefficients decrease (Figure 6c). When looking at the coefficient for the tree density, it can be observed that the city centre has negative coefficients, whereas the peripheral areas have coefficients near zero or positive ones. This implies that in those areas the tree density does not seem to reduce crime as much as in the city centre (Figure 6d). Tourist attractions density again follows a pattern in which the city centre, with most tourist attractions, has a relatively low coefficient (Figure 6e).

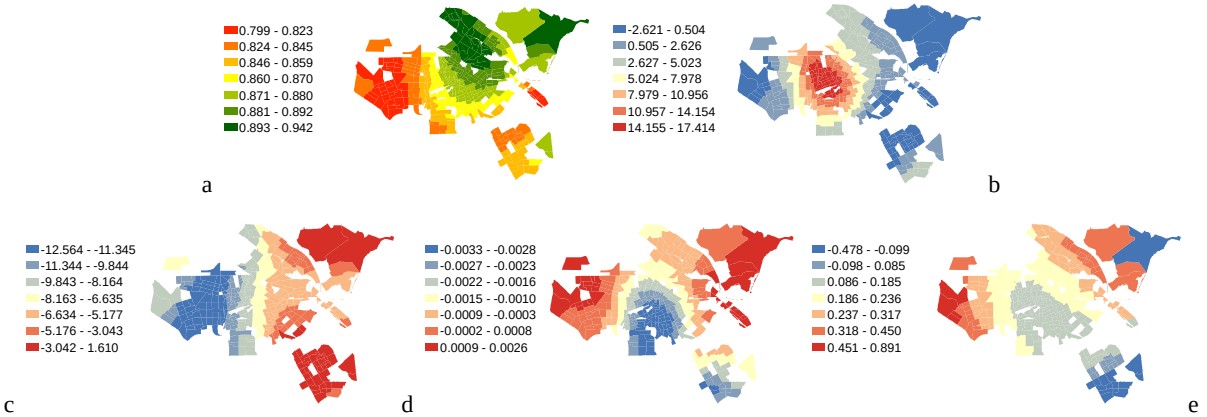


Figure 6: Maps representing results GWR combined crimes model (a) Local R-squared values; (b) Coefficients intercept combined crimes model; (c) Coefficients mixed land-use combined crimes model; (d) coefficients tree density combined crimes model; (e) coefficients tourist attraction density combined crimes model.

6 DISCUSSIONS AND CONCLUSIONS

In this research, multiple crime types were researched in regard to their relation to characteristics of the built environment and some regarding the social disorganisation theory as control variables. Firstly, existing literature was consulted to obtain the most relevant theories and contributions on this matter. Per crime type an exploratory regression analysis was performed to obtain the most suitable OLS regression model. Finally, a geographically weighted regression analysis was performed to obtain local variations in the relations between characteristics of the built environment and crime.

As regards the CPTED principles, in this study, some confirming findings can be observed. The number of intersections increasing crime is in line with the CPTED principle of access control, as the number of intersections increases the permeability of the neighbourhood and thus weakens the access control. Mixed land-use should act as a measure to improve natural surveillance, which it does as all the signs are negative. The vacancy rate is also in line with CPTED, namely the image and milieu principle. As vacancy is argued to have a negative effect on the image of the neighbourhood, resulting in more crime. The vacancy rate is positively correlated with drugs and nuisance related crimes, violent crimes and theft. The number of rented homes, arguably, can be seen as a negative measure of territoriality, as people are more inclined to defend their own property. The percentage of rented homes is positively correlated with drugs and nuisance related crimes, theft and crime in general. Hence, variables representing all CPTED principles are in line with the CPTED strategy. However, there are also some variables which are not found to be reflecting the CPTED strategy. CCTV for example, which should act as a measure of surveillance and access control, however, shows a positive correlation. The same goes for the streetlighting as a measure of natural surveillance, artworks as a measure of territoriality and parking places as a measure of access control.

When taking spatial relationships into account, it can easily be observed that for burglary, vandalism, violent crimes and crime in general the models improve significantly. Drugs and nuisance related crimes as well as theft seem to have a limited, if any, improvement. Hence, it could be argued that drugs and nuisance related crimes and theft are stationary as there were no significant model improvements when considering spatial relationships. Moreover, taking into account spatial variation of the coefficients provides the opportunity to observe where certain variables are more influential and where they are not.

As regards to policy making to decrease criminal activities in the city centre of Amsterdam, it could be argued that due to the high number of tourists and retail and catering facilities, that the number of pedestrians is already sufficient to provide natural surveillance. On the other hand, as Angel (1968) suggested, the number of potential victims also increases with a high land-use intensity [50], which is evident of the case in the city centre of Amsterdam. Hence, formal surveillance is more recommended rather than measures which increase natural surveillance. Measures such as limiting retail and catering facilities could help reduce crime, but would have negative economic consequences. Concerning tourism, it is recommended to evaluate whether the benefits of the high number of tourists outweigh the disadvantages such as crime, but also the deterioration of the city centre, social and environmental sustainability issues and the nuisance in general that the residents of Amsterdam experience. Limiting the number of tourists could be done by implementing a higher tourist tax or by regulating the number of hotel rooms and short-stay rental platforms.

Concerning other areas of Amsterdam, it is recommended to implement more diverse land-uses in its neighbourhoods, as the results of this study show that this might beneficial in reducing crime. Mixed land-use will in turn also lower the population density, which stimulates crime, as multiple functions besides residential are present in the area.

In general, it can be concluded that the built environment does have an influence on the occurrence of crime and that this influence differs among crime types. Moreover, different characteristics of the built environment influence different types of crime. It should be stated that there is consistency in variables between crime types, i.e. the percentage of rented homes and the vacancy rate are consistently positively correlated in all models in which they were included. Further research is recommended to increase the knowledge on the influence of the built environment on crime and to do this for multiple contexts and levels of analysis to get a more thorough understanding of this matter. Moreover, it is recommended to consider

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

spatial statistics more often, as it could increase general model performance and help understanding local differences, however, this requires the availability of spatial data.

7 REFERENCES

1. Jacobs, J. The Death and Life of Great American Cities, 1st. ed; Random House inc.: New York, USA, 1961.
2. Newman, O. Defensible space, 1st ed.; Macmillan: New York, USA, 1972.
3. Jeffery, C. R. Crime Prevention Through Environmental Design, 1st ed,; SAGE Publications Inc, Thousand Oaks, USA, 1971.
4. A Donnelly, P. G. Newman, Oscar: Defensible Space Theory. In Title Encyclopedia of Criminological Theory, 1st ed.; Cullen, F., Wilcox, P., Eds.; SAGE Publications Inc, Thousand Oaks, USA, 2010; pp. 664–667.
5. Cozens, P. M. Crime Prevention Through Environmental Design. In Environmental Criminology and Crime Analysis, 1st ed.; Wortley, R., Mazerolle, L., Eds.; Routledge: New York, USA, 2008; pp. 153–177.
6. Fennelly, L; Crowe, T. Crime Prevention Through Environmental Design, 3rd ed.; Butterworth-Heinemann: Amsterdam, Netherlands, 2013. https://doi.org/10.1016/C2012-0-03280-2
7. Broken Windows. Available online: https://www.theatlantic.com/magazine/archive/1982/03/broken-windows/304465/ (accessed on 6 April 2021)
8. Wuschke, K.; Kinney, B. J. Built Environment, Land Use, and Crime, in the Oxford Handbook of Environmental Criminology, 1st ed.; Bruinsma, G. J. N., Johnson, S. D., Eds; Oxford University Press: New York, USA, 2018, pp. 475-496.
9. De Vries, S.; Verheij, R. A.; Groenewegen, P. P.; Spreeuwenberg, P. Natural environments - Healthy environments? An exploratory analysis of the relationship between greenspace and health. Environ. Plan A 2003, Volume 35(10), pp 1717-1731. https://doi.org/10.1068%2Fa35111
10. Weijs-Perrée, M.; Dane, G.; van den Berg, P. Analyzing the Relationships between Citizens' Emotions and their Momentary Satisfaction in Urban Public Spaces. Sustainability 2020, Volume 12, pp. 7921. https://doi.org/10.3390/su12197921
11. Shepley, M.; Sachs, N.; Sadatsafavi, H.; Fournier, C.; Peditto, K. The impact of green space on violent crime in urban environments: An evidence synthesis. Int. J. Environ. Res. Public Health 2019, Volume 16(24), pp 4-10. https://doi.org/10.3390/ijerph16245119
12. Bogar, S.; Beyer, K. M. Green Space, Violence, and Crime: A Systematic Review. Trauma, Violence, and Abuse 2016, Volume 17(2), pp. 160-171. https://doi.org/10.1177/1524838015576412
13. Gulak, M.; Kun, U.; Koday, Z.; Koday, S. Preventing Terrorist Attacks to Critical Infrastructure(s) by Use of Crime Prevention Through Environmental Design (CPTED). In Understanding and Responding to the Terrorism Phenomenon, 1st ed.; Nikbay, O, Hancerli, S., Eds.; IOS Press: Amsterdam, Netherlands, 2007, volume, pp. 298-312.
14. Hedayati Marzbali, M.; Abdullah, A.; Ignatius, J.; Maghsoodi Tilaki, M. J. Examining the effects of crime prevention through environmental design (CPTED) on Residential Burglary. International Journal of Law, Crime and Justice 2016, Volume 46, pp. 86-102. https://doi.org/10.1016/j.ijlcj.2016.04.001
15. Hedayati Marzbali, M.; Abdullah, A.; Razak, N. A.; Maghsoodi Tilaki, M. J.). The relationship between socio-economic characteristics, victimization and CPTED principles: Evidence from the MIMIC model. Crime. Crime, Law Soc. Chang. 2012, Volume 58(3), pp. 351-371. https://doi.org/10.1007/s10611-012-9389-7
16. Lee, J. S.; Park, S.; Jung, S. Effect of crime prevention through environmental design (CPTED) measures on active living and fear of crime. Sustainability 2016, Volume 8(9), pp. 872. https://doi.org/10.3390/su8090872
17. Sohn, D. W. Residential crimes and neighbourhood built environment: Assessing the effectiveness of crime prevention through environmental design (CPTED). Cities 2016, Volume 52, pp. 86-93. https://doi.org/10.1016/j.cities.2015.11.023
18. Block, R. L.; Block, C. R. Space, place, and crime: Hot spot areas and hot places of liquor-related crime. In Crime and Place, 1st ed.; Eck, J. E., Weisburd, D., Eds.; Criminal Justice Press: Monsey, USA, 1995, Volume 4. Pp. 145-184.
19. Hillier, B. Can streets be made safe? Urban Des. Int. 2004, Volume 9(1), pp. 31-45. https://doi.org/10.1057/palgrave.udi.9000079
20. Yang, X. Exploring the influence of environmental features on residential burglary using spatial-temporal pattern analysis. Doctor of Philosophy, University of Florida, Gainesville, may 2006.
21. Bennet, T.; Wright, R. Constraint to Burglary: the Offender's Perspective. In Coping with Burglary, 1st ed.; Clarke, R., Hope, T., Eds.; Kluwer Nijhof Publishers Group: Dordrecht, Netherlands, pp. 181-200.
22. Felson, M. Four Images of the Delinquency Area. In the Oxford Handbook of Environmental Criminology, 1st ed.; Bruinsma, G. J. N., Johnson, S. D., Eds; Oxford University Press: New York, USA, 2018, pp. 150-159.
23. Fuentes, C. M.; Hernandez, V. Housing finance reform in Mexico: the impact of housing vacancy on property crime. Int. J. Hous. Policy 2014, Volume 14(4), pp. 368-388. https://doi.org/10.1080/14616718.2014.955332
24. Cui, L.; Walsh, R. Foreclosure, vacancy and crime. J Urban Econ 2015, Volume 87, pp. 72-84. https://doi.org/10.1016/j.jue.2015.01.001
25. Sampson, R. J.; Groves, W. B. Community Structure and Crime: Testing Social-Disorganization Theory. Am. J. Sociol. 1989, Volume 94(4), pp. 774-802. https://doi.org/10.1086/229068
26. Geerts, W. Top 100 City Destinations 2018. Euromonitor International 2018. http://go.euromonitor.com/rs/805-KOK-719/images/wpTop100CitiesEN_Final.pdf?mkt_tok=eyJpIjoiTURFeE56TTBOV1JrTW1GaSIsInQiOiJ0Tk5ibkJYZ3JFd2t5eWh1Qll6YjJMNjVabFdnWlRhbTRVZ1I5czNwNnhDRm02dFlEcjV3T1krMDc3bjN5YXpkUnJ3QnNpSm9xUkV0aHpnWkdJUWpobWUzS0Y5ZXJhcHQ4ZTBG
27. Bhati, A.; Pearce, P. Vandalism and tourism settings: An integrative review. Tour Manag 2016, Volume 57, pp. 91-105. https://doi.org/10.1016/j.tourman.2016.05.005
28. Merrill, S. O. C. Graffiti at heritage places: Vandalism as cultural significance or conservation sacrilege? Time Mind 2011, Volume 4(1), pp. 59-75. https://doi.org/10.2752/175169711X12893985693711

29. Jud, G. D. Tourism and Crime in Mexico. Soc Sci Q 1975, Volume 56(2), pp. 324-330.
30. Crime Prevention. Available online: https://www.unodc.org/unodc/en/justice-and-prison-reform/CrimePrevention.html (accessed 23 December 2021)
31. Wortley, R.; Mazerolle, L. Environmental Criminology and Crime Analysis: Situating the Theory, Analytic Approach and Application. In Environmental Criminology and Crime Analysis, 1st ed.; Wortley, R., Mazerolle, L., Eds.; Routledge: New York, USA, 2008; pp. 1-18.
32. Shaw, C. R.; McKay, H. D. Juvenile Delinquency and Urban Areas. University of Chicago Press: Chicago, USA, 1942.
33. Rogerson, M.; Pease, K. Moving Home as a Flight from Crime: Residential Mobility as a Cause and Consequence of Crime and a Challenge to Crime Prevention Through Environmental Design, in Rebuilding Crime Prevention Through Environmental Design, 1st ed.; Armitage, R., Ekblom, P., Eds; Routledge: London, United Kingdom, Pp. 8-22.
34. Blau, P. D. Inequality and Heterogeneity: a Primitive Theory of Social Structure, 1st ed.; Free Press: New York, USA, 1977.
35. Bruinsma, G. J. N.; Pauwels, L. J. R.; Weerman, F. M.; Bernasco, W. Social disorganization, social capital, collective efficacy and the spatial distribution of crime and offenders. Br. J. Criminol. 2013, Volume 53(5), pp. 942-963. https://doi.org/10.1093/bjc/azt030
36. Davies, T.; Bowers, K. J. Street Networks and Crime, in the Oxford Handbook of Environmental Criminology, 1st ed.; Bruinsma, G. J. N., Johnson, S. D., Eds; Oxford University Press: New York, USA, 2018, pp. 545-576.
37. Kimpton, A.; Corcoran, J.; Wickes, R. Greenspace and Crime: An Analysis of Greenspace Types, Neighboring Composition, and the Temporal Dimensions of Crime. J Res Crime Delinq 2017, Volume 54(3), pp. 303-337. https://doi.org/10.1177/0022427816666309
38. Geregistreerde misdrijven; soort misdrijf, wijk, buurt, jaarcijfers. Available online: https://data.politie.nl/#/Politie/nl/dataset/47018NED/table?ts=1623857669357 (accessed on 16 February 2021)
39. NWB wegen - Wegvakken (RWS). Available online: https://maps.rijkswaterstaat.nl/dataregister/srv/dut/catalog.search;jsessionid=59390E5197AFB7492E306528AAA2A7E3#/metadata/60caa9e5-60c5-4072-a575-e11ef5a07mgl (accessed on 7 April 2021)
40. Geo services – PDOK. Available online: https://www.pdok.nl/geo-services/-/article/cbs-bestand-bodemgebruik#9fb93ef2a6a0ba65aa0c9cd14eb22b3d (accessed on 16 April 2021)
41. API's en Geo-webservices. Available online: https://api.data.amsterdam.nl/api/ (accessed on 23 February 2021)
42. OVL Amsterdam | Data overheid. Available online: from https://data.overheid.nl/en/dataset/ovl-amsterdam (accessed on 14 February 2021)
43. Wijk- en buurtkaart 2019. Available online: https://www.cbs.nl/nl-nl/dossier/nederland-regionaal/geografische-data/wijk-en-buurtkaart-2019 (accessed on 14 February 2021)
44. Attracties | Data overheid. Available online: https://data.overheid.nl/dataset/xnx2w6oy1lsppq (accessed on 7 May 2021)
45. StatLine - Bevolking 15 tot 75 jaar; opleidingsniveau, wijken en buurten, 2019. Available online: https://opendata.cbs.nl/statline/#/CBS/nl/dataset/84773NED/table (accessed on 20 April 2021)
46. Kubrin, C. E.; Weitzer, R. New directions in social disorganization theory. J Res Crime Delinq 2003, Volume 40(4), pp. 374-402. https://doi.org/10.1177/0022427803256238
47. Cahill, M.; Mulligan, G. Using geographically weighted regression to explore local crime patterns. Soc. Sci. Comput. Rev. 2007, Volume 25(2), pp. 174-193. https://doi.org/10.1177/0894439307298925
48. Akaike, H. A New Look at the Statistical Model Identification. IEEE Trans. Automat. Contr 1974, Volume 19(6), pp. 716-723. https://doi.org/10.1109/TAC.1974.1100705
49. Malczewski, J.; Poetz, A. Residential burglaries and Neighborhood socioeconomic context in London, Ontario: Global and local regression analysis. Prof Geogr 2005, Volume 57(4), pp. 516-529. https://doi.org/10.1111/j.1467-9272.2005.00496.x
50. Angel, S. Discouraging Crime Through City Planning. 1st ed.; Berkeley, Institute of Urban & Regional Development: Berkeley, USA, 1968.

🏆 *reviewed paper*

The Influence of Non-Motorised Transport Systems around the World: a Case Study of Singapore, Shanghai, Lagos, Jakarta, Johannesburg and Cape Town

Kiara Lawrence, Trynos Gumbo, Zaakirah Jeeva

(Kiara Lawrence, University of Johannesburg, Department of Urban and Regional planning, Office 6062, Sixth Floor, John Orr Building, Beit and Siemert Street, 2028. Johannesburg, South Africa, kiaralaw20@gmail.com)
(Prof Trynos Gumbo, University of Johannesburg, Department of Urban and Regional planning, Office 6062, Sixth Floor, John Orr Building, Beit and Siemert Street, 2028. Johannesburg, South Africa, tgumbo@uj.ac.za)
(Dr Zaakirah Jeeva, Unit of Environmental science and Management, North-West University, Potchefstroom,2520, zaakirah.jeeva@gmail.com)

1 ABSTRACT

For the past few decades, cities around the world have sprawled and citizens have become extremely reliant on motorised transport, to access services. This has created problems around severe traffic congestion and the emission of greenhouse gases. In recent years there has been a drive to create cities that are less dependent on motorised transport. Subsequently, non-motorised transport (NMT) such as walking, running, cycling, are considered as one of the more desirable forms of transportation as it has various environmental, social and health benefits. Since, majority of trips start and end with NMT means that the improvement of NMT will also improve motorised transportation. The research study adopted a case study research design through the analysis of literature on the integration of NMT and public transport in six cities (Singapore, Shanghai, Lagos, Jakarta, Johannesburg and Cape Town). Data was collected through Google Scholar and the Web of Science and was displayed form of literature and a table with lessons learnt from each city. The study found that NMT provision boosts the use of public transport and vice versa. Government policies, plans and regulations need to be put into place to control the use of dockless bikes. Safety measures, good infrastructure and maintenance of NMT lanes are imperative to the increased usage by users. Integration tools such as smart payments to seamlessly link NMT and public transport use can also increase the use of both NMT and public transport. By analysing all six cases, the table listing the lessons learnt can be applied to future planning and development around NMT and public transportation integration.

Keywords: Accessibility, Infrastructure, Safety, Non-motorized Transport, Public transport

2 INTRODUCTION

For the past few decades, cities around the world have been undergoing a swift and quite imbalanced development of transport systems which are extremely reliant on motorised transport (Gumbo and Moyo 2022). This has created problems around severe traffic congestion and the emission of greenhouse gases (Moody 2012: 1). Studies have shown that the transport sector emits greenhouse gases the fastest when compared to any other sector. The transportation sector was then re-aligned, with new policies and guidelines to try and remedy this situation. Most of these 'solutions' were and are focussed around mass transit systems which commonly involve trains, buses and minibus taxis, rail based Mass Rapid Transit (MRT) and Bus Rapid Transit (BRT) which fall under public transportation (Gumbo et al. 2022). However, a 'historical' yet environmentally sustainable and cheaper method of transportation is available in the form of Non-motorised Transport (NMT). NMT is considered as one of the more desirable forms of transportation as it has various environmental and health benefits. Traditionally, NMT was seen and used independently of motorised transport (Rahman 2013: 1-2).

Faster, newer modes of transport usually replace older slower modes. This led to a reduced investment in walking and cycling as they are relatively slow modes of transport. Given that walking and cycling are considerably slower, they continue to be equally important. NMT's improve the overall health of users as it is a simple form of exercise (United Nations Centre for Regional Development 2018: 23-24). Walking is the most affordable NMT as it is free, cycling requires an initial investment that pays off in the long run as it is faster and requires less effort than walking (Götschi, Garrard and Giles-Corti 2016: 1-2). Physically, socially and economically disadvantaged people mostly rely on NMT to get from point A to B which is often to and from work, thereby improving NMT will help achieve social equity (Risimati, Gumbo and Chakwizira 2021). A lot of time, money and planning goes into improving motorised transport, the fact that majority of trips start and end with NMT means that the improvement of NMT will also improve motorised transportation. Walking and cycling act as recreational activities to users, by promoting NMT, a better lifestyle for all is promoted (Litman 2017: 2).

The paper starts by identifying literature around NMT, walkability, public transportation and transportation on the whole. It then goes on to analyse six different case studies on their relationship with NMT and public transportation application and integration. It ends by drawing on the various shortcomings and successes of each case study in the form of a table on the lessons learnt.

3 OBJECTIVES

- To investigate the concept of NMT through walkability and transportation through a literature review.
- To analyse different forms of NMT and public transportation in the six different case studies; Singapore, Shanghai, Lagos, Jakarta, Johannesburg and Cape Town in terms of their integration of NMT and public transportation as well as the lessons learnt from each case.

4 CONCEPTUAL SYNOPSIS

The concept of walkability is quite significant when trying to find out whether it is feasible to travel on foot. Walkability can be seen to have three components which are density, mix and access (Dovey and Pafka 2019: 96-101). Density is integral to walkability as the higher density of people concentrated to a certain area, will mean that more facilities and services will be provided in that area within walking distance and will make walking more feasible. Mixed land usages improves access through many different land uses within an area; it shortens the distance from one place to the next. Urban planning studies have found that mono-functional land zones prevented these close connections, making walkability very challenging. Access networks refers to the pedestrian flow, either accelerated or slowed down. The concept of 'small blocks' and 'pools of use' which are now referred to as pedestrian permeability and catchments, are used to describe a zone within walking distance based on distance and time (Dovey and Pafka 2019: 96-101).

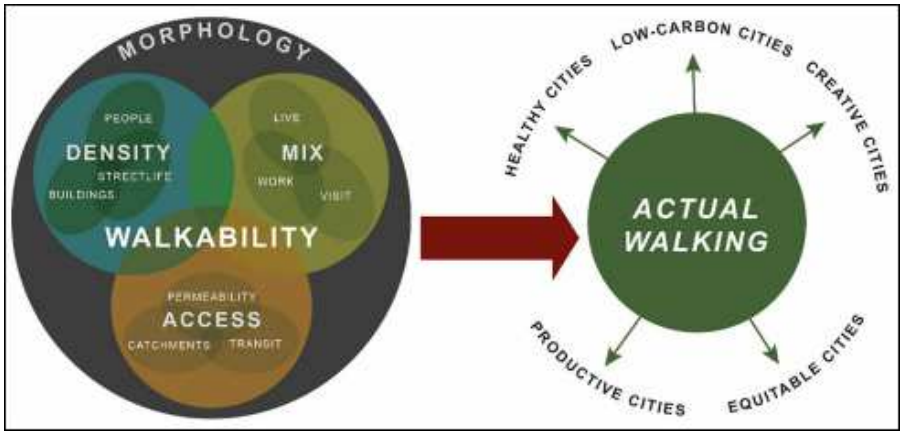


Fig. 1: The urban DMA (Density, Mix and Walkability) and actual walking (Dovey and Pafka 2019: 103)

Transportation is and has been a challenge in urban development and poses many issues for planning. Urban development in most developing cities are dependent on motorised transport as it is given priority whereas very little to no space on road reserves are given to the provision of NMT's and its users. Motorised transport comes with many consequences such as a high resource consumption (fuel and materials to mass produce these vehicles) and pollution in the form of greenhouse gases. Solutions to try and lessen the burden of heavy traffic on roads include reducing the total number of trips which would be possible through the provision of a more mixed land us neighbourhood. The other two methods are making public transport safer and more affordable and the promotion of NMT's (Selala and Musakwa 2016: 587).

Almost all urban motorised trips (private and public) are multi-modal, in the sense that there is some sort of walking involved to and from the 'main' mode of transport, which is usually public transportation and private vehicles. The difference is that this trip to and from private vehicles is almost negligible as it costs nothing and is very short due to the fact that there is ample parking fairly close to the desired destination of users. This is why majority of private motorised vehicle users continue to use private motorised transportation (Ortegon-Sanchez and Hernandez 2016: 3-4).

NMT can be very useful in short trips as they have a considerably lower environmental impact (Ortegon-Sanchez and Hernandez 2016: 3-4). NMT's include any form of transport that is not motorised such as

walking, cycling, skating, animal drawn and so forth (Selala and Musakwa 2016: 587-588). NMT's also allow for users to have workable times and routes that suit them.

5 METHODOLOGY

The study adopted a case study analysis research design where several cases were investigated based on the desired criteria. This study falls under a qualitative research approach. Secondary data was used in the form of books, journal articles and conference papers. This data was then analysed and displayed in the form of a literature review. The sources were identified using keywords "non-motorised transport"/"non-motorized transport" and "public transport". The data for the different case studies, Singapore, Shanghai, Lagos, Jakarta, Cape Town and Johannesburg were also sourced out from various journal articles, conference papers and other publications. All keywords for both the literature review and the case studies were sourced through Google Scholar and the Web of Science. The data was analysed in terms of each relationship to NMT and thereafter public transportation. The data was then presented in the form of literature and a table of the lessons learnt in each case study.

6 RESULTS AND DISCUSSION

The results below look at six case studies which focus on the relationship between NMT and public transportation. Two case studies (Singapore and Shanghai) look at developed countries, two case studies (Lagos and Jakarta) look at developing countries and two case studies (Johannesburg and Cape Town) look at NMT and BRT systems in South Africa. Each case study provides a very different experience and challenges that come along with trying to integrate NMT and public transportation for an overall better user experience in terms of affordability, safety, infrastructure, accessibility and legislative frameworks which regulate both NMT and public transport.

6.1 Singapore

Singapore's Land Transport Authority (LTA), is going to implement a widespread network of cycle paths in order promote a heathier and sustainable mode of transport. This will be implemented in selected Housing and Development Board Areas to encourage cycling and walking. These pathways will lead to and from mass rapid transit (MRT) stations, bus stations, schools, shops and other nodes (Zhou et al. 2020: 2).

Dockless bike-sharing (Figure 2) in Singapore have stations facilitate an integrated smartphone app with a scanning QR code for payment and there are GPS sensors are implanted in bikes to track and manage them. This allows scholars and researchers access to ridership data. A study conducted with over 10000 bikes, 1,5 million observations during a nine-day period found that an increase in the introduction of new bikes lowers the amount of trips. The built environment higher density and mixed land use increase the use of dockless bikes. Better infrastructure and support systems also encourage the use of bikes. However, rainfall and hot weather conditions negatively affects the amount of bike users (Shen, Zhang and Zhao 2018: 695).

Fig. 2: Dockless bike-sharing in Singapore (Source: Abdullah 2018)

The study found that there was high bike usage around (MRT) stations and bus stops which implies that dockless bikes are used for many last mile trips. Singapore will look towards integrating dockless bikes with public transportation through the use of smart payments. This has a great potential of increasing not only dockless bike trips but public transport usage as well (Shen, Zhang and Zhao 2018: 695).

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

6.2 Shanghai

Shanghai is known for having the largest port and longest subway system in the world. The city of Shanghai, China has an ever-growing population recorded at 26 million in 2019 and is predicted to rise to 31 million by 2030. The city is characterised by tall buildings feeding to its high population of 5800 inhabitants per , which is around the same density of London or Rio de Janeiro (Sudmant 2020: 11). The two main social and environmental challenges faced within the city are traffic congestion and air pollution due to rapid population growth. Shanghai docked bike sharing began in 2009 stations were installed in 5 of the central business districts. The number of public bikes rose to more than 80,000 in 2017, making it the city with the largest number of public bikes in the world. However, in 2015, dockless bikes were introduced and the number of bikes on the streets of Shanghai have grown exponentially due to the low costs (Figure 3) to 260,000 at the end of 2016, then 630,000 by April 2017 and 1.5 million by August 2017 (Sudmant 2020: 11).

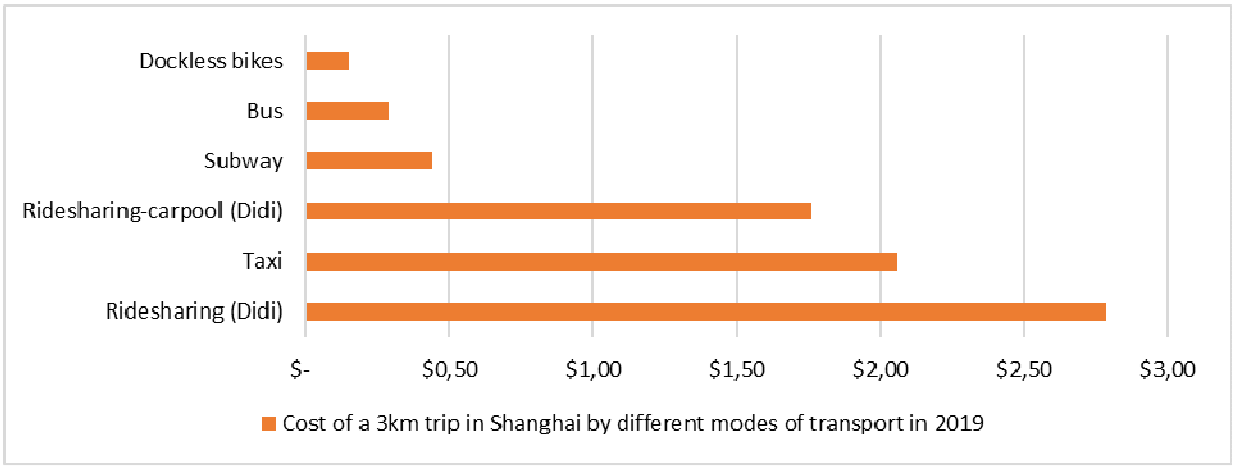


Fig. 3: Cost of a 3km trip in Shanghai by different modes of transport in 2019 (Source: Sudmant et al. 2020: 11)

The problems arose for Shanghai when there became an oversupply of bikes, some areas reporting around 16 bikes per residents, this led to the shutdown of 10 bike companies. Sidewalks were overcrowded with bikes and in some areas, there was lack of biking infrastructure which led bikers to compete with vehicles, making it difficult for users to depend on cycling as their commute. Policy directives were the main turning point for Shanghai (Sudmant 2020: 12-13).

In 2017, the city introduced national urban bike-sharing regulations (Sudmant 2020: 12-13). The benefits of these regulations could be seen in 2018 when real-time mapping and 'georeferencing' was introduced in the form of a mobile map was sent to all users on where they could and could not park, including a parking ban in 7 locations. This reduced illegal parking by 30%. Police had registered over 890,000 dockless bikes and regulations around e-payments and insurance made users feel a sense of security. The regulations around dockless biking policies are to promote non-motorised transport. Planning in Shanghai is guided by the Shanghai Master Plan (2017-2035) and the main aim is for "one networked, multimodal, fully covered and highly intensive" public transportation network. By 2035, the plan looks at making 85% of all trips green, meaning either public transport, walking or cycling. Another strategy introduced to promote NMT was to bring 'homes and workplaces closer together' by creating compact, connected, and coordinated urban development. Mixed use development coupled with improved public transport, bicycle lanes/widening of sidewalks and speed bumps increases the use of NMT (Sudmant 2020: 12-13).

6.3 Lagos

Lagos has a growing population, from 15-18 million in 2012 and is expected to rise to an estimated 25 million in 2025 (Olawole 2012: 2). There are around 6 million trips taken in Lagos every day, with 70-77% of these trips being through bus based public transport and the rest relying on private vehicles (Alade, Adeniji and Alade 2018: 3). Lagos introduced their first BRT system (Figure 4) in 2008 which caught the attention of many (Olawole 2012: 2). The BRT scheme transports approximately 10000 passengers per hour. Unfortunately, BRT stops are poorly maintained and designed as well as located badly (Alade, Adeniji and Alade 2018: 3). The lack of law enforcement at BRTs in Lagos makes it difficult to demarcate BRT lanes.

This gives way for private vehicles to come in and use BRT lanes, making it hard for buses and passengers to have ease of access (Haas 2019: 12).

Fig. 4: Lagos BRT buses (Source: Adekola and Ogundipe 2017: 10)

NMT, more especially walking is the most common form of mobility in low-income households in Lagos (Alade, Adeniji and Alade 2018: 4). Around 30% of mobility in Lagos is through walking and cycling. The relationship between pedestrians in Lagos is dangerous as there are very few walkways, footbridges, under passing and so forth for pedestrians and no cycle lanes for bicycles. Pedestrians are forced to share the carriageway with motor vehicles. The inefficiency in NMT planning also leads to poor public transport provision with many pedestrian accidents occurring at unsafe bus stops. The lack of proper NMT infrastructure to cross over primary roads and highways restricts the easy movement of people and goods creating poor pedestrian mobility. The problem lies with transport policy neglecting the promotion of NMT (Alade, Adeniji and Alade 2018: 4).

6.4 Jakarta

In 2019, it was reported that less than 10% of Jakartans travelled by private cars. During the COVID-19 pandemic, there was a huge growth in the amount of cycling around the world (Institute for Transportation & Development Policy 2021: 6-8). Fortunately for Jakarta, the city had already been planning a 500-kilometre network of cycle lanes around the city and the foundations were already laid out. A study done in the city centre of when lockdown restrictions were eased showed that the amount of cycling (Figure 5) had increased by an impressive 1000% from the previous year, other parts of the city showed an increase of 500% and more. This smooth transition is owed to the work done to increase the number of cyclists by the Institute for Transportation and Development Policy (ITDP) for years prior to the pandemic (Institute for Transportation & Development Policy 2021: 6-8).

Fig. 5: Cyclists in Jakarta (Source: Institute for Transportation & Development Policy 2021)

Through the ITDP involvements, in 2019, the Transjakarta BRT system was able to reach 1 million riders per day (Institute for Transportation & Development Policy 2021: 6-8). This is due to the integration of multimodal transport, service improvements and enforcement. Other measures taken to improve the user

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

utilisation of Transjakarta was to make sure that busses were on time and reliable through bus drivers being paid based on distance travelled instead of per passenger. The BRT also has 200 kilometres of dedicated lanes in 13 corridors which the police make sure are clear of any other vehicle that is not the BRT. By ensuring the increase in cycling (NMT), there was an increased dependency on public transportation (BRT), lowering private motorised vehicle use (Institute for Transportation & Development Policy 2021: 6-8).

6.5 Cape Town

The National Department of Transport released a Public Transport Strategy and Action Plan in 2007. This led to the city of Cape Town to implement Integrated Rapid Public Transport System (Barendse 2016: 35). The City of Cape Town Integrated Rapid Transit System Operational Plan Phase 1 Report found the need to integrate different modes of transportation to maximise customer utilisation, particularly the integration of NMT (Barendse 2016: 42-45). The NMT were provided to assist with the integration of the MyCiti BRT services (Figure 6). A 3-metre-wide shared bicycle and pedestrian facility was implemented along the entire 16km of the R27 Corridor. Along the Trunk Route, 500 metres of secondary network paths were provided for pedestrians and cyclists. However, the class of NMT was decided using the existing road reserve, whereby, there were no demarcation of cycle lanes, or a cycle lane was painted on the existing road. No road widening provisions were made for cyclists, leading one to realise that cycling was not given much importance (Barendse 2016: 42-45).

Fig. 6: MyCiti BRT in Cape Town (Source: eNCA 2016)

In order to calm traffic, speed limits were implemented. Other traffic calming options such as speed humps and roundabouts were not implemented as it would have negative impacts on bus speeds and user comfort when busses would have to go over or around these. Pedestrian priority at intersections where stations are located have block crossing. Tactile paving was also applied to warn cyclists that priority should be given to pedestrians which again suggests that cyclists are being neglected (Barendse 2016: 42-45).

6.6 Johannesburg

The NMT provided along Soweto–Johannesburg CBD and Line 1B to aid in ease of access to Rea Vaya (Figure 7) stations in both Soweto and the Johannesburg CBD and Line 1B which is the University of Johannesburg and the University of Witwatersrand routes. The feasibility study of NMT infrastructure was conducted between 2012-2013 and was analysed using seven indicators (Okoro and Lawani 2022: 71-74).

Fig. 7: Rea Vaya buses (Source: Business Insider SA 2014)

- Level of usage: the demand for the provided NMT is high as many pedestrians utilise it, however, cyclists barely use the NMT. The BRT (Rea Vaya) is in low demand as users have issues of accessibility, with their homes being too far away from stops and would rather use taxis or an Uber.
- Traffic congestion: traffic is very much evident during peak hours of the day as Rea Vaya buses must stop alongside the road because there is no dedicated parking for the buses. Other forms of private transport usually take up the space that should be for the Rea Vaya buses.
- Quality and condition of infrastructure: the overall infrastructure of the roads, walkways and cycle lanes were good. However, some users reported that maintenance was required in terms of vegetation, trash and the paving being loose on walkways, as well as the road markings not being clear enough.
- Maintenance: streets and NMT facilities are well maintained. The community contributes to the upkeep of the street and NMT.
- Safety and security: there are no security measures in place and users do not feel safe in terms of crime and road congestion not being safe for those who walk or cycle. Users also reported that the police are unhelpful, and the public transport should be more directly linked to the NMT.
- User satisfaction: users of the NMT are satisfied but expressed that many of the users must take one or more taxis just to get to the Rea Vaya. Costs were lessoned through using the NMT.
- New business ventures: there have been new business ventures along the NMT such as secure parking of bicycles, lockers, places selling refreshments, Wi-Fi, bicycle repairs/maintenance and so forth (Okoro and Lawani 2022: 71-74).

7 LESSONS LEARNT

All case studies have had both shortfalls and successes. Below (Table 1) provides a list of lessons learnt from each case study which other cities looking to implement NMT within a public transport realm can take into account.

City	Lessons learnt
Singapore	• Smartphone apps with a scanning QR code for payment assists with faster payment. • GPS sensors installed on dockless bikes not only assists with bike management but also provides valuable data. • The introduction of new bikes lowers the amount of trips. • Better infrastructure and support services increases the amount of trips, however when there is a lack of shelter, weather conditions such as rainfall and hot weather conditions decrease the amount of trips. • To increase both NMT and public transport trips, an integrated payment system is required.
Shanghai	• Private companies not controlled by government regulation leads to an oversupply of bikes – creates overcrowding and the shutdown of bike companies. • Government policy and regulation of bike use – the registration of bikes with police, e-payments and insurance and the creation of the Shanghai Master Plan (2017-2035) to connect NMT and public transport all improved the dockless bike problem of an oversupply of bikes. • Real-time mapping and 'geo-referencing' mobile app of where and where not to park bikes reduced illegal parking by 30%.
Lagos	• Poor demarcation planning of BRT lanes creates accessibility issues for buses and users. • Poor to no NMT planning for users is not only unsafe but also hinders efficient public transport planning and use.
Jakarta	• A large cycle network throughout the city combined with the COVID-19 pandemic boosts cycling dramatically. • The increase in NMT use increases the dependency of public transport use. • Increased usage of public transport due to multi-modal transport integration, service improvements and enforcement.
Cape Town	• An integrated rapid transit systems which plans for both public transportation and NMT increases usage of both.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

	• Using the existing road reserve to demarcate cycle lanes or not even creating cycle lanes indicates that cycling is not given priority – cyclists are also warned to give pedestrians priority on NMT lanes. • No traffic calming tools are used around the BRT to ensure buses remain on time and users are comfortable. • Intersections near BRT stations have block crossing for pedestrian safety and accessibility.
Johannesburg	• BRT is not very accessible to users – creating a low demand of the NMT for cyclists but the demand surprisingly remains high for pedestrians. • NMT creates an opportunity for new businesses along the route such as bicycle repairs/maintenance and refreshments. • Poor demarcation planning of BRT lanes creates accessibility issues for buses and users. • Community engagement and maintenance of NMT contributes to the upkeep of the street and NMT.

Table 1: Lessons learnt (Source: Authors)

It is evident that each case study has distinct lessons that cities aorund the world can learn from. One main point that clearly stands out is that the improvements in NMT increases the usage of public transport and vice versa.

8 CONCLUSIONS AND RECOMMENDATIONS

Evidence suggests that NMT has a positive impact on all cities. However, when left to private companies there could be an oversupply of equipment required for NMT, for example, the case of Shanghai where there was an oversupply of bikes which not only overcrowded sidewalks but also led to many bike companies closing down. When government intervenes and implements policy it assists the regulation and smooth process of bike use. Singapore focuses on the integration of trips, NMT leads to public transportation and other important nodes. Singapore looks to strengthen the integration of NMT and public transport through the use of smart payments making the process seamless. Lagos has put many plans into place with regards to the BRT but when it comes to NMT planning, Lagos fall short with pedestrians and cyclists having to share road space with motor vehicles, which is not only unsafe but inefficient. Jakarta was able to seamlessly transition into cycle transport as infrastructure and plans supporting NMT were implemented just as the COVID-19 pandemic had struck which left people finding it easier and safer to travel via NMT. The NMT in Jakarta also gave way to the increased use of the BRT system. Cape Town implemented NMT along BRT routes to improve the integration of transport for users, however, no traffic calming methods were implemented to reduce speeds and user comfort on the BRT. Johannesburg's NMT, though helpful to get to the BRT, other modes are required from users' homes to the NMT. Users do not feel safe using the NMT but the community is involved in the maintenance and upkeep of NMT and users believe that they save money from using it. More projects integrating NMT and public transport systems need to be carried out in all cities around the world, however, future projects need to take into account the lessons learnt from the different case studies.

9 REFERENCES

ABDULLAH, Z. Bike-sharing in Singapore gathers speed after 1 year, but there may be bumps ahead. 2018.
ADEKOLA, P.O. and Ogundipe, A. An assessment of the state of environmental management in Nigerian capital cities. J. Geogr. Enviro. Earth Sci. Int, 12, pp.1-13. 2017.
ALADE, W., ADENIJI, F. and ALADE, B. Making Lagos a Cool City: A Study of Transport System and Travel Behaviour. 2018.
BARENDSE, C.J. Enhancing integrated transport planning: A spatial multi-criteria analysis approach to the MyCiTi integrated rapid transit system, South Africa (Master's thesis, University of Cape Town). 2016.
BUSINESS INSIDER SA. Joburg pensioners can travel for free on Rea Vaya busses – but only during these times. 2021.
DOVEY, K. and PAFKA, E. What is walkability? The urban DMA. Urban studies, 57(1), pp.93-108. 2020.
ENCA. Cape Town company to manufacture green MyCiTi buses. 2016.
GÖTSCHI, T., GARRARD, J. and GILES-CORTI, B. Cycling as a part of daily life: a review of health perspectives. Transport Reviews, 36(1), pp.45-71. 2016.
GUMBO, T., MOYO, T., NDWANDWE, B., RISIMATI, B. and MBATHA, S. Urban Public Transport Systems Innovations in the Era of the Fourth Industrial Revolution: Perspectives, Reflections and Conjectures, Springer Nature Switzerland AG. 2022.
GUMBO, T. and MOYO, T. Exploring the Interoperability of Public Transport Systems for Sustainable Mobility Developing Cities: Lessons from Johannesburg Metropolitan City, South Africa, Sustainability, 12, 5875; 1-16. 2020.
HAAS, A.R. Key considerations for integrated multi-modal transport planning. Cities That Work. 2019.

INSTITUTE FOR TRANSPORTATION & DEVELOPMENT POLICY. Jakarta, Indonesia is what resiliency looks like. 2021.
LITMAN, T.A. Economic value of walkability. Canada: Victoria Transport Policy Institute. 2017.
MOODY, M. The case for transition to a sustainable transport system in Stellenbosch (Doctoral dissertation, Stellenbosch: Stellenbosch University). 2012.
OKORO, C. and LAWANI, K. Optimising sustainable mobility: A performance assessment of non-motorised transport infrastructure in Johannesburg, South Africa. Journal of the South African Institution of Civil Engineering, 64(2), pp.67-76. 2022.
OLAWOLE, M.O. Accessibility to Lagos bus rapid transit (BRT LITE) bus stops: an empirical study. In International Conference on the role of urban mobility in (re) shaping cities–CODATU XV (Vol. 22). 2012.
ORTEGON-SANCHEZ, A. and HERNANDEZ, D.O. Assessment of the potential for modal shift to non-motorised transport in a developing context: Case of Lima, Peru. Research in Transportation Economics, 60, pp.3-13. 2016.
RAHMAN, M.M. Planning for sustainability of non motorised public transport in a developing city (Doctoral dissertation, Queensland University of Technology). 2013.
RISIMATI, B., GUMBO, T. and CHAKWIZIRA, J. Spatial Integration of Non-Motorised Transport and Urban Public Transport Infrastructure: A Case of Johannesburg, Sustainability, 13, 11461; 1-17. 2021.
SELALA, M.K. and MUSAKWA, W. The potential of Strava data to contribute in non-motorised transport (NMT) planning in Johannesburg. International Archives of the Photogrammetry, Remote Sensing & Spatial Information Sciences, 41. 2016.
SHEN, Y., ZHANG, X. and ZHAO, J. Understanding the usage of dockless bike sharing in Singapore. International Journal of Sustainable Transportation, 12(9), pp.686-700. 2018.
SUDMANT, A., MI, Z., OATES, L., TIAN, X. and GOULDSON, A. Towards sustainable mobility and improved public health: Lessons from bike sharing in Shanghai, China. 2020.
UNITED NATIONS CENTRE FOR REGIONAL DEVELOPMENT. Intergovernmental eleventh regional environmentally sustainable transport (est) forum in Asia 2-5 October 2018, Ulaanbaatar, Mongolia: Mobility and NMT in Sustainable Urban Development –Role of City Developers, (Background Paper for EST Plenary Session-5). 2018.
ZHOU, Q., CHE, M., KOH, P.P. and WONG, Y.D. Effects of improvements in non-motorised transport facilities on active mobility demand in a residential township. Journal of Transport & Health, 16, p.100835. 2020.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

🏆 *reviewed paper*

The Struggle to Belong: Middle Classing and Social Change in Post-Apartheid South Africa

Vuyiswa Letsoko, Kammila Naidoo, Trynos Gumbo

(Vuyiswa Letsoko, University of Johannesburg, Department of Urban and Regional Planning, Cnr Siemert & Beit Streets, Doorfontein, 0184, Johannesburg, South Africa, 2028, vuyisway@uj.ac.za)
(Prof. Kammila Naidoo, University of Johannesburg, Department of Sociology, 5 Kingsway Ave, Rossmore, Johannesburg, 2092 kammilan@uj.ac.za)
(Prof. Trynos Gumbo, University of Johannesburg, Department of Urban and Regional Planning, Cnr Siemert & Beit Streets, Doorfontein, 0184, Johannesburg, South Africa, 2028, tgumbo@uj.ac.za)

1 ABSTRACT

The social and urban landscape in Johannesburg has been profoundly influenced by its' legacy of colonial and apartheid rule. Apartheid legislation such as the Group Areas Act of 1950 significantly embodied apartheid at an urban scale as it segregated and policed social space on the basis of racial classification where large numbers of people classified as native (also referred to as African, bantu or black), Indian (or Asian) and coloured were relocated to planned settlements to the periphery of cities and leaving the inner city and many areas to the north, east and west as white residential zones. The demise of apartheid and its administration in 1994 has resulted in Johannesburg becoming more racially integrated over time. Conversely, the democratic era has also been associated with a change in the class structure in the country, in particular, the growth of the black middle class. There is no longer always a direct relationship between race and income which means that black, Indian and coloured people are able to live in former white areas and neighbourhoods. Given the rise of crime and violence in the city, residential gated communities have been seen as the common housing option for middle- and upper-class social groups of the country. These developments were initially proliferated by mainly white groups in society, however changes in class dynamics in the country have resulted in growth of the black middle class living within these spaces, therefore creating racially integrated residential pockets in the city. The lived experiences of the black middle class within these spaces, remains under-researched. The study employs a qualitative thematic exploration through the use of in-depth interviews with a group of black middle-class residents residing in two South African residential gated communities in Johannesburg to unpack the politics of belonging to the community and the pressures and complexities of gated living and how that impacts identity formation and self-realisation. The interview data indicated the negative impacts of stereotype threat as black residents live with the historical legacy of being viewed as part of an inferior race. The findings outline various strategies that black residents employ to reaffirm their belonging to the community. Furthermore, the results provide a multi-layered analysis of race, identity, difference, space and place in a post-apartheid urban setting. The study makes recommendation for the decolonisation of privatised residential communities to create more inclusive and cohesive communities.

Keywords: South Africa, class, social change, black middle class, belonging

2 INTRODUCTION AND CONTEXTUALISATION

A central focus of the apartheid state was to cement racial segregation and limit social interaction between racial groups whilst discriminating against non-white groups of society in all spheres - political, social and economic (Lemon, 2021). The Group Areas Act of 1950 significantly embodied apartheid at an urban scale as it segregated and policed social space by "controlling the use, occupation, and ownership of land and buildings on a racial basis, and emphasised separate residential areas, educational services, and other amenities for the different race groups" (Maharaj, 2020:43). Furthermore, it was devoted to imposing control of inter-racial property transactions and occupation with the aim of establishing areas that are exclusively occupied by each racial group (Southall,2022). These processes of controlling the movement and living spaces of Black, Coloured and Indian race groups engendered "mercilessly divided" cities (Seekings, 2000:832) and fragmented racially integrated neighbourhoods in different parts of the country. such as Sophiatown in Johannesburg (see Lodge, 1983); Cato Manor in Durban (see Maharaj, 1994) and District Six in Cape Town (see Hart, 1988 and Western, 1996). This has resulted in a unique and prominent spatial impact on South Africa's current landscape (Singh and van Eeden, 2017).

The demise of apartheid in 1994, represented a time for change and opportunity, as this transition equally saw a change in the class structure of the country, more particularly the growth of the black middle class (Ballard, 2015). The expansion of the black middle class in the post-apartheid era has been largely attributed

to the enactment of legislation transforming the socio-economic and political landscape and the adoption of affirmative action and black economic empowerment to readdress inequalities resulting from the colonial rule (Khunou, 2015). Furthermore, the de-racialisation of public and private spheres of society such as government, education, the workplace also resulted in racially mixed social spaces and higher upward mobility of historically designated black groups into the middle class (Southall,2022). This upward mobility and new found freedom provided by the democratic era also had significant implications for residential desegregation and diversity as some black middle class took the opportunity to move from the townships to suburbia or former white suburbs – the locus of white power, privilege and status (Ndlovu, 2020; Donaldson, et al 2013).

This trend is also apparent in contemporary developments, residential gated communities which are privatised physical locations whose access is restricted by walls, fences, gates or booms that detach their communities from their surrounds (Liu and Song, 2017). Ballard (2005:2) opines that these developments were initially conceived by the white population as comfort zones in the post-apartheid era "in order to create living environments which would facilitate their modern, European, sense of themselves" that has been lost as a result of democracy and integration. While these were initially conceptualised as white spaces, changes in class dynamics in the country have resulted in growth of the black middle class living within these spaces. therefore creating racially diverse pockets in the city which still remains largely segregated. While research on the black middle class in South African cities is currently on the rise, there remains a gap in literature pertaining to how the black middle-class experience are belonging to contemporary suburbia and what these experiences tell us about social change. The main objective of the study is to address this gap by unpacking the politics of belonging by the black middle class in residential gated communities in Johannesburg suburbs and the pressures and complexities of gated living and how this intersects with black identity formation and self-realisation in the post-apartheid era.

3 LITERATURE REVIEW

3.1 Conceptualising the black middle class in South Africa

The concept of class has been extensively theorised in social sciences and literature has largely focused on class analysis in western societies. Mercer and Lemanski (2020) indicate that in Europe and America status (income and education) is considered a primary indicator of class rather than income but. given that income and status interconnect, they reveal roughly the same population group. However, Lentz (2017) shows how the inverse is true in the global South, as emphasis on income-based class measures is largely critiqued for ignoring the lived experiences of being middle-class. Historically, Nduna, (2017) highlights that class originated from the industrial revolution in Britain where it was constructed as a social stratum with members falling within a lower, middle and upper class. While the lower class refers to the groups in society that occupy the lowest socioeconomic position and have the least money, the upper class refers to the highest socio-economic members of society who are also the owners of the means of productions, distribution and institutions that enable them to maintain this level of economic control (ibid). The middle class on the other hand has been defined and described in various ways resulting in what Lents (2017:18) terms a 'conceptual quagmire'.

While there is no global consensus on the definition of the middle class, Mercer and Lemanski (2020) indicate that the dominant definitions of the middle class in the global South have been established by the International Labour Organisation and the African Development Bank where the term is broadly defined as households with a daily per capita consumption of US$4 to US$13. While these quantitative measures of class are useful, Melber (2017: 2) opines that they can often be misleading as they suggest that 'everyone not starving is middle-class'. Other academics have focused their definitions of the middle class on homeownership (Krige, 2015), standard of living (Nhlapho and Anderson,2010), credit worthiness (James, 2015) and political attitudes and position (Southall,2004). From these broad themes derived on how the middle class is defined, one is able to see that the two main indicators of the middle class namely i) wealth and ii) status.

In the Global South, the rise of the "new" black middle class has become a topic of public and scholarly interest (de Coninck, 2018). Black in this context refers to previously disadvantaged groups of society formerly referred to bantu and what the BBBEE refer to as African (Nduna, 2017). Visagie (2013) notes that

the metrics used to identify class in South Africa is occupation, per capita household income, income measures based on lifestyle, and status. Therefore, the terms "black" and "middle class" are merged to form the "black middle class" to refer to the groups in society who were previously disadvantaged and are now liberated to have access to better lifestyle and status. Furthermore, Simpson (2008) explains that this group is also characterised by individuals engaging in white-collar professional jobs given their higher levels of education and skills.

The black middle class in South Africa, is particularly unique due to the intersection of class and race given the country's history of apartheid that stunted the growth and potential of the African middle class resulting in a polarised and highly unequal country (Zizzamia et al., 2016). Meanwhile white privilege and black deprivation were normalised by colonisation and apartheid, black upward mobility inverts apartheid's intended social hierarchy (Ballard, 2015). In fact, the nickname adopted by media to refer to this group was "black diamonds" suggesting that their emergence was considered rare and unusual. However, this group has since experienced considerable growth since the end of apartheid. This can be seen in the table below based on a report released by Unilever in 2016 that indicated that there were approximately 5.81 million black middle-class individuals in South Africa (BusinessTech, 2016).

Year	Number in Millions
2004	1.74
2008	2.67
2012	4.22
2014	5.33
2016	5.61

Table 1: Black Middle Class in South Africa 2004 – 2016. Source: BusinessTech, (2016)

One of the challenges in literature concerning the black middle class is that in some instances, certain individuals have a challenge with self-identifying as a black middle-class individual resulting in an over-reliance on statistical data in capturing the black middle-class experience. Khunou and Krige (2013) highlight that in South Africa there is an overlap in race, class, gender and life trajectories which are key determinants of whether an individual self-identifies as being black and middle class or not. They further suggest that racial economic differences, white middle-class exclusionary practices, and the resistance to "market labels" had an impact on whether the term was considered acceptable to them or not. Studies in the UK and USA also found that self-identifying and middle class is a complex process and has been met with contestations from black people for various reasons (Maylor and Williams, 2011; Rollock et al., 2011; Thomas, 2015). This indicates that there is actually no single way to be considered black and middle class.

3.2 Race, class and belonging in Johannesburg: from residential segregation to integration

The City of Johannesburg is often termed a dual-city given its high levels of inequality. A key contributor to this inequality is the legacy of apartheid planning which legitimised exclusionary practices through the use of artificial and unnatural growth patterns that led to the manifestation of a fragmented urban form in South African cities (Harrison & Williamson, 2001). During the high apartheid era (1948-1978), buffer zones such as highways, railway lines, open spaces and servitudes were used to cement racial and spatial divisions in South African cities (Spocter, 2021). The Group Areas Act (Act 41 of 1950) was one of the key instruments that were used to reinforce this apartheid ideology and gave rise to the apartheid spatial form depicted in the Fig. 1.

The figure below presents the widely cited spatial model of the apartheid city which was developed by Davis (1981) that indicates the spatial implementation of the group areas principles. The description of the apartheid city model is well captured by Lemanski, Landman and Durington (2008:141):

"The city was exclusively White, with blacks considered 'temporary sojourners'. Black Africans, Coloureds and Indians were forced to settle in or were relocated to 'townships' on the urban periphery. The [apartheid] government produced rows of identical ('matchbox') houses in these dormitory areas, rarely accompanied by adequate engineering services, social infrastructure or parks and open spaces."

The apartheid city was systematised in such a way that non-white areas were denuded of facilities, adequate basic services, and employment opportunities. Non-whites could only enter "white group areas" as workers, servants, or consumers and passed laws were implemented as a form of social control and to regulate the level of access allowed by these groups in society (Morris,2004). The Group Areas Act (Act 41 of 1950) dismantled racially integrated spaces in Johannesburg such as Sophia town and uprooted people and their

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

families from their homes to poorly built and under-serviced townships (Maharaj, 2020). In 1994 when the country gained democracy, there were a number of transformations that impacted on the socio-spatial structure of the city. For instance, while affluent former white only suburbs, for the most part, retained their privileged socio-spatial and economic status as they experienced massive investments in infrastructure developments post-1994 such as new residential areas, malls, and commercial complexes etc. Butcher (2021) notes that residential de-racialisation through such market force developments from the early 1990s have been key drivers of the social geography in Johannesburg. These spaces also saw changes in their demographics as the demise of the Group Areas Act and other influx control laws resulted in greater mobility and residential desegregation for people of colour. They were no longer bound by their "racial zones' and had greater choice of their residential location (Spocter, 2021). This led to the movement of black middle-upper-classes to formerly white only residential areas (Donaldson, et al, 2013). Ballard (2005) explains that the acceptance of other 'races' into these former white areas was however conditional and the black middle class found themselves needing to assimilate and adapt to the culture, norms and standards that were practised by the 'host' white group.

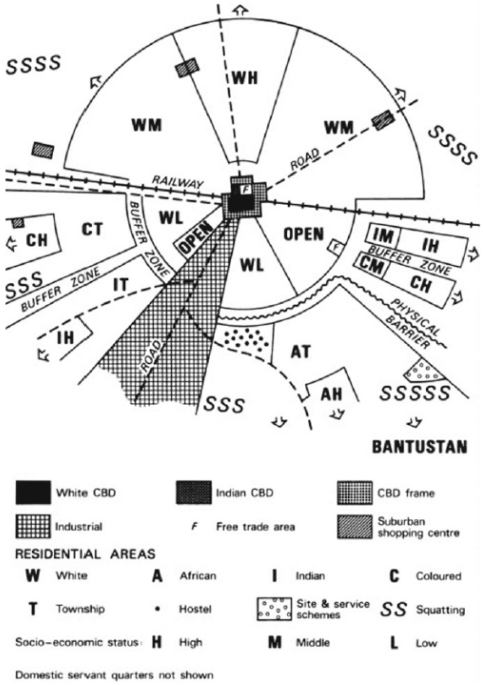


Fig. 1: Apartheid City Model. Source Davies (1981)

One of the core objectives of the democratic government has also been to integrate communities to undo the spatial injustices of apartheid. Seekings (2008) explained that integration in the post-apartheid is taking place mainly in state-driven low-income projects, apartment blocks or voluntary integration in new private housing areas. Similarly, residential gated communities have become a key characteristic of the post-apartheid suburb and while they were initially conceptualised as home only for the white elite in society, they too are starting to become diverse and racially integrated (Ballard, Jones and Ngwenya, 2021). This indicated the potential for these spaces to promote integration in the city and also serve as vessels which are semi-open borders of interaction between different social groups and communities (Salcedo and Torres, 2004). Not only does this produce new communities but also platforms for new forms of conflicts and politics of belonging in the city. The concept of belonging has recently emerged as a critical issue confronting contemporary society (Yuval-Davis, 2015). Due to the multidimensional nature of the concept and its application in various fields (e.g. politics, sociology and psychology) it is problematically broad and this also means that finding a single definition for the concept proves to be challenging. Ujang and Zakariya, (2015) highlight that the concept is also used interchangeably with the concepts of rootedness and sense of place and is generally understood as a human need that promotes a relationship, ability to shape identity, recognition, acceptance and attachment with someone or something. This definition of belonging is best suited in the context of the study in that it draws on the consciousness around a person's relationship to a community and facilitate an individual or collective ability to gauge how and why one differs from others. Here, one is able to assess how the black

middle class navigate difference in their individual and collective ability and how this impacts on their belonging in the community. Khaile, Roman and Davids (2020) explain that belonging has various social benefits. Not only is it closely linked to social cohesion but it elevates social relations, recognition and attachment that can assist in "developing a view of oneself to space and others and having the ability to claim or resist exclusion" (ibid,2020:60). They also explain that belonging is a necessary imperative and requirement of nation building (ibid, 2020). This was also evident in the South African Cities Network report that explained that "all citizens must have a sense of belonging spatially, socio-culturally and economically to our cities and cities were expected to enhance this sense of belonging through making and managing spaces and places that people can identify strongly with and frequent freely, without fear of intimidation or being unwelcomed – this is the way of the inclusive city" (2016:127).

4 METHODOLOGY

The research forms part of the findings of a larger PhD study concerning social interactions within residential gated communities in Johannesburg in the post-apartheid era. By critically focusing on the lived experiences of residents of gated communities, this study adopts a phenomenological approach to understand black middle class resident's perceptions and experiences of belonging in a residential gated community. At its most basic, phenomenology can be defined as an "approach to research that seeks to describe the essence of a phenomenon by exploring it from the perspective of those who have experienced it" (Neubauer, Witkop and Varpio, 2019:91). The research is designed as a qualitative study. This approach is best suited for the study as it enables the researcher to delve into the lived experiences of individuals, exploring certain feelings and emotions that are difficult to quantify (Creswell,2007). It employed in-depth semi structured interviews with eight black middle-class residents residing in two residential gated communities in Greenstone Hill, Johannesburg and sampled using purposive and snowball sampling techniques. The locality of these two residential gated communities that were the focus of the study are depicted in the figure below (shaded in red and yellow).

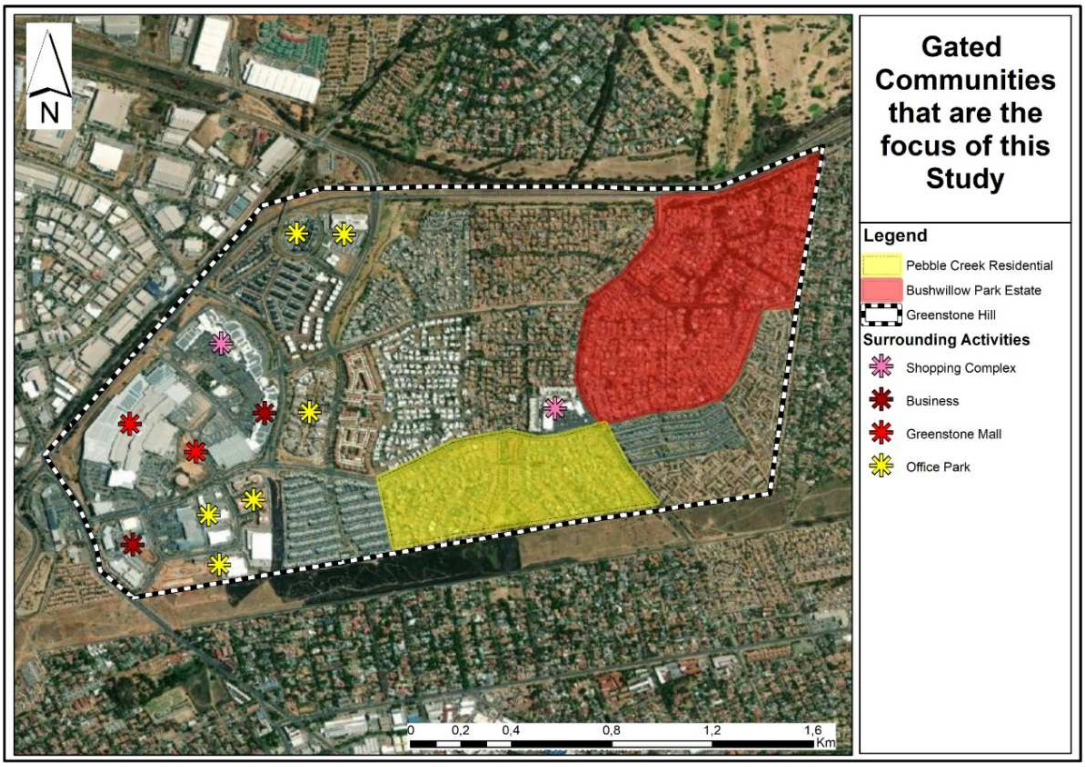


Fig. 2: Residential gated communities' locality

Greenstone Hill is a predominantly residential suburb located in the north-east of the City of Johannesburg within Region E. Although the history of this residential suburb is not well documented, it is relatively new and was initially a green field belt which transformed into the spatial expressions of privately driven city building. The area is commonly referred to as Greenstone and is made up of secured business parks, warehouse complexes, shopping malls, townhouse complexes and gated residential communities with free-

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

standing houses. Property24 (2021) reported that the property prices for sectional title schemes and houses sold in the area ranged between R1 592 500 - R3 150 000 in 2020/2021. The majority of the buyers, sellers and owners fall within an age group range between 18 – 49 years which means the area is a relatively young area.

5 RESULTS AND DISCUSSION

Neighbourly relations in the post-apartheid era are both complex and fragile. This is especially the case given the countries legacy of segregation where social mixing of different races and ethnicities were almost non-existent just twenty-eight years ago and the knowledge and familiarity on these lines are still weak and at times often based on the experiences of someone else. This is partly due to the persistence of mono-racial, mono-ethnic, and mono-cultural neighbourhoods that continue to define the socio-spatial dynamics of cities. Racial integration processes and urban transformations stemming from desegregation in the post-apartheid era brought with it feelings of uneasiness and uncertainty. Whilst the discussions in the literature review have shown how residential gated communities provide platforms for diverse everyday entanglements (of race, class, gender, nationalities, cultures etc.), the "other" is still unfamiliar and is filled with potentially misleading images resulting in heightened intergroup social anxieties and reduced sense of belonging. The discussions below present the key findings of the study based on the results of the data emanating from the interviews.

5.1 Self-identifying as black and middle class

A widespread notion in literature as well as in the slogans and images of advertisements relating to gated communities is the presentation of spaces that provide an exclusive lifestyle and private environment (Farid and Ahmed, 2018). An observation that was made during the collection of the data was that most of the residents self-identified as being black and middle class and this was mainly driven by their level of education, prosperity in their jobs and their ability to afford the lifestyle that a residential gated community provides. There was a general sense from the interviews that the pride of residing in a gated community coincided with status, wealth and class.

"Living in a gated community has that status to it right…as well as a better life for your family. I grew up in the rural side of Limpopo, Ga-Marishane to be precise and living here and the life I grew up in is completely different and yes it does give you that sense that you have made it, that you are taking up space but this is really just the start…ultimately I'd like to build a home in Dainfern or Serengethi which provides more space."

The above coincides with one of the main reasons behind the choice to move into a residential gated community while the other key issue was the concerns relating to crime but also to ensure that there is a sense of investment and legacy that is left for their children. Here, we also see the impacts of the apartheid legacy and how this has impacted on the life choices that have led to many of the black middle-class groups in the country move to residential spaces that represent opportunity and how the township is never regarded as such a space. From an identity perspective, one of the participants indicated that the label of black middle class was unnecessary and used to further cause divisions in the country. She explained the following

"What is the obsession with racial classifications in the country? I believe that more than anything it causes more divisions. I mean could we not just be considered as middle class, why do we have to term it as black middle class and white middle class? That draws lines between social groups that we are trying to unite as a country in a post-apartheid era. The middle-class experiences are the same in my opinion regardless of race."

The above further indicates the challenges with conceptualising the middle class and more especially the black middle class and how this differs to white middle class experiences. The participants' view above are in contrast with another participant who believes the differences of the black middle class may not be largely different from an economic perspective, however from a social perspective he believes that unlike the white middle class, black middle class individuals continually find themselves at "a constant battle of defining our space and validating our existence and my reason for being and demonstrating that I had earned my space"(participant). This also aligns to Fanon's (1986:25) views that despite black peoples achievements and the wearing of European clothes,... using European furniture and European forms of social intercourse;... using bombastic phrases in speaking or writing the European language ...', to achieve a sense of equality, he remains 'barred from all participation in a white world'. This suggests that the experience of the black

middle class cannot merely be equal to that of the white middle class and vice versa. Moreso, Moore (2008) observed that many of the first generation black middle-class often have lower-class relatives who are relying on them for help which further complicates the experiences of a black middle class resident. In fact, many of the participants indicated that the recent economic challenges facing the country as a result of Covid, have placed additional pressures on their ability to retain their middle class status. These sentiments are apparent in the participant's views below:

'While I do agree to a certain extent that I and my family are considered to be a middle class family, situations in the country are really quite bleak so while I can afford the lifestyle of living in a gated community and afford my family this type of quality of life and you know sense of peace…the flip side of that is that many of us here, especially after Covid are starting to really feel the pinch and find ourselves going deeper and deeper into loans and stuff just to keep up with the middle class lifestyle…living in an estate is expensive, there are rates, taxes and levies which need to be paid so it is tough to keep at it while also looking after your family back home [outside the gated community]."

5.2 Stereotype threat and navigating belonging

Belonging as expressed by the participants was identified as a feeling (attitude and behaviour) as well as a state of being (experienced in connection to others in the community). While these were largely based on personal experiences they were also connected to their experiences towards the community. One participant described the social aspect of belonging as being closely related to their ability to feel that they are not judged and are considered an ordinary member of the community, like other residents from other races. This however was not the case as there was a general sense of detachment and avoidance regarding the broader community by the black residents and a skewed sense of belonging not only to the community but to the space of the gated community. Some of the avoidance of interaction and getting involved can be traced to the preconceptions that black people have of what others think of them. Pettigrew (2010) talks about the stereotype threat, which is triggered by the awareness and attention that others view your group as inadequate. The belief that some people are still thinking that they are better than black people, because they were taught that way during apartheid, divides people. The inherited memories of the time when black populations were not allowed in certain urban areas, has left a strong imprint in people´s minds. The non-belonging of black people emerged in both the self-reflective notions of black African residents. This is present in the interview excerpts below:

"Estates were never made for black people, so it makes sense why we will feel like we are out of place"

"Home" is back home in Hammanskraal [a township in the North of the City of Tshwane], I struggle to consider this as home and you see this with other black people who will say ke ya hae over the festive season, December comes and it is quiet in Joburg…white people have gone on holiday and blacks have gone back home… this is not where your family is…family is in the townships and the rural areas for us blacks."

Additionally, conversations with the black participants in the study indicated that some of the black residents in this study live with the historical legacy of being viewed as part of an inferior race. Maldonado-Torres (2016) called this the "zone of non-being" where he conceptualises the zone of blackness as the zone of damnation, suggesting that in historically racist contexts, to be Black is to be seen as cursed and damned. But, the form of how this works goes further than this. Black subjectivity is located within the tension between the "desire" to be White (regarded as human) and complete resignation because "the hell of coloniality is that of self-erasure: blackness must disappear or at least be covered-over by whiteness" (2016). One of the participants expressed the following in relation to this:

"You are not able to fully express yourself as a black person in a gated community for fear of being told that you are too loud or that you are being too ghetto or black…so one needs to adopt a different type of behaviour, like a white behaviour…unlike when you are in the township…when I enter the gates of the estate I immediately just lower down the volume on my radio, pull up the windows, you know act civil…this is very different from the township, I mean when you approach the township already you have your music blasting really loud…you roll down the windows because you are almost certain that on your drive home you will bump into someone and have a brief conversation, or just greet people man".

The above excerpts briefly compare the lived experiences of the township versus life in a gated community. Unlike much of the research that paints the township as a negative and crime-ridden space, these sentiments

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

shed some light on the positive memories and experiences expressed by some participants in the study. The township is depicted as a friendly space with a sense of connection in contrast to the individualistic nature of the gated community. The above also indicates that black residents use assimilation and adaptation strategies to conform to the norms of gated living, even though this might have a negative impact on how they experience their communities. While residing in a gated community was a choice that all the black residents interviewed made for themselves, they also indicated how moving back to the township was not an issue given the lack of investment and infrastructure in the township communities. Furthermore, the township was commonly seen as an undeveloped space that leaves very little desire and retention of the black middle class. This was captured in the interview excerpts below:

I could never see myself moving back to the township…the moment most black people make it and earn a decent income, one automatically thinks of moving out…the government also has failed those spaces but it is also because the township was never made to shine, it is just the social engineering of apartheid and the legacy it has left…there are no good schools, places of recreation especially for kids. The government just deserted those space and I see it every time I go to Katlehong and that also makes one feel a bit sad and guilty because your community is suffering. yet you are living on the brighter side of life…poverty has trapped a lot of people in the township and I think the advantage of mobility is one of the biggest advantages for black middle class families in times of today… this also makes it very hard for a black prosperous person to actually belong anywhere in the city… the townships are underdeveloped and the suburbs do not fully cater for the black experience, so where do we belong actually or find that sense of belonging?

The above dialogue highlights a certain level of guilt that some residents have about having access to such a lifestyle in comparison to the majority of the individuals who are adversely affected by socio-economic inequalities in the country. Furthermore, the above also indicates the rationale behind the middle class deciding to leave the township space. Donaldson, et al, (2013) however indicate that there are some black middle class residents that decide to stay in the township regardless of their economic mobility. They explained that in their study more than half (53 per cent) of the black middle class residents in their sample of 180 participants remained residents of the township, compared with only 32 per cent who had moved to former whites-only suburbs. This observation also raises the following question, which is why do some of the black middle class not leave townships and what are those who do escaping? Donaldson, et al, (2013) explains that this is due to the perception that there is no ubuntu where a black person is likely to be considered an "outcast" (Ndlovu, 2020) within the suburban context which therefore will also have negative impacts on belonging. However, the sad reality is that the township spaces still remain largely untransformed. In fact residential desegregation is more prominent in the former white only residential areas and the same cannot be said about the township space which remains predominately black. Posel (2010: 160) terms this 'racially politicised consumption' that has resulted in the reinforcement of regimes of belonging – black people only belonging to the township, white people belonging to the suburb. Ndlovu (2020:575) explains that this is unsurprising though as townships were socially engineered as a zone to limit and cripple the rights of blacks to own land or homes and therefore the township in the post-apartheid, "emerges as a place set up to prove that, since all black people are poor, nothing should suggest the contrary".

5.3 Navigating a double consciousness: privilege, identity, and culture

For many of the participants the gated community is considered "for whites only" even if the demographic reality showed differently. Even though black respondents did not give harsh labels or stereotyping attributes to non-black residents the same way as the other race groups did of the them, the prejudice towards non-black groups was very much present. It just took a different verbal form. The gated community, therefore, becomes a stage for the Black middle class where "whiteness" is performed, and Black identity redefined for civility to prevail. "Whiteness" in the narrative above is positioned as individualistic, unfriendly, and non-sociable. Furthermore, the gated community was perceived as both an opportunity and challenge. Many of the Black residents expressed a sense of guilt for living a lifestyle that was quite different to back 'home'. One participant conveyed the following sentiments:

"I don't know but there seems to be this thing ko kasi [in the township] that if you live in a white space, you have made it and stuff…people even sometimes think you are now less of a black person just because you stay in the suburbs or they make funny comments about you, that you are better than them…people will say you are lucky and stuff but like…I have worked hard for my family to build a home and stay here, it didn't

come easy and definitely was not cheap but also you have that sense of guilt…a lot of people back home are still struggling and here you are sitting in all this privilege so it is sometimes a hard pill to swallow."

The above sentiments links to Du Bois' (1982) theory of 'double consciousness' that is employed as a coping mechanism for black people living in a pluralistic society and find themselves being members of two different communities resulting in feeling pressured to adhere to both sets of standards and evaluating oneself on the basis of others' perceptions. A common statement among black residents is that that they do not consider the gated community as their home. Home connotes safety and familiarity. The search and longing for home has become pressing in an age of global uncertainty, profound change and displacement. As Duyvendak (2011) argues, the world is increasingly homesick (for the places of origin) and nostalgic (for the 'good old days'). Home, therefore, reflects a desire to stabilise the disruptions of identity arising from the loss of place (Woodward, 2002). In a world we experience as increasingly alienating, it offers the promise of return, unity, fullness and stability (Brickell, 2012; Nichols, 2008). It is through the trope of home that articulations of belonging come to be figured (Yuval-Davis, 2006). The simplicity of the statement, 'I belong here' evokes an intuitive knowing that often requires little interrogation to understand its meaning (Antonsich, 2010). Belonging for the black resident was in the townships and rural settings, where black residents felt their culture and traditions were best understood. For instance, one of the participants explains this in the context of the custom of slaughtering which was considered unsuitable in the gated community:

"Just try slaughter a goat here and you will see the backlash you will get…that is what I mean when I say the space is not for Africans…How can I say I belong here if my cultural and traditional practices are frowned upon? Like for me it makes no sense why we are not able to slaughter here, I am a homeowner, I have the space in my home but I still can't slaughter…my concern really is that although we have homesteads back in the rural or township spaces where we practice our culture freely, what about our kids?...Black culture and traditions are fading because of such spaces or maybe it's a way to keep us out? Who knows?" (Participant)

As Ballard (2010) has analysed, slaughtering in the suburbs has caused contradictions between the African heritance and the white culture. The established middle class has condemned the custom, especially in the suburban areas, while black African people have seen it as their right to express their culture, and thus an entitlement of full citizenship and the free use of space. Furthermore, the above narrative also exposes a relationship between the resident, the gated community and the rural / township setting and further reveals why the gated community could be a conflicting environment for a black resident. While the township and the rural spaces were considered home for the black residents, these spaces were also considered "unprogressive" and "non-developmental" whilst the gated community presented spaces of opportunity and status. Conversely, the rules that are set in these communities can also be limiting and do not consider the diversity of the country to cater for the transformation and decolonisation of spaces within the city. One of the participants in the study also indicated how he believed that the gated community was providing a fake experience of the country and how this also has the potential to negatively impact on black identity formation in the post-apartheid era. He explains this in the following way

My concern really is, and I am not quite sure how this can be remedied considering the high numbers of people migrating to cities on a daily basis, that these estates are not only giving our kids a false sense of the world and of South Africa, but they also have negative prospects for young boys and how they form their identity in the suburbs as a black African child to learn isintu [tradition]…as time goes by our traditions and our cultures will be neutralised and diminished because urban spaces have no place for them…our kids' black identity is at threat, it has already started with the languages. In the home most kids only know English and not their mother tongue…so it remains important to plug these kids in and out of the rural and township space so they can know their roots.

The above also indicates the role of the township and rural spaces to realign one's blackness. This observation was also made by Chevailer (2015) who explained that black suburban middle class frequent the township for everyday activities, such as getting their hair done, going to a braai or socialising. One participant indicated that these trips have a deeper meaning in that they are a way in which they "reconnect with my people" but also to "fulfil my needs since the businesses and the salons here cater largely for white people, so I drive to Soweto every month end to get my hair done...also I feel like I can be myself, speak my language and be around people who I grew up with and understand".

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

6 CONCLUSION

This paper gave an insight into the dynamics of belonging for black middle-class residents in two residential gated communities in Greenstone Hill, Johannesburg. The study revealed that moving to former white urban spaces in the post-apartheid era is considered a symbol of increased social status, therefore contributing to how the black groups in society who have been able to reap the benefits of upward mobility self-identify as being black and middle class. There is also a consensus that while the term black middle class is challenging to define, it is approached in various ways but the lifestyle and ability to afford life within a gated estate is one of the key determinants of this social class according to the participants in the study. While these spaces, present opportunity for the black middle class, in comparison to the township and rural space, which are considered as forgotten spaces given the lack of government intervention and investment, there are also some considerable limitations that meet the black suburban middle class. These include their inability to practise their traditions and cultures freely, stereotypical views of non-black neighbours and performativity to assimilate and adapt to the rules and behaviours of these residential spaces that may be based on individualistic and westernised ideals of community.

7 REFERENCES

Ballard, R (2005) Bunkers for the Psyche: How Gated Communities have Allowed the Privatization of Apartheid in Democratic South Africa. Dark Roast Occasional Paper Series No 24. Cape Town: Isandla Institute.

Ballard,R. (2015) 'Black Middle Class in South Africa ("Black Diamonds")' in John Stone, Routledge Dennis, Polly Rizova, Anthony Smith, and Xiaoshuo Hou (eds) The Wiley Blackwell Encyclopaedia of Race Ethnicity and Nationalism. John Wiley & Sons, Ltd.

BusinessTech, (2016). This is what it means to be middle class in South Africa. 11 September 2016. Rerieved from:https://businesstech.co.za/news/business/134749/black-vs-whitemiddle-class-in-south-africa/.

Butcher, S.(2021). New Ward for a New Johannesburg? Reformatting Belonging and Boundaries in the City's South. Urban Forum,32:183–204.

Chevalier, S. (2015) 'Food, malls and the politics of consumption: South Africa's new middle class', Development Southern Africa 32 (1): 118–29.

Canham, H.,& Williams,R.(2017).Being Black, Middle Class and the Object of Two Gazes. Ethnicities, vol. 17, no. 1, pp. 23–46. JSTOR, https://www.jstor.org/stable/26413933.

Davies, R. J.(1981). The Spatial Formation of the South African City. GeoJournal, 1981, pp. 59–72. JSTOR, http://www.jstor.org/stable/45185147.

Donaldson, R., T. Mehlomakhulu, D. Darkey, M. Dyssel and P. Siyongwana (2013) 'Relocation: to be or not to be a black diamond in a South African township?', Habitat International 39: 114–18.

Fanon F (1986) Black Skin White Masks. New York: Grove Press.

James, D. (2015) Money from Nothing: indebtedness and aspiration in South Africa. Johannesburg: Wits University Press.

Khaile,T.,Roman,N.V.,&Davids,G.J.(2020). Possible effects of spatial injustice on the sense of Belonging of black communities' in south African.Metros: a review of literature. Journal of Culture, Society and Development, Vol.62.

Khunou G and Krige D (2013) Comment & Analysis: Why is it hard to be black and 'middle class'? Mail & Guardian, November 8–14, 27.

Krige, D. (2015) '"Growing up" and "moving up": metaphors that legitimise upward social mobility in Soweto', Development Southern Africa 32 (1): 104–17.

Lemanski, C., Landman, K., & Durington, M. (2008). Divergent and similar experiences of 'gating' in South Africa: Johannesburg, Durban and Cape Town. Urban Forum, 19, 133-158.

Lentz, C. (2017) 'African middle classes: lessons from transnational studies and a research agenda' in H. Melber (ed.), The Rise of Africa's Middle Class: myths, realities and critical engagements. Johannesburg: Wits University Press

Maylor U and Williams K (2011) Challenges in theorising 'Black middle-class' women: Education, experience and authenticity. Gender and Education 23(3): 345–356.

Melber, H. (2017) '"Somewhere above poor but below rich": explorations into the species of the African middle class(es)' in H. Melber (ed.), The Rise of Africa's Middle Class: myths, realities and critical engagements. Johannesburg: Wits University Press.

Mercer,C.& Lemanski,C.(2020).The lived experiences of the African middle classes Introduction.Africa,90 (3) 2020: 429–38.

Moore KS (2008) Class formations. Competing forms of black middle-class identity. Ethnicities 8(4): 492–517.

Ndlovu,T.(2020). Shuttling between the suburbs and the township: the new black middle class(es) negotiating class and post-apartheid blackness in South Africa. Africa, 90,(3),568–86.

Nduna,N.T.(2017). Black middle-class tourists' segment in South Africa: a critical analysis. African Journal of Hospitality, Tourism and Leisure, Volume 6 (4).

Neubauer,B.E, Witkop, C.T., Varpio, L.(2019). How phenomenology can help us learn from the experiences of others. Perspect Med Educ.8(2):90-97. doi: 10.1007/s40037-019-0509-2.

Nhlapo, M. S., & Anderson, B. A. (2010). Profiling South African middle class households: 1998e2006. Pretoria: Statistics SA. www.statssa.gov.za/publications/ Report-03./Report-03-03-01.pdf

Rollock N, Gillborn D, Vincent C, et al. (2011) The public identities of the black middle classes: Managing race in public spaces. Sociology 45(6): 1078–1093.

Simpson, J. B. (2008). Black diamonds: the new South African middle class. Management Today, 24(4), 43e46.

Spocter,M. A.(2021).Comparison of Security in City and Small-Town Gated Developments in the Western Cape province, South Africa. Journal of Asian and African Studies,vol57(2):165-181.

Southall,R.(2022): The middle class and suburbia: desegregation towards non-racialism in South Africa?, Journal of Contemporary African Studies.
South African Cities Network; Johannesburg Development Agency. (2014). Spatial Transformation of Cities: Conference Report.
Southall, R. (2004) 'Political change and the black middle class in democratic South Africa', Canadian Journal of African Studies / La Revue Canadiennedes Études Africaines 38 (3): 521–42.
Thomas CS (2015) A new look at the black middle class: Research trends and challenges. Sociological Focus 48(3): 191–207.
Zizzamia, R., Schotte, S., Leibbrandt, M. & Ranchhod, V. 2016. Vulnerability and the middle class in South Africa. (Southern Africa Labour and Development Research Unit Working paper 188). Cape Town, University of Cape Town.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

🏆 *reviewed paper*

Theoretical Framework for Integrated Neigbourhood Development to Ensure Ecological, Social and Climatic Performance

Sophie Thiel, Ernst Gebetsroither-Geringer, Katrin Löning, Theresa Fink, Martin Schneider, Marianne Bügelmayer-Blaschek, Doris Damyanovic, Florian Reinwald

(Mag Dr. Ernst Gebetsroither-Geringer, AIT Vienna, ernst.gebetsroither@ait.ac.at),
(Dipl. Geogr. Katrin Lönig, pulswerk GmbH, loening@pulswerk.at)
(Theresa Fink, MSc, AIT Vienna, theresa.fink@ait.ac.at)
(Martin Schneider, MSc, AIT Vienna, martin.schneider@ait.ac.at)
(Marianne Bügelmayer-Blaschek, PhD, AIT Vienna, marianne.buegelmayer-blaschek@ait.ac.at)
(Assoc.Prof. DI Dr. Doris Damyanovic, BOKU Vienna, doris.damyanovic@boku.ac.at)
(DI Dr. Florian Reinwald, BOKU Vienna, florian.reinwald@boku.ac.at)

1 ABSTRACT

Urban development is traditionally a planning task in which many individual aspects, strategies and measures have to be considered and coordinated. Socio-economic, socio-demographic and socio-cultural change, fast growing cities, densification, supply of green infrastructure, resource management to name a few, are all urgent issues of our time that require an intensive examination of the challenges for urban development, as well as the development of coping strategies. Last but not least, the needs of climate protection, the consequences of climate change and the global loss of biodiversity are (emerging) pressing challenges for urban planning which have to be considered within all processes. At the same time, more and more data and tools are available, which - properly processed, used, examined and evaluated - support the cities in the design and implementation of their urban planning and urban development strategies. These tools are also increasingly used to automate and simplify these processes and analyses.

Due to the complexity of challenges the common approach in urban planning is a sectoral approach (Ovink & Boeijenga 2018, Juschten et al. 2021) where individual experts analyse their field of action and based on these develop sectoral solutions and measures. There are numerous sectoral strategies in and for cities, some of which contain contradictory planning requirements with respect to other sectors and therefore depict the need of intersectoral and comprehensive planning strategies. The second approach necessary for integrated neighbourhood development is to consider the different planning and policy levels. Planning decisions at higher levels influence local decision-making possibilities and vice versa.

The aim of this contribution is to present the development of a theoretical and methodical concept for integrated and participatory neighbourhood development processes. The article is based on a research project in the market town of Lustenau with around 25,000 inhabitants in the Austrian state of Vorarlberg. The market town of Lustenau is taking a large-volume educational building project in the quarter Rotkreuz to address integrated, inter- and transdisciplinary development of an existing neighbourhood. The research question is: “How can integrated neighbourhood development be implemented taking into account climate protection, climate change adaptation, ecosystem services of urban nature, biodiversity and social concerns?”. This contribution describes how these fields can be characterised, analysed and incorporated in master planning processes and how digital tools support the analysis and balancing of these different requirements.

Keywords: urban planning, social justice, biodiversity, climate resilience, digital tools

2 INTRODUCTION – INTEGRATED PLANNING AS AN ANSWER TO THE SOCIETAL CHALLENGES CHALLENGES

With the large-scale educational building project in the neighbourhood Rotkreuz, the municipality of Lustenau wants to address the integrated development of an existing urban quarter. This includes existing non-profit housing estates from the 1940s and 1980s, school and kindergarten buildings, communal catering, a planned new "Assisted Living" project, as well as new public open spaces serving the diverse community and connecting the area ("Rotkreuz Generations Park"). These plans and changes affect the entire neighbourhood.

The main role of urban planning is to coordinate different demands on limited space. Urban planning is therefore an inter- and transdisciplinary field (Despres et al 2011). Grand environmental challenges like climate change, global resource scarcity or societal challenges pose new challenges for urban development

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

which have to be taken into account (see chapter 3 for details). Due to the large number of people and sectors and their diverse interests and issues involved, planning processes and construction projects are becoming increasingly complex. This complexity leads to lengthy and expensive planning processes, which is challenging especially for smaller communities and cities. On the other hand, there are more and more data and digital tools that can support analysis and planning itself on different planning levels.

Using the example of the market town of Lustenau, this article shows which challenges currently have to be taken into account in planning and how these requirements can be supported by using various analysis and simulation tools. The aim of this contribution is to present the development of a theoretical and methodical concept for integrated and participatory neighbourhood development processes. The research question is: "How can integrated neighbourhood development be implemented taking into account climate protection, climate change adaptation, ecosystem services of urban nature, biodiversity and social concerns?". Starting with a description of the actual societal challenges urban planning has to face, five fields of action for an integrated neighbourhood development are described and digital tools presented, that support integrated neighbourhood development.

3 CHALLENGES IN URBAN DEVELOPMENT AND INTEGRATED NEIGBORHOOD DEVELOPMENT

The EU has identified 7 priority societal challenges[1] that also affect urban planning or where planning is expected to come up with solutions (Cohen-Shacham et al. 2016). For the urban development processes in Lustenau the following aspects are central (for the selection of challenges see also Section 4.1):

3.1 Climate change and loss of biodiversity

Due to climate change, meteorological patterns are occurring with altered frequency and intensity (IPCC 2022a, APCC 2014). Over the past years, extreme precipitation events, prolonged droughts resulting in wildfires, and yearly summer heat records occurred. Further changes in climate signals and an increase in extreme events are expected in the future according to different simulations. Extreme events can impact settlement areas through multiple aspects: endangering the health of the population, damaging crucial infrastructure for e.g. mobility or energy and thereby altering the energy supply and demand, as well as other sectors (ÖROK 2021). In particular, changes in temperature and precipitation have an impact on spatial development. Above all, rising temperatures, heavy rain events, but also longer periods of drought are a challenge for settlements with densely populated areas being particularly affected due to sealing and overbuilding. The construction and overbuilding and the associated sealing of natural surfaces, as well as the increase in process energies are the main factors responsible for the development of urban heat islands. The urban heat island effect and disturbed local water cycles exacerbate the effects of climate change (Kuttler 2011, Pauleit & Breuste 2011). Further, the sealed surfaces allow no infiltration of rainwater, therefore str also lacking the cooling effects of evapotranspiration. At the same time, the water absorption capacity of available green spaces, such as unsealed soils and vegetation is often impaired because of too compact characteristics – consequences of the permanent vibrations due to traffic, leading to a change in the water regime. Overall evapotranspiration, groundwater recharge and purification capacities of the soil are reduced, while surface runoff and pollution levels of water bodies as well as the dryness of the air increase.

Since 2013, the potential of climate-effective green structures in settlements has been promoted by the EU Green Infrastructure Strategy (GI) (European Commission 2013). The Green Deal and the EU Biodiversity Strategy 2030 (European Commission 2020) refer to the necessary interlinkages between these structures and strengthening biodiversity. However, the potential for biodiversity in cities and settlements is still widely neglected, both by urban planners and by nature and species conservationists. The appeal for a “Doppelte Innenentwicklung” [To use space reserves in the building land in a structurally sensible way, but at the same time to develop urban greenery] as a response to population growth, land consumption and climate protection means that conserving urban biodiversity, which has received little attention to date, is even more

[1] 1. Health, demographic change and wellbeing, 2. Food security, sustainable agriculture and forestry, marine and maritime and inland water research and the bioeconomy, 3. Secure, clean and efficient energy, 4. Smart, green and integrated transport, 5. Climate action, environment, resource efficiency and raw materials, 6. Europe in a changing world - inclusive, innovative and reflective societies, 7. Secure societies - protecting freedom and security of Europe and its citizens.

necessary (Kühnau et al. 2017). This calls for nature-inclusive planning that understands the value of built urban nature. In this context, nature-inclusive means offering plants and animals opportunities for living and settling in their own dynamics and no longer seeing nature and settlement as opposites (Fassbinder 2002; Hauck & Weisser 2015).

3.2 Demographic changes and social justice

More than half of the world's population currently lives in cities and this proportion will continue to rise (United Nations 2019). Certain groups have always been more exposed to the risks of social exclusion and marginalisation because of their age, their gender identity, their physical abilities, their socio-economic status and their ethnicity, religion or origin. This exposure phenomenon has come to the fore of understanding cities and developing policies for them (Andersen & Van Kempen 2003, Atkinson 2000, Madanipour 2004, Woodward & Kohli 2001).

Climate change combined with poor planning is leading to a climate crisis for people. Climate impacts and consequences of climate policy measures are more severe in socio-economically disadvantaged groups. Key vulnerability characteristics are low income, age above 65 years, health impairments, migration background or low education level. A total of 56 % of the Austrian population over the age of 15 exhibit at least one of these characteristics and can therefore be considered particularly vulnerable to the consequences of climate change (BMSGPK 2021). Also, infants and children below the age of 5 years and women are more vulnerable to climate change. When certain impact processes, e.g. heat or immission load, meet vulnerability characteristics the result is material or health deprivation (BMSGPK 2021).

3.3 Energy and mobility

77.01 % of the greenhouse gas emissions of all member states of the European Union can be attributed to the energy sector (Europäisches Parlament 2019). Around a third of this is due to transport. In the energy sector, there is potential for climate protection both in the area of using the energy potential of sustainable forms of energy and in the area of increasing efficiency, e.g. of heating and cooling requirements.

While in the building sector energy consumption could be reduced between 2011 and 2020 there was a further increase in energy consumption in the mobility sector in the whole of Austria and in Vorarlberg. Despite efforts and investments to facilitate public transport, cycling and walking, the overall greenhouse gas emissions in Austria increased alarmingly by 74.4 % in the mobility sector between 1990 and 2019 (BMK 2021). Transport – with over 40 % as the largest cause of climate-damaging emissions – must make a significant contribution to the reduction of CO2 emissions in the future. To achieve the national target according to the federal government's integrated climate and energy strategy, emissions from the mobility sector in Austria are to be reduced by 31 % compared to 2005 (BMNT/BMVIT 2018). Given the limited successes to date and even more foreseeable gains in the mobility sector while at the same time the Austrian federal government wants to achieve climate neutrality by 2040, this is a particular challenge. Therefore, changes in the modal split are predominantly relevant for the reduction of greenhouse gases from mobility.

3.4 Settlement structure and infrastructure

The settlement structure has a central influence on the challenges described above. The share of the building sector alone accounts for around 10 % of Austrian greenhouse gas emissions in 2019 (UBA 2021). In addition, the settlement structure determines the use of land, the use of resources for development or, via the degree of sealing, the degree of greening. A denser and more compact urban structure is the prerequisite for short distances and dense public transport as well as walking and cycling networks, and are the basis for optimising the energy system and using land sparingly. Single-family houses have the highest proportion of energy demand compared to denser building types, both during construction and operation with their development infrastructure and road construction requirements being energy intensive (alpS GmbH 2019).

With clever planning, the energy transition is supported by measures that promote energy-efficient spatial and settlement structures in a way that supports structural energy savings, mobility and grid-based energy supply (Stöglehner 2021).

The settlement structure, the development structure and the density also determine the possibilities for building and maintaining everyday life infrastructure. In combination with good accessibility and a high quality of everyday life infrastructure facilities, overall distances are shorter, chains of paths are supported,

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

the autonomy of the residents is promoted and in turn the energy consumption for mobility is reduced (Sturm et al. 2018).

3.5 The interplay of challenges - integrated urban planning is necessary

All of these challenges have in common that they mutually influence or condition each other. In the context of energy planning, denser overall development and compact buildings are a prerequisite for short distances and a dense public transport, footpath and cycle path network. At the same time, they are the basis for the optimisation of the energy system and the economical use of land and soil (alpS GmbH 2019). However, denser development leads to a loss of green spaces and thus biodiversity. This means that their ecosystem services, such as temperature regulation are lost and the local water cycles are disrupted by the high degree of sealing. Changes in demographics also have an impact on the use of buildings. The population density tends to decrease in neighbourhoods that are affected by an ageing population (alpS GmbH 2019). This means that the infrastructure is less utilised or new infrastructure facilities are necessary - e.g. assisted living instead of children's playgrounds. All these connections and interactions make an integrated neighbourhood development necessary.

There is a need for comprehensive and inclusive approaches to overcome these challenges (Ovink & Boeijengap 2018). Integrated urban planning aims at overcoming sectoral or silo approaches to foster the collaboration of different sectors and disciplines. Collaboration instead of competition or compromising is necessary. Only with an integrated approach the value for all stakeholders can increase. In other cases only an average result (compromise) or a one-sided optimization (competition) is achieved (Wertheim 2002).

Current challenges manifest themselves on different policy and planning levels (Kok & Veldkamp 2011). In addition to horizontal intersectoral coordination, integrative neighbourhood development thus also requires vertical coordination at the various planning and policy levels as well as fields of action in urban planning. (Geerlings and Stead 2003). Measures to reduce CO2 emissions from transport need for example have to be considered on a large scale (e.g. modal split) but also on the local level (qualities of road open spaces). The same applies e.g. to biodiversity, where a small biotope can make a local contribution, but at the same time the large-scale distribution has to be considered.

As urban planning sets the preconditions that determine long-term influences the build environment and thus also social structure, green spaces or energy consumption, a horizontal integration of different planning fields but also a vertical integration of planning and policy levels is necessary for integrated neighbourhood development. This is where the IQ_Lustenau research project comes in.

4 MATERIALS AND METHODS

4.1 Inter- and transdisciplinary, integrated research process set in a real laboratory

In order to meet the challenges of sustainable urban development, Wolfram et al. (2016) point to research that should capture the spatial-institutional complexity of urban transformation processes and move to multi-systemic approaches. In an interdisciplinary and transdisciplinary, collaborative approach, the research team is developing a novel toolset tailored to the different integrative planning processes that demonstrate its feasibility in a proof of concept.

The research approach and methods follow the real laboratory approach (see also Chapter 5.1), which enables the research team to test new technologies (tools) in the existing project location without having to be anchored in the legal framework (BMWi, 2019). The aim is to couple the development of the toolset with a regulatory learning process in order to ultimately implement it in day-to-day planning (Wolfram et al., 2016; BMWi, 2019).

4.2 Desktop research, policy analysis and participation

In order to provide a framework for programming the process of integrated neighbourhood development, basic research was carried out on urban planning processes (e.g. master planning processes) and on the requirements of an integrated planning process. The aim was to define planning instruments and procedures for programming, which should enable high-quality preparation and process control. In order to record the needs of the community and to develop measures in a co-creative manner, a comprehensive policy analysis of the spatial and social development target system of the community was carried out on the one hand and a

participation process was initiated with the various departments of the community on the other hand. The policy analysis was conducted to identify different strategies for urban development on federal state and city level following the method of qualitative content analysis (Mayring 2021, Kuckartz 2016).

An integrated neighbourhood development requires the inclusion of different perspectives. Interviews with planning experts of the market town were conducted and workshops implemented to identify the sectoral challenges and objectives. Based on these results, five fields of action for integrated neighbourhood development could be identified (see chapter 5).

4.3 Data, tools and instruments to support resilient, integrated neighbourhood development

In recent years, the progressive application of computational design tools to urban systems in urban design practices has enabled exploration of physical space. In comparison to conventional forms a new type of digital modelling is revolutionising the planning process and the way we can design resilient urban environments (Koenig et al. 2020). A parametric model is able to generate many iterations of design that can be modified, examined and evaluated. The use of digital tools should support the planner in generating more resilient designs by providing a fact-based decision-making basis. There are different tools and processes at the scale levels (e.g. GIS, Rhino, CAD, Building information modelling) of planning – the interfaces and interrelationships stand out as particularly important. In order to design a resilient and integrated neighbourhood, coordinated processes and procedures are needed in the exchange of data and the performance indicators.

In addition, there is more and more (social-space-related) data available nowadays that - properly processed - supports urban planning and urban development in seeking coping strategies for the emerging problems of our time (see section 2). Increasingly, digital planning instruments and planning tools are being used to automate and simplify this processing (Speranza 2016). For this reason, computational urban planning methods and digital tools are particularly effective in simulating measures and the effects of planning decisions in a transdisciplinary approach. This includes micro-climate, biodiversity, energy, mobility and other planning aspects. New capabilities of digital collaboration (online, virtual/mixed reality) allow experts from different disciplines to be involved in co-creation processes. This enables a high degree of transparency and time-saving planning processes and use-oriented results in scenarios can also be developed.

5 RESULTS – FIVE FIELDS OF ACTION AND DIGITAL TOOLS THAT SUPPORT INTEGRATED NEIGHBOURHOOD DEVELOPMENT

Due to the project's spatial scale as well as its social and political importance, the following challenges were identified within stakeholder workshops and discussions with the municipality for the development of the neighbourhood Rotkreuz: (1) Consideration of different social groups and their demands on settlement, infrastructure and green space; (2) Lack of awareness and analysis of climate change and loss of biodiversity, as well as the need to provide space for the development of ecologically resilient urban districts; (3) Integration of measures for climate protection, for climate change adaptation, ecosystem services of urban nature and social issues in everyday municipal planning for district development.

Figure 1: Overview of the neighbourhood Rotkreuz. The area outlined in red includes the school and kindergarten conversion, a new park, assisted living and the redesign of street open spaces that influence the whole neighbourhood.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

5.1 Objectives and guiding principles for urban development of the market town Lustenau

To embed the integrated development process of the neighbourhood Rotkreuz in present policies, several pre-existing guiding principles were identified in policies at local, regional and federal state level. These guidelines for spatial development frame the integrated process for Lustenau as described above:

- Targeting cross-divisional cooperation (Eichberger 2006; Amt der Vorarlberger Landesregierung 2019a) and "taking collaborative action" involving various stakeholders (alpS GmbH 2019)
- Long-term protection of the functional capacity of ecosystems and their biological diversity through the preservation and creation of biotope network areas and stepping stones (Amt der Vorarlberger Landesregierung 2020)
- Preserving existing biotopes and natural elements – i.e. trees, shrubs, meadows, dry stone walls, water bodies, etc. – to ensure a high level of biodiversity (Lenz et al. 2022; Amt der Vorarlberger Landesregierung 2019a)
- Preserving, developing and connecting open spaces and green infrastructure as a key driver of quality of life (Eichberger 2006)
- Frugal and responsible use of land should be enforced by active land policy and by actively addressing climate change adaptation (Eichberger 2006; alpS GmbH 2019)
- Polycentrism should promote urban quarters with site-specific qualities (Eichberger et al. 2016)
- Moderate densification, neighbourliness and short distances shape the community (Eichberger 2006)
- Promoting environmentally friendly mobility – i.e. cycling, walking, public transport – with a primary design focus on re-establishing social relations, high quality of stay and overall safety for inner-city streetscape (Amt der Vorarlberger Landesregierung 2011; AG Lustenau mobil 2012)
- Understanding immigration and pluralism as a strength and opportunity and strengthening social cohesion by participatory processes (Amt der Vorarlberger Landesregierung 2019b)

Accordingly, these thematic guidelines aim at polycentric, compact urban structure with small-scale, mixed-use urban quarters that offer living, working, educational and recreational opportunities for high quality of life for all while preserving natural resources.

5.2 The five fields of action of an integrated neighbourhood development

Based on the challenges and guiding principles described above, the requirements for an integrated neighbourhood development and the goals of the market town of Lustenau in the area of spatial development, five fields of action were identified, which are analysed and processed in the project and supported by digital tools (see Figure 1 below): (1) climate smart; (2) biodiversity, (3) social justice, (4) sustainable mobility, and (5) accessibility. The following sections describe which topics and content must be considered in order to be able to support integrated neighbourhood development. Based on this, it is shown which tools can support them. Tools were identified for these fields of action that enable qualification or quantification, support the weighing of the interactions of measures and thus enable integrated planning processes (see section 4.3).

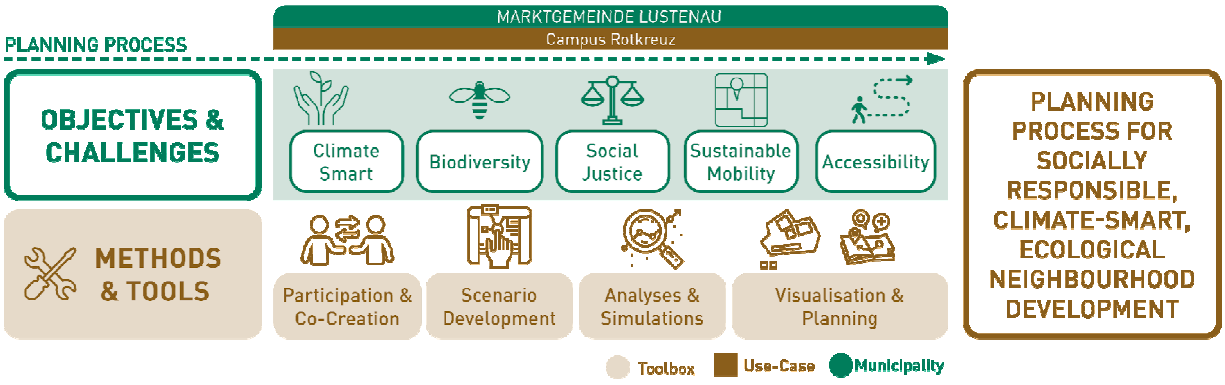


Figure 2: Use of the various tools to achieve the necessary goals for the implementation of socially just, climate-resilient and ecological neighbourhoods in the various phases of an integrated planning and implementation process.

5.2.1 Climate smart

This field covers both: climate change mitigation and climate change adaptation. Measures in this area have both synergies and conflicting goals and must therefore be considered together from the outset. In the face of current climate trends of rising temperatures, increasing heavy rain events but also droughts municipalities are required to implement climate smart strategies to keep their districts both liveable and enjoyable for their inhabitants and reduce energy consumption. Especially in cities with dense urban environments, locally strengthened effects of climate change such as the Urban Heat Island Effect (UHI) demand even greater efforts. Climate resilience in general refers to the capacity to cope with hazardous events and trends, while also maintaining the capacity for transformation (IPCC 2022b).

The federal state of Vorarlberg and thus the municipality of Lustenau are also confronted with those developments. According to the ÖKS15 (2016) scenario in the state of Vorarlberg, the mean air temperature will increase by 1.2 °C (RCP4.5 climate protection scenario) to 1.4 °C (RCP8.5 - business-as-usual scenario) by 2050 and up to 4 °C by 2100 (RCP8.5). Due to the proximity to the river Rhine and the generally high groundwater level in the region, there is a high risk of flooding despite flood protection measures. In this case, too, climate-conscious planning must minimis e the impact of flooding in the region. Therefore, it is important to incorporate relevant climate forecasts (e.g. EURO-CORDEX, or derived climate indicators) into planning practice in order to show the precipitation amounts that are likely to occur in the whole region.

More than two thirds of the total energy consumption of households in Lustenau is used for room heating (alpS GmbH 2019). 40 % of the single-family houses are heated with oil. In multi-apartment buildings, gas dominates as an energy source. In comparison, biomass plays a minor role in Lustenau (alpS GmbH 2019). The average energy consumption per person for the provision of room heating, hot water and electricity is largest in single-family houses with 11,645 kWh per year and smallest in the multi-apartment buildings with 4,769 kWh per year (alpS GmbH 2019). Overall, the mix of energy of the market town of Lustenau is determined by the fossil energy carriers oil and gas. For households, the share of renewable energy is about 30 % (alpS GmbH 2019).

The A/V ratio (the quotient of the heat-exchanging outer surface A, which gives off the heat to the environment, and the heated building volume V) is an indicator for the compactness (built-up area and number of floors) and the energy demand of a building. The smaller the A/V ratio, the more compact and thus energy efficient the building. Average A/V ratio for the market town of Lustenau is 0.74. For comparison, the Hannes Grabherr housing estate in Negrellistraße - one of the densest residential areas in Lustenau - has an A/V ratio of 0.47 (alpS GmbH 2019).

5.2.2 Biodiversity

Biodiversity loss and climate change are interlinked in many ways, since nature-based solutions in the field of green infrastructure - as one of the most effective adaptation strategies - require functioning ecosystems. The loss of biodiversity therefore reduces the ability to adapt to climate change. At the same time, climate change itself is one of the main reasons for the loss of biodiversity and, therefore, requires a strong, committed climate policy. Achieving climate change adaptation goals will not be possible without intact, vital, resilient and diverse nature. However, despite efforts in nature and species conservation and some successes in individual areas, further losses of biodiversity could not be stopped. In 2019 in Austria 44 % of the habitat types and 34 % of the species assessments show an unfavourable to poor conservation status (BMK 2020 – based on the EU Habitats Directive). These, in turn, are a prerequisite for high biodiversity. The main strategy for the settlement areas is to preserve and to expand public green spaces as well as private and semi-public gardens. Existing natural structures must also be preserved, corridors developed and particularly sensitive areas protected.

The settlement area of the market town of Lustenau comprises 780 ha, of which 8.3 % are road areas, 16 % are building areas and 1.2 % are water areas. 87.5 % are designated as building land, of which 13 % are building land reserves (alpS GmbH 2019, 8). An infrared evaluation indicated a share of sealed area in the municipality of already 48 % in 2015 (alpS GmbH 2019, 26) with the trend rising. A part of yet undeveloped building plots are important biodiversity refuges and serve as stepping stones for the biotope network (Pulswerk 2022). Simultaneously, they can act as a source of cooling and cold air conduits. This must be

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

considered with regard to the necessary (re)densification of inner-city areas in order to reduce overall land consumption and to use synergies with this already existing green infrastructure.

Instead, a gradual de-densification of residential quarters – a development contrary to redensification efforts – was found in the averagely low occupancy rate of buildings (three inhabitants per building) in Lustenau with every second single-family house hosting only up to two persons (Eichberger et al. 2016).

In conclusion, in Lustenau there is a high proportion of undeveloped, greened areas, some of which are still ecologically valuable remnants (e.g. typical orchard meadows), but most of these remaining biotopes are on the fringe of their existence due to being designated as building land. The difficult legal framework conditions call for strategic protection of these orchards as well as deliberate densification concepts with alternative implementation strategies (Eichberger 2006; Eichberger et al. 2016).

5.2.3 Social Justice

A central approach to deal with social change processes and the related (urban) spatial and planning challenges, as well as in the implementation of target group-oriented urban planning, is to focus on social space. The concept of social space includes the mutual addressing and consideration of the interactions between the built environment and different social groups. Henri Lefebvre (1991) describes (social) space as (socially) produced and effective in everyday life. The socio-geographic approach was adopted in urban and spatial sociology and leads to a relational understanding of space, as arrangements of living beings and social goods in places (Löw 2001). Understanding these relational social constructs means to better understand interrelations between places and people which is key for being able to foster social justice in urban planning. Structural principles such as gender and classcross all levels of socio-spatial constitution, in which societal privileges or disadvantages are embedded. The relational perspective can be applied to (de)construct such social constructs in order to address inequalities and discrimination and acknowledge that all these social concepts are always a product of interconnected, social processes (Crenshaw 2015, Damyanovic & Horelli 2019, Knapp 2005, Thiel 2020).

To aim at socially just (public open) spaces means to involve a complex web of multiple spatial, social and economic factors to provide all residents with the same opportunities to access, use and enjoy the city as well as to fully participate in the production of urban space (Harvey 2012; The World Bank, 2020). Dale and Newman (2009) pointed out the need to link liveability with social equity, or else risk gentrification at the cost of accessibility and social inclusion. The guiding principle for action in that regard is a gender-equitable city of short distances that is suitable for everyday life, with barrier-free urban spaces and open spaces that can be used in a variety of ways.

In the last 15 years, the number of people living in Vorarlberg has increased by 40,000 to over 390,000 with immigration having a key role in this. Compared to the population development of the whole of Austria, this growth is above average. The population growth is and will be mainly taking place in the urban areas in the Rhine Valley, especially in the district of Dornbirn, where Lustenau is located (Amt der Vorarlberger Landesregierung 2019b). According to the "Regional Population Forecast" („Regionale Bevölkerungsprognose“) from the federal state of Vorarlberg an increase of about 12 % compared to the reference year 2020 is expected for the market town of Lustenau by the year 2050 (Amt der Vorarlberger Landesregierung Landesstelle für Statistik 2022). In the district of Dornbirn the proportion of the population of particularly vulnerable groups - such as those over 85 years of age for example - will increase from 2,000 today to over 5,700 by 2050 according to the small-scale population forecast of ÖROK (2021). To achieve social justice, planning has to employ a site- and group-specific approach that creates more equitable processes, access to resources, and systems for all groups.

5.2.4 Sustainable mobility

According to urban planning at human scale, walking must be the measure of urban planning and urban development (Kohr 2002). On this basis, the size of settlements is compatible with nature and humans, resulting in a corresponding structural diversity within which people can move over distances that are appropriate for pedestrians. Consequently, there is no excessive need for private motorised mobility, since the essentials of daily life are organised locally (see also next section). In this context, the development of the city and urban living spaces via sustainable and future-proof forms of mobility such as walking and cycling as well as public transport is essential (Zopf 2012).

The modal split of Lustenau clearly highlights Vorarlberg's efforts to promote cycling – the share of ways done by bike gained more than five per cent between 2013 (17 %) and 2017 (22 %). However, it also shows the missing investments in public transport (it's modal split share dropped from 13 % in 2013 to 7 % in 2017) and walking (dropped from 19 % in 2013 to 12 % in 2017), while still more than every second trip is done by car (alpS GmbH 2019). To shift short and medium car trips to cycling and walking requires infrastructure enhancement, ongoing public outreach, rules and laws promoting bicycling and walking, and land-use planning measures (Amt der Vorarlberger Landesregierung 2019a).

5.2.5 Accessibility

One of the goals of integrated city planning is to provide the population with goods and facilities for daily/weekly needs that are close to home and suitable for everyday use. A full range of everyday life infrastructure facilities in the neighbourhood makes it easier for people with care and support obligations (for children or care-dependent adults) to reconcile family work, gainful employment and leisure time (Damyanovic & Horelli 2019, Damyanovic et al. 2021). In combination with good accessibility and a high quality of the everyday life infrastructure facilities, a complete infrastructure offer supports chains of routes (combination of tasks) and promotes the autonomy and independence of the residents.

A transformation of cities towards human scale is what the "15-Minute City" concept proposes: A neighbourhood-oriented approach in which people can reach all facilities necessary to meet their daily needs within fifteen minutes on foot or by bicycle (Blaschke 2022; Moreno et al. 2021). Thus, promoting social dimensions, urban proximity, and diversity via increasing use of technologies (Allam et al. 2020). A neighbourhood suitable for everyday life must include a gender-equitable approach which means designing barrier-free urban spaces and open spaces that can be used in a variety of ways. The provision of adequate everyday life infrastructure amenities in the neighbourhood facilitates the reconciliation of (unpaid) care work, employment and leisure time and promotes the autonomy and independence of all residents.

In planning this objective is supported by a polycentric urban structure. The area around the planned education campus in Lustenau is to take on this central function for the entire quarter. The range and location of infrastructure facilities - technical, social and green infrastructure - and their expansion are therefore one of the fields of action for an integrated neighbourhood development.

5.3 Digital tools to support integrated neighbourhood development

In the framework of the research project 'IQ Lustenau' tools and methods were selected to support a holistic assessment (active mobility, biodiversity, microclimate, social justice) of sustainable and integrated neighbourhood development. Cross-scale (GIS, 3D building models) approaches were selected and the interfaces to the simulation programmes were defined. These will be explained in more detail below and will further be used in the project for the analysis of spaces and the evaluation of different planning scenarios.

5.3.1 Rhinoceros 3D / Grasshopper

In recent years, the use of parametric planning methods for cities has increased rapidly. This is due to the possibility of evaluating the performance of many scenarios (Fink 2018). The software environment Rhinoceros 3D and the parametric native plug-in Grashopper have numerous interfaces for connection to GIS programs, CAD and BIM. Therefore, there is a wide range of possible applications and the coupling to simulation environments, as well as the possibility of analyses within Grasshopper. Numerous libraries are available to perform environmental, planning, mobility and other performance evaluations. For the integrated neighbourhood development in the example of IQ Lustenau, the graph-based analysis of accessibility (walkability) as well as parametric modelling of densification scenarios are suitable. The use of Ladybug tools enables the analysis of solar radiation, shading, sunshine hours and other microclimatic indicators. Another toolbox from DeCoding Spaces supports graph-based analysis to evaluate the accessibility of everyday life infrastructure.

11.1.1 SMTG+ Rapid Assessment Tools

As part of the Smart through gender+ research project, a rapid assessment tool was developed at city and district level. The district level tool is based on GIS data and manually mapped data and was developed using Grasshopper. It contains an interface for simplified operation and analysis of important planning topics (e.g.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

analysis of supply with everyday life infrastructure). It is structured in static visualisation (e.g. visualisation of manually mapped data), dynamic visualisation (crosswise evaluation of statistical data) and dynamic simulation (accessibility, real walking distances). The tool on city level was developed using R-Shiny and can import and assess GIS data to create needs and potential maps for different user groups. Furthermore, analyses of demand, based on demographic data and supply, can be carried out using the available PoIs (Points of Interest). These result in demand and potential maps which are created individually for individual user groups and can be visualised interactively.

5.3.2 PALM-4U

As stated above, the assessment of climate resilience emphasises on higher temperatures in future climate scenarios. Evaluations of this field of action (climate smart) requires a state-of-the-art high-resolution urban model with the ability to simulate biometeorological quantities to distinguish between the impacts and effects of the developed scenarios on the comfort of people. The model of choice to fulfil the high requirements is PALM-4U, an integrated component of the PALM (formerly an abbreviation for Parallelized Large-eddy Simulation Model) model framework. It can be initialised using regional climate model data, thus incorporating the available climate projections of the representative radiative concentration pathways. In addition to the entire PALM modelling environment, PALM-4U features a separate energy balance solver for building and paved surfaces, fully interactive land surface and radiation schemes, including shadowing effects and reflections between urban structures, a heat transfer model between atmosphere and buildings and direct output of biometeorological quantities. It is designed for application of climate research in urban contexts and practical city planning related to urban microclimate (Maronga et al. 2021, PALM-4U 2022). PALM-4U simulates urban areas with spatial resolutions up to under 10 m.

5.3.3 SUMO: Simulation of Urban Mobility

SUMO is an open source, microscopic, multi-modal traffic simulation (see Lopez et al 2018). It allows to simulate how a given traffic demand which consists of single vehicles (cars, bicycles, public transport buses and trains) and pedestrians moves through a given transport network. The simulation allows to address a large set of traffic management topics on a microscopic level: each vehicle and each person is modelled explicitly, has an own route, and moves individually through the network (SUMO 2022). The network is based on the OSM graph of the considered region. SUMO is used for traffic safety and risk analysis, for the calculations of emissions (noise and pollutants) and to provide traffic forecasts for city authorities. In the use case of IQ Lustenau, SUMO can be used to evaluate the different scenarios of the integrated neighbourhood development with respect to their mobility impacts and to their greenhouse gas emissions.

6 DISCUSSION - REQUIREMENTS FOR AN INTEGRATED NEIGHBOURHOOD DEVELOPMENT

When addressing complex sustainability challenges (as mentioned in section 3) cities are embracing experiments to respond to particular societal, economic and environmental issues in a given urban place (Bulkeley et al. 2016). A real laboratory approach frames integrated (i.e. cooperative, dialogue-oriented and trans-sectoral) neighbourhood development processes where consideration of synergies and trade-offs of various sectoral requirements is necessary. The success of integrated neighbourhood development depends on the formation of appropriate foundations for the subsequent planning and implementation steps.

6.1 Experimental spaces

Instead of following a policy of incremental steps due to its insufficiency in addressing complex (urban) sustainability challenges (Wilson et al. 2020) cities around the world are embracing experiments to “design, test and learn from innovation in real time in order to respond to particular societal, economic and environmental issues in a given urban place” (Bulkeley et al. 2016). Various stakeholders collaborate in these (real-life) laboratories, testbeds, or platforms which combine technological innovations, nature-based solutions, and community activities in terms of comprehensive structural and cultural change (Grin et al. 2010; Eneqvist & Karvonen 2021; Suitner, 2021). Such experimental spaces have been successful in urban climate change governance with social innovations emerging as essential components (Schartinger 2018, Fazey et al. 2018). Social innovations are new ways of working together for the purpose of addressing societal needs or goals by establishing, renewing, or changing social practices and interactions more

effectively than previous social configurations have done (Moulaert et al. 2013). Such a perspective allows to view urban experiments as innovative processes of ideas and implementation in a specific structural and socio-political context (Bulkeley et al. 2016; Suitner, 2021).

6.2 Dialogue-oriented and cooperative trans-sectoral process

Likewise, neighbourhood development requires dialogue-oriented and cooperative, trans-sectoral processes that can only be realised with continuous information flows and feedback (Reinwald et al. 2021). Increased communication and coordination efforts result from the necessity to develop an inter- and transdisciplinary planning approach and implementation process in order to make the differing goals (trade-offs) visible as well as to consider the various sectoral requirements. Therefore, having an interdisciplinary planning team from the fields of architecture, spatial planning, landscape planning, mobility planning, energy planning, (micro-)climatology, climate resilience, urban ecology, social planning, participatory planning, etc. in combination with representatives of the municipality, property owners, developers, external experts and specialist planners, residents, citizen representatives, etc. at an early stage is crucial for neighbourhood development projects. Due to this wide range of stakeholders, interests and issues, dedicated (temporary) organisational structures are created for integrated urban development projects (see SIR 2021 or Scheuvens et al. 2010). Various stakeholders collaborate in such experimental spaces to aim at comprehensive structural and cultural change in urban climate change governance with social innovations emerging as essential components (Suitner 2021).

6.3 Integrated view on planning and policy levels

As with any planning task, dealing with a specific place begins with an analysis of its qualities and development possibilities (Scheuvens et al. 2010). A comprehensive basic analysis from different perspectives and on different scales is more and more state of the art (Reinwald et al. 2021). An analysis of the fields of action described above creates the basis for this. The central challenge is that more and more spatial research is being carried out, more and more data is available, but the effort and the necessary prerequisites to be able to carry out such analysis are also increasing. At the same time, there are also more and more strategies at different planning and policy levels in different sectors. It is becoming increasingly difficult to provide the necessary integration performance to be able to analyse and develop a space in a truly integrative manner. Being able to assess the many interactions, dependencies, conflicts of aims or synergies is difficult even for interdisciplinary teams.

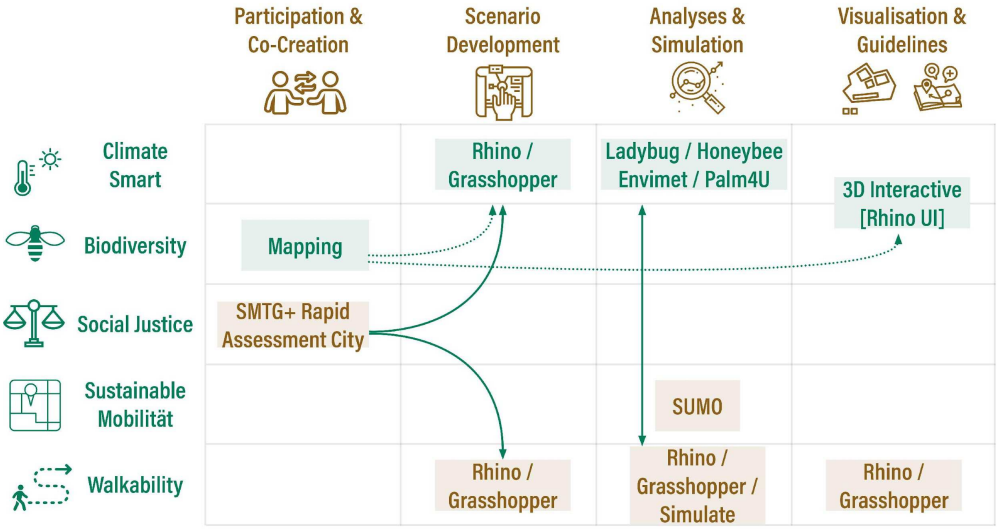


Figure 3: Matrix as overview of the IQ Lustenau phases and their designated tools.

6.4 Tools that support the assessment of the five fields of action

To support this holistic assessment for a sustainable neighbourhood planning, digital planning instruments and planning tools are being used by automating and simplifying these processes (Speranza 2016).

The use of the selected tools was transferred to the planning phases and analysis of the fields of action. Here, the potentials for the use of GIS for mapping and data collection through the overall city explorer (online) in

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

participatory processes already become apparent. This data complements urban and statistical data, which serve as the basis of further analyses. For the development of the planning scenarios, Rhinoceros 3D was chosen because of the native plug-in Grasshopper, which enables parametric modelling and the import of GIS data. Furthermore, microclimatic simulations can be performed using the Ladybug and Honeybee libraries within the same software environment. For further microclimatic considerations, the 3D scenarios can be exported and simulated in Palm4U or Envimet and used for visualisation in Rhino 3D. The sustainable mobility analyses in SUMO can also be linked to the parametric planning models using a common database for traffic demand generation. In the visualisation phase, the results can be interactively visualised and evaluated at the overall city level as well as at the small-scale for the area.

6.5 Including biodiversity as a grand challenge of integrated neighbourhood planning

The conservation of biotopes and stepping stones as connecting elements is challenging the dynamic development of settlements. As in many municipalities, there is a lack of data bases for inner-city biodiversity and its ecosystem services. Therefore, these aspects are hardly considered in the practice of settlement developments. In particular, the existing, mature elements, such as naturally grown soil, old trees and meadows, geomorphological irregularities, etc. must be located and integrated into initial planning processes. They are non-recreatable within a one or two generations time period and are important parts of nature-based solutions for climate change adaptation and health care. Nature-inclusive planning requires a transdisciplinary planning process that considers the expertise of development, implementation and maintenance (Löning et al. 2020). Processing biodiversity-related data and information and integrating them into digital tools in order to support the (integrated) planning and decision-making process in the best possible way is a particular challenge. A challenge for integrated neighbourhood development is that all fields of action are equally consciously included in the consideration process. In some fields of action, the data situation is much better, which can also lead to these fields being given an overweight. To prevent a bias here, the project will test a simplified assessment system that takes biodiversity equally into account.

7 CONCLUSION

The urban challenges of densification and transformation have become even more complex by the global impact of climate change and loss of biodiversity. Neighbourhood planning must perform well in many different areas and scales (quality of life, microclimate, mobility, social justice). However, there is no solution that offers a perfect performance for all challenges. Therefore, intelligent methods and planning processes are needed that support a discourse for decision-making and provide fact-based considerations for decision-making. It is necessary to make the effects of planning decisions on the different planning and policy levels transparent and clear in order to enable sustainable neighbourhood development. Furthermore, the effects on future developments (mobility transition, transport transition, demographic developments, climate change) must be considered as well to ensure sustainable and integrated planning. In order to integrate the challenges of decision-makers in cities and municipalities into planning tools, a discourse on the content of the requirements for planning and methodology is needed. Furthermore, urban data collection and management must go hand in hand with planning processes to enable the basis for analyses at the city and district level as a foundation for qualified decision making.

A successful integrated planning - taking into account actual challenges urban development is facing - is defined by the following requirements: (1) space and time for experiments and thinking outside of the usual work context, (2) a planning process that actively involves multiple stakeholders and experts in different fields throughout the whole process, (3) an integrated view of a neighbourhood to analyse different fields of actions and scales and (4) support through digital tools that help prepare the extensive existing data material for decision-making on the different planning levels.

The contribution shows that considering the five fields of action - (1) climate smart; (2) biodiversity, (3) social justice, (4) sustainable mobility, and (5) accessibility – is a necessary prerequisite for implementing an integrated neighbourhood development. It is also shown that the many sectoral fields of action and planning levels must be considered together in order to make conflicting goals visible and to use synergies. By using digital tools, the effects in the different fields of action and scales can be analysed and presented. The next step is to develop a consistent toolset and tailor it to the needs of the municipalities.

8 ACKNOWLEDGEMENT

The project is being funded by the Austrian Climate and Energy Fund and is being carried out as part of the "Leuchttürme für resiliente Städte 2040" program (FFG Project number: FO999891997).

9 REFERENCES

AG – Arbeitsgruppe Lustenau mobil: Mobilitätsbericht 2. Lustenau MOBIL – Anders unterwegs. Lustenau, 2012.

Allam, Z.; Moreno, C.; Chabaud, D.; Pratlong, F. Proximity-Based Planning and the "15-Minute City": A Sustainable Model for the City of the Future. In: The Palgrave Handbook of Global Sustainability; Springer International Publishing: Cham, Switzerland, 2020; pp. 1–20.

alpS GmbH: Energieraumplanung (ERP) Marktgemeinde Lustenau. Projektbericht. Innsbruck, 2019.

Amt der Vorarlberger Landesregierung, Fachbereich Energie, Klimaschutz und klimarelevante Ressourcen (ed.): Schritt für Schritt zur Energieautonomie in Vorarlberg. 101 enkeltaugliche Maßnahmen. Bregenz, 2011.

Amt der Vorarlberger Landesregierung Abteilung Allgemeine Wirtschaftsangelegenheiten (ed.): Mobilitätskonzept Vorarlberg 2019. Bregenz, 2019a.

Amt der Vorarlberger Landesregierung Abteilung Raumplanung und Baurecht (ed.): Raumbild Vorarlberg 2030. Zukunft Raum Geben. In: 33 Schriftenreihe der Abteilung Raumplanung und Baurecht, Amt der Vorarlberger Landesregierung. Bregenz 2019b.

Amt der Vorarlberger Landesregierung: Fachgrundlage und Maßnahmenhandbuch Biotopverbund Vorarlberger Rheintal. Bregenz, 2020.

Amt der Vorarlberger Landesregierung Landesstelle für Statistik: Regionale Bevölkerungsprognose 2022 bis 2050. Bregenz, 2022. Online: https://vorarlberg.at/documents/302033/472239/Regionale+Bev%C3%B6lkerungsprognose+2022+bis+2050.pdf/d74924eb-7b89-6129-3bac-0e89ca015152?t=1644489177226

Andersen, H. T., Van Kempen, R.: New trends in urban policies in Europe. Cities, 20(2), 77–86. 2003.

APCC: Österreichischer Sachstandsbericht 2014 - Austrian Assessment Report 2014. Vienna, 2014. Online: https://ccca.ac.at/wissenstransfer/apcc/aar14

Atkinson, R.: Combating social exclusion in Europe. In: Urban Studies, 37, 1037–1055. 2000.

Blaschke, H.: Digitale Tools zur Unterstützung des akteurinnen-und akteursorientierten Planungsansatzes der 15-Minuten-Stadt. Wien, 2022. Online: https://repositum.tuwien.at/bitstream/20.500.12708/20042/1/Blaschke%20Helena%20-%202022%20-%20Digitale%20Tools%20zur%20Unterstuetzung%20des%20Akteurinnen...pdf

BMK – Bundesministerium für Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie (ed.): Konsultationsunterlage: „Mögliche Elemente einer Biodiversitäts-Strategie Österreich 2030 - (Expertinnen- und Expertenpapier basierend auf den Biodiversitätsdialogen 2030). Vienna, 2020. Online: http://biodiversitätsdialog2030.at/index.html

BMK – Bundesministerium für Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie (ed.): Energie in Österreich. Zahlen, Daten, Fakten. Vienna, 2021. Online: https://www.bmk.gv.at/dam/jcr:bbe5cd73-a161-46fc-8c80-2eb5fc500acb/Energie_in_OE2021_UA.pdf

BMSGPK – Bundesministerium für Soziales, Gesundheit, Pflege und Konsumentenschutz: Soziale Folgen des Klimawandels in Österreich. Vienna, 2021.

BMNT/BMVIT – Bundesministerium für Nachhaltigkeit und Tourismus, Bundesministerium für Verkehr, Innovation und Technologie: Die österreichische Klima- und Energiestrategie 2030. Vienna, 2018.

BMWi – Bundesministerium für Wirtschaft und Energie: Freiräume für Innovationen. Das Handbuch für Reallabore. Frankfurt, 2019. Online: https://www.bmwi.de/Redaktion/DE/Publikationen/Digitale-Welt/handbuch-fuer-reallabore.pdf?__blob=publicationFile

Bulkeley, H., Coenen, L., Frantzeskaki, N., Hartmann, C., Kronsell, A., Mai, L., ... & Palgan, Y. V.: Urban living labs: governing urban sustainability transitions. In: Current Opinion in Environmental

Sustainability, 22, 13-17. 2016.

Cohen-Shacham, E., Walters, G., Janzen, C. and Maginnis, S. (eds.): Nature-based Solutions to address global societal challenges. Gland, Switzerland, 2016.

Crenshaw, K.: Demarginalizing the Intersection of Race and Sex: A Black Feminist Critique of Antidiscrimination Doctrine, Feminist Theory and Antiracist Politics. University of Chicago Legal Forum, 1989(1), 2015. Online: https://chicagounbound.uchicago.edu/uclf/vol1989/iss1/8

Dale, A. & Newman, L.: Sustainable development for some: Green urban development and affordability. Local Environment. 14. 669-681. 2009. https://doi.org/10.1080/13549830903089283

Damyanovic, D.; Horelli, L.: Evaluation of spatial development from the gender+ perspective: a methodological proposal. In: Zibell, B.; Damyanovic, D.; Sturm U. (eds.): Gendered approaches to spatial development in Europe, 157-180; Routledge, Oxon, New York, 2019. ISBN 978-1-138-58766-3

Damyanovic, D.; Fink, T.; Gebetsroither-Geringer, E.; Grimm-Pretner, D.; Kozlowska, A.; Reinwald, F.; Stollnberger, R.; Tummers, L.; Untner, S.; Wankiewicz, H.; Weichselbaumer, R.: Ein Tool-Set zur Unterstützung einer Gender+-gerechten Stadtplanung. Ergebnisbericht des Forschungsprojekts SmartThroughGender+ – Integration von Gender+ in digitale Stadtplanungs-Tools und Entwicklung eines Tool-Sets für Gender+-gerechte Stadtplanung, Wien, 2021. DOI: 10.5281/zenodo.5763862

Despres, C.; Vachon, G.; Fortin, A.: Implementing Transdisciplinarity: Architecture and Urban Planning at Work. In: Doucet, I.; Janssens, N.: Transdisciplinary Knowledge Production in Architecture and Urbanism; Springer, Heidelberg. 2011. 10.1007/978-94-007-0104-5_3.

Eichberger A.: REK – Räumliches Entwicklungskonzept. Lustenau, 2006.

Eichberger A., Hämmerle M. & Salzmann G.: Siedlungsanalyse Lustenau. Dornbirn – Bregenz, 2016.

Eneqvist, E. & Karvonen, A.: Experimental governance and urban planning futures: Five strategic functions for municipalities in local innovation. In: Urban Planning, 6(1), 183-194.2021.

EURO-CORDEX: Coordinated Downscaling Experiment - European Domain. n.d. https://cordex.org/data-access/cordex-rcm-list/
Europäisches Parlament: Treibhausgasemissionen nach Ländern und Sektoren. Brüssel, 2019. Online: https://www.europarl.europa.eu/news/de/headlines/society/20180301STO98928/treibhausgasemissionen-nach-landern-und-sektoren-infografik
European Commission: EU Biodiversity Strategy for 2030, 2020. Online: https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1590574123338&uri=CELEX:52020DC0380
European Commission: Green Infrastructure (GI) — Enhancing Europe's Natural Capital, 2013. Online: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52013DC0249
Fassbinder, H.: The Concept of Biotope City. Vienna, 2002. Online: http://www.biotope-city.net/
Fazey, I., Schäpke, N., Caniglia, G., Patterson, J., Hultman, J., & van Mierlo, B.: Ten essentials for action-oriented and second order energy transitions, transformations and climate change research. In: Energy Research & Social Science 40, 54-70. 2018.
Fink, T.: On urban planning and procedural modeling, TU Graz, Graz, 2018.
Geerlings, H.; Stead, D.: The integration of land use planning, transport and environment in European policy and research. Transport Policy. 10(1), pp. 187-196. 2003. Online: http://www.elsevier.com/locate/tranpol,
Grin, J., Rotmans, J., & Schot, J. (eds.): Transitions to Sustainable Development. New Directions in the Study of Long-Term Transformative Change. In collaboration with Frank Geels and Derk Loorbach. New York & London, 2010.
Hauck T., Weisser W.: AAD Animal Aided Design. München, 2015.
Harvey, D.: Rebel Cities: From The Right to the City to The Urban Revolution. London, 2012.
IPCC – Intergovernmental Panel on Climate Change: AR6 Synthesis Report: Climate Change. 2022a. Online: https://www.ipcc.ch/report/sixth-assessment-report-cycle/
IPCC – Intergovernmental Panel on Climate Change: Climate Change 2022 - Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.)]. Cambridge University Press. In Press. 2022b.
Juschten, M; Reinwald, F; Weichselbaumer, R; Jiricka-Purrer, A.: Developing an Integrative Theoretical Framework for Climate Proofing Spatial Planning across Sectors, Policy Levels, and Planning Areas. Land-Basel. 10(8), 772, 2021.
Knapp, G.-A.: »Intersectionality« – ein neues Paradigma feministischer Theorie? Zur transatlantischen Reise von »Race, Class, Gender«. Feministische Studien, 23(1), 68–81. 2005. https://doi.org/10.1515/fs-2005-0107
Kohr, L.: Das Ende der Großen – zurück zum menschlichen Maß. Salzburg, 2002.
Koenig, R., Bielik, M., Dennemark, M., Fink, T., Schneider, S., Siegmund, N.: Levels of Automation in Urban Design Through Artificial Intelligence 46, 21. 2020.
Kok, K.; Veldkamp, Tom.: Scale and Governance: Conceptual Considerations and Practical Implications. ECOLOGY AND SOCIETY. 2011. 16. 23. 10.5751/ES-04160-160223.
Kühnau C., Böhm M., Reinke M., Böhme C., Bunzel A.: Doppelte Innenentwicklung –Perspektiven für das urbane Grün, Empfehlungen für Kommunen, 2017. Online: https://www.bfn.de/publikationen/broschuere/doppelte-innenentwicklung-perspektiven-fuer-das-urbane-gruen
Kuckartz, U.: Qualitative Inhaltsanalyse: Methoden, Praxis, Computerunterstützung (3., überarb. Aufl.). Weinheim, 2016.
Kuttler, W.: Klimawandel im urbanen Bereich. Teil 2, Maßnahmen, 2011. Online: https://enveurope.springeropen.com/track/pdf/10.1186/2190-4715-23-21?site=enveurope.springeropen.com
Lefebvre, H. The Production of Space. Oxford, 1991. (Original: La production de l'espace, Paris, 1974.)
Lenz D.; Braun M.; Götzelmann M.; Löning K.: Erläuterungen Kommunalgebäudeausweis Vorarlberg – Neubau / Generalsanierung. Version 2022-1. 2022
Lopez, P. A.; Behrisch, M.; Bieker-Walz, L.; Erdmann, J.; Flötteröd, J.-P.; Hilbrich, R.; Lücken, L.; Rummel, J.; Wagner, P.; Wiessner, E.: Microscopic Traffic Simulation using SUMO. 21st International Conference on Intelligent Transportation Systems (ITSC), 2018, pp. 2575-2582, doi: 10.1109/ITSC.2018.8569938.
Löning, K. Koch. N., Kern S., Hämmerle M.: Developing Biodiversity in Business Areas. Amt der Vorarlberger Landesregierung (Hrsg). Bregenz, 2020.
Löw, M.: Raumsoziologie. Erste Auflage. Frankfurt am Main, 2001.
Maronga, B., Banzhaf, S., Burmeister, C., Esch, T., Forkel, R., Fröhlich, D., Fuka, V., Gehrke, K. F., Geletič, J., Giersch, S., Gronemeier, T., Groß, G., Heldens, W., Hellsten, A., Hoffmann, F., Inagaki, A., Kadasch, E., Kanani-Sühring, F., Ketelsen, K., Khan, B. A., Knigge, C., Knoop, H., Krč, P., Kurppa, M., Maamari, H., Matzarakis, A., Mauder, M., Pallasch, M., Pavlik, D., Pfafferott, J., Resler, J., Rissmann, S., Russo, E., Salim, M., Schrempf, M., Schwenkel, J., Seckmeyer, G., Schubert, S., Sühring, M., von Tils, R., Vollmer, L., Ward, S., Witha, B., Wurps, H., Zeidler, J., and Raasch, S.: Overview of the PALM model system 6.0, Geosci. Model Dev., 13, 1335–1372. 2020. https://doi.org/10.5194/gmd-13-1335-2020
Madanipour, A.: Marginal public spaces in European cities. Journal of Urban Design, 9(3), 267–286. 2004. https://doi.org/10.1080/1357480042000283869
Mayring, P.: Qualitative Content Analaysis. A Step-by-Step Guide. London, 2021.
Moreno, C.; Allam, Z.; Chabaud, D.; Gall, C.; Pratlong, F. Introducing the "15-Minute City": Sustainability, Resilience and Place Identity in Future Post-Pandemic Cities. Smart Cities 2021, 4, 6.
Moulaert, F.: Social Innovation: Institutionally Embedded, Territorially (Re)produced. In: MacCallum, D., Vicari Haddock, S., Moulaert, F., & Hiller, J. (Hrsg.): Social Innovation and Territorial Development. London: Routledge, 11-25. London, 2013.
Ovink, H.; Boeijenga, J.: Too Big. Rebuild By Design: A Transformative Approach To Climate Change; Nai010 Publishers: Rotterdam, 2018.
ÖKS15: Klimafactsheet | Klimaszenarien für das Bundesland Vorarlberg bis 2100. 2016. Online: https://www.bmk.gv.at/dam/jcr:1b43e8f1-925e-47a3-b12b-a3314b2a991e/Factsheet-Vorarlberg.pdf.
ÖROK: Österreichisches Raumentwicklungskonzept ÖREK 2030. 2021.
PALM-4U. PALM-4U components. URL https://palm.muk.uni-hannover.de/trac/wiki/palm4u. retrieved on July, 8 2022.

Pauleit, S., Breuste, J.H.: Land-Use and Surface-cover as Urban Ecological Indicators. In: Niemelä, J., Breuste, J.H., Elmqvist, T., Guntenspergen, G., James, P., McIntyre, N. (Eds.), Urban ecology: patterns, processes, and applications. Oxford University Press, Oxford, New York, pp. 19–30, 2011.

Pulswerk (eds.): Kartierung und Bewertung der Biodiversität im Quartier Rotkreuz, Lustenau. 2022.

Reinwald, F; Auböck, M; Berger, A; Damyanovic, D; Fassbinder, H; Graßmugg, A; Gruber, E; Gutmann, R; Hafner, S; Huber, M., Kraus, F; Lainer, R; Ring, Z; Romm, T; Scharf, B; Unterberger, B; Wolf, T.: Biotope City – Bauanleitung für die grüne Stadt der Zukunft. BMK, 2021. Online: https://nachhaltigwirtschaften.at/de/sdz/publikationen/schriftenreihe-2021-26-biotope-city.php

Schartinger, D.: Social innovation with environmental impact: Current and future challenges. In: Howaldt, J., Kaletka, C., Schröder, A., & Zirngiebl, M. (eds.): Atlas of Social Innovation – New practices for a better future. Sozialforschungsstelle, TU Dortmund, 176-178. Dortmund, 2018.

Scheuvens R., Tschirk W. & Krassnitzer P: Planung als Prozess. Gestaltung dialogorientierter Planungs- und Umsetzungsmethoden. Werkstattbericht Nr. 109. Magistratsabteilung 21 B − Stadtteilplanung und Flächennutzung Süd-Nordost (ed.). Wien, 2010.

SIR – Salzburger Institut für Raumordnung und Wohnen (ed.): Nachhaltige Siedlungsprojekte. Tipps, Instrumente, Beispiele. Salzburg, 2021.

Speranza, P.: Using parametric methods to understand place in urban design courses. Journal of Urban Design 21, 661–689. 2016.

Stöglehner G.: Neue Wege in der Energieraumplanung. In: Giffinger R., Berger M., Weninger K., Zech S., Energieraumplanung - ein zentraler Faktor zum Gelingen der Energiewende; TU Wien, Wien, 2021.

Sturm, U.; Tuggener, S.; Damyanovic, D.; Kail, E.: Gender sensitivity in neighbourhood planning: the example of case studies from Vienna and Zurich. In: Zibell, B.; Damyanovic, D.; Sturm U., Gendered approaches to spatial development in Europe, 124-156; Routledge, Oxon, New York, 2019. ISBN 978-1-138-58766-3

Suitner, J. Towards Transformative Change. Die Schlüsselelemente experimenteller Ansätze in der städtischen Klimawandelanpassung erforschen. In: Der öffentliche Sektor – The Public Sector | 2021 | Vol. 47(2). Wien, 2021.

The World Bank: Handbook for Gender- Inclusive Urban Planning and Design. International Bank for Reconstruction and Development / The World Bank. 2020.

Thiel, S.: Fostering Inclusion in Urban Public Open Space Planning in Europe. From Symbolic Values to Implementation Efforts. Seeking Traces in Amsterdam and Vienna. Vienna, 2020.

UBA – Umweltbundesamt: Treibhausgas-Bilanz 2019 nach Sektoren. Wien, 2021. Online: https://www.umweltbundesamt.at/news210119/sektoren

United Nations: 2018 Revision of World Urbanization Prospects. Department of Economic and Social Affairs, 2019. Online: https://www.un.org/development/desa/publications/2018-revision-of-world-urbanization-prospects.html

Vuckovic, M., Loibl, W., Tötzer, T. and Stollnberger, R.:, Potential of Urban Densification to Mitigate the Effects of Heat Island in Vienna, Austria, Environments, 6, 82. Vienna, 2019.

Wertheim, E.: Negotiations and resolving conflicts: An overview. Northeastern University, College of Business Administration. 2002. Online: https://www.europarc.org/communication-skills/pdf/Negotiation%20Skills.pdf.

Wilson, R.S., Herziger, A., Hamilton, M., & Brooks, J.S.: From incremental to transformative adaptation in individual responses to climate-exacerbated hazards. In: Nature Climate Change, 10, 200-208. 2020. https://doi.org/10.1038/s41558-020-0691-6

Wolfram, M., Frantzeskaki, N., Maschmeyer, S.: Cities, systems and sustainability: status and perspectives of research on urban transformations. Current Opinion in Environmental Sustainability 22, 18–25. 2016. https://doi.org/10.1016/j.cosust.2017.01.014.

Woodward, A., Kohli, M. (eds.): Inclusions and Exclusions in European Societies. London, 2001.

Zopf, M.K.: Die grüne Stadt der Zukunft - Interdisziplinäre Beiträge zur nachhaltigen Stadtentwicklung und Freiraumgestaltung im Bezug zur Stadtregion Wien. Diplomarbeit am Institut für Landschaftsarchitektur. Wien, 2012. Online: https://abstracts.boku.ac.at/download.php?dataset_id=9473&property_id=107

🏆 *reviewed paper*

Towards Climate Resilient Coastal Cities: a Framework to Deploy Nature-Based Solutions in the Urban Planning Strategies of the North Coast Cities in Egyptp

Manar T. Mohammed, Asmaa E. Hasan, Khalid S. M. Al-Hagla

(Assistant Lecturer Manar T. Mohammed, Faculty of Engineering, Alexandria University, Alexandria, Egypt, manartalal@alexu.edu.eg)
(Lecturer Asmaa E. Hasan, Faculty of Engineering Alexandria University, Alexandria, Egypt, Asmaa.elsayed@alexu.edu.eg)
(Professor Khalid S. M. Al-Hagla, Faculty of Engineering, Alexandria University, Alexandria, Egypt, khagla@alexu.edu.eg)

1 ABSTRACT

Coastal zones of the Mediterranean region are severely affected by the effects of extreme climatic events, along with human-induced pressures, which causes their growing vulnerability. That leads to the urgency for sustainable and resilient long-term strategies for coastal development projects. In Egypt, the North Coast zone is considered a hotspot for climate-related changes. It is undergoing a series of new urban development projects expanding the urban areas along the coast of the Mediterranean Sea. As anthropogenic consequences along its coasts increase, the need for sustainable Nature-Based Solutions (NBS) will increase accordingly.

Recently, adaptive management strategies have been considered an important tactic to atone the unknown environmental conditions that coastal areas struggle with. Adaptive management was exploited to lessen such uncertainty by incorporating adaptive management into climate change adaptation strategies. In response to this need, this paper proposes a framework for nature-based solutions. It consists of four stages, it is founded on a novel approach that combines system analysis and building scenarios. Moreover, the first stage mainly depends on using the structure of the DPSIR (Driving force–Pressure–State–Impact–Response) model to improve ecosystem services and generate the evidence-base for the environmental, social, and economic benefits of nature-based solutions for implementation. The last two steps mainly reflect the adaptive management process and it is well-suited to capitalise on the transformational character of nature-based solutions' as it encourages "breakthrough" leaps rather than incremental improvements.

In essence, this framework aims to employ nature-based solutions in urban planning strategies to increase the climate resilience of coastal cities and. in particular, to identify suitable and less suitable strategies to be deployed in each zone. The framework has yet to be tested in a real-world case study; instead, this paper intentionally focuses on describing its structure, goals, and methodology, discussing its features, and framing its role from a climate resilience standpoint. As a result, the paper lacks a results section. Finally, conclusions are drawn regarding its potential adoption and further development.

Keywords: climate change adaptation, ecosystem services, nature-based solutions, adaptive management, Climate resilient

2 INTRODUCTION

Climate change is a real challenge that the world is facing nowadays (IPCC, 2014). Rapid urbanisation and increasing anthropogenic activities cause increasing climate change impacts and consequences that lead to improper and imbalanced functioning in the socio-ecological system, increasing vulnerability and reducing resilience (Mahmood, Zhang, Li, & Rahman, 2021). Moreover, most coastal cities are already dealing with noticeable changes from sea level rise, increasingly severe and more frequent coastal storms, and escalating loss of coastal resources such as fisheries and coral reefs, since pollution leads to warming and acidifying waters and other stressors to severely degrade coastal ecosystems. Therefore, researchers are focusing on promoting social-ecological resilience to face the climate change impact on coastal communities (Garmestani et al., 2019). Accordingly in the socio-ecological system, climate change resilience is defined as an element which refers to the capacity to absorb stress and maintain functions by adapting and evolving into a sustainable configuration for future climate change impacts (Hayes, Desha, Burke, Gibbs, & Chester, 2019).

In 2015 the UN proposed 17 Sustainable Development Goals (SDGs) which are considered the benchmark of progress of all signatory countries worldwide to promote sustainability by 2030 (UN, 2017). Most of the SDGs urge taking action to mitigate and adapt to climate change impacts such as Goals 1-3,6,7,9,11 and 13. Furthermore, SDG-11 (Sustainable cities and communities) seeks greater efficiencies in urban planning and management practices that address ageing infrastructure and ongoing air, water, and soil pollution, while SDG-13 promotes directly enhancing the adaptive capacity and resilience to climate change (UN, 2017).

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Meanwhile in Egypt, the Sustainable Development Strategy (SDS) presents Egypt Vision 2030 which has followed the Sustainable Development Goals (SDGs) as a general framework for improving the quality of life and welfare, taking into consideration the rights of new generations in a prosperous life; thus, dealing with three main dimensions which are environmental, economic, and social dimensions (UNDP, 2018). Hence, climate change resilience became a vital factor of sustainable development and is notably important to governments, policymakers, researchers, and educators. Lately, researchers globally advocate that nature-based solutions address societal challenges such as climate change and provide biodiversity benefits. However, the potential of nature-based solutions in building climate resilience and addressing climate change adaptation through urban planning in coastal cities has remained research rhetoric.

This study examines the effectiveness of nature-based solutions for tackling climate change adaptation and enhancing climate resilience. As a result, the study begins by reviewing the body of knowledge already available on climate resilience and nature-based solutions. The complexity and multifunctional features of nature-based solutions are then highlighted. The effectiveness of nature-based approaches in fostering climate resilience and adaptation is then examined. As a result, a framework is created that concentrates on the application of nature-based solutions and how it responds to climate resilience. To build climate resilience, this research stresses the use of nature-based solutions in local urban design as an effective urban policy instrument. According to this research, it is essential to include nature-based solutions into local urban planning. Furthermore, the framework has yet to be tested in a real-world case study in the Northwestern Mediterranean coastal zone, more specifically the New Alamein City. Instead, this paper intentionally focuses on describing its structure, goals, and methodology, discussing its features, and framing its role in terms of climate resilience. As a result, the paper lacks a results section where the findings of its potential application to a study area should be discussed, as well as the strengths and weaknesses of the framework. Finally, conclusions are drawn regarding its potential adoption and further development.

3 MATERIALS AND METHODS

A systematic literature review was conducted to develop the framework's scope and content. It was conducted using the databases Google scholar, Web of science and Scopus with the keywords "nature-based solutions" AND "framework" being used. The content was written in English and published until July 2022. The articles chosen was that proposed a novel framework and/or applied it to a case study/studies.

The following information was extracted from the selected publications: approach type (conceptual, practical, or both), sustainability dimension addressed (environmental, social and economic,), settlement type (urban, peri-urban, rural, or general). Beisdes, if the framework proposed a qualitative or quantitative assessment, and the purpose of the framework regarding Nature-based solutions (planning, evaluation, or both), a literature review was conducted to identify the main concepts related to Nature-based solutions, the main themes included, and the main gaps. Besides reviewing all strategies and policies of the Egyptian government regarding the climate change adaptation and mitigation actions in general and specially the Northwest Coast of the Mediterranean during the last decades. Identifying the main actions related to climate change impacts and main gaps. All of these were incorporated into the framework created here.

4 THE EGYPTIAN MEDITERRANEAN COASTAL ZONE AS A CLIMATE CHANGE HOTSPOT

The Mediterranean region and in particular its coastal zones are severely affected by impacts of extreme climatic events for example storm surges, coupled with human-induced pressures such as uncontrolled building on coasts, resulting in growing vulnerability. (Satta, Puddu, Venturini, & Giupponi, 2017). Giorgi (2006) referenced that based on the results of global climate change projection models, the Mediterranean region was identified as one of the most vulnerable to climate change and as a key "Hot-spot". The Mediterranean is highlighted in the International Panel on Climate Change (IPCC) report as one of the regions that are most susceptible to the effects of global warming. The necessity of evaluating potential climate change effects on this sensitive region, which will become substantially warmer and drier, is highlighted by the background of global warming. (IPCC, 2013).

Depending on the sub-region, an increase in air temperature of 1.5 to 4°C was seen in the Mediterranean basin. A warming trend can be observed in North Africa as well, albeit it is more challenging to quantify due to the observing system's more sporadic nature. Besides, sea-level rise (SLR) will lead to increases in coastal

flood and erosion risks along the entire Mediterranean coast. (UNEP/MAP, 2017). Policies for the Mediterranean country‘s sustainable development need to mitigate these risks and consider adaptation options, although currently, it lacks adequate information, specifically for the most vulnerable southern Mediterranean societies, where fewer systematic observation schemes and impact models are based (Cramer et al., 2018; Milano et al., 2013). Utmost climate models point to a significant shift toward drier conditions during winter and spring when southern Mediterranean countries receive the bulk of their annual precipitation. Coupled Model Intercomparison Project phase 5 (CMIP 5) (Taylor, Stouffer, & Meehl, 2012) Global Climate Models (GCMs) project predicts that annual precipitation decreases could locally reach 40% under an (RCP8.5) higher emission scenario i.e. business-as-usual scenario (Zappa, Hoskins, & Shepherd, 2015). Accordingly, this would severely affect the habitability and stability of the basin in the next coming decades (Dubrovský et al., 2014).

4.1 The Northwestern coast of Meditternean Climate change impact

The Northern Egyptian coastline extends 1000 km along the southeast of Mediterranean Sea as shown in Figure 1 (Iskander, 2021). Egypt’s coastal zones are expected to be affected by a 50 cm sea level rise that will affect 2 million people and cause land and real estate losses worth about 35 billion US$ (Agrawala et al., 2004). The overriding roots are the rapid infrastructure and urban development, increasing tourism and recreational activities, pollution from residential, agricultural, commercial, and industrial activities and the anticipated impact of climate change and sea level rise, significantly on the low-lying areas (Kafrawy & Soliman, 2012). These are mainly anthropogenic-induced stressors. These will aggravate vulnerability and add to the impacts of climate change and sea level rise that will manifest themselves in sectors such as agriculture, irrigation, population and health, as well as infrastructure shown in Table 1 (El-Masry, El-Sayed, Awad, El-Sammak, & Sabarouti, 2022; Kafrawy & Soliman, 2012)

Figure 1: The north coast of Egypt extended on the Mediterranean Sea as well as The northwestern coast zone is highlighted.

Aspects		SLR	Saltwater intrusion	Extreme storm occurrences	Increase water temperature	Change of acidity
Ecosystem/Nature	Erosion	■		■		
	Soil salinization	■	■		■	■
	Endangered Ecosystem	■	■	■	■	■
	Land subsidence	■				
Socio-economic activities	Agriculture	■	■	■	■	■
	livestock	■	■		■	■
	Fisheries	■	■	■	■	■
	Industry	■		■		
	Infrastructure	■		■		
	Human settlement	■	■		■	■
	Health	■	■	■	■	
	Water resources	■	■	■	■	■

Table 1: Impacts of climate change on the Egyptian coastal cities (Ismail, 2018).

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Furthermore, west of Alexandria city, cities are stretching along 525 km of the Northwestern Coast of Egypt on the Mediterranean Sea as shown in Figure 1. This propitious region will be the focus of the study since it has attracted in the past many touristic projects with massive investments (Elsharnouby, Soliman, Elnaggar, & Ouda, 2012). However lately, Egypt is focusing on the Northwestern Coast zone, a part of Egypt Vision 2052 to build new urban settelments along the coast. Many proposals identified this region as a potential development zone, it reaches a depth of about 40 km from the shoreline and is supposed to include new urban settlements to attract more population to settle on the North Coast such as the New Al-Alamein City (Attia, Shafik, & Ibrahim, 2019). Thus, the different social and economic development areas along the Mediterranean coast of Egypt are under immense and continuous pressure. Due to climate change and expanding urban and tourist development in new locations vulnerable to natural disasters and other factors, the disaster risks are predicted to grow by 2030. There will be increased hazards of coastal erosion, marine submersion, and water scarcity, as well as increased dangers of land subsidence, seismic activity, and flooding (Kafrawy & Soliman, 2012). Therefore, a compelling need emerges to understand coastal zones in the Mediterranean region and how they could evolve under the effects of climate change and to develop methodologies that can assess the resultant vulnerabilities and risks. Proactive adaptation to these hazards is essential for maintaining the functions of coastal zones. Nature-based solutions for shore protection such as beaches and shore nourishment as well as dune or wetland restoration are becoming a more common alternative to hard structures (Cramer, Guiot, Marini, Secretariat, & Bleu, 2020).

4.2 Egypt's National Strategy for Adaptation and Mitigation to Climate Change Risks

The Egyptian government's concern for climate change has resulted in the development of a national strategy addressing the phenomenon of climate change based on the sectors affected and those influencing the issue of climate change. The first level is concerned with adaptation to climate change, while the second is concerned with mitigating its severity. Furthermore, some efforts have been made to protect coastal areas and improve the resilience of these zones. Egypt undertakes these efforts primarily for current development and environmental priorities, which are synergistic with climate change adaptation. Nonetheless, attempts are mostly limited to "hard" adaptations, which, given the significance of the obstacle, are still somewhat inadequate in terms of covering vulnerable regions (Kader & Haron, 2020).

Also, Egypt submitted its Nationally Determined Contribution (NDC) and Third National Communication (NC3) to the UN Framework Convention on Climate Change (UNFCCC) in 2016, in support of its efforts to achieve its development and economic goals and increase its adaptive capacity to climate change. Egypt's NDC aligns with the country's overarching goals of reducing vulnerability and poverty while achieving long-term sustainable economic development. Key areas of focus include environmental sustainability, water resources, energy, sustainable land management, agriculture, and health (WBG, 2020). The Egyptian government recently launched the National Climate Change Strategy to support the transition to a greener, climate-resilient economy. The private sector is increasing its adaptation efforts and will play a critical role in this transition. Egypt has also issued the region's first sovereign green bond to finance projects in clean transportation and sustainable water management in order to develop the green finance market. Egypt is also coordinating global action on climate adaptation, mitigation, and finance as the host of COP27.

Nevertheless there is still some research and institutional gaps to improve the government strategies to build resilience to climate change, these gaps are:

4.2.1 Research gaps

- Improve understanding of key vulnerabilities and development impacts associated with projected climate change trends in Egypt, as well as potential soft adaptation responses.
- Increase public, scientific institutions, and local communities participation in planning and management.
- Strengthen environmental monitoring capabilities for more effective environmental management.
- Improve understanding of the impacts on Egypt's coastal zones, including investment in risk assessments and soft adaptation options.
- More research is needed to understand the vulnerability and adaptation of Egypt's biodiversity to the effects of climate change.

4.2.2 Institutional gaps

- Ensure that the National Environmental Strategy goals are integrated into sectoral and regional plans, as well as financial opportunities with donors.
- Systematic observations of sea surface temperature, coastal land use, and sea level variations must be institutionalised to ensure that results are available to the scientific community and policymakers.
- Promote energy efficiency options by improving financing options and providing legal support for public-private partnerships.
- Implement cross-sectoral climate-smart nature solutions for Egypt's urban planning and water management sectors at the national and sub-national levels.

5 DEFINITIONAL AND CONCEPTUAL ASPECTS OF NATURE-BASED SOLUTIONS (NBS)

While there is still an ongoing debate on defining Nature-based solutions (Nesshöver et al., 2017), the definitions elaborated by the International Union for Conservation of Nature (IUCN) and the European Commission (EC), as most conceptualizations, build upon or refer to (Calliari, Staccione, & Mysiak, 2019). Nature-based solutions are defined by the European Commission as "living solutions inspired by, continuously supported by and using nature, which is designed to address various societal challenges in a resource-efficient and adaptable manner and to provide simultaneously economic, social, and environmental benefits" (European Commission, 2015). IUCN defines nature-based solutions as "actions to protect, sustainably manage, and restore natural or modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits" (Cohen-Shacham, Walters, Janzen, & Maginnis, 2016).

The IUCN definition provides and encompasses eight foundational principles which are the consideration of local natural and cultural contexts, application at the landscape scale, and a forward-looking attitude in considering the evolution of ecosystems and associated benefits, besides the endorsement of nature conservation norms, fairness, and equity in delivering societal benefits (Cohen-Shacham et al., 2016). On the other hand, the European Commission's definition embraces locally adapted, cost-effective, and resource-efficient solutions that are "inspired by, supported by or copied from nature" and "simultaneously provide environmental, economic and social benefits and promote building resilience" by bringing "more, and more diverse, nature and natural features and processes into cities, landscapes and seascapes" (European Commission, 2015).

Conclusively the common factor is a recognition of the role that nature can play in tackling major societal challenges, such as disaster risk management, and climate change adaptation and mitigation. The term "solutions" implies a problem-centred approach, thus the identification of problems or challenges that could be effectively addressed by NBS is a key aspect of this approach (Potschin et al., 2016). Another shared distinctive trait that concerns the capacity of NBS is "multifunctionality" (Kabisch et al., 2016), in other words, to deliver simultaneous benefits to society, the economy and the environment (Albert, Spangenberg, & Schröter, 2017). Moreover, it builds upon an anthropocentric view of the benefits that natural resource management can bring to humans (Nesshöver et al., 2017). In particular, the European Commission emphasises the way NBS can contribute to the application of participatory processes for co-design, co-creation and co-management (Pauleit, Zölch, Hansen, Randrup, & Konijnendijk van den Bosch, 2017), and reliance on multidisciplinary, evidence-based strategies (Nature, 2017).

5.1 Building Climate Resilience for coastal cities by nature-based solutions

Climate resilience is based on two interacting concepts: "adaptation", and "mitigation (Christopher M Raymond et al., 2017). In the case of nature-based solutions, which involve elements of ecosystems, the two concepts are closely linked as any adaptation of an ecosystem can further influence the mitigation potential, for example by sequestering carbon in vegetation, with an overall dramatic effect on climate resilience. Furthermore, there is a growing scientific and engineering interest in investigating how natural processes can provide management solutions to coastal environment degradation and vulnerability. Climate change and associated sea level rise, along with drivers such as subsidence, reduced sediment supply, and coastal squeeze, are major risk factors for the sustainability of coastal systems. Using natural processes to deal with these risk factors is considered a challenging task (Slinger, Stive, & Luijendijk, 2021). Nature-based

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

solutions include using existing natural systems (for example, protecting a marsh), managing or restoring those systems (for example, restoring a marsh), or developing new systems (e.g., combining mud flats, marshes, and concrete levees to create a horizontal levee) (Cohen-Shacham et al., 2016). All of these natural-based solutions types can help to improve coastal resilience and risk reduction by utilising natural processes and landforms to protect both ecosystems and the built environment (Whelchel, Reguero, van Wesenbeeck, & Renaud, 2018). They can provide not only protection from sea-level rise and storms (Arkema et al., 2013; Shepard, Crain, & Beck, 2011), but also mitigation of climate change through carbon sequestration, recreational opportunities, habitat for key species, and other benefits (Bilkovic, Mitchell, Mason, & Duhring, 2016; Gedan, Kirwan, Wolanski, Barbier, & Silliman, 2011). As illustrated in Figure 2 the different Nature-based Solutions strategies that could be implemented in coastal cities to prevent coastal erosion and urban flooding. These advantages—ecosystem services or contributions of nature to people—help connect healthy, functioning ecosystems to human well-being (Guerry et al., 2015; Guerry et al., 2022).

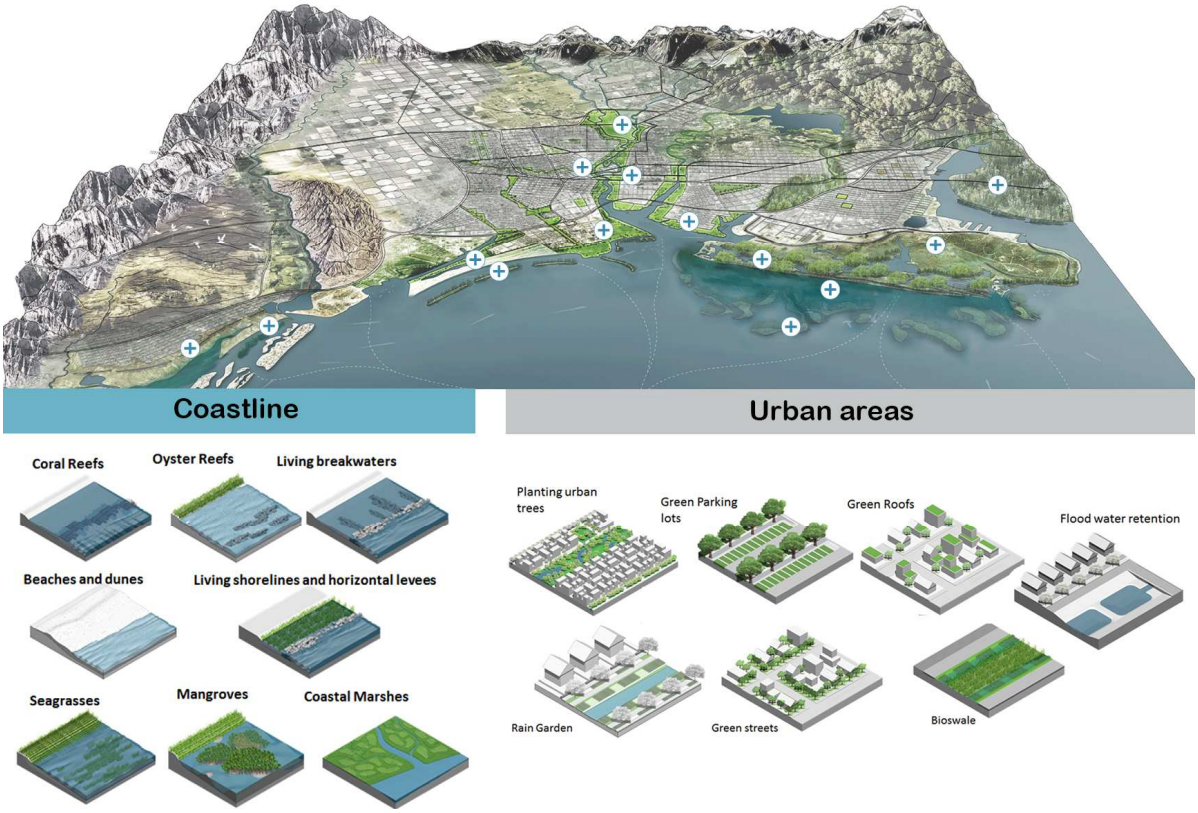


Figure 2: Illustration depicting the diversity and location of nature-based solutions approaches across coastal and urban landscapes. Adapted from www.nrcsolutions.org.

5.2 Right scale for implementation

One of the major issues in implementing Nature-based solutions for urban climate resilience and in understanding their potential impact and effectiveness is related to the scale of intervention. Action on climate mitigation can span the micro level of a single building, the meso level of the whole city or country and the macro level of the entire planet, though it has essentially a macro (global) scale effect by affecting global concentrations of greenhouse gases. Climate adaptation is more often planned and implemented at the meso (national) to micro (local) level, and the impacts are also at these levels. There are some common actions and indicators, but also some that are specific to the different scales of climate action to be addressed, as identified below. To reduce global greenhouse gas concentrations, nature-based solutions for climate resilience can either be macro-scale mitigation or meso- and micro-scale adaptation. Meso-scale adaptation involves planting vegetation to improve the local or regional microclimate through cooling, shading, and shelter (Christopher M Raymond et al., 2017).

5.3 Transdisciplinary collaboration for Nature-based Solutions Implementation

For building resilience understanding the interconnectedness of citizens, physical spaces, and policies as a social-ecological system (SES) is crucial. It provides a framework for developing urban resilience and sustainability approaches (Vandergert, Collier, Kampelmann, & Newport, 2016). Emerging research suggests that multi-stakeholder experiments that bring together expertise from individuals, organisations, agencies, and institutions at multiple organisational levels can promote a social-ecological approach. The outcomes of these collaborations must eventually be translated into the planning/policy framework via adaptive governance processes to ensure that transformation opportunities are not missed. Thus, this paper demonstrates how nature-based solutions can support multifunctional ecosystem service benefits (Connop et al., 2016; Folke, Hahn, Olsson, & Norberg, 2005; Wilkinson, 2011).

Furthermore, while significant progress has been made in the design and testing of ecosystems and their role in risk mitigation, these solutions have yet to be fully evaluated and standardised. As a result, some nature-based climate adaptation projects have been poorly designed, resulting in ineffective and unsustainable outcomes. As with engineering solutions, there is no "one size fits all" approach because climatic, ecological, and hazard characteristics vary and are frequently poorly understood. However, the traditional infrastructure sector has a long history of fully developed protocols and standards, whereas nature-based solutions are emerging approaches that require the same level of investigation of lessons learned (Connop et al., 2016; Folke et al., 2005; Wilkinson, 2011) and standard development. As a result, guidelines and standards for nature-based solutions must be developed to assist project designers, implementers, funders, evaluators, and others involved in project development. The guidance also aids in developing a shared understanding of the likely effectiveness and risk reduction outcomes. Accordingly, this framework aims to be a first step toward standardisation.

5.4 Nature-based solutions frameworks

There aren't many frameworks for recognising, evaluating, and guiding the design and implementation of cross-sectoral initiatives and policies, as well as the role and co-benefits of nature-based solutions. An illustration of a conceptual framework for evaluating the co-benefits of nature-based solutions across components of socio-cultural and socio-economic systems, biodiversity, ecosystems, and climate was established by Christopher M. Raymond et al. (2017). After reviewing numerous documents from science and practice served as the framework's primary source of inspiration. Following the database searches, each article was screened for eligibility and retrieved the full-text version of each potentially relevant reference. The systematic literature review criteria were met by a number of articles. Most of the articles were published in 2019, followed by 2020, and a few of them in 2017 and 2018. There was no time limit for the initial search, and the first Nature-based Solutions framework was published in 2017, demonstrating the novelty of this research field (Christopher M Raymond et al., 2017). The articles were divided into two categories: "conceptual" papers in which the frameworks were not applied in practice such as Cohen-Shacham et al. (2019) and "practical" papers in which a case study/experience related to the framework's application was presented such as Lafortezza and Sanesi (2019). Some articles addressed both conceptual and practical aspects of the NBS framework. In terms of the location or type of settlement to which the analysed frameworks can be applied, the majority were general (applicable to any context), some applied to an urban context, and the least of them applied to a rural context. There were no studies that specifically looked at "peri-urban" areas. The environmental and social dimensions were the concern of the majority of the research (Dumitru, Frantzeskaki, & Collier, 2020), those two pillars of the three pillars of sustainability were used in more frameworks than the economic dimension.

Accordingly, creating robust monitoring and evaluation frameworks to assess the impacts of nature-based solutions will enable cities to evaluate the strengths and weaknesses of specific interventions in achieving strategic city goals. As part of a broader movement toward evidence-based policy and management, various stakeholders are increasingly demanding more evidence of policy effectiveness. It will also provide an essential tool for the adaptation of design and implementation features, thereby increasing their performance. It may also strengthen the case for investments in Nature-based solutions, as most Egyptian cities struggle to persuade investors that climate adaptation strategies especially soft solutions such as nature-based solutions can meet the diverse objectives and interests of their stakeholders. Finally, for mainstream change to occur, rigorous evaluation is required. Robust evaluation is required for a shift in mainstream approaches to urban

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

resilience and regeneration planning, which are still dominated by redundancies resulting from viewing ecological, social, and economic objectives as distinct and sometimes contradictory, as reflected in the silo-thinking of urban policy practice.

6 PROPOSED FRAMEWORK FOR IMPLEMENTING CLIMATE PROOF NATURE-BASED SOLUTIONS IN COASTAL CITIES

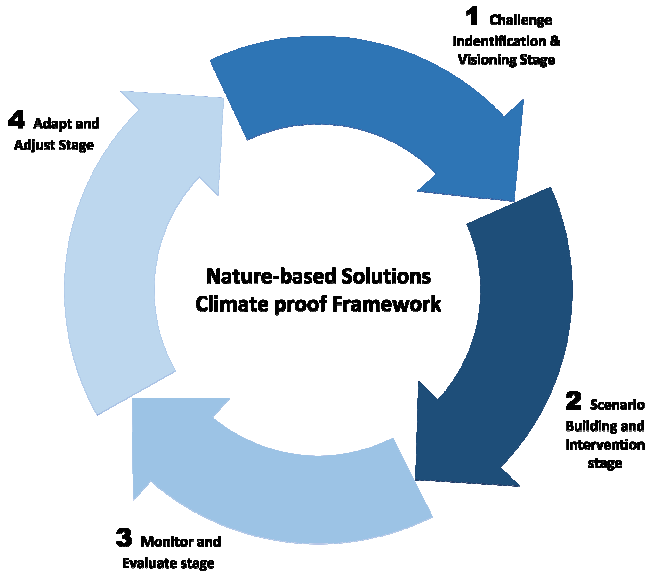


Figure 3: Schematic diagram of the framework showing different stages. (By Author)

As mentioned earlier scholarly work has highlighted the need to assess the social implications of Nature-based Solutions and how they link to just and equitable cities (Haase et al., 2017). This paper focuses on a framework that is specifically designed to address the Nature-based solutions implementation and mainstreaming process. Despite these and other credible works, it is appropriate to move forward with a more practical framework that complies with European Commission standards to support the process of developing and delivering nature-based solutions for sustainable urbanisation and building climate resilience. Given the complex mechanisms that typically underlie urbanisation and its effects on the delivery of ecosystem services, the framework should situate nature-based solutions in the appropriate context downstream from the overall cause-and-effect process of urbanisation.

Besides, since ecosystems are self-organising and adapt in response to numerous interactions across many levels of scale the results of management interventions, thus nature-based solutions cannot be predicted with certainty. As a result, a framework that includes in-depth reflection, which is a component of experiential learning, can express the challenges and strategies better for managing uncertainty. Long-term monitoring is also necessary for NBS to be successful. The ability of managers to evaluate the efficacy and outcomes of management interventions and adjust management accordingly is essential for the long-term stability of nature-based solutions. To obtain a wide range of social and environmental advantages, monitoring programmes should be institutionalised inside organisations and stakeholder groups that manage a landscape. Overall, an adaptive management framework is required for nature-based solutions to function well (Brears, 2020; Cohen-Shacham et al., 2019; Kabisch, Korn, Stadler, & Bonn, 2017).

This idea of an adaptive management framework makes it a circular and flexible scheme, making each stage dependent on the others but not necessarily in the same sequence. The four stages are shown in Figure 3. They are 1) challenge identification at the visioning stage; 2) scenario building and intervention stage; 3) monitor and evaluation stage; 4) adapt and adjust stage. Multiple types of engagement and communication are required to reach stakeholders of different power, expertise and interest at each stage. Below the proposed framework is described and each stage is illustrated in some detail as shown in Figure 4.

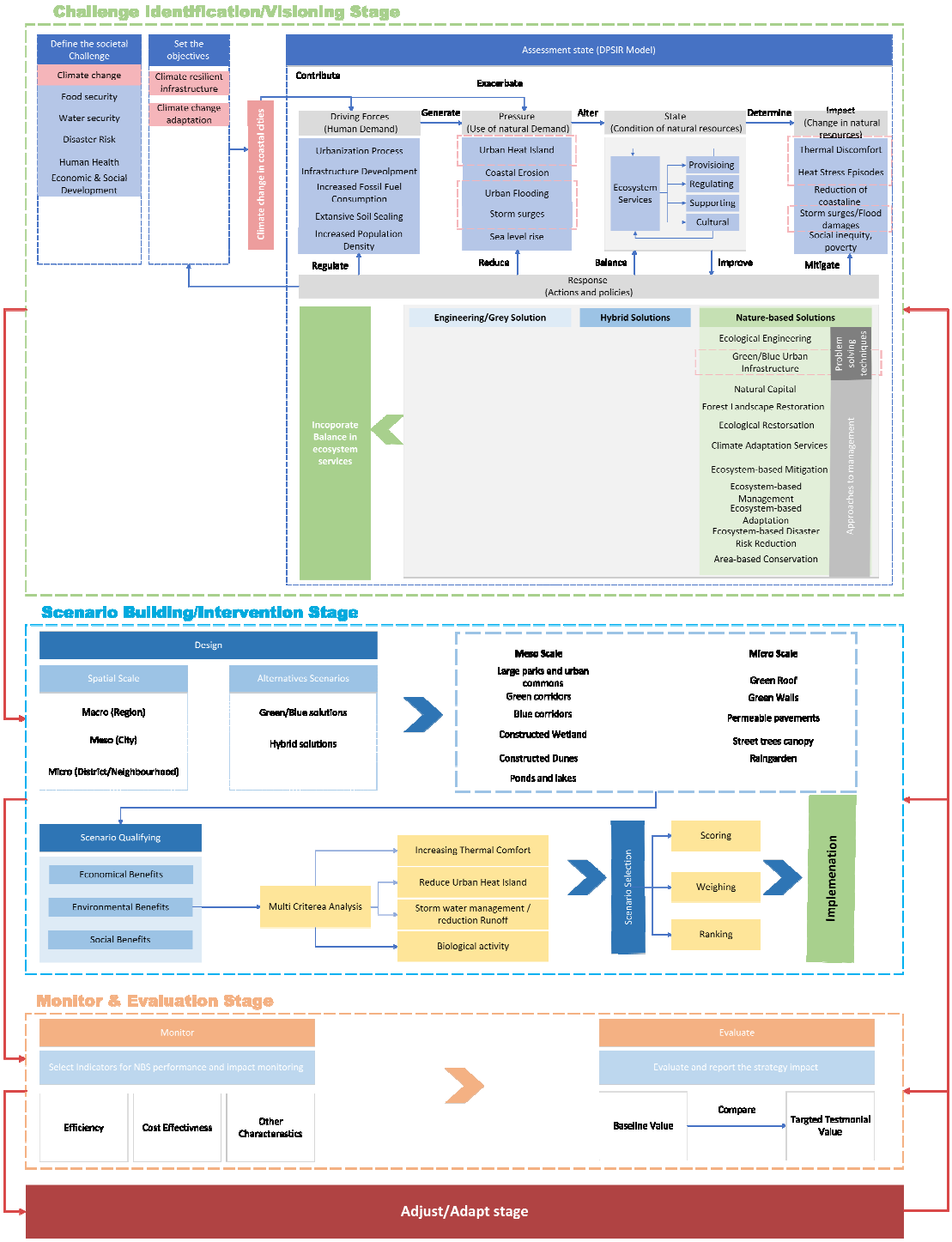


Figure 4: The proposed framework for implementation of Nature-based solutions in Coastal Cities.

6.1 Challenge identification and visioning stage

In many cases, the problems that nature-based solutions must address are multidimensional and complex. After identifying the problem areas, criteria for assessing the relationships between problem dimensions and potential blind spots, or missed opportunities, must be established. Therefore, in this stage, the question to be asked is "What are the project's identified needs and challenge areas, and what criteria will be used to understand problem dynamics?" The process of this stage is done in two steps. The first step is identifying the societal challenge of the coastal area that needs to be addressed setting the objectives of this project. The second step is understanding and assessing the current situation to define the problem dynamics. According to Lafortezza and Sanesi (2019) the European-born DPSIR (Driving Force – Pressure – State – Impact - Response) standardised framework is used to mainstream this step of investigating their effects on the dynamics of urban areas (Gabrielsen & Bosch, 2003). The DPSIR model is an environmental assessment tool

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

and one of the most important decision-making tools that have emerged in the last fifteen years to analyse the cause-effect relationships that exist between society and the environment and to support decisions in response to environmental issues (Gregory, Atkins, Burdon, & Elliott, 2013; Spanò, Gentile, Davies, & Lafortezza, 2017). Gaps in ecosystem service delivery/supply, as well as trade-offs between ecosystem services, can be used to complement problem analysis. After identifying the issues and assessing the current situation, the next critical step is to determine the adequate response with which nature-based solutions and alternative grey/hybrid solutions can address them. The multiple benefits that nature-based solutions are providing must be identified and compared to the benefits of alternative green or grey/hybrid solutions.

6.2 Scenario Building and Implementation Stage

During this stage, the urban planner's design and identify a set of concrete actions that will lead to the desired situation according to the urban planning intervention scale. The proposed scenarios include various actions that can be taken to achieve the main objective and sub-objectives identified during the visioning stage. Thus, moving from the 'archetype solution' to concrete ones is implied by this step. Natural, or hybrid solutions can be used as alternatives. They always include a 'doing nothing scenario as a baseline for appreciating the difference brought about by various courses of action. Because nature-based solutions or hybrid solutions are based on ecosystem services, identifying this type of alternative requires matching stakeholders' desires and needs (ecosystem services demand) as developed during the visioning stage with what local ecosystems can deliver (ecosystem service supply). Ecosystems are typically multifunctional, containing a wide range of (potentially interacting) ecosystem services. When a group of services appears together repeatedly in time and/or space, it is referred to as a 'bundle,' (Raudsepp-Hearne, Peterson, & Bennett, 2010) and the positive and negative associations between its services are referred to as synergies and trade-offs (Mouchet et al., 2014).

Given that nature-based solutions imply ecosystem management for societal and environmental benefits, the impact on ecosystem services associations should be considered. If there is a mismatch between ecosystem Service supply and ecosystem services demand, a different option can be chosen, or the objectives can be refined. Climate resilience must be tested after the alternatives have been identified and designed. This enables considering nature-based or traditional investment options over the medium to long term, and not just in terms of the hazard they are designed to address. A mapping of the expected 'performance' of climate-proof alternatives should be carried out as a preliminary step to the quantitative assessment. In fact, nature-based solutions may be competitive with traditional grey interventions only if their multifunctionality is considered. This entails breaking down the expected effects of each alternative in terms of (in)direct environmental, social, and economic benefits and costs, in order to provide a comprehensive basis for assessing and selecting alternatives. Accordingly in this step multi criteria analysis (MCA) is used to select and rank NBS measures because of its ability to integrate and overcome differences between technical and social approaches (Loc, Duyen, Ballatore, Lan, & Das Gupta, 2017). MCA also allows for the evaluation of potential measures using a variety of criteria defined by different units, both quantitative and qualitative (Ruangpan et al., 2021). Based on the results of this qualitative screening, decision-makers can return to the definition of alternatives to refine them. Indeed, as the effects of climate change enter the picture, the effectiveness of an alternative in achieving the predefined objectives and sub-objectives may be jeopardised. As a result of the feedback loop, more climate-resilient options can be designed through an iterative and participatory process.

6.3 Monitoring and evaluating stage

Monitoring involves observing system characteristics after implementation and gathering evidence on how nature-based solutions and measures perform in practice. The disparity between expected and actual outcomes reveals information about the system's response. The interventions should be reviewed and modified to address the challenge or potential new needs (evaluate and adapt). This could lead to several feedback loops over time. To assess the effectiveness and impact of nature-based solutions, information from various monitoring sources and fieldwork is compared to current targets, such as annual targets compared to annual achievements, or long-term targets compared to cumulative annual achievements.

The monitoring and evaluations of s nature-based solutions projects have three major goals: (1) provide information and responses for further advancements and timely project execution, (2) account for expenses

incurred, and (3) fill gaps for effective and successful implementation of future projects. Precise and measurable 'Key Performance Indicators (KPIs)' and 'Key Impact Indicators (KIIs)' are required to monitor the potential effects of implementing nature-based solutions on the specific societal challenge in coastal cities.

6.4 Adapt and adjust stage

The previous phase (evaluation) may also result in a corrective action (adapt) to ensure the measure's long-term effectiveness. This could imply combining nature-based solutions with a more traditional approach, for example. Alternatively, the process could be reversed and new objectives for the system of interest defined. Furthermore, the proposed assessment framework forms part of a larger approach to the implementation of nature-based solutions in coastal cities. As nature-based solutions in coastal cities evolve, they must be managed continuously, and their effectiveness monitored. Therefore, the adapt and adjust stage in adaptive management can help achieve this goal (van Wesenbeeck et al., 2017). This allows for more effective revision and refinement of actions to achieve the desired/expected outcomes (Williams, 2011).

7 DISCUSSION AND CONCLUSION

The growing emphasis on nature-based solutions in policy and research has encouraged efforts to define guiding principles and to design effective assessment frameworks that meet public policy requirements while empirically demonstrating the societal value of 'working with nature.' This framework proposes what reconciles and complements previous efforts while introducing new, complementary elements to support a comprehensive evaluation of nature-based solutions' effectiveness in coastal cities of the Mediterranean Zone. In other words, while the theoretical level is well defined, the potential multiple benefits of the nature-based solutions approach in coastal cities in terms of climate-adaptive and resilient built environment transformation are rarely realised due to a lack of understanding of the scientific knowledge that supports regenerative solutions. A regenerative climate-resilient urban planning that incorporates nature-based solutions has several measurable consequences, including the ability to combine for instance recreation with flood risk management, heritage with urban cooling, health promotion with economic growth and social inclusion.

The reference framework presented in this paper takes an interdisciplinary approach and demonstrates how nature-based solutions can effectively function as downstream responses in urban areas and city regions to meet sustainability goals. The framework's strength lies in its standardised DPSIR structure and applicability, as it allows for the disentanglement of the complex factors and mechanisms underlying the process of climate resilient urbanisation and the consolidation of the close "cause-effect relationship" between ecosystem services and nature-based solutions. In other words, the framework serves as a streamlined support tool for city managers, policymakers, and decision-makers, breaking down complex concepts through a direct application of nature-based solutions for co-developing climate-resilient coastal cities facing urbanisation pressures. Furthermore, this cascading framework efficiently serves the purpose of demonstrating 1) how nature-based solutions work well within ecological processes and human-environment interactions, and 2) that nature-based solutions are to be considered as the proven response to today's urgent climate change issues at both the local and regional scales through its interactive process or loop system.

The current study's next steps will consider its implementation in an existing study area in order to support the inclusion of climate resilience in local urban planning strategies and promote their importance among stakeholders and decision-makers. The author intends to apply the current framework to the study areas in the northwestern Egyptian Mediterranean coast, particularly on one of the new development cities such as Alamein New City, in order to achieve the results envisaged by the framework.

8 REFERENCES

Agrawala, S., Moehner, El Raey, M., Conway, Aalst, M., Hagenstad, & Smith, J. (2004). Development and Climate Change in Egypt.

Albert, C., Spangenberg, J. H., & Schröter, B. (2017). Nature-based solutions: criteria. Nature, 543(7645), 315-315. doi:10.1038/543315b

Arkema, K. K., Guannel, G., Verutes, G., Wood, S. A., Guerry, A., Ruckelshaus, M., . . . Silver, J. M. (2013). Coastal habitats shield people and property from sea-level rise and storms. Nature Climate Change, 3(10), 913-918. doi:10.1038/nclimate1944

Attia, S., Shafik, Z., & Ibrahim, A. (2019). New Cities and Community Extensions in Egypt and the Middle East: Springer.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Bilkovic, D. M., Mitchell, M., Mason, P., & Duhring, K. (2016). The Role of Living Shorelines as Estuarine Habitat Conservation Strategies. Coastal Management, 44(3), 161-174. doi:10.1080/08920753.2016.1160201

Brears, R. C. (2020). Nature-based solutions to 21st century challenges: Routledge.

Calliari, E., Staccione, A., & Mysiak, J. (2019). An assessment framework for climate-proof nature-based solutions. Science of The Total Environment, 656, 691-700. doi:https://doi.org/10.1016/j.scitotenv.2018.11.341

Cohen-Shacham, E., Andrade, A., Dalton, J., Dudley, N., Jones, M., Kumar, C., . . . Walters, G. (2019). Core principles for successfully implementing and upscaling Nature-based Solutions. Environmental Science & Policy, 98, 20-29. doi:https://doi.org/10.1016/j.envsci.2019.04.014

Cohen-Shacham, E., Walters, G., Janzen, C., & Maginnis, S. (2016). Nature-based solutions to address global societal challenges. IUCN: Gland, Switzerland, 97.

Connop, S., Vandergert, P., Eisenberg, B., Collier, M. J., Nash, C., Clough, J., & Newport, D. (2016). Renaturing cities using a regionally-focused biodiversity-led multifunctional benefits approach to urban green infrastructure. Environmental Science & Policy, 62, 99-111. doi:https://doi.org/10.1016/j.envsci.2016.01.013

Cramer, W., Guiot, J., Fader, M., Garrabou, J., Gattuso, J.-P., Iglesias, A., . . . Paz, S. (2018). Climate change and interconnected risks to sustainable development in the Mediterranean. Nature Climate Change, 8(11), 972-980.

Cramer, W., Guiot, J., Marini, K., Secretariat, M., & Bleu, P. (2020). Climate and environmental change in the mediterranean basin–current situation and risks for the future.

Dubrovský, M., Hayes, M., Duce, P., Trnka, M., Svoboda, M., & Zara, P. (2014). Multi-GCM projections of future drought and climate variability indicators for the Mediterranean region. Regional Environmental Change, 14(5), 1907-1919. doi:10.1007/s10113-013-0562-z

Dumitru, A., Frantzeskaki, N., & Collier, M. (2020). Identifying principles for the design of robust impact evaluation frameworks for nature-based solutions in cities. Environmental Science & Policy, 112, 107-116. doi:https://doi.org/10.1016/j.envsci.2020.05.024

El-Masry, E. A., El-Sayed, M. K., Awad, M. A., El-Sammak, A. A., & Sabarouti, M. A. E. (2022). Vulnerability of tourism to climate change on the Mediterranean coastal area of El Hammam–EL Alamein, Egypt. Environment, Development and Sustainability, 24(1), 1145-1165. doi:10.1007/s10668-021-01488-9

Elsharnouby, B., Soliman, A., Elnaggar, M., & Ouda, M. (2012). Study of environment friendly porous suspended breakwater for the Egyptian Northwestern Coast. Ocean Engineering, 48, 47–58. doi:10.1016/j.oceaneng.2012.03.012

European Commission. (2015). Towards an EU research and innovation policy agenda for nature-based solutions & re-naturing cities: Final report of the Horizon 2020 expert group on 'Nature-based solutions and re-naturing cities' Retrieved from Luxembourg:

Folke, C., Hahn, T., Olsson, P., & Norberg, J. (2005). ADAPTIVE GOVERNANCE OF SOCIAL-ECOLOGICAL SYSTEMS. Annual Review of Environment and Resources, 30(1), 441-473. doi:10.1146/annurev.energy.30.050504.144511

Gabrielsen, P., & Bosch, P. (2003). Environmental indicators: typology and use in reporting. EEA, Copenhagen.

Garmestani, A., Craig, R. K., Gilissen, H. K., McDonald, J., Soininen, N., van Doorn-Hoekveld, W. J., & van Rijswick, H. F. M. W. (2019). The Role of Social-Ecological Resilience in Coastal Zone Management: A Comparative Law Approach to Three Coastal Nations. Frontiers in Ecology and Evolution, 7. doi:10.3389/fevo.2019.00410

Gedan, K. B., Kirwan, M. L., Wolanski, E., Barbier, E. B., & Silliman, B. R. (2011). The present and future role of coastal wetland vegetation in protecting shorelines: answering recent challenges to the paradigm. Climatic Change, 106(1), 7-29. doi:10.1007/s10584-010-0003-7

Giorgi, F. (2006). Climate change hot-spots. Geophysical Research Letters, 33(8). doi:https://doi.org/10.1029/2006GL025734

Gregory, A. J., Atkins, J. P., Burdon, D., & Elliott, M. (2013). A problem structuring method for ecosystem-based management: The DPSIR modelling process. European Journal of Operational Research, 227(3), 558-569. doi:https://doi.org/10.1016/j.ejor.2012.11.020

Guerry, A. D., Polasky, S., Lubchenco, J., Chaplin-Kramer, R., Daily, G. C., Griffin, R., . . . Vira, B. (2015). Natural capital and ecosystem services informing decisions: From promise to practice. Proceedings of the National Academy of Sciences, 112(24), 7348-7355. doi:10.1073/pnas.1503751112

Guerry, A. D., Silver, J., Beagle, J., Wyatt, K., Arkema, K., Lowe, J., . . . Sharma, J. (2022). Protection and restoration of coastal habitats yield multiple benefits for urban residents as sea levels rise. npj Urban Sustainability, 2(1), 13. doi:10.1038/s42949-022-00056-y

Haase, D., Kabisch, S., Haase, A., Andersson, E., Banzhaf, E., Baró, F., . . . Wolff, M. (2017). Greening cities – To be socially inclusive? About the alleged paradox of society and ecology in cities. Habitat International, 64, 41-48. doi:https://doi.org/10.1016/j.habitatint.2017.04.005

Hayes, S., Desha, C., Burke, M., Gibbs, M., & Chester, M. (2019). Leveraging socio-ecological resilience theory to build climate resilience in transport infrastructure. Transport Reviews, 39(5), 677-699. doi:10.1080/01441647.2019.1612480

IPCC. (2013). Climate Change 2013: The Physical Science Basis. . Retrieved from Cambridge, United Kingdom New York, NY, USA:

IPCC. (2014). Climate Change 2014: Impacts, Adaptation, and Vulnerability Part B: Regional Aspects Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, United Kingdom and New York, NY, USA.: Cambridge University Press.

Iskander, M. M. (2021). Stability of the Northern coast of Egypt under the effect of urbanization and climate change. Water Science, 35(1), 1-10. doi:10.1080/11104929.2020.1864255

Ismail, H. (2018). Climate change and its impact on coastal cities: A case study from Alexandria (Master's Thesis), American University in Cairo, AUC Knowledge Fountain.].

Kabisch, N., Frantzeskaki, N., Pauleit, S., Naumann, S., Davis, M., Artmann, M., . . . Bonn, A. (2016). Nature-based solutions to climate change mitigation and adaptation in urban areas: perspectives on indicators, knowledge gaps, barriers, and opportunities for action. Ecology and Society, 21(2). doi:10.5751/ES-08373-210239

Kabisch, N., Korn, H., Stadler, J., & Bonn, A. (2017). Nature-based solutions to climate change adaptation in urban areas: Linkages between science, policy and practice: Springer Nature.

Kader, Z., & Haron, A. (2020). Coastal cities Resilience for Climate Change Case study: Egyptian North coast cities. Journal of Urban Research, 35, 137-153. doi:10.21608/jur.2020.90276
Kafrawy, S., & Soliman, A. (2012). Potential Impacts of Natural Hazards on the Egyptian North Western Coast.
Lafortezza, R., & Sanesi, G. (2019). Nature-based solutions: Settling the issue of sustainable urbanization. Environmental Research, 172, 394-398. doi:https://doi.org/10.1016/j.envres.2018.12.063
Loc, H. H., Duyen, P. M., Ballatore, T. J., Lan, N. H. M., & Das Gupta, A. (2017). Applicability of sustainable urban drainage systems: an evaluation by multi-criteria analysis. Environment Systems and Decisions, 37(3), 332-343. doi:10.1007/s10669-017-9639-4
Mahmood, R., Zhang, L., Li, G., & Rahman, M. K. (2021). Geo-based model of intrinsic resilience to climate change: an approach to nature-based solution. Environment, Development and Sustainability. doi:10.1007/s10668-021-01925-9
Milano, M., Ruelland, D., Fernandez, S., Dezetter, A., Fabre, J., Servat, E., . . . Thivet, G. (2013). Current state of Mediterranean water resources and future trends under climatic and anthropogenic changes. Hydrological Sciences Journal, 58(3), 498-518. doi:10.1080/02626667.2013.774458
Mouchet, M. A., Lamarque, P., Martín-López, B., Crouzat, E., Gos, P., Byczek, C., & Lavorel, S. (2014). An interdisciplinary methodological guide for quantifying associations between ecosystem services. Global Environmental Change, 28, 298-308. doi:https://doi.org/10.1016/j.gloenvcha.2014.07.012
Nature. (2017). 'Nature-based solutions' is the latest green jargon that means more than you might think. Nature, 541(7636), 133-134. doi:10.1038/541133b
Nesshöver, C., Assmuth, T., Irvine, K. N., Rusch, G. M., Waylen, K. A., Delbaere, B., . . . Wittmer, H. (2017). The science, policy and practice of nature-based solutions: An interdisciplinary perspective. Science of The Total Environment, 579, 1215-1227. doi:https://doi.org/10.1016/j.scitotenv.2016.11.106
Pauleit, S., Zölch, T., Hansen, R., Randrup, T. B., & Konijnendijk van den Bosch, C. (2017). Nature-Based Solutions and Climate Change – Four Shades of Green. In N. Kabisch, H. Korn, J. Stadler, & A. Bonn (Eds.), Nature-Based Solutions to Climate Change Adaptation in Urban Areas: Linkages between Science, Policy and Practice (pp. 29-49). Cham: Springer International Publishing.
Potschin, M., Kretsch, C., Haines-Young, R., Furman, E., Berry, P., & Baró, F. (2016). Nature-based solutions. OpenNESS ecosystem services reference book. ed M. Potschin, K. Jax. EC FP7 Grant Agreement(308428).
Raudsepp-Hearne, C., Peterson, G. D., & Bennett, E. M. (2010). Ecosystem service bundles for analyzing tradeoffs in diverse landscapes. Proceedings of the National Academy of Sciences, 107(11), 5242-5247. doi:10.1073/pnas.0907284107
Raymond, C. M., Breil, M., Nita, M., Kabisch, N., de Bel, M., Enzi, V., . . . Cardinaletti, M. (2017). An impact evaluation framework to support planning and evaluation of nature-based solutions projects. Report prepared by the EKLIPSE Expert Working Group on Nature-Based Solutions to Promote Climate Resilience in Urban Areas: Centre for Ecology and Hydrology.
Raymond, C. M., Frantzeskaki, N., Kabisch, N., Berry, P., Breil, M., Nita, M. R., . . . Calfapietra, C. (2017). A framework for assessing and implementing the co-benefits of nature-based solutions in urban areas. Environmental Science & Policy, 77, 15-24. doi:https://doi.org/10.1016/j.envsci.2017.07.008
Ruangpan, L., Vojinovic, Z., Plavšić, J., Doong, D.-J., Bahlmann, T., Alves, A., . . . Franca, M. J. (2021). Incorporating stakeholders' preferences into a multi-criteria framework for planning large-scale Nature-Based Solutions. AMBIO, 50(8), 1514-1531. doi:10.1007/s13280-020-01419-4
Satta, A., Puddu, M., Venturini, S., & Giupponi, C. (2017). Assessment of coastal risks to climate change related impacts at the regional scale: The case of the Mediterranean region. International Journal of Disaster Risk Reduction, 24, 284-296. doi:https://doi.org/10.1016/j.ijdrr.2017.06.018
Shepard, C. C., Crain, C. M., & Beck, M. W. (2011). The Protective Role of Coastal Marshes: A Systematic Review and Meta-analysis. PLOS ONE, 6(11), e27374. doi:10.1371/journal.pone.0027374
Slinger, J., Stive, M., & Luijendijk, A. (2021). Nature-Based Solutions for Coastal Engineering and Management. Water, 13(7), 976.
Spanò, M., Gentile, F., Davies, C., & Lafortezza, R. (2017). The DPSIR framework in support of green infrastructure planning: A case study in Southern Italy. Land Use Policy, 61, 242-250. doi:https://doi.org/10.1016/j.landusepol.2016.10.051
Taylor, K. E., Stouffer, R. J., & Meehl, G. A. (2012). An Overview of CMIP5 and the Experiment Design. Bulletin of the American Meteorological Society, 93(4), 485-498. doi:10.1175/BAMS-D-11-00094.1
UN. (2017). Resolution adopted by the general assembly of United Nations on 6 July 2017, Work of the Statistical Commission pertaining to the 2030 Agenda for Sustainable Development. Retrieved from
UNDP. (2018). Sustainable Development Goals Report: Egypt 2030. Retrieved from
UNEP/MAP. (2017). Regional Climate Change Adaptation Framework for the Mediterranean Marine and Coastal Areas. Retrieved from Athens, Greece:
van Wesenbeeck, B. K., IJff, S., Jongman, B., Balog, S. A. B., Kaupa, S. M., Bosche, L. V., . . . Taishi, Y. (2017). Implementing nature based flood protection: principles and implementation guidance.
Vandergert, P., Collier, M., Kampelmann, S., & Newport, D. (2016). Blending adaptive governance and institutional theory to explore urban resilience and sustainability strategies in the Rome metropolitan area, Italy. International Journal of Urban Sustainable Development, 8(2), 126-143. doi:10.1080/19463138.2015.1102726
WBG. (2020). Climate Risk Profile: Egypt Retrieved from
Whelchel, A. W., Reguero, B. G., van Wesenbeeck, B., & Renaud, F. G. (2018). Advancing disaster risk reduction through the integration of science, design, and policy into eco-engineering and several global resource management processes. International Journal of Disaster Risk Reduction, 32, 29-41. doi:https://doi.org/10.1016/j.ijdrr.2018.02.030
Wilkinson, C. (2011). Social-ecological resilience: Insights and issues for planning theory. Planning Theory, 11(2), 148-169. doi:10.1177/1473095211426274
Williams, B. K. (2011). Adaptive management of natural resources—framework and issues. Journal of Environmental Management, 92(5), 1346-1353. doi:https://doi.org/10.1016/j.jenvman.2010.10.041
Zappa, G., Hoskins, B. J., & Shepherd, T. G. (2015). The dependence of wintertime Mediterranean precipitation on the atmospheric circulation response to climate change. Environmental Research Letters, 10(10), 104012. doi:10.1088/1748-9326/10/10/104012

🏆 *reviewed paper*

Virtual Exploration of Urban Spatial Changes due to Regional Tramway Line Construction

Klaus Wickenhauser, Michael Greiner, Christoph Traxler, Gerd Hesina

(Klaus Wickenhauser, MSc., VRVis Zentrum für Virtual Reality und Visualisierung Forschungs-GmbH, Donau-City-Straße 11, 1220 Vienna, Austria, kwick@vrvis.at)
(Dipl.-Ing. Michael Greiner, GEOCONSULT Wien ZT GmbH., Hütteldorfer Straße 85, 1150 Vienna, Austria, michael.greiner@vienna.geoconsult.at)
(Dr. Christoph Traxler, VRVis Zentrum für Virtual Reality und Visualisierung Forschungs-GmbH, Donau-City-Straße 11, 1220 Vienna, Austria, traxler@vrvis.at)
(Dr. Gerd Hesina, VRVis Zentrum für Virtual Reality und Visualisierung Forschungs-GmbH, Donau-City-Straße 11, 1220 Vienna, Austria, hesina@vrvis.at)

1 ABSTRACT

For most large infrastructure projects, it is mandatory to assess their impact on the urban and rural environment before they are started. Many shareholders want to involve the public or even are obliged to do so due to legal provisions. For interactive exploration, a 3D viewer is needed that supports very complex scenes. They should be realistically rendered for sufficient credibility. Applied research on this topic (in close cooperation with industrial partners) resulted in GEARViewer, a geospatial rendering framework. It supports huge geospatial scenes consisting of large-scale terrain models, buildings, roads, tramways, railways, tunnels, vegetation and a skylight model. Everything is georeferenced. It can import GIS data and turn this into 3D objects. In the future, it will also support Building Information Modeling (BIM) standards. Furthermore, it also simulates traffic in a simplified way including cars, trams, trains and pedestrians. It was used for many planned projects in Austria and Germany.

In this paper, we describe one of the projects for the city centre of Innsbruck, created with the GEARViewer. It supported several stages of the segment wise planning and realization of a new regional tramway line over multiple years. Depending on progress, the project visualization incorporated varying levels of details into the existing city model, from graphic planning concepts during route optimization to detailed depictions of stops and road design shortly before constructional implementation. In this way, shareholders and citizens can experience the geospatial transformation and changes of the street network and traffic flow in the affected regions of the city. The system allows the regular creation of videos, screenshots, interactive online panorama tours and live demonstrations for publications and citizen information events. In order to fit the current state of planning, the system and model were constantly extended and updated. It supported the project progress and associated votes and discussions by supplying the display of variants, flexible viewpoints and realistic visualization.

Keywords: tramway, 3D city models, Spatial transformation, High performance visualization, interactive exploration

2 INTRODUCTION

The planning of infrastructure projects results in large projects with many moving parts and involved parties. It ranges from multiple different domain experts, planning and creating specific aspects and parts of the process pipeline, to different stakeholders making decisions or residents interested in how the planned project will change the topology of the environment. Traditionally this is done in a 2D environment, by drawing plans, architectural drawings, pre-rendered pictures or interactive visualizations with limited scope. Many tools have been created over the last decades to support specific stages of this process, therefore, they are very specialized to solve individual problems but are non-optimal for other tasks. GIS systems are powerful in creating, planning and comparing different scenarios. They generally work in 2D but lack an interactive, large-scale 3D visualization and are unsuited for the involvement of the general public.

Tools for visualization on the other hand have reached impressive visual fidelity in recent years but often only cover specific aspects of the requirements with high cost and time investment in creating and processing all necessary assets. Game engines and adjacent tools can display high fidelity and detailed objects in increasingly large areas, but often require very long development cycles and their data and scenes are highly specialized, processed and therefore changes can be very costly both in regards to resources and time. On the other hand tools more specialized for rapid prototyping and changing like in medicine and engineering, are often limited to specialized aspects or limited scene extends.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

This leads to a situation where tools either allow the efficient planning and changing of data or the visualization and presentation of the data. Bridging this gap efficiently has become increasingly important to allow the involvement of experts from multiple fields but also non-experts, that have no detailed knowledge or experience in interpreting specialized tools. The projects and ideas can be better communicated, visualized and changes can be incoporated more easily, faster and cost-efficiently. According to our experience this can help with the addressing of unnecessary misunderstandings and fears and provide a common ground for all involved stakeholders for positive and productive discussions. Especially for planning and discussions, photo-realism is less important than the ability to explain complex relations, augument 2D planning data to a spatial 3D context and having a toolset to answer complex questions promptly. To help involved people really immerse themselves in the scene it is also helpful to allow for visual cues like, shadows, vegetation, street networks with driving cars and other animated parts.

In this paper we will present the GEARViewer an interactive geospatial planning and visualition tool developed at VRVis and Geoconsult in collaboration with large infrastructure providers and civil engineering consultants. After a discussion of related work, we will talk about the basic pipeline, involved data sources and provide detail about design decisions. Finally, we will describe how the GEARViewer is applied in a real-world use case, - a new tramline in the city centre of Innsbruck.

3 RELATED WORK

GIS are the most common tools to study how large-scale construction projects affect an urban or rural environment. They are a key asset of the planning process and efficiently allow to create and compare different alternatives. This is especially true for street, railway and tramway networks, which typically cover wide areas. Eliot (2014) gives a general overview on GIS concepts, services and resources. The book by Nyerges and Jankowski (2009) describes how GIS supports decision making in urban and regional scenarios. In Telega et al. (2021) GIS is used to measure the walkability of a city, which is an important indicator of the wellbeing of citizens and the sustainability of the urban planning. GISs are also important for collaboration and communication between different teams and stakeholders. Eikelboom et al. (2015) carried out user studies to evaluate how efficient different geo-design tools are for communicating stakeholder values. They found out that aggregation and ranking of such values are easier for expert users.

GIS are not well suited to inform the general public, which is an obligation in most large-scale construction projects. Most people are not familiar to interpret large area plans, let alone compare different layers representing planning variants or simply the status before and after the construction (see Figure 1). Sieber (2006) gives an overview of how GIS can be used for public participation in the planning process. They found out at the time of their publication that the efficiency of participation is low and the cost is relatively high. A more recent and very comprehensive study based on over 200 real life planning cases was presented by Kahila-Tani et al. (2019). Although public participation has several advantages, they identified problems with information overflow, the digital divide, data collection strategies and methodological challenges among others.

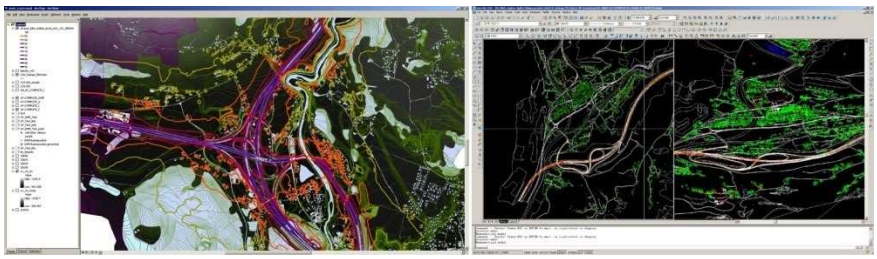


Figure 1: GIS system examples.

A major disadvantage of GIS is that it is based on maps and therefore restricted to 2D data. But a 3D visualization is essential to fully comprehend and experience the spatial effects of large-scale constructions. The support of 3D scenes in GIS has improved in recent years but many applications are still limited in their complexity. One of the first approaches was presented by Moser et al. (2010), where 3D city block models integrated into a GIS improves visibility and air flow analyses. Ferreira et al. (2015) introduced a decision support system for architects and city planners based on 3D models of buildings, whereby the focus is also on visibility analysis. Today ArcGIS by ESRI (2022) provides a 3D GIS that can handle large geospatial

scenes. InfraWorks by Autodesk (2022) visualizes infrastructure projects such as road construction in the environmental context and can derive virtual reality presentations from it.

Höhl (2020) presents an efficient open-source pipeline to generate 3D scenes from GIS data, which are optimized for XR applications. It only uses QGIS with a plug-in to extract terrain models and the Unity game engine with a plug-in that supports geo-references and CityGML for building models. Serious games could be a good alternative to engage the public and mediate information by edutainment. Brase et al. (2022) and Hemming et al. (2022) use the pipeline from Höhl (2022) to integrate open geospatial data into a game engine to create large game worlds. They authored a strategy game where players have to fight consequences of a flood.

Compared to these tools, the GEARViewer is able to cover even larger areas with high accuracy and many details that increases the realism of 3D scenes (see Figure 2). It makes analysis of planning variants highly efficient by enabling fast 3D model switching, like layers of a true 3D GIS. Furthermore, the GEARViewer allows to easily create media directly from the 3D scene, which has proofed to be well suited for a broad audience such as videos or interactive panoramas. These low-threshold media formats give nevertheless a realistic impression of planning variants and can be accessed in a web browser.

Figure 2: Render view showing visualization aspects.

4 DATA SOURCES & INTERACTIVE VISUALIZATION

In this chapter we will present a systerm overview of the toolset and some of its key aspects. To help with the visual immersion of the user it includes daylight illumination and adjustable illumination parameters (e.g. a rudimentary switch to night), shadows and other visual cues like vegetation and simple reflections. The whole scene can be explored either with a free fly camera or by imposing certain restrictions, like walking on the ground or driving along the street networks. While visualization is an important aspect of all viewers a more encompassing toolset helps with the presentation of the finished planning project. This includes measuring tools for distances and occlusions, a 2D map support for linked movement and positioning and the selection of scenes and toggles for parts of these scenes (see Figure 3).

Figure 3: Feature overview – GUI, projected textures, actors and annotations.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

This is done by creating a digital twin of the existing project area and then suplementing or exchanging the planning stages and their variants and allow the switching between them for comparison.

4.1 Building a digital twin

The idea of a digital twin is the creation of a virtual replica of a physical object or system. Originally it was used in manufacturing to run simulations on complex constructs like motors before actual having to build devices. This idea has become increasingly important and prominent in many other fields. It moved beyond manufacturing and into interdisciplinary domains, artificial intelligence and data analytics. It gives professionals the ability to optimize their workflows at a conceptional level and create many what-if scenarios and variant analyses. The idea of a digital twin has therefore expanded from machine parts to include bigger, more complex but also sometimes more abstract systems.

It is also a system that lends itself well for complex infrastructure projects. Broo et al (2022) describes that there is an urgent need to make infrastructure systems more efficient, resilient and sustainable. Furthermore, they give an overview over mulitple approaches and different aspects in which a digital twin can utilize real world data for planning and analysis. This includes physical and spatial parts and installed sensors, that relay a multitude of data to create a cyber-physical system.

The GEARViewer concerns itself at the most part with the spatial aspects, meaning the geospatial and visual representation of the real-world domain and it's planning additions and variants. This ranges from producing a DGM representation from laser scans, orthophoto texturing from arial overflights to positioning data at the correct geo-referenced locations (e.g. trees from local cadastre data). Some smaller specialized projects within the GEARViewer framework extend this a little. A project with the Austrian Federal Railways (ÖBB) allowed for the on-the-fly update of digital signs on the Austrian autobahn. The definition of the scene and creation of the twin is done by employing a powerful XML based scene description that is loaded at startup. It defines a myriad of different nodes specialized to many of the mentioned visualization and planning tasks, from simple-geo referenced geometry with it's rendering attributes to animation networks and how they are combined into scenarios (see Figure 4).

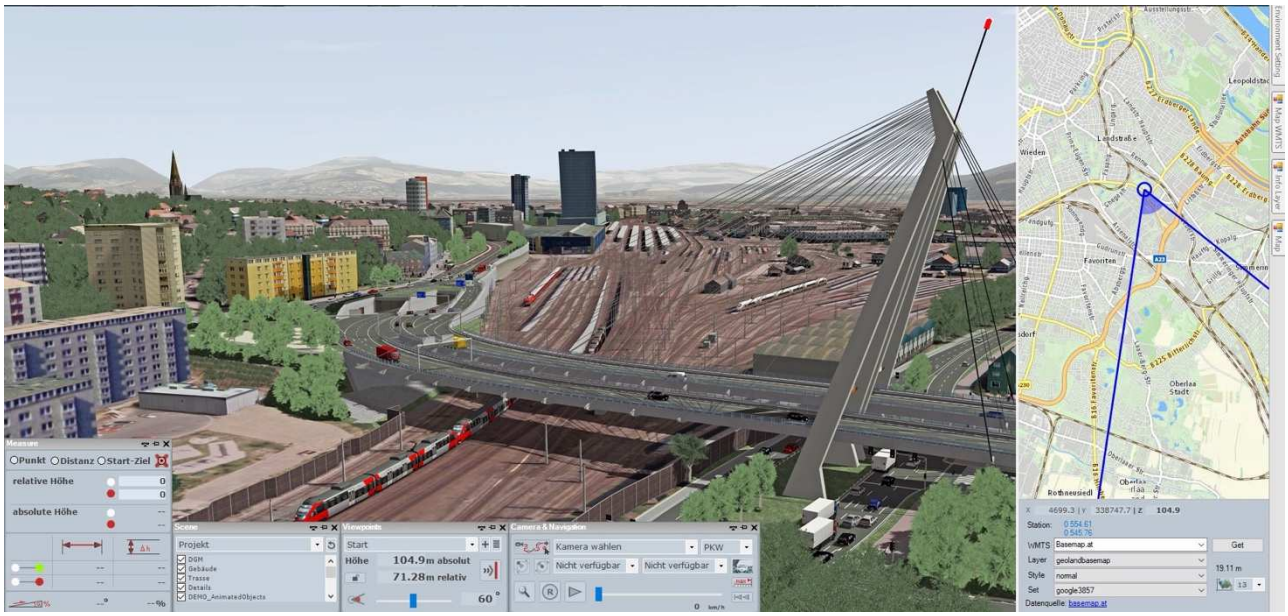


Figure 4: Finished digital twin with established scenarios and animation system.

4.2 Data sources

To build such a digital twin a lot of data from different sources is necessary to be processed, handled and displayed. To support the loading of the data, a flexible import mechanism is provided. On the most basic level it allows for loading of some mainstream geometric formats (e.g. OBJ) and some more specialized to the industry (e.g. VRML). In addition, it allows the loading of more abstract formats to be used in various different routines. This is an important aspect because most other real-time rendering systems require tedious detours to be able to handle these types of data.

- Geo-referenced imagery

This is an image file georeferenced with a world file. In most cases these are orthophotos created by aerial overflights or from some kind of tile-map (e.g. basemap). In principle this can be anything as long as it is a geo-referenced image. They can either be mapped to geometry such as the terrain, streets and building roofs or function as the data source for the 2D map.

- ESRI shapefiles

These are ESRI GIS specific file formats that are used to export or import point, line and polygon data with various additional attributes. This is one of the bridge gapping aspects of the tools. GIS systems are used for their powerful 2D based planning aspects and the shapefile output in turn is plugged into the GEARViewer for various different behaviours; Including the positioning of objects (trees, lampposts, …), the definition of line geometry (power lines, annotation geometry, …) and the use of property lines to automatically extrude buildings from them, which allows for a rapid inclusion of vasts amount of building data needing little preprocessing work. Another rapid prototyping aspect is the placement of lines (e.g. noise protection walls) that are then procedurally converted into linear geometry defined by profile cutouts.

- Geometry data

Simple geometry data to be included in the scene. Common use cases are buildings, bridges, or sections of hand modeled terrain, that will replace parts of the existing domain. The formats mostly used in the tool are VRML and OBJ. A majority of tools used in infrastructure planning export their data in these formats.

- ArcGrid

A file format suitable for creating and exchanging large terrain models. It basically is a heightmap stored as an image that is used to automatically create terrain geometry with a level of detail hierarchy.

4.3 Variant Analysis

Another vital aspect of the digital twin is the possibility to create different what-if scenarios, compare, and analyse the different variants and permutations. A very important question in current infrastructure planning projects is answering the question in which way the project will transform urban and rural areas. First of all the elevation of the 2D planning steps into a 3D environment already gives experts and non-experts visual cues on how the process will spatially change the affected area. Supported by the digital twin aspects of the surrounding decoration domain, it's easy to recognize the area and therefore immediately get a feeling for the actual changes or additions in the project are in question.

To really help with analysing the impact on the project area, the system allows the definition of different scenarios, denoting important milestones over the lifetime of the project. It really helps to discern what sturctures or areas are affected when the changes can be viewed over time. In addition to changes over time, the scenarios also allow for the definition of variants of a certain point in the project (see Figure 5).

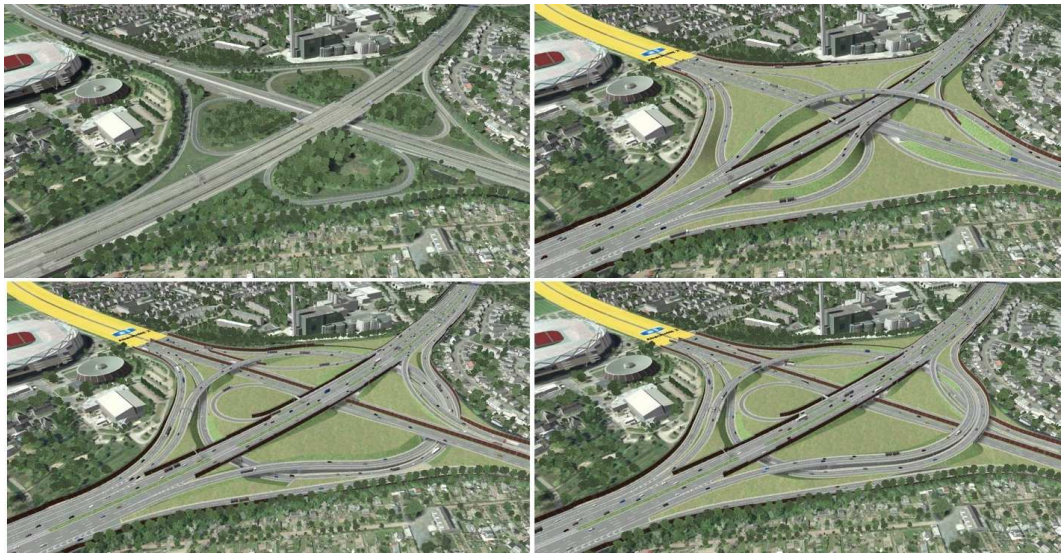


Figure 5: Variant analysis for an interchange. Only the relevant geometry and animation is exchanged.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Another important point that is addressed by variant analysis methods is doubts and concerns of residents, living in the affected project areas. A frequent occurrence in presentations with a more public character is stakeholders voicing concerns about how the changes transform the environment they are used to. Either on an emotional level or in regards to environmental concerns. It is possible to prepare expected scenarios as variants or in a more limited capacity create some structures, like noise-protection-walls on the fly to test other more favorable options (see Figure 6).

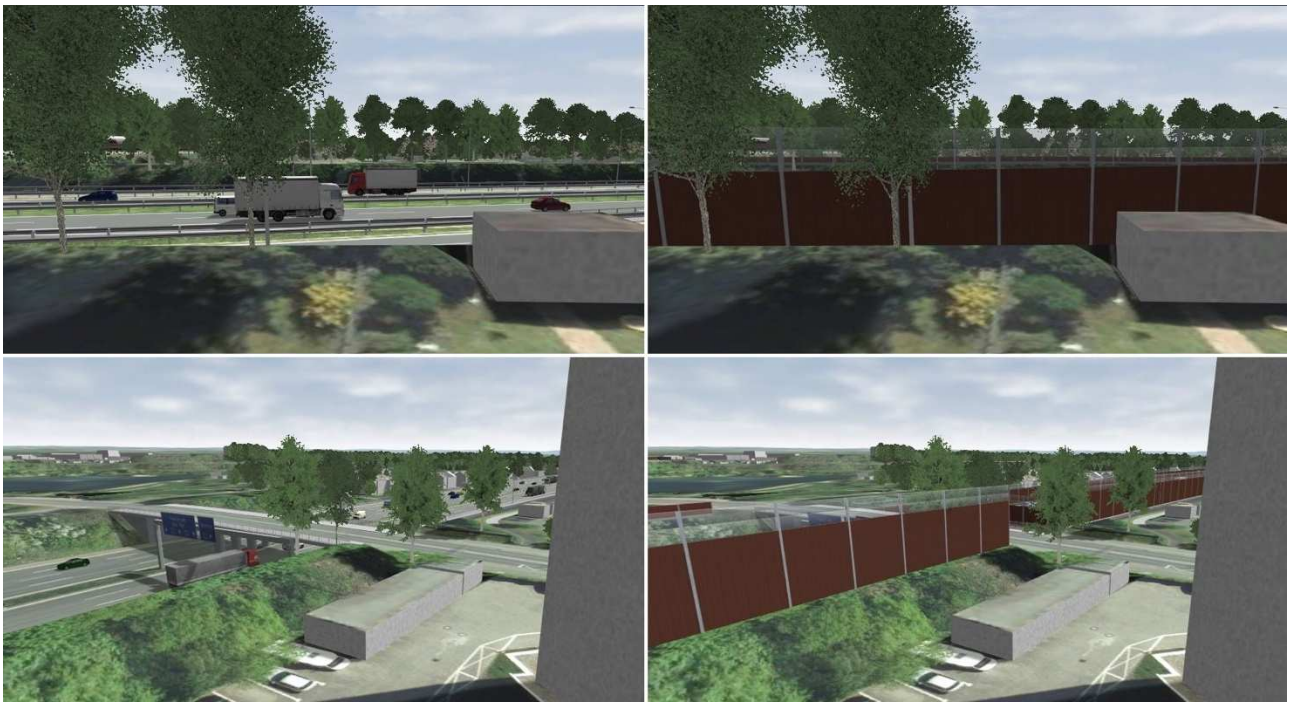


Figure 6: Inclusion of noise protection walls to address concerns of residents of the project area.

4.4 Presenting the finished planning projects

Another important aspect for this tool is the communication of the created scenarios and variants to the various different types of stakeholders. This can happen in different environments with changing requirements.

A common scenario is the presentation to a handful of people at events that provide sufficient hardware to use the viewer directly and employ all it's visualization and presentation capabilities. This is where the 3D display of large project data and the variant management comes in really handy. It allows the display of the exact viewpoints and permutations currently required. Either by officials who need to make decisions about specific parts or residents who are interested in how the planned project would change the environment from e.g. their apartment window. Furthermore it allows the discussion of potential changes or eliviation of fears. Sometimes it is possible to change the opinion of residents by including a hill that obstructs the view on a new factory or by including a noise protection wall (see Figure 6). The ability to really undestand these changes in an accurate 3D environment has often helped fundamentally in these scenarios.

Sometimes it is not possible, feasible or even required to employ the whole visualization capability. It is therefore possible to create various forms of output for further external use. This includes videos and screenshots at various resolutions. The screenshots can be geo-referenced for further accurate handling. Another aspect that has come in handy many times is the output in form of geo-referenced panorama images. These allow a low-cost 360 degree visualization of selected viewpoints. External tools allow the processing of batches of these panorama images to create a semi-interactive tour through the project area.

The last important output in terms of presentation is the ability to cutout an area from a project scenario, allowing a non-interactive leightweight 3D visualization of regions of interest or the further processing of the data with other tools.

5 INNSBRUCK USE CASE

This chapter explains how the workflows, pipeline stages and features come together in a finished real life use case. The process in question was a prestigious project commissioned by the City of Innsbruck a few years ago, with the goal to create a new regional tramline to connect the city centre with the periphery for better commuting and improving the access residents and tourists have to varying parts of the urban and surrounding area (see Figure 7).

Figure 7: Project area depicting the planned regional tramline.

The whole process resulted in a multiple year spanning endeavour, planned and managed by a joined effort between the IVB (Innsbruck transport services), Geoconsult and VRVis employing the GEARViewer as one of the fundamental planning and visualization tools.

Depending on the progress the project was embedded into a stockmodel of the city in varying levels of detail. This process allowed the participating parties to plan for but also show the spatial transformation of the affected urban areas during frequent citizen information events and media articles. Figure 8 shows how two streets were efficiently connected during the planning process. This improved the traffic flow and enabled a more efficient access to public transportation in the area in question. In addition, the visualization placated residents by showing that it will still allow for trees and green areas without too much visual polution.

Figure 8: Connection of inaccessible areas for traffic with a tramway station.

A disadvantage of a realistic rendering is that it sometimes disctracts from important information by showing too much details. 3D scenes can also easily provide important annotations known from traditional 2D systems (such as GIS). Figure 9 shows how an integral and busy intersection is overlayed and annotated with colors to give stakeholders an easier understanding of how multiple interlocking parts will play out once finished. The yellow area depicts the sidewalk for pedestrians; the gray area shows the street while the blue area is a new area exlusive to the tramway. In addition, it shows residents that nature is also an important part of the urban environment with added green areas, where vegetation will be planted.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Figure 9: Use of colours for annotations to depict and explain complex changes to different stakeholders.

Furthermore, it was possible to account for refurbishing parts of the city by removing old and derelict buildings in favor of separate streets exclusively for the tramline, allowing for efficient public transportation without putting strain on narrow streets that cannot be extended otherwise (see Figure 10).

Figure 10: Addition of tramline exclusive tracks outside of the existing street by removing derelict buildings.

When planning a new public transportation system an important question is where to place and how to space out the stations, so that they make sense and allow access to important parts of the cities infrastructure. The visualization helped the various stakeholders to identify and visually communicate their placements. Figure 11 shows a youth hostel that was incorporated into the tramline network by including a dedicated station. In addition, this again allowed critique of residents during presentations to transform the urban area with additional green areas and trees.

Figure 11: Addition of a station to increase accessibility of a youth hostel. Addition of parking space and more green areas.

An interesting problem was presented by a smiliar but disjointed project about extending roads that progressed during the planning phase. It was situated at the outskirts of the project area but close enough that an inclusion was warranted. The solution to include the changes, without having to procure expensive but ultimately relatively unimportant geometric data, was to use orthophotos which needed to be created anyway and use the terrain texturing routines to switch between visual representation in the distance (see Figure 12).

In the process of finishing this project a plethora of outputs for presentation were created, including all metioned output formats like screenshots, videos, cutouts and in person presentations. In addition, a panorama tour was created . We want to emphasize that everything you can see in the panorma tour can also be interactively explored in a 3D scene with the GEARViewer.

Figure 12: Progress of another project during the planning phase. Visualized as differing orthophotos of the relevant area.

6 CONCLUSION AND FUTURE WORK

The goal of the GEARViewer is to bridge the gap between the worlds of 2D GIS based planning and specialized 3D visualization and planning tools to allow the display of large scale and interactive digital twins, while giving the opportunity to augument them with changes needed for the infrastructure project at hand. The presented feature set supports a streamlined content creation workflow that natively supports different geospatial formats for many different use-cases that (semi) automatically create different forms of geometry. A variant analysis system allows the creation of different scenarios, the ability to switch between them and make comparisons. To allow stakeholders to recognize the project areas in question, the tool has an interactive 3D visualization and improves visual fidelity by including rendering aspects like shadows, vegetation and animation systems. It is possible to produce varying outputs for different requirements in regards to further processing and handling. This includes animation system simulations, cutouts from the project and material for media and presentions in the form of screenshots, videos and panoramas.

The original viewer was in development for over 10 years and therefore subjected to some limitations based on the underlying software. To allow for future state of the art improvements in different fields, the viewer is currently in the process of being migrated into the Visdom project, developed by VRVis. The focus of the Visdom framework is flooding simulations, but for that it also supports complex geospatial scenes covering wide areas. It also creates digital twins of urban and rural areas for physically accurate simulation. The resulting visualizations are highly interactive and are suitable for experts and non-experts alike. There are differences in the details of how the scenes are produced and the requirements of the people working on them; but many synergistic aspects can be found, which helps both projects in turn.

The most immediate goal is taking advantage of the newer nature of the framework and use its advanced rendering techniques to improve the performance and quality of the GEARViewer. Visdom supports the combination of geospatial data with application specific attributes, which are needed for the flooding simulation. Similar mechanisms could be used to extend the GEARViewer capabilities for the inclusion of BIM based aspects. Another aspect for future improvement is to enhance the digital twin by anchoring dynamic data into the geospatial context such as sensor measurements for traffic, railway, wind and many more.

Independent of the synergistic features a general goal is to continuously improve usability and react to additional requirements in regards to new or improved data source types. Futhermore, a goal is to utilize the new found potential in regards to the rendering software to including more state-of-the-art rendering techniques (e.g. day/night visualization with dynamic lighting and environmental effects, …)

7 ACKNOWLEDGEMENTS

VRVis is funded by BMK, BMDW, Styria, SFG, Tyrol and Vienna Business Agency in the scope of COMET - Competence Centers for Excellent Technologies (879730) which is managed by FFG.

8 REFERENCES

Autodesk InfraWorks Website: https://www.autodesk.eu/products/infraworks/, last accessed 2022.07.11, 2022.

Brase, R.; Zhuge, W.; Höhl, W. Nykus Exploration – Open Geodata in a Survival Game. Poster at Federal Forum for Remote Sensing and Copernicus 2022, Berlin, https://mediatum.ub.tum.de/download/1662306/1662306.pdf.

Broo D.G., Bravo-Haro M., Schooling J.: Design and implementation of a smart infrastructure digital twin. Automation in Construction, Volume 136, 104171, ISSN 0926-5805, https://doi.org/10.1016/j.autcon.2022.104171, 2022

Eikelboom, T.; Janssen, R. Comparison of Geodesign Tools to Communicate Stakeholder Values. Group Decis. Negot., 24, 1065–1087, 2015.

Elliott, R.: Geographic information systems (GIS) and libraries: concepts, services and resources. Library Hi Tech News, Vol. 31 No. 8, pp. 8-11. https://doi.org/10.1108/LHTN-07-2014-0054, 2014.

Esri 3D GIS Website: https://www.esri.com/en-us/arcgis/3d-gis/overview, last accessed 2022.07.11, 2022.

Ferreira N., Lage M., Doraiswamy H., Vo H., Wilson L., Werner H., Park M., Silva C.: Urbane: A 3D framework to support data driven decision making in urban development. Proceedings of IEEE conference on visual analytics science and technology (VAST), pp. 97-104, 2015.

Hemming, P.; Kobalt, C.; Marsoner, L., Giesse, S.; Höhl, W. Grimma Floodfighters – Open Geodata in a Real-time Strategy Game. Poster at Federal Forum for Remote Sensing and Copernicus 2022, Berlin, https://mediatum.ub.tum.de/download/1662305/1662305.pdf.

Höhl, W. Official Survey Data and Virtual Worlds—Designing an Integrative and Economical Open Source Production Pipeline for xR-Applications in Small and Medium-Sized Enterprises. Big Data Cogn. Comput. 2020, 4, 26. https://doi.org/10.3390/bdcc4040026.

Kahila-Tani M., Kytta M., Geertman S.: Does mapping improve public participation? Exploring the pros and cons of using public participation GIS in urban planning practices. Landscape and Urban Planning, Volume 186, Pages 45-55, ISSN 0169-2046, https://doi.org/10.1016/j.landurbplan.2019.02.019, 2019.

Moser J., Albrecht F., Kosar B.: Beyond Visualisation – 3D GIS Analyses for Virtual City Models, International Archives of the Photogrammetry. Remote Sensing and Spatial Information Sciences, Volume XXXVIII-4/W15, 2010.

Nyerges, T.L., Jankowski, P.: Regional and Urban GIS: A Decision Support Approach. ISBN: 9781606239063, https://books.google.at/books?id=QyEIBAixuzkC, Guilford Press, 2009.

Sieber, R. Public Participation Geographic Information Systems: A Literature Review and Framework. Ann. Assoc. Am. Geogr., 96, 491–507, 2006.

Telega, A.; Telega, I.; Bieda, A. Measuring Walkability with GIS—Methods Overview and New Approach Proposal. Sustainability, 13, 1883. https://doi.org/10.3390/su13041883, 2021.

🏆 *reviewed paper*

Virtual Space and Reality Experiment Systems for "Human-Dimensional" Downtown Planning and Design

Toshiyuki Kaneda, Yuko Sonobe, Shuqi Hao

(Prof. Dr. Toshiyuki Kaneda, Nagoya Institute of Technology, Gokiso, Showa, Nagoya, Japan, kaneda@nitech.ac.jp)
(Yuko Sonobe, Nagoya Institute of Technology, Gokiso, Showa, Nagoya, Japan, y.sonobe.437@stn.nitech.ac.jp)
(Shuqi Hao, Nagoya Institute of Technology, Gokiso, Showa, Nagoya, Japan, zhuang6500@yahoo.co.jp)

1 ABSTRACT

With the digital transformation that contributes to the urbanism of the human dimension proposed by Jan Gehl, the authors discuss a framework with two pillars of information infrastructure that have emerged recently: mobile-phone location data and three-dimensional (3D) spatial open space data. In recognition of this, we report on research into two experimental systems, namely, virtual space and virtual reality, that use 3D spatial models. The former discusses the primary performance of the experimental system based on a gaming experiment of stopping behavior in the Osu district, a traditional shopping area in Nagoya City, with and without a plan to convert the area into a mall. The latter is a simulation investigation of the effect of signs on wayfinding using the "visibility" parameter from the virtual reality experiment as a vision-driven agent.

Keywords: vision-driven agent, Virtual Reality, Virtual Space, human dimension, digital twin

2 INTRODUCTION

The human-dimensional urbanism that Jan Gehl advocates in "Cities for People" criticizes the lack of consideration for the small and middle scales in urban planning and design that emerged because of the modernism movement and suggests a process that begins with a survey of people's activities, followed by space planning and then architectural design (Gehl, 2012). The methodology emphasizes a small-scale design through an activity survey before space planning. However, the activity survey is a "one-shot" survey conducted by a survey team, and the space design is mainly by hand-drawing, a traditional practice established in the 20th century.

Currently, the digital twin of the 21st century is making "high-frequency" sensing possible in each large-/middle-/small-scale aspect of urban space in principle, and an ecosystem by mushroomed internet of things is being formed. Among these, the authors focus on mobile-phone location data (MPLD) and three-dimensional (3D) spatial open data as new urban information infrastructures. MPLD offers basic statistics on the density of human activity in urban environments from the large to middle scales, such as downtown areas, where statistics have hitherto been unavailable. In addition to Virtual Singapore and Smart City Zurich, the Japanese government's Project PLATEAU has become the leading project.

In this study, we discuss a digital twin framework based on the two pillars of MPLD and 3D spatial open data, with a view to the digital transformation that contributes to urbanism in the human dimension as proposed by Jan Gehl. Section 4 outlines the virtual space experimental system using the Osu area, a traditional shopping district in Nagoya City, as a case study, followed by a confirmation of the basic performance of the system through a "shop-around behavior" experiment and the findings from the experimental procedure. Section 5 outlines a simulation analysis of the effect of signage in a wayfinding situation using the "visibility" parameter (sign detectable ratio) taken from the virtual reality (VR) experiment as a vision-driven agent. In conclusion, the differences between the two experimental systems and their further research development will also be discussed.

3 FRAMEWORK OF DIGITAL TWIN TECHNOLOGIES FOR "HUMAN-DIMENSIONAL" MID-SCALE PLANNING AND DESIGN

To the author, the digital twin of urban planning appears to have two sources. One is the tradition of urban simulation, as discussed by Micheal Batty. From a macroscopic urban planning perspective, one might describe the actual system and its virtual model as "twins" because of the unprecedented level of detail in the spatial elements. Nevertheless, one should remember that in model theory, they are only "homomorphic" in their relationship.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

The possibility of a wide variety of sensing systems with high frequencies (short time slice) can be combined in a low-frequency (long time slice) urban simulation model in socio-economic fields, as discussed by Batty (2018) as "frequency." This opens up the possibility of various compositions that have not been fully explored.

The second is the possibility of viewing the virtual system as a new participatory experience tool, as the Yamu group discussed in a case study in Herrenberg, as an environment for citizens' "creative" participation and "visioning" experience (Dembski, Wössner & Yamu, 2019). Visioning, in particular, is a process by which urban society creates one of several possible visions of the future. Although they are mirror images, they are more reminiscent of a "metaverse" than a "twin." However, from the perspective of planning theory, this possibility should be pursued no less than the other.

The framework of the authors' digital twin technologies is shown in Figure 1. The MPLD above is attractive for its abundance of data, which more than compensates for the current lack of location accuracy of personal cellular phones. It provides basic statistics on the density of people's activities in urban spaces from the large scale to the middle scale, for which there were no formal statistics before. For details, please refer to other articles (Kaneda, Ota & Zhang, 2022; Ota, Takahashi & Kaneda, 2021).

The 3D spatial data for planning and design in the middle scale, which is the focus of this paper, were easy to obtain in the past. However, significant progress has been made in developing various BIM cloud-sourced open databases. Virtual Singapore and Smart City Zurich 2018 are pioneering examples and offer great urban planning potential, especially for citizen participation (Schrotter & Hürzeler, 2020; Virtual Singapore, 2018).

The Japanese government's Ministry of Land, Infrastructure, Transport, and Tourism's PLATEAU project is a national policy project that will be launched in 2020 and that has presented standard specifications for CityGML covering not only buildings but also terrain, roads, and urban facilities, intending to develop urban spatial data in Japan. It has also made remarkable progress in providing city governments with digital data for primary urban planning surveys based on the Urban Planning Act (Project PLATEAU, 2020).

Next, we will discuss our methodology for planning and designing middle scale urban spaces in the 21st century, which is established through the development of MPLD and 3D spatial data. The systematic data science that deals with the relationship between middle scale urban space and user behavior is an attractive theme for the authors.

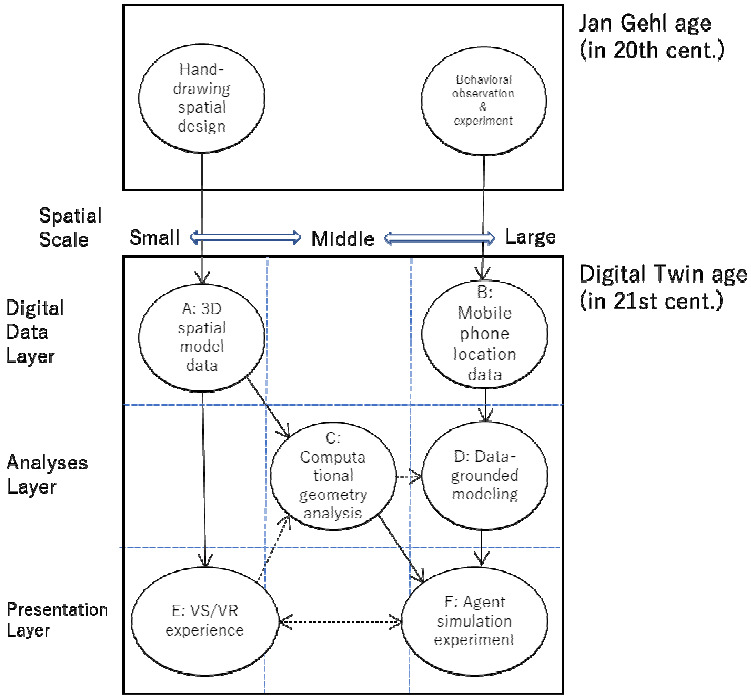


Fig. 1: A framework of digital twin technologies for human-dimensional downtown planning and design.

Space Syntax from UCL, which works with the interaction between user behavior data of urban space and visual data of the built environment, is one of the scientific methods that we have been focusing on. The rise

of Space Syntax as a universal urban science in the 21st century is partly due to the widespread use of computational geometry that combines network theory, such as visibility graph analysis and agent analysis (Turner, 2001; Turner & Penn, 2002; Turner et al., 2001). The author's research has also confirmed the contribution of urban form factors to the number of pedestrians on the streets. However, new data science requires an easy-to-understand 3D extension methodology.

Section 4 of this paper deals with the possibility of a virtual space and VR experimental system that contributes to downtown planning and design research by creating and using 3D spatial data. This system enables us to efficiently explore the direction of the "future environment" desired by people and its specific image by collecting and analyzing the user's subjective sense of liveliness and behavioral data in the virtual space under certain experimental conditions. The experiment conducted by the authors in the Osu district, a shopping district in Nagoya City, is still in the primary stage of comparison with actual data. Nonetheless, the experiment's core functionality, such as behavior prediction and consumer attractiveness, has been proven. The Osu district is a "human-dimensional" shopping district. It is being developed in much greater detail than the LOD1 provided by Project PLATEAU, and it is necessary to proceed while incorporating issues from CG research, including the uncanny valley.

The invention of EVA by Turner & Penn (2002) was the invention of the vision-driven agent model, which has great potential as a tool to "constructively" examine the influence of visual-spatial characteristics such as wayfinding behavior simulation. The authors have been working on the development of VD18s, VD19, and VD22 as agent models for use in 3D spaces, as shown in Section 5 (Kaneda et al., 2019; Maekawa et al., 2022).

Among the behavioral measurements by the virtual space and VR experimental systems, the authors focus on the easy use of the eye-tracker system. Currently, urban behavior analysis has been constrained by the premise that "attention is a resource," as stated by H. A. Simon and later, but the eye-tracker system opens the door to measuring the micromotive behavior of subjects through microbehavior. These possibilities will stimulate research in multiple directions, and in Section 5, the authors report their use in refining vision-driven agent modeling.

Section 5 of this paper discusses a case study of the wayfinding behavior of a 3D conical vision-driven agent, in which "visibility data" obtained from a VR environment experiment were used as a parameter to reproduce the wayfinding behavior in a subway station, and the assessment by sign layout setting was analyzed.

4 VIRTUAL OSU: VIRTUAL SPACE EXPERIMENTAL SYSTEM IN THE CASE OF DOWNTOWN OSU

4.1 Aim for Virtual Osu

The Osu district is a 400-m-long, 600-m-wide shopping district with 1,200 shops comprising mainly small-scale stores positioned south of Wakamiya Odori Street, midtown of Nagoya City. This area, which combines numerous temples and commercial streets, can rightly be called the highlight of the Chukyo area (population of approximately 10 million in Aichi, Gifu, and Mie prefectures) that constantly attracts diverse customers, including men and women of all ages, with its fascinating "hotchpotch" of the old and the new. As the features of this area, there are nine shopping streets with a grid-like shape layout, each of which attracts specific customers with a characteristically detailed shop configuration. There are 20,000 visitors per day on weekdays and 30–50,000 on weekends and holidays, and foreign tourists have been visiting recently. This is also the district where the authors have continued their research for more than 20 years (Kaneda, 2020).

In this section, Osu's virtual space experimental system is created and actual performance related to the detailed design of shopping mall facades, among others, is confirmed through an experiment on stopping behavior with and without a test mall plan.

4.2 3D Spatial Model of Osu

On the basis of the literature (Gehl, 2013a, 2013b), the system functions and spatial model introduced to measure urban attractiveness and comfort in the human dimension are shown in Table 1. Figure 2 depicts the size of the Osu region that this study specifically addressed. The Akamon-dori, Otsu-dori, Shintenchi-dori,

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Uramonzenmachi-dori, Honmachi-dori, and Banshoji-dori collections of street portions from six different streets were used as the unit area for the virtual space experiment. Unity ver2019.2.8f1 was used to construct the virtual space experimental system (Kino et al., 2020). A spatial model of the existing street and a street believed as a pedestrian mall on Akamon-dori was created. The virtual space model was modeled in Rhinoceros based on real-space, and textures were applied by UV mapping in Maya. The virtual space model used in the experiment was based on actual measurements, and the level of detail was equivalent to level of details (LOD) 3 in CityGML (Hirate, 2020). Before and after Akamon-dori was transformed into a pedestrian mall, the facade of buildings along the street remained unchanged. The experimental area’s dimensions, street’s width, and positioning of the buildings were based on Osu Street’s real dimensions, with a 7.5-m maximum height for each structure.

A plan and a cross-section of the street where the pedestrian mall was studied are shown in Figure 3. Examples of street components and dimensions are depicted in Figure 4. The subject’s walking speed was set to 3.0 m/s at full speed and 1.5 m/s at half speed. The subject’s position in the virtual space was recorded every second as coordinates, and the walking path trajectory was recorded by outputting a csh file. An eye mark was used to capture eye movement, and the monitor’s gazing point was produced as two-dimensional coordinate data.

System functions	Evidence from Jan Gehl’s references	Number
Walking trajectory	General knowledge of gait patterns can be obtained.	2) p. 39
Optional activities	City quality is so crucial for optional activities.	1) p. 134
Walking speed	Pedestrians usually walk faster on streets that invite linear movement, and their pace falls while traversing squares.	1) p. 120
Eye Movement	Heads move from side to side, and walkers turn or stop to see everything.	1) p. 120

Spatial models	Evidence from Jan Gehl’s references	Number
Steet components	Street patterns, the design space, rich detail, and intense experiences influence the quality of pedestrian routes and the pleasure in walking.	1) p. 129
Facade	The quality of the ground floors is so crucial to a city’s overall appeal.	1) p. 81

Table 1: Desired functions and their sources of the virtual space experimental system. 1) Gehl (2013a), 2) Gehl (2013b)

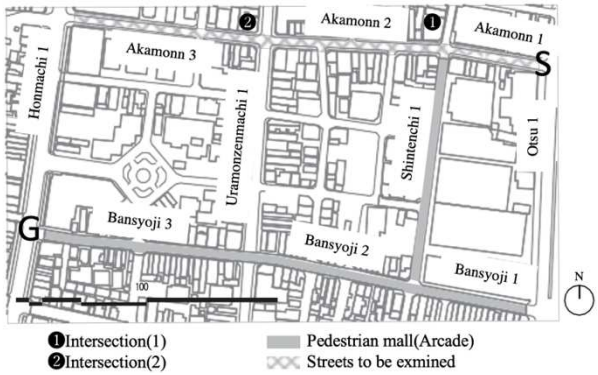


Fig. 2: Osu area targeted for the virtual space experimental system.

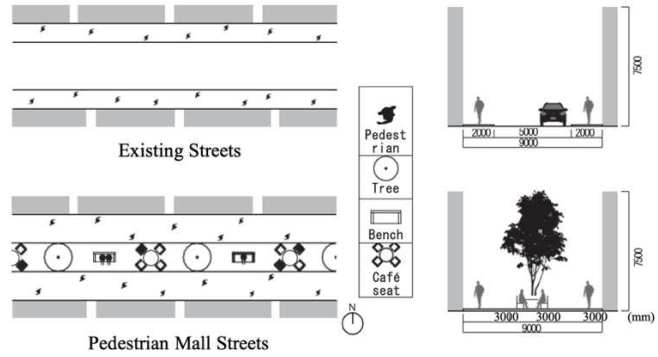


Fig. 3: Plan and cross-section of Akamon-dori.

Fig. 4: Examples of street components and dimensions.

4.3 Virtual Space Experiment

This experiment was designed to explore the factors of passing/stopping behavior and awareness evaluation by having the subjects walk through the unit space of the investigation (Figure 2) with and without the pedestrian mall on Akamon-dori under the experimental conditions. A walking experiment was conducted from the east end of Akamon-dori to the west end of Banshoji-dori to evaluate the effectiveness of the

experimental system (marked S to G in Figure 2). The experiment's summary is shown in Table 2. In the experiment, we took up unscheduled stopping behavior, which is one of the optional activities in shopping areas. We implored the participants to stop at a store and take a picture. After completing the walk, the participants watched a video recording of the experiment. They conducted an impression assessment and a post-experiment questionnaire (Kozaki et al., 2017; Ministry of Land, Infrastructure, Transport and Tourism, Government of Japan, 2020). Thereafter, the same walking experiment was conducted on the designated streets. Fifteen subjects were tested in the existing Osu area. Then, five subjects were tested in each case of low (0.047 persons/m²), medium (0.133 persons/m²), and high (0.218 persons/m²) pedestrian density on a street that was created to be a pedestrian mall on Akamon-dori. Figure 5 depicts the space in the four instances. Additionally, pedestrian density was a requirement for the trial as a factor affecting awareness.

(A) Walking trajectory recordings: Figure 6 depicts the route choice rate and the number of pedestrians at intersections (1) and (2), following the walking route trajectories recorded in the experiment. At both intersections (1) and (2), the route choice rate of Akamon-dori increased because of the conversion to a pedestrian mall.

(B) Optional activities: Subjects were asked to stop at stores and take pictures as optional activities during the walk. The experiment's outcomes were calculated and written down. The individuals in the investigation's walking path trajectory records of the store stops and images are displayed in instances in Figure 7. The number of alternative activities per person at locations in retail districts is shown in Figure 8. Streets with a sample size of four or larger were selected, and the number of store stops and the number of photographs taken were tabulated. The subjects' head movements when selecting a route and product and their shopping search behaviors were observed when they stopped at stores. Product search and shopping behavior were mainly observed in the subjects' gaze toward the street components that made up the building facades and store product shelves. Optional activities were more common in Akamon 3 and Shintenchi 1. This is due to numerous open facades and the high density of stores. The number of optional activities was low in Akamon 2 and Honmachi 1. This is because some buildings are under construction and several of the facades are closed because of the sparseness of the facilities.

Date	Nov. 9–13, 2020	**Subject**	15 engineering students
Method	(1) Practice of spatial cognition in virtual space. (2) Conduct a virtual space experiment (screen recording and action logging will be conducted at the same time as the start of the experiment). (3) Evaluate impressions of the streets while viewing the recorded images and conduct a post-experiment questionnaire.		
Assumed situation	(1) Visiting alone to accomplish an errand with no time constraints. (2) Going through the main street. (3) Look at a map and know the location of the destination in advance. (4) Permission is granted to go sightseeing at your own discretion while heading to your destination.		
Cases	Existing case/pedestrian mall case of Akamon street with pedestrian density (low/medium/high).		

Table 2: Virtual Osu experiment.

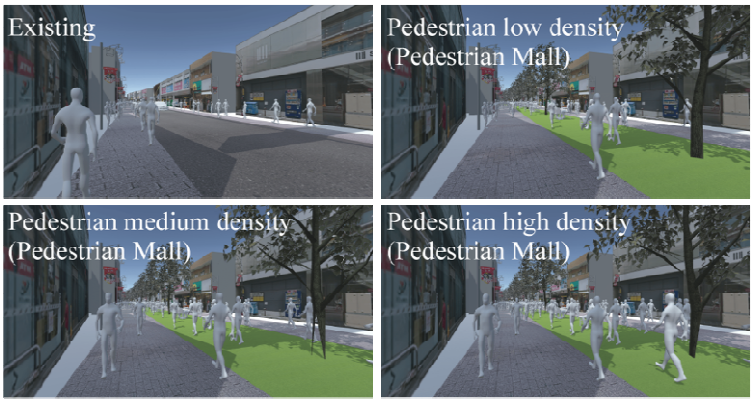
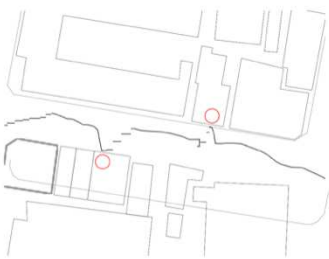


Fig. 5: Space in the four cases used in the experiment. Fig. 6: Route choice rate and the number of pedestrians at intersections.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER



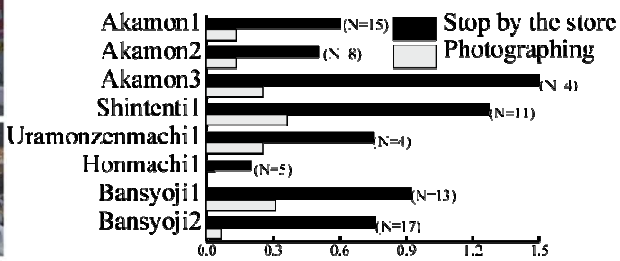
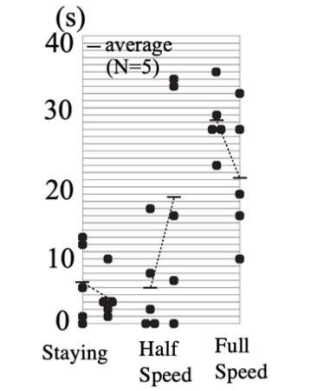


Fig. 7: Examples of recorded store stops. Fig. 8: Number of optional activities per person at shopping district sites.

(C) Walking speed: The walking speed at Akamon 1 is depicted in Figure 9. The distance traveled by the subject per second was calculated from the coordinate data that recorded the subject’s position in the experiment. A speed of 2 m/s or more was given full speed, 1 m/s or more but less than 2 m/s was considered half speed, and less than 1 m/s was considered stopping. The half speed time tended to increase and the full speed time tended to decrease on the streets converted to pedestrian malls compared to the existing streets. It is assumed that the pedestrian mall has increased the number of streets that people want to see at a leisurely pace. Conversely, stopping time decreased. This may be because the system has lost its novelty and the subjects have become more adept in the gaming operation.

(D) Eye movement: Subjects’ eye movements were recorded as eye marks from the video recorded in the experiment. The number of eye movements at Akamon 1 is shown in Table 3. The eye marks registered in the experiment were recorded as the gazing zones shown in Figure 10, which are located in the street components. The streets were categorized into five zones: the sky above, left wall, right wall, road surface, and the back of the street toward travel. Then, the wall was classified into gazing zones for each store, and the road surface was categorized into three zones. In addition to the gazing zones, gazing at street components was recorded separately. Then, 20-s eye mark positions were recorded every 0.3 s, and the number of eye movements was tabulated. On the pedestrian mall transformed streets, the number of eye movements rose higher than that on the previous roadways. The pedestrian mall is claimed to have increased the number of attractions on the route.



Left: existing Right: pedestrian mall

Subject	Existing	Pedestrian Mall	Difference
A	30	38	8
B	27	27	0
C	25	28	3
D	19	27	8
Average	25	28	3

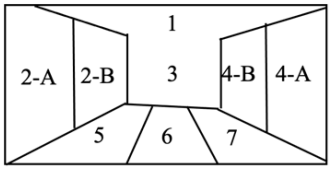


Fig. 9: Time per walking speed. Table 3: Number of eye movements in seconds at Akamon-dori. Fig. 10: Gaze zone position.

(E) Impression evaluation: at the end of the walk, the participants completed an impression evaluation questionnaire while watching a video recording of the experiment. Figure 11 depicts the impression evaluation of the four instances at Akamon 1. Pedestrian mall streets received higher ratings in all situations, particularly on high density streets. The low score for “Have good visibility” may be due to the large number of pedestrians obstructing visibility. The low scores in the “Want to walk” category are thought to be because people do not want to walk on streets with too many pedestrians. Additionally, the “Adequate sidewalk width” was significantly improved by the pedestrian mall conversion, which means that dissatisfaction with the existing sidewalk width was eliminated. Medium density was the highest for “Adequate traffic volume,” which means that respondents felt that neither too many nor too few pedestrians were adequate. Although the facades did not change before and after pedestrian mall conversion, pedestrian density and pedestrian mall conversion may affect the impression of neighboring buildings as pedestrian

mall-converted streets tend to be rated higher in the items related to surrounding buildings as well. The impression ratings for each street are shown in Figure 11. The reason for the higher assessment of the Honmachi-dori in the items related to street composition can be attributed to the presence of trees as street components and wider sidewalks. Shintenti-dori and Banshoji-dori received high ratings for surrounding buildings, possibly due to the full-cover arcade and dense store density. The low evaluation of Uramonzenmachi-dori in the "Want to walk," "Want to stay," and "Want to come back" categories are thought to be due to the street's low attractiveness. The increase in the selection ratio of Akamon-dori above is believed to be due to an improvement in the impression evaluation.

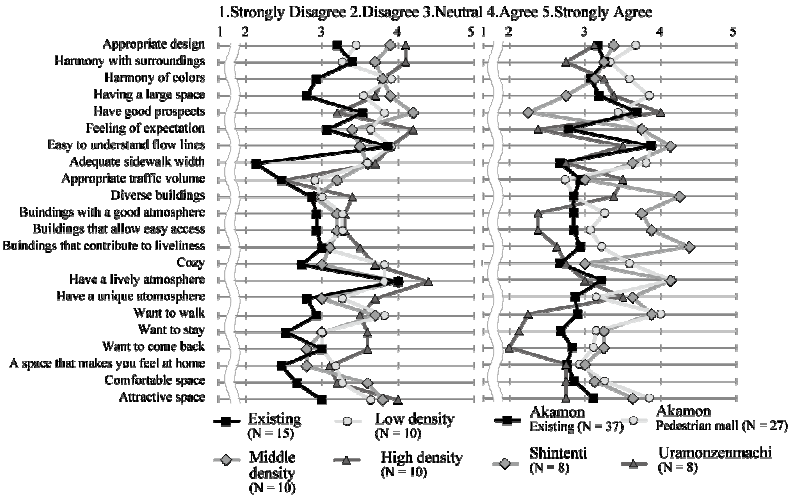


Fig. 11: Impression evaluation at Akamon-dori and on each street.

4.4 Further Development Directions

The virtual space experimental system's repeatability and operability will be improved in the future.

On the basis of the above research, future work will include constructing a system for VR experiments to acquire behavioral sequences such as eye and head movements in shopping district spaces. The objective is to clarify pedestrians' dynamic spatial awareness and to help in creating an urban area with a rich walking experience. Using the Osu shopping district as the research target, we will analyze the impact of pedestrian flow and density on people's route choices and behavior.

The analysis will be conducted from two axes: an actual space experiment and a VR experiment. In the real-space experiment, subjects will be asked to walk in the actual Osu shopping district as a preliminary experiment and their behavior logs will be obtained. The VR experimental system will be built based on the real-space investigation. A spatial model of the simulated case will be produced, and the subjects will be requested to walk in the same manner. As a behavior log, we will record the travel trajectory, starting spots, time, and optional activities and locations. We are also planning to analyze the behavior factors based on the records using a questionnaire survey.

5 VD22: COMBINATION STUDY BETWEEN VR EXPERIMENT AND VISION-DRIVEN AGENT SIMULATION

5.1 Introduction

Because the guide signs show the destination information, the layouts of the guide signs will affect the pedestrians' wayfinding behavior in subway stations. This part proposes a vision-driven pedestrian agent model VD22 that simulates the pedestrians' wayfinding behaviors on a three-dimensional walking surface by detecting signs, which can help the urban designers and managers evaluate and improve the layouts of the guide signs. A VR experiment was conducted to measure the internal parameter, sign detectable ratio, for introducing the model VD22. Finally, the efficacy of the VD22 model was confirmed by comparing the agent simulation results with the VR experimental results.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

5.2 VR Experiment

We selected the Oasis 21 Square, which includes two subway stations and an outdoor square space. An immersive virtual reality environment was built on Unity (ver2019.2.8f) to design the VR experimental system, in which the spatial and temporal data can be recorded in real time. Using the VR equipment with an eye-tracking function, the participants’ gaze points can also be recorded. The subjects were divided into two groups of 30 architectural students. Each participant was required to complete three tasks. The participants in the experiment had a first-person perspective and could move and rotate in the visual space using the VR controller.

We calculated the sign detectable ratio proposed by Iwata et al. (2013) and Gu et al. (2015) based on the calculation method of the sign detectable ratio in the horizontal and vertical directions in a hemisphere area. We also examined the read ratio of each sign and the walking trajectory of the pedestrians. The results showed that the pedestrians’ walking trajectory was directly related to sign recognition. This demonstrates that an appropriate layout of guide signs will quickly and accurately guide the pedestrians to their target destinations.

5.3 VD22 Pedestrian Agent Model and Agent Simulation

Vision-driven pedestrian agent models, namely, VD18s (Yokoyama et al., 2020) and VD19 (Maekawa et al., 2021) built by our laboratory based on the EVA model (Penn et al., 2002), are vision-driven agent models that detect the sign and perform the wayfinding behavior according to the sign information direction. Model VD19 encoded the ratio as a sign detectable probability measured by Iwata et al. (2013), which achieved the wayfinding behavior by detecting signs in three-dimensional space. However, owing to the constraint of sign detectable ratio in vertical directions, model VD19 could not move on three-dimensional surfaces such as stairs and slopes.

VD22, a 3D vision-driven agent, is an enhanced version of agent model VD19. Agent model VD22 was built by importing the sign detectable ratio measured in the VR experiment. It approaches its move on the three-dimensional walking surface by accurately detecting signs in vertical directions. Agent model VD22 always follows guide signs to its destination. It will perform a natural movement requiring the direction of the deepest sightline without detecting a sign. It moves at a walking speed of 1.0 m/s, which reduces to 0.75 m/s when moving on stairs and slopes, and decisions are made at 0.3-s intervals with a constant probability. The spatial and sign recognition by agent model VD22 and the dimensions of the visual range used in agent model VD22 are shown in Figure 12.

We implemented agent simulation 100 times of Tasks 1 and 2 (both are approximately 100 m of unmanned subway transfer corridor, including stair climbing), each using our new agent model VD22. Compared to the VR experiment, the agent model maintained a constant speed throughout the process, except for some pauses and deceleration during sign recognition. Regarding the walking trajectory, it was generally straight compared with the results of the VR experiment.

5.4 Comparison of the Simulation and VR Experimental Results

To compare the walking trajectory between the VR experiment and agent simulations, we established three patterns for each task and determined the proportions of the patterns in Tasks 1 and 2. The findings demonstrate that the proportions of the patterns in Tasks 1 and 2 simulation results are highly comparable to those in the VR experiment, which confirms our new agent model VD22, and the sign detectable ratio determined in the VR experiment and encoded into agent model VD22.

An analysis of variance was used to determine the difference in walking distance and time of the results between the agent simulations and VR experiments for Tasks 1 and 2. There is no significant difference in walking distances in Task 1 (p-value > 0.05) and Task 2 (p-value > 0.05). However, in terms of walking time, there was a significant difference in Task 1 ($F = 7.7$, p-value < 0.001) and Task 2 ($F = 5.2$, p-value < 0.001). The VR experimental results are significantly longer than the simulation results, which is linked to the following two factors:

a) The VD22 model is incapable of detecting pauses and deceleration.

b) The participants were unfamiliar with how to move using the VR controller, which led to some time spent during the experiment.

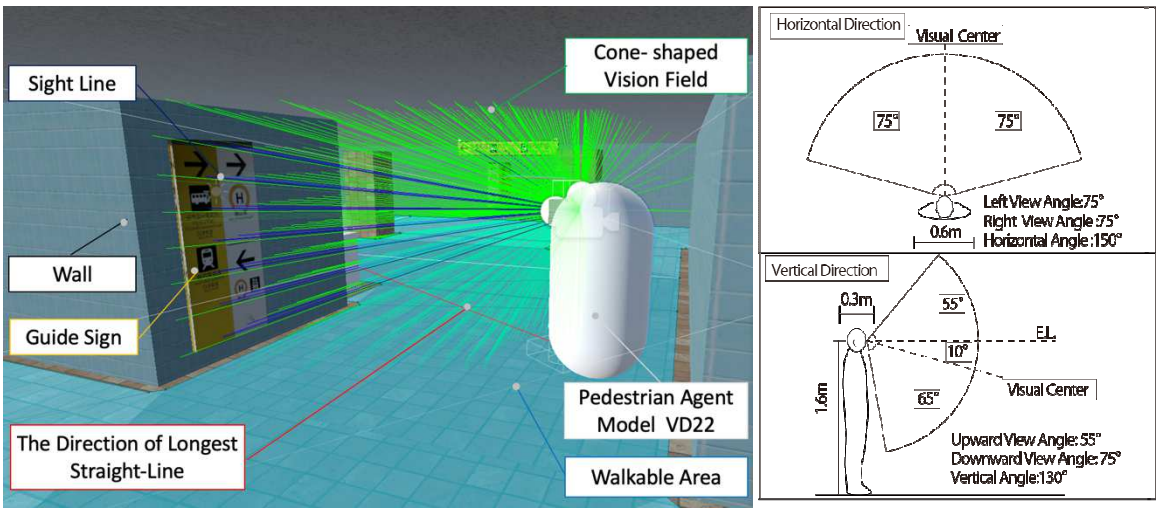


Fig. 12: Spatial recognition and sign recognition (left) and the dimensions of the visual range of agent model VD22 (right).

5.5 Summary and Future Work

We built a vision-driven agent model VD22 to simulate the pedestrians' wayfinding behavior by detecting guide signs, which will help the urban designers and managers improve the layouts of guide signs in subway stations. A VR experiment was conducted to obtain the internal parameter, sign detectable ratio, in the horizontal and vertical directions. Our new agent model, VD22, can perform a wayfinding behavior on a three-dimensional walking surface. Finally, the effectiveness of the VD22 model was validated by comparing the results of agent simulation and VR experiments.

The VD22 model was created at a barren metro station. Future studies might benefit from an agent model that handles stops and decelerates under varied pedestrian concentrations. To identify the parameters for the new agent model, an examination of guide sign identification and pedestrian wayfinding behavior at different pedestrian densities will be necessary.

6 CONCLUSIONS

In this paper, we positioned virtual space and VR as significant digital twin technologies that contribute to human-dimensional urbanism and reported on the research of two experimental systems in which the authors were involved. This digital twin was triggered by two IT innovations, namely, the mobile-phone location and 3D open data, and is the confluence of two different sources: urban simulation and participatory experience tools.

Virtual Osu, described in Section 4, is a virtual space environment based on a 3D model of the Osu shopping district. Its fundamental performance as a virtual space experimental system was demonstrated through a gaming experiment conducted as a mall planning and design case study. The concepts of walking trajectory, optional activities, walking speed, and eye movement can be treated as the "human dimension" mentioned by Gehl. The analysis of the subjects' spatial behavior in the virtual space was confirmed to simulate their actual behavior by comparing it with the data of their actual shop-around behavior obtained from the questionnaire survey. The factor analysis using PLS regression obtained the effect analysis on the facade's details. Nevertheless, owing to space limitations, the report will be left to the next issue (Hirate, 2021).

For the sign layout problem described in Section 5, we measured the sign detectable ratio in human sign recognition using VR experiments, conducted a vision-driven agent simulation with these parameters as input, and confirmed its reproducibility. Virtual space and virtual reality require many 3D building models, but VR is characterized by conversion to viewpoint-centered coordinates using immersive VR goggles. It is also capable of unprecedented micromotive analysis, such as eye movement, opening the way for innovative future exploratory research. These combinations of the elemental technology of this digital twin stimulate remarkable research.

7 ACKNOWLEDGEMENTS

The Japan Society for the Promotion of Science has funded this research through KAKENHI Grant Number 18H03825.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

8 REFERENCES

BATTY, Michael: Digital twins. Environment and Planning B: Urban Analytics and City Science, Vol. 45, Issue 5, pp. 817-820, 2018.

DEMBSKI, Fabian, YAMU, Claudia and WöSSNER, Uwe: Digital twin. In Virtual Reality and Space Syntax: Civic Engagement and Decision Support for Smart, Sustainable Cities: Proceedings of the 12th International Space Syntax Conference, Beijing, China, pp. 8-13, 2019.

GU, Zongchao and OHNO, Ryuzo: Sign detectability in railroad station considering flow direction of pedestrians. AIJ Journal of Technology and Design, Vol. 21, Issue 48, pp.765-770, 2015.

HIRATE, Hiroshi: Analyses on the crowding effect of street space in Osu District, Nagoya–Based on the shop-around behavior survey data virtual space experiments data. Nagoya Institute of Technology Masters Thesis Collection, 2020.

IWATA, Ayaka, ISAGAWA, Teruyuki, OSAWA, Akihiko and OHNO, Ryuzo: A study on guide sign’s detectability in a railway station, AIJ, Vol. 5376, pp. 775-776, 2013. (In Japanese)

GEHL, Jan: Cities for People, Island Press, 2013.

GEHL, Jan: How to Study Public Life, Island Press, 2013.

KANEDA, Toshiyuki (Ed.): Downtown Dynamics, Springer Japan, 2020.

KANEDA, Toshiyuki, MAEKAWA, Youtarou, KINO, Tomohiko, MATSUMOTO, Yoshimasa and SUSAKI, Kasumi: Modeling and simulation of a vision-driven pedestrian agent. Proceedings of the 12th Space Syntax Symposium, Vol. 312, 2019.

KANEDA, Toshiyuki, OTA, Akira and ZHANG, Yufan: Analyses of factors for busy streets with space configuration indicators. 13th International Space Syntax Symposium (sss13), Bergen, Norway, 2022.

KINO, Tomohiko, OHASHI, Satoshi and KANEDA, Toshiyuki: A Virtual Space Gaming Experiment System for Analyzing Waiting Behavior in a Public Square. In Downtown Dynamics Springer, Tokyo, pp. 221-234, 2020.

KOZAKI, Miki, LIM, Jongyeon, AKASHI, Yasunori and HIRATA Kotaroh: Research on pleasantness in streets of commercial district, Proposal of evaluation methodology considering psychological and physical evaluation. Journal of Environmental Engineering, AIJ, Vol. 82, Issue 738, pp. 705-714, 2017.

MAEKAWA, Youtarou, SHIMAKURA, Takumi, HAO, Shuqi, and KANEDA, Toshiyuki: Wayfinding simulation with sign recognition in a public square by a vision-driven pedestrian agent dealing in three-dimensional virtual space, In 17th International Conference on Computers in Urban Planning and Urban Management, 2021.

MINISTRY OF LAND, INFRASTRUCTURE, TRANSPORT AND TOURISM, GOVERNMENT OF JAPAN: Project PLATEAU, 2020. https://www.mlit.go.jp/plateau/

MINISTRY OF LAND, INFRASTRUCTURE, TRANSPORT AND TOURISM, GOVERNMENT OF JAPAN: Indicators to Measure the Comfort Level of a Town, 2020. https://www.mlit.go.jp/toshi/content/001337958.pdf

OTA, Akira, TAKAHASHI, Hiroshi and KANEDA, Toshiyuki: Factor Analysis of Rent Using Space Syntax Measures: Comparative Analysis by Building Use around Shibuya Station, 2021 ASAMI, HIGANO, FUKUMI (Eds.): Frontiers of Real Estate Science in Japan, Springer.

PENN, Alan and TURNER, Kevin T: Space Syntax-Based Agent Simulation. In Schreck Enberg, Michael and Sharma, S, Pedestrian and Evacuation Dynamics, Berlin, Springer-Verlag, pp. 99-11, 2002.

SCHROTTER, Gerhard & HURZELER, Christian: The digital twin of the city of Zurich for urban planning. PFG–Journal of Photogrammetry, Remote Sensing and Geoinformation Science, Vol. 88, Issue 1, pp. 99-112, 2020.

TURNER, Alasdair and PENN, Alan: Encoding natural movement as an agent-based system: An investigation into human pedestrian behaviour in the built environment. Environment and planning B: Planning and Design, Vol. 29, Issue 4, pp. 473-490, 2002.

TURNER, Alasdair, DOXA, Maria, O' SULLIVAN, David and PENN, Alan: From isovists to visibility graphs: A methodology for the analysis of architectural space. Environment and Planning B: Planning and Design, Vol. 28, Issue 1, pp. 103-121, 2001.

TURNER, Alasdair: Depthmap: A program to perform visibility graph analysis. In Proceedings of the 3rd International Symposium on Space Syntax, Vol. 31, pp. 31-12, 2001.

VIRTUAL SINGAPORE (2018) Virtual Singapore 2019. Government of Singapore. https://www.nrf.gov.sg/programmes/virtual-singapore.

YOKOYAMA Yoji, MAEKAWA, Youtarou and KANEDA, Toshiyuki: Wayfinding Simulation of Sign Layout in a Public Square by a Vision-Driven Pedestrian Agent in a Virtual Space, Kaneda (Ed.), Downtown Dynamics. Springer, pp. 235–250, 2020.

🏆 *reviewed paper*

Walkability Assessment of Elderly People in Collective Relocation after the Great East Japan Earthquake – a Case Study in Kesennuma City, Japan

Takahiro Kanamori, Wanglin Yan

(Takahiro Kanamori, Keio University, 5322 Endo, Fujisawa, Kanagawa, Japan, leonis@sfc.keio.ac.jp)
(Prof. Wanglin Yan, Keio University, 5322 Endo, Fujisawa, Kanagawa, Japan, yan@sfc.keio.ac.jp)

1 ABSTRACT

Ten years have passed since the Great East Japan Earthquake, and collective relocation has been completed in the tsunami-affected areas. While collective relocation has ensured safety from the tsunami, the lives of elderly residents after relocation are expected to change drastically due to the distance from the highly convenient coastal areas. This paper clarifies how, in the midst of population decline and aging community, the collective relocation to areas with rugged terrain had an impact on the living conditions of elderly residents, particularly regarding daily movement on foot, and how these conditions have changed since the collective relocation. Specifically, the amount of walking load from each collective relocation complex to the nearest living facilities was calculated for the 5th and 10th year after the earthquake. The analysis revealed that while an increasing number of complexes improved their walking accessibility due to the increase in local living facilities, 15 of the 103 complexes in Kesennuma City required a very large amount of physical effort to reach all living facilities.

Keywords: Elderly People, Walkability, Aging, Collective Relocation, Post-Disaster Reconstruction

2 INTRODUCTION

The Great East Japan Earthquake that occurred on March 11, 2011, caused extensive damage to the Tohoku and other coastal areas of the Pacific Ocean by the tsunami. In the tsunami-affected areas, the Collective Relocation Projects (hereinafter “CRP”) and Disaster Recovery Public Housing Projects (hereinafter “DPP”) were executed as collective relocation, relocating residents from low-lying coastal areas to higher ground and other locations with less tsunami risk. Most of the sites for collective relocation were decided within five years since the earthquake, and these projects were implemented at an unprecedented scale.

Among the tsunami-affected areas, the Sanriku coastal area is characterized by a rias coastline with steep terrain extending close to the shore. The intricate topography forms inner bays, and many areas have a thriving aquaculture industry due to the tranquil environment, and fishing has flourished in the offshore areas. Given such background, urban areas have been formed in low-lying coastal areas for its convenience. However, in the reconstruction from the earthquake, lowland coastal areas that remain at risk of L2 tsunamis (the largest class of tsunami), even with seawalls and land raising, were designated as disaster hazard area under Article 39 of the Building Standards Act, and restrictions were placed on the location and structure of residential buildings. As a result, housing reconstruction was mainly carried out outside the disaster hazard area, and the coastal areas, which had been the center of livelihood and daily services, were spatially separated from the inland and highland areas, which were the new residential areas. In other words, the reconstruction of housing after this earthquake may have prioritized the reduction of tsunami disaster risk at the expense of the increase in livelihood risk.

This earthquake occurred in the midst of a rapidly shrinking and aging population, and many of the residents who participated in the collective relocation project can be assumed to be elderly. As mentioned above, within the Sanriku coastal area, many small and dispersed housing complexes were built in steep terrain areas due to topographical constraint. Combined with the difficulty of developing convenient living facilities, many housing complexes are considered to have poor living convenience. Ten years have passed since the earthquake, and the collective relocation projects and land readjustment projects have been completed, and new roads have generally been laid out. The structure of the city has changed significantly compared to five years ago, when the sites for collective relocations were largely determined, as new public transportation networks and commercial areas have been formed. The demand for reconstruction has also changed, and the living environment seems to have changed drastically, with stores closing and some districts failing to reach their planned population due to delays in reconstruction projects. This may have resulted in a gap between the lifestyle and what was initially envisioned. In addition, the combination of these demographic changes, disaster reconstruction projects, and topography are expected to have a significant impact on the lives of the

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

elderly in the collective relocation complex. In particular, problems in terms of walking mobility for the elderly are likely to become apparent in the near future, and mobility will become difficult in the area with its rugged terrain.

This paper focuses on Kesennuma City, Miyagi Prefecture, where a large-scale collective relocation project was implemented as a result of the tsunami. The purpose is to examine how, in the midst of population decline and aging community, the collective relocation to areas with rugged terrain had an impact on the living conditions of elderly resident, particularly regarding daily movement on foot, and how these conditions have changed since the collective relocation. Specifically, this paper calculates the amount of physical load calculated based on the effect of inclination on the body and physical functions, and conduct a walking accessibility assessment from each collective relocation complex to the nearest living facilities. The target focus of these assessments is mainly on the 5th and 10th year after the earthquake.

3 LITERATURE REVIEW

Many studies have addressed and provided insights into issues related to lifestyles and the aging society. One such study, particularly focusing on the understanding of aging population and its walking mobility, is the study by Hasegawa, who studies the differences in housing attitudes in relation to the aging population in detached housing complexes (Hasegawa et al., 2011). This study revealed that the older the members in the elderly households are, and the less convenient housing complexes are, the stronger residents show anxiousness over their daily transportation means. In particular, the study points out that the inconveniences experienced in regard to hospital visits and daily shopping are major factors resulting in residents changing their residence. Considering the increase in the number of elderly residents who will be unable to drive in the near future, taking into account residents' lifestyle from the perspective of walking mobility will be crucial for elderly residents. In this context, the concept of walkability is important when focusing on walking mobility. A study of walking accessibility for the elderly conducted by Hara et al. (2009) revealed that the area reachable on foot is significantly smaller than that in plain areas. This study considers the effects of physical ability and topography, and this paper believes that it is important to consider walkability from these perspectives.

On the other hand, the elderly nowadays often drive cars, and such a tendency is prominent in rural cities, as cars are significant means in maintaining livelihood (NPA, 2022). However, research indicates that elderly drivers perceive their driving ability to decrease due to their declining physical ability (Nihei et al., 2012) and this indicates high likelihood of inducing traffic accidents. Therefore, studies such as by Yamamoto et al. (2012), have argued that accessibility improvements that do not rely on automobiles are necessary to encourage elderly drivers to return their licenses. In conclusion, debating on the walking mobility of elderly residents is significant from the standpoint of promoting self-supportive and independent life for the future of the elderly.

Many studies addressing the impact of collective relocation on livelihoods have focused on uncovering the situation of residents/participants in the collective relocation (Tanaka, 2011) or on the situation concerning the divisive collective relocation (Tanaka et al., 2010). Most of these studies analyze disaster reconstruction based on non-tsunami disasters such as the Niigata Chuetsu Earthquake, which was a landslide disaster, and not many have addressed large-scale collective relocation for the reconstruction from tsunami disasters. Although there are a few studies on the Great East Japan Earthquake, few of them discuss the impact of collective relocation as regards population decline and aging society, and none of them discuss the impact of collective relocation on the walking environment of the elderly residents, nor provide quantitative evaluation of the relocation and comprehensively take into account these factors in their studies.

4 STUDY AREA

4.1 Study Area

Kesennuma City, located in the northeastern tip of Miyagi Prefecture, about 400 km north of Tokyo, is one of the cities that was severely damaged by the tsunami. The city has a particularly large number of collective relocation complexes among the affected areas. According to a tsunami trace survey conducted by Miyagi Prefecture, the maximum inundation depth in the city was 15 to 19 meters and the maximum run-up height was over 20 meters (Miyagi Prefecture, 2012). The inundated area covered 18.65 km², or 5.6% of the city

area (Kesennuma City, 2011). The tsunami also caused fires, and as a result of these damages, more than 1,400 people were killed or missing (as of April 30, 2022), and more than 10,000 buildings were completely or partially destroyed (Miyagi Pref, 2022).

Kesennuma City geographically consists of areas stretching along from north to south, and include a remote island, Oshima, at its bay port. The city has a 30 kilometer stretch of inlets and a steep terrain characteristic of a rias-coastline, and the elevation rises sharply as one moves slightly away from the coast. Most of the city's urban areas and settlements are concentrated in a limited number of low-lying coastal plains, hills, and inlets. The city has a total population of 61,147 (2020 Census), but the population has decreased by 12,342 in the 10 years since 2010, the year before the earthquake. The aging rate of the population is 38.3% (2020 Census), an increase of 7.5% since 2010.

4.2 Collective Relocation Projects

CRP is a project that allows five or more households to relocate to a higher ground or other safe area while maintaining their communities, with purchase of the land from which they are relocating to and the cost of relocating their homes being subsidized. DPP provides inexpensive rental housing to disaster victims who cannot or do not wish to build their own houses. In the study area, about 30% of the 9,130 affected households participated in the CRP and DPP (Kesennuma City, 2018).

Collective relocation complexes in the city can be broadly classified into three types: collective relocation complexes (hereinafter "CRC"), disaster recovery public housing complexes (hereinafter "DPC"), and mixed-use complexes with a mixture of CRC and DPC (hereinafter "MRC"). In the study area, 2,994 units in 103 housing complexes, including 60 CRC, 33 DPC, and 10 MRC (September 2021) have been completed and the affected people have started living in their new homes.

These collective relocation complexes vary in location from those developed in coastal areas to inland areas (Figure 1), and the number of relocated units in each complex varies from 5 to 67 units in CRC and from 7 to 320 units in DPC (RA, 2021). The reasons behind the 5 units minimum relocation requirement and the decentralization of complexes include the relaxation of the minimum relocation requirement for CRP from 10 to 5 units and the difficulty of acquiring land for relocation sites, which has resulted in the creation of many very small complexes.

4.3 Target Living Facilities

A study by Sato et al. (2013) focused on leisure, safety, daily living affairs, purchasing, transportation, and medical care as the minimum necessary living facilities from the perspective of continued residence of the elderly in a regional core city. In addition, a national survey on the living conditions of the elderly (MLIT, 2005) revealed that the frequency of daily shopping and hospital visits was higher than other daily activity purposes. Based on these findings, public transportation, commercial facilities, and medical facilities are defined as living facilities that are considered to be minimally necessary for people to live on foot in the study area. Table 1 shows the number of living facilities under each facility categories in each year.

4.3.1 Public Transportation

Public transportation in the city includes local buses and Bus Rapid Transit (BRT). Before the earthquake, the JR Kesennuma Line and JR Ofunato Line had been in operation but were inoperable immediately after the earthquake due to the damage caused by the tsunami. Currently, all of the city's railroads have resumed service with the introduction of BRT. Some routes have been drastically changed in accordance with the status of reconstruction of coastal areas and housing. Based on the above, this paper defines bus routes and BRT as public transportation.

Living Facility		**2016**	**2021**
Public Transportation	Bus Stops, BRT Stations	259	270
Commercial Facility	Supermarkets	14	13
	Pharmacies	8	12
	Convenience Stores	33	41
Medical Facility	Hospitals (Internal Medicine)	19	20

Table 1: Number of Facilities under Each Category of Living Facility (July 2018)

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

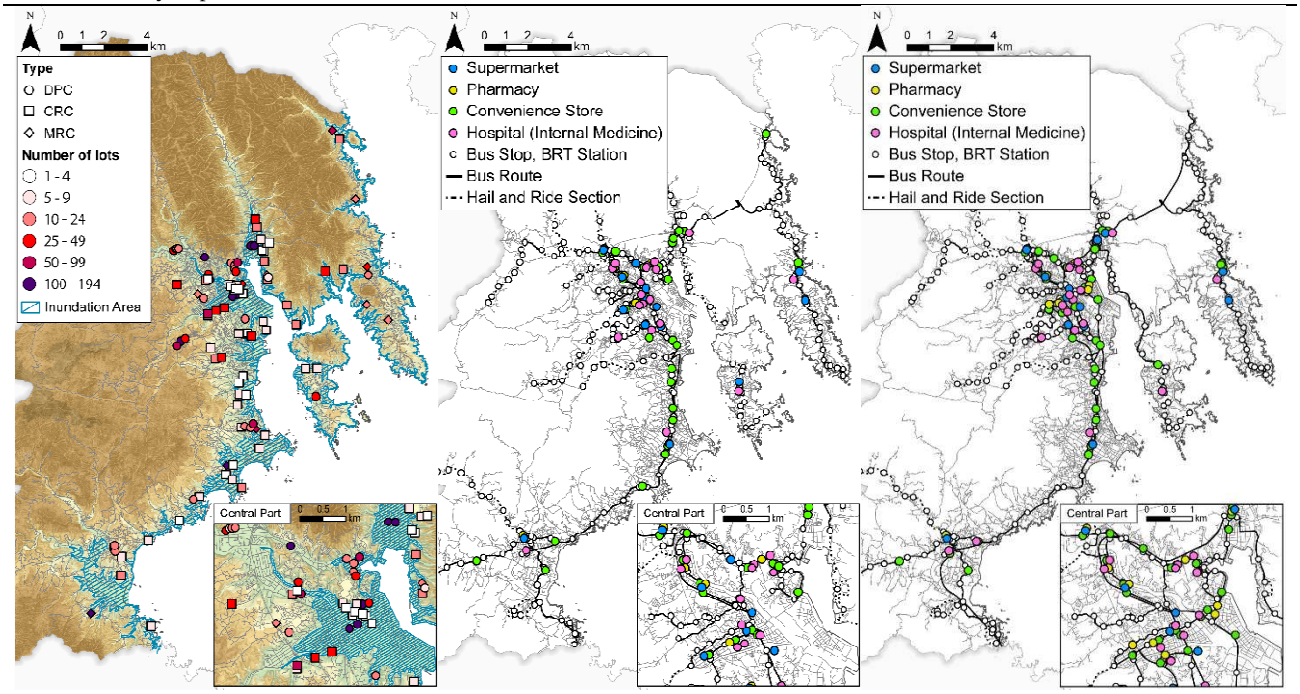


Fig. 1: Location and scale of collective relocation complex (left). Fig. 2: Location of living facilities in 2016 (middle) and 2021 (right)

4.3.2 Commercial Facilities

There is a wide variety of commercial facilities in the city, ranging from a commercial complex to supermarkets, pharmacies, convenience stores, and local stores. Given that the local stores are known to have only a limited range and number of products which they handle, and studies have shown that the frequency of elderly purchasing at such stores is significantly lower than that of other commercial facilities, this paper limits its focus of commercial facilities to supermarkets, convenience stores, and pharmacies, excluding local stores. However, in some areas, the local stores are relatively larger than in other areas and are serving as supermarkets and convenience stores provided that there are no other commercial facilities in the vicinity. Therefore, in each area of Karakuwa and Oshima some among such stores were treated as commercial facilities and classified as supermarkets or convenience stores based on the national categorization (METI, 2005). Pharmacies are classified under commercial establishments, as pharmacies offer a wide range of food products as well as medical supplies and a similar classification has been given in other existing studies (Suzuki et al., 2014).

4.3.3 Medical Facilities

General hospitals and clinics with internal medicine departments, which are considered to be frequently used by the elderly based on previous studies (Sato et al., 2013) are the focus of this study.

5 METHODOLOGY

This paper assesses the walking accessibility of the elderly on the shortest one-way road route from each collective relocation complex to the nearest living facilities (public transportation, supermarkets, pharmacies, convenience stores, hospitals (general hospitals and clinics including internal medicine) throughout Kesennuma City.

5.1 Definition of Walking Accessibility

This paper defines the evaluation method of walking accessibility based on a previous study (Hara et al., 2009). Hara et al. developed a walking accessibility index based on the evaluation method suggested by Sato et al. (2006), while improving it by using metabolic conversion walking distance, which takes into account physical ability and topographical conditions.

The Walking Energy Consumption (E) is calculated using the following equation (1). The Relative Metabolic Rate (RMR) represents the activity intensity of walking up a gradient along the pathway, and their

relative load is expressed as (RMR + 1.2). Basal Metabolic Rate per Unit Weight and Time (BMR) × Weight (W), represents the basal metabolic rate per unit of time. The Volume of Basal Metabolic Rate represents the minimum amount of energy required for basic life functions, and the Basal Metabolic Rate (BMR) and Weight (W) vary with age. Walking Time (T) is the value obtained by dividing the Road Distance to the Destination Facility (l) by the Walking Speed (v).

Walking load (R) is expressed by equation (2), and Walking Accessibility to the Destination Facility (A) is expressed by equation (3). The Estimated Daily Energy Requirement per Unit Body Weight (a) ×Weight (W) represents the estimated daily energy requirement. The estimated daily energy requirement is the average daily value of habitual energy intake that is estimated to have the highest probability of zero energy balance (MHLW, 2010). This value is determined by the physical activity level, which is determined by the content of daily activities in addition to the Volume of Basal Metabolic Rate. In this paper, the physical activity level is set in "Level II (moderate)", representing the activity level in sedentary lifestyle with some light exercise involved. The Amount of Walking Load to the Destination Facility (R) is the Energy Consumption (E) of walking from the starting point to the destination, divided by the estimated daily energy requirement. The Walking Accessibility to the Destination Facility (A) is the walking load (R) minus 1. In other words, walking accessibility in this study refers to the ratio of the amount of energy that can be consumed other than by walking to the nearest living facilities out of the daily energy requirement. The closer the value of walkability (A) is to 1, the better the walkability from the relocation site to the nearest living facilities.

The Relative Metabolic Rate (RMR) are calculated as shown in equation (4), as it differs depending on the gradient (s). The Relative Metabolic Rate (RMR) increases as the gradient becomes steeper and decreases as the gradient becomes more gradual. However, even on a gradual gradient, it becomes a heavy load on the body of an elderly person when climbing a hill, and similarly with a steep gradient, it becomes a heavy load

$$E = (RMR + 1.2) \times BMR \times W \times T \quad (1)$$

$$R = E/(a \times W) \quad (2)$$

$$= (RMR + 1.2) \times BMR \times W \times T \times \{1/(a \times W)\}$$

$$= (RMR + 1.2) \times BMR \times W \times (l/v) \times \{1/(a \times W)\}$$

$$A = 1 - R \quad (3)$$

when v = 80 (4)

$$RMR = 10.0 \qquad (s \leq -0.25)$$

$$RMR = -58.07s - 4.52 \qquad (-0.25 \leq s \leq -0.11)$$

$$RMR = 3.113e^{4.6145s} \qquad (-0.11 \leq s \leq 0.25)$$

$$RMR = 10.0 \qquad (0.25 \leq s)$$

Age	***v*** **(m/min)**	***BMR*** **(kcal/kg/min)**	***a*** **(kcal/day)**	***W*** **(kg)**
65 to 74	47	0.01367	34.46	58.71

Table 2: Parameters

Variable	**Description**	**Units**
A	Walking Accessibility to the Destination Facility	-
R	Amount of Walking Load to the Destination Facility	-
E	Energy Consumption	kcal
RMR	Relative Metabolic Rate	-
BMR	Basal Metabolic Rate per Unit Weight and Time	kcal / kg / min
W	Weight	kg
T	Walking Time	min
a	Estimated Daily Energy Requirement per Unit Body Weight	kcal / kg / day
l	Road Distance to the Destination Facility	m
v	Walking Speed	m / min
s	Gradient	%

Table 3: Abbreviations and Meaning

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

As mentioned above, the Basal Metabolic Rate per Unit Weight and Time (BMR) and Weight (W) vary with the age of the walker. The Estimated Daily Energy Requirement per Unit Body Weight (a) and Walking Speed (v) also differ. This paper focuses on elderly in the early stage of life (65 to 74 years old) who are expected to commute by foot, using the values in Table 2 as parameters. For parameters other than that of Walking Speed (v), various parameters are obtained from the results of the daily life area needs survey conducted by Kesennuma City (Kesennuma City, 2014), using the average values for men and women. While the data referred to by Hara et al. (2009) are national averages, this paper did not adopt the same methodology given that physical conditions may differ by region. On the other hand, the same values were adopted in this paper from the previous study by Hara et al. (2009). Since the Relative Metabolic Rate (RMR) for walking up a gradient at a speed other than 80 m/min is unavailable, the same value, as the previous study (Sato et al., 2006), of moving at 80 m/min is used, while reflecting decrease in physical ability and walking speed due to aging in Walking Time (T). The interpolation is performed by reflecting the decline in physical ability and walking speed due to aging in the walking time (T). The abbreviation and meaning of each component described in this section are shown in Table 3.

5.2 Data Management

The data of collective relocation complexes were based on the “Land-Use Plan Map” (March 2016) and the " Overall Picture of Restoration and Reconstruction " (September 2021). The collective relocation complexes include several large complexes that are more than 500 m wide, and in these complexes, walking accessibility differs significantly at both ends of the complex. Therefore, for these large housing complexes, the data will be divided by construction zone and residential groupings as appropriate to enable a more detailed evaluation.

5.3 Method of Analysis

Network analysis is used for this analysis. First, a 5-meter mesh is used for the elevation data, and all road data are divided into 10-meter segments. Slope angle is reflected to each segment while the value of the walking load is stored per segments. Next, after finding the focal point of the relocation complexes, using the nearest road from the focal point as the starting point, the shortest road route to the nearest living facilities is extracted and walking accessibility of the route is analyzed. The walking accessibility value is calculated as a round-trip and then divided by 2 to obtain an average value per one-way trip. For public transportation, since some bus routes have hail and ride sections, only such sections are used as the routes to the nearest bus route.

6 RESEARCH FINDINGS

In the assessment of walking accessibility, collective relocation complexes are classified using the “walkable area” as criterion. Given the difficulty to assess relative walkability in absolute values, this paper defines the existing concept of walkable area as "an area where people can walk on a flat road with no gradient”. Furthermore, the threshold is set as the amount of walking load when a person aged 65 to 74 walks in a walkable area and the amount of walking load when walking twice as far. The assessment is conducted after classification of results into three classes (Table 4).

Classification	Transportation Walking Accessibility	Commercial/Medical Facility Walking Accessibility
Complex A (Within Walkable Distance)	0.9854～1 (0～400 m)	0.9818～1 (0～500 m)
Complex B (Outside Walkable Distance)	0.9709～0.9854 (400～800 m)	0.9636～0.9818 (500～1,000 m)
Complex C (Outside Walkable Distance)	～0.9709 (800m～)	～0.9636 (1,000 m～)

Table 4: Classification of Collective Relocation Complexes

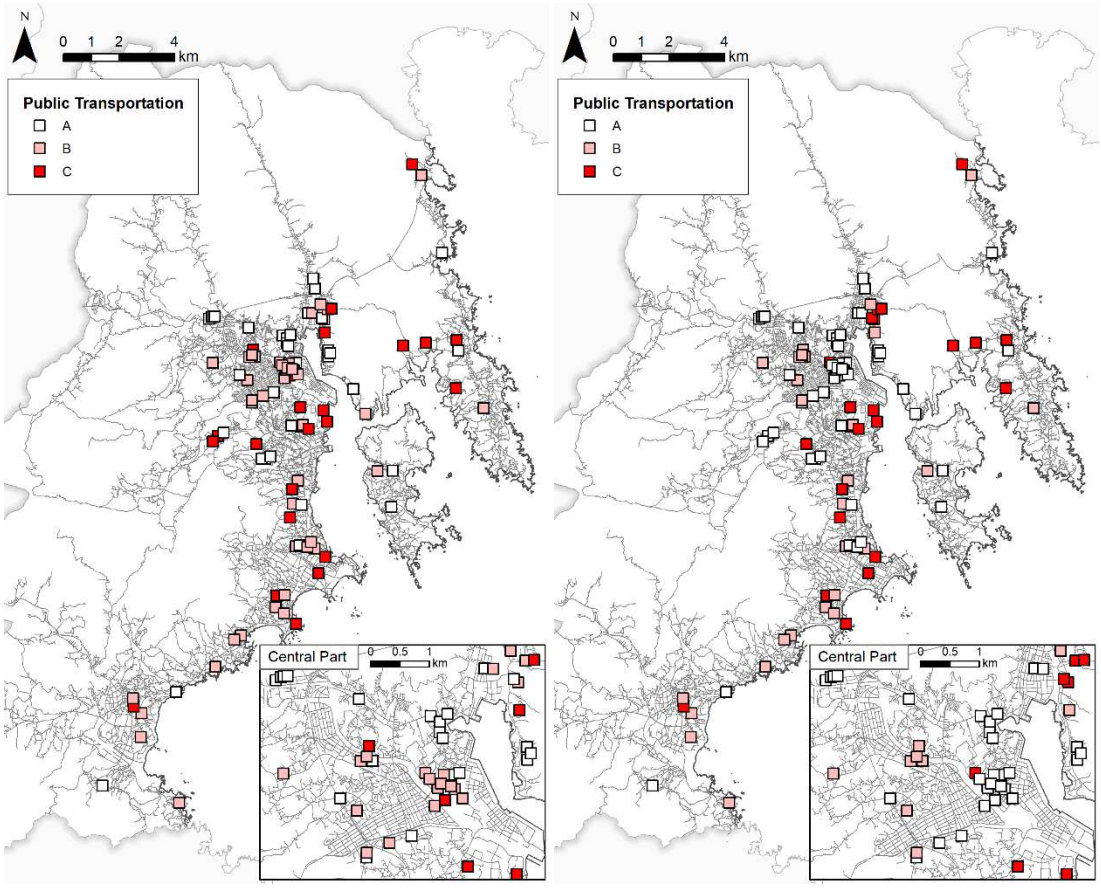


Fig. 3: Accessibility of public transportation in 2016 (left) and 2021 (right)

According to a survey on public transportation conducted by the Cabinet Office (CAO, 2016), the largest number of respondents thought 5 to 10 minutes as an acceptable time range between their home to the nearest station/bus stop, 235 m to 470 m in distance. Furthermore, bus stops are located every 400 m in many sections in the study area. Based on these factors, this paper defines the walkable distance for public transportation as 400 m. For commercial/medical facilities, walkable distance is based on the survey result conducted by the Cabinet Office (CAO, 2009). In this survey, the largest number of respondents in their 60s answered 501 to 1,000 m as the "walkable range", while the largest number of respondents in their 70s and above answered 500 m. Thus, the walking range is defined as 500 m in this paper. The complexes that can be reached within above walkable distance load are defined as "A complexes," those that can be reached with up to twice the load are "B complexes," and those with significantly greater load are defined as "C complexes".

6.1 Public Transportation

Walking accessibility of public transportation is shown in Figure 3. The classifications resulted in 38 complexes falling under complex A, 42 in B, and 23 in C, in 2016, while 53 were classified under complex A, 28 in B, and 22 in C in 2021. Given the infrastructural role of public transportation, bus stops and BRT stations are laid out throughout the city, thus many of the collective relocation complexes have better walking accessibility than other living facilities. In terms of changes over time, as of 2016, less than 40% of all collective relocation complexes were able to reach the nearest public transportation facility with the amount of load within walkable distance, but by 2021 this had improved to 50%. Most of the collective relocation complexes' walking accessibility has improved due to the extension of bus routes to the complexes and the detouring of bus routes given the completion of land readjustment projects in low-lying areas. On the other hand, 20% fall under C and there is no change seen between 2016 and 2021. In terms of location, in both 2016 and 2021, A were mostly found in densely populated areas with good public transportation in the center of the city, while complex C were found to be distributed not only on the fringes but also in areas close to the center.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

6.2 Commercial Facilities

First, for supermarkets, there were 8 complexes falling under complex A, 19 in B, and 76 in C, in 2016, while 11 in A, 18 in B, and 74 in C in 2021. While the number of complexes with improved walkability increased, only about 10% of the complexes could be reached by walking load in both 2016 and 2021, and C had over 70%, resulting in overall poor walking accessibility. Compared to public transportation, supermarkets have generally poor walking accessibility outside the center of the city, as the location of facilities are concentrated in the central area. In Oshima, the only supermarket on the island closed due to a new bridge being built in 2019 as part of a reconstruction project, and a supermarket operated by a local company near Kesennuma Station closed, indicating the withdrawal of facilities.

Next, for pharmacies, there were 7 under complex A, 4 in B, and 89 in C, in 2016, while 21 in A, 14 in B, and 68 in C in 2021. Note that since there are no pharmacies on Oshima, the three complexes on the island were excluded for 2016 because there are no facilities that can be reached on foot, and were included for 2021 because a bridge connecting Oshima to the mainland has since been built. The number of pharmacies decreased significantly in C and doubled in A, as four pharmacies were opened in the center of the city after the land readjustment projects was completed.

Convenience stores had 20 under complex A, 34 in B, and 46 in C complexes in 2016, while 31 in A, 27 in B, and 45 in C complexes in 2021. Note that as of 2016, there were no convenience stores on Oshima, so the three complexes on the island were excluded because there were no facilities that could be reached on foot. Convenience stores are scattered over a wide area of the city, resulting in A being second only to public transportation. In terms of temporal changes, B decreased, and A increased significantly. This was contributed by the increase in the number of convenience stores, which increased by eight over the five years since 2016, with many opening in the center of the city. There are 10 complexes (as of 2021) where there are no supermarkets and pharmacies within walkable area and only convenience stores are within walkable area, indicating that convenience stores may have become an important living facility to support daily life.

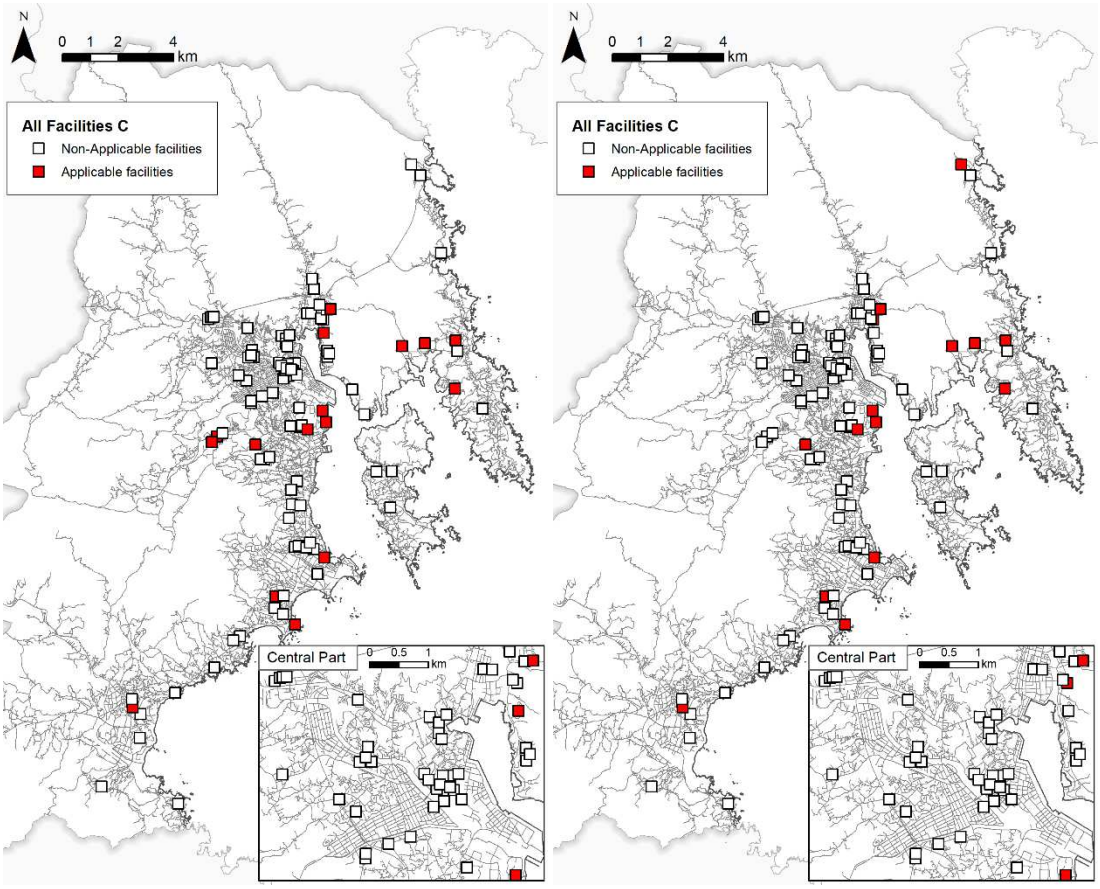


Fig. 4: Accessibility of all living facilities C in 2016 (left) and 2021 (right)

6.3 Medical Facilities

In 2016, there were 8 complexes classified as complex A, 25 in B, and 70 in C. In 2021, there were 16 in A, 21 in B, 66 in C. The number of the complexes within walkable distance was about 10% in 2016, while complexes classified as complex A has doubled due to the construction of a hospital in an area where a land readjustment project was completed. On the other hand, even in the central area, many complexes are outside of walkable area.

6.4 Multiple Living Facilities

The results of walking accessibility to each living facilities, classified into the three classifications in the previous section, indicated there were 46 complexes with 845 units (as of 2021) classified as complex B or C, where all living facilities were not within walkable distance. In particular, there were 499 units in 16 complexes in 2016 and 341 units in 15 complexes in 2021 which fell under complex C in terms of all living facilities (Figure 4), indicating that there are still a number of complexes that may be in a serious situation, with no significant change in their numbers. In terms of location, several are located in areas close to the center of the city, as well as in areas away from the city center. In addition, there are 40 complexes with 1,075 units (as of 2021) that have become C complexes in terms of all living facilities except public transportation. In such complexes, the continuation of public transportation may determine the continuation of residence, and the maintenance of local bus routes may become a major focus.

7 DISCUSSION

The results of the analysis revealed that in many of the collective relocation complexes are strongly affected by gradients, which places a heavy burden on the physical condition of elderly residents when traveling on foot to the nearest living facilities. Although public transportation, with its large number of facilities and distribution in mid-mountainous areas, made more complexes more accessible compared to walking accessibility to commercial and medical facilities, still only about 50% of the complexes were reachable within walkable distance load. Most of the commercial and medical facilities are located in central areas, with the exception of convenience stores, and due to this influence, it was found that only a small number of facilities can be reached within walkable distance load. In particular, 15% of the complexes require more than twice the load to reach all facilities within walkable distance, indicating that there is a certain number of complexes in serious condition. Many of these complexes are relatively small, which may make public transportation more difficult. In addition, these small-scale complexes are also arranged by council-type, in which residents themselves, discuss and decide where to relocate. Given that public aid will become more and more difficult with the decline in population, developing a system in which it considers livelihood risks from the perspective of self-aid and mutual aid is crucial. From the perspective of self-aid, it is necessary to present to residents the risks of living after relocation when selecting a new location, and from the perspective of mutual aid, it is necessary to consider whether residents can support each other.

In regard to changes seen overtime, the number of the complexes which saw an increase in walking accessibility has increased overtime since 2016, as reconstruction projects have increased the number of different living facilities, with the exception of supermarkets, as these have especially increased in many central areas. On the other hand, on a micro level, some complexes were affected by the withdrawal or relocation of facilities due to reconstruction projects and population decline, which worsened walkability in a few of these complexes. In such complexes, there is a possibility that a gap has emerged between the lifestyle envisioned before the relocation, and it is necessary to clarify the actual situation to see if residents are able to adapt to the changes in their lifestyles. In addition, such commercial facilities, which are strongly influenced by market principles, could easily be withdrawn as the population declines. Therefore, ensuring safety while also ensuring livelihood convenience through self-aid, mutual aid, and public aid will be an issue, including for future disaster reconstruction.

8 CONCLUSIONS

This paper focused on collective relocation as a post-disaster reconstruction project in the midst of a declining and aging population. We used objective indicators to identify issues in walking accessibility to the nearest living facilities for the elderly in the collective relocation complexes in an aging society. The results showed that many of the collective relocation complexes were affected by gradients and that they were

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

relocated to locations where there were no nearby living facilities, resulting in poor walking accessibility. In terms of changes over time, as infrastructure improvements in coastal areas were completed, living facilities were also increasing, which improved the walking accessibility of many of the complexes. On the other hand, a small number of complexes experienced a deterioration in walkability, as some of the facilities were withdrawn or relocated due to the reconstruction projects and population decline. This may have resulted in a gap between the lifestyle and what was initially envisioned.

In Japan, where cities have developed in low-lying coastal areas, there is a major dilemma as to which countermeasures should be prioritized, disaster risk or livelihood risk. This study is expected to provide fundamental knowledge from the viewpoint of advance reconstruction from the Nankai Trough Mega Earthquake, which is predicted to cause a tsunami with a high probability of occurrence in the near future.

9 ACKNOWLEDGEMENT

This research was supported by the Ushioda Grant 2021 and Taikichiro Mori Memorial Research Grants 2021 from Keio University.

10 REFERENCES

HASEGAWA, Naoki, SUZUKI, Hiroshi: A study on the situation of living consideration in detached housing estates by aging and location - A case study in Kani city -, Journal of Architecture and Planning, Vol76, Issue 663, pp.965-971. 2011.

HARA, Takuya, ISHIZAKA, Koichi, OHASHI, Yoshiko: Evaluation of residential area from a point of elderly people's walking accessibility in local center city, Journal of Architecture and Planning, Vol74, Issue 635, pp.129-135. 2009.

National Police Agency: Driver's license statistics -Supplementary material 2-. 2020.

NIHEI, Misato, KAMATA, Minoru: A survey of the elderly in regional cities on their attitudes toward driving and giving up driving, Journal of Mechanical Systems for Transportation and Logistics, Vol. 5, Issue. 1, pp. 98–109. 2012.

YAMAMOTO, Kazuo, HASHIMOTO, Seiji: A study on the structure about the consciousness of relinquishment of the driver's license - Comparison of who have driver's license and who relinquishment of the driver's license -, Journal of the City Planning Institute of Japan, Vol.47, Issue 3, pp.763-768. 2012.

MIYAZAKI, Kosuke, TOKUNAGA, Yoshiyuki, KIKUCHI, Takehiro, KOEDA Akira, TANIMOTO, Keishi, KITA, Hideyuki: An analysis of activity of elderly people in rural area, Infrastructure planning review, Vol.22, Issue 3, pp.583-591. 2005.

TANAKA, Masato: The realities and background of the moving of residents by the collective relocation project after the Niigata ken chuetsu earthquake - Cases of Nishidani district and Kotaka district, Nagaoka city -, Journal of Architecture and Planning, Vol.76, Issue 665, pp.1251-1257. 2011.

TANAKA, Masato, NAKAKITA, Emi: The Realities of Separation of Disaster-stricken Villages by the Collective Relocation Project and Its Impact on Residents - Case of Nishidani district, Nagaoka City, Niigata Prefecture -, Journal of Social Safety Science, Vol.13, pp.463-470. 2010.

Miyagi Prefecture: First Year Record of The Great East Japan Earthquake (in Japanese). 2012.

Kesennuma City: Disaster Reconstruction Plan (in Japanese). 2011.

Miyagi Prefecture: Evacuation Situation and Damage to the Great East Japan Earthquake. 2022.

Kesennuma City: Results and Future Responses to the Intention Survey for the Project for Relocation of Houses at Risk Due to Proximity to Cliffs and Septic Tank Subsidy (in Japanese). 2018.

Kesennuma City: Progress of Collective Relocation Project (in Japanese). 2021.

Kesennuma City: Progress of Disaster Recovery Public Housing Project (in Japanese). 2021.

Reconstruction Agency: Housing Reconstruction Schedule (in Japanese). 2021.

SATOH, Eiji, MITSUHASHI, Nobuo: A study on residential sustainability for the elderly in the local city - Case study of evaluation on residential environment at Utsunomiya city -, Journal of Architecture and Planning, Vol.78, Issue 691, pp.1965-1972. 2013.

Ministry of Land, Infrastructure, Transport and Tourism: Survey on sustainable community development in an aging society (in Japanese). 2005.

SUZUKI, Yu, KIMURA, Kazuhiro, HINO, Satoru, KANEKO, Yuki: Shopping status of elderly and support measures from the view point of various of shopping, Journal of Japan Society of Civil Engineers, Ser. D3(Infrastructure Planning and Management), Vol.70, Issue 5, pp.I_371-I_382. 2014.

Ministry of Economy, Trade and Industry: 2005 Commerce in our country (in Japanese). 2005.

Ministry of Health, Labour and Welfare: Dietary Reference Intakes for Japanese (2010), 2010.

Kesennuma City: Daily living area needs assessment (in Japanese). 2014.

SATOH, Eiji, YOSHIKAWA, Tohru, YAMADA, Asuka: Investigation of converted walking distance considering resistance of topographical features and changes in physical strength by age - Model for location planning of regional facilities considering topographical condition and aging society Part 1 -, Journal of Architecture and Planning, Vol.71, Issue 610, pp.133-139. 2006.

Cabinet Office: Public Opinion Poll on Public Transportation (in Japanese). 2016.

Cabinet Office: Public Opinion Poll on Walkable Community Development (in Japanese). 2009.

🏆 *reviewed paper*

Wayfinding based Usability of Complex Buildings

Shorouq Hossam, Asmaa Hasan, Khalid S. Al-Hagla

(Eng. Shorouq Hossam, Dept. of Arch., Faculty of Engineering, Alexandria University, shorouq.mostafa@alexu.edu.eg)
(Dr. Asmaa Hasan, Dept. of Arch., Faculty of Engineering, Alexandria University, asmaa.elsayed@alexu.edu.eg)
(Prof. Khalid S. Al-Hagla, Dept. of Arch., Faculty of Engineering, Alexandria University, khagla@alexu.edu.eg)

1 ABSTRACT

Usability is a key concept in evaluating the performance of buildings as it puts user experience at the core of its criteria. This measuring tool is crucial in complicated buildings, especially those based on complex circulation systems, where users may be lost. However, modern techniques have proved efficient in performing evaluation for buildings' related aspects whether before the building is constructed or later in the operation stage.

This paper investigates the potential for using way-finding as an indicator of the quality of user experience in hospitals. It correlates -on one end-, way-finding' understandings, and the usability key aspects; effectiveness, efficiency, satisfaction, learn-ability, and security on the other end. It abstracts these correlations to draw a theoretical model that could be used as a framework for further investigations. To validate its theoretical findings, this paper uses a questionnaire to collect information concerning the users' satisfaction with way-finding in hospitals in Alexandria, Egypt. The results show the importance of way-finding as a cornerstone in evaluating user experience in complex buildings and shaping their usability profile accordingly.

Keywords: Hospitals, Wayfinding, Building usability, User experience, Complex buildings

2 INTRODUCTION

Visiting a building for a specific purpose is considered as a travel. An important part of a travel is to know where to go and how to reach there (Hegarty, Montello, Richardson, Ishikawa, & Lovelace, 2006). Kuliga, (2016) described user experience as interactive, dynamic, and cognitive process. Some aspects of Architecture have an impact on this experience such as building functionality, purpose, layout, and structure.

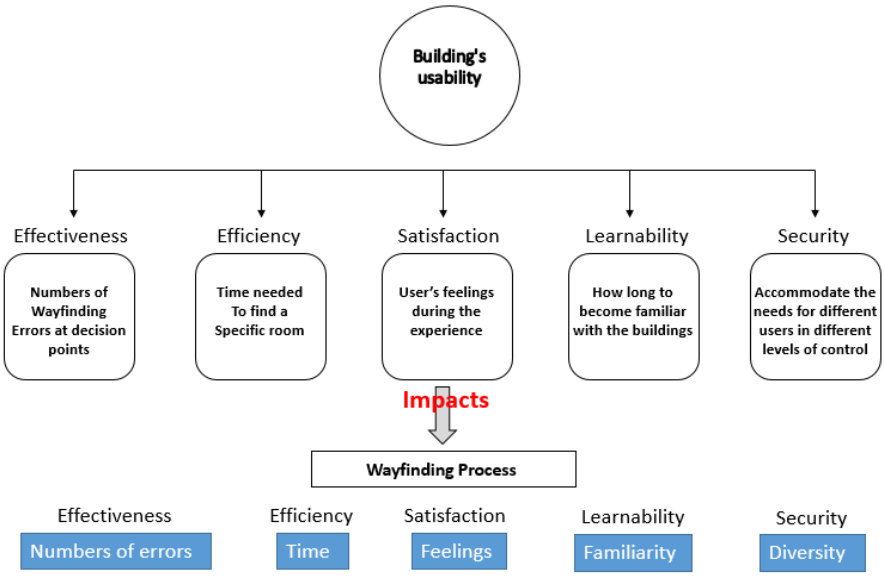


Figure 1: Usability factors (source: Author)

Education, work, and living in all are different purposes of buildings. Depending on how the buildings serve this purpose, buildings grant efficiency, effectiveness, and satisfaction for their users. However, most occupants, architects, constructors, and owners rarely carry out evaluations of how their buildings perform (Blakstad, Hansen, & Knudsen , 2008). Usability is achieved by the interaction of user experience, buildings, design, and management processes (Fenker, 2008). User experience includes perceptual and emotional components over time while usability tends to be focused on effectiveness and efficiency measures of a task

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

(Nenonen, Rasila, Junnonen, & Kärnä, 2008). It is required that a user can move towards any desired direction without delay or having any difficulties to be a successful journey.

According to Morag Ido et al (2016), it is important to evaluate wayfinding in hospitals to be efficient and suitable for occupants. In hospitals wayfinding is essential because patients are almost under pressure and may have to navigate their way to many places in during their visit. Good wayfinding experience enhance healing since it provides patients with a sense of empowerment and control, in addition to reducing fear, anxiety, and stress. Furthermore, poor wayfinding can cause additional costs through staff interrupting their work, lost time to provide directions, dissatisfaction because of the frustration of users, and lost business. Improving the user-friendly and user centered wayfinding process requires an examination of 'building usability' in different architectural design stages (Kuliga, 2016). Krukar et al. (2016) mentioned that the concept of "building usability" has varied definitions.

Through the usage of hospitals as an example of complex buildings, this article focuses on examining the usability of wayfinding-based wayfinding and how it affects user experience, with as simple note about the new wayfinding technological tools. Furthermore, this research will shed light on the usability definition in buildings and evaluating it by its five factors during the wayfinding process as the following Figure 1 explains. Finally, the results of a questionnaire based on users experiences while visiting hospitals.

3 INCORPORATING WAYFINDING AS A FACTOR INFLUENCING USABILITY

To reach a usable wayfinding design, there are multiple requirements, such as building performance, functionality, security and shelter, spatial legibility, privacy and social interaction, learning opportunities, in addition to aesthetic appeal and delightful experiences (Steele, 1973). As Montello and Raubal (2013) claimed, effective environments might be simple to orient in, result in a suitable level of privacy or sociability, appear engaging without being overly complicated, and enhance feeling of safety.

User-centered wayfinding design guarantee a satisfying architectural experience and provide building users with learning, and reaching their goals effectively and efficiently (Krukar, Dalton, & Hölscher, 2016). A usable wayfinding decreases wayfinding process errors and allows for predictability. It is good for supporting the cognitive processes of wayfinders (Arthur & Passini, 1992/2002).

Way-finders use environmental information, guidelines (for example, verbal or visual) and their cognitive and spatial abilities for the purpose of making wayfinding decisions (Montello D. , 2005). These decisions complexity are distinguished by the given environment structure, the tasks and goals of the way-finder in addition to way-finder own characteristics. Thus, taking environmental factors only into consideration is rather limited (Giannopoulos, et al., 2014).

If the way-finder has adequate information about the structure, according to Passini (1992), a complete plan can be generated. Furthermore, only partial planning (or "sub-tasks" in Passini's terminology) can begin postponing local choices until additional information becomes available. Planning requires cognitively retracing the trip and generating mental ideas of what to expect during the way. An essential factor for studying human wayfinding and the cognitive abilities is the direct observation of human behavior (Hölscher, Meilinger, et al., 2004).

3.1 The concept of wayfinding in the usability factors

ISO 9241-11, 1998 defines usability as 'the extent to which a system can be utilized by specific users to achieve specific goals with efficiency, effectiveness, and satisfaction in a specific context of use'. According to the international usability guidelines, Abran et al. (2003) suggested an 'enhanced usability model' in addition to the established aspects of usability included security and learnability as important measures. Krukar et al. (2016) explained how these usability components (cf. Abran et al., 2013; Table1: left) for evaluations can be expressed in terms of measurements for evaluating building usability (Table1: right). For example, (effectiveness) refers to decisions made during wayfinding that were disappointing. (Efficiency), on the other hand, can be measured in terms of how long it takes to navigate your way around while providing a positive user experience is (satisfaction).

Abran's approach combines a variety of previous usability definitions in the field of human-computer interaction. It indicates that usability is a quality of a product (in this case, a building) which makes it easy to use, safe and stress-free to operate. On the most basic level, usability is about avoiding frustrating the user.

Currently, this concept is implemented in software development projects, as opposed to, this goal has rarely been planned for in architectural projects. As a result, out built environment does not lack of annoying, frustrating, confusing, or mentally tiring spaces (Krukar, Dalton, & Hölscher, 2016).

Usability components	Usability evaluation measures	Building Usability – An example for wayfinding design evaluation
Effectiveness	task accomplishment (success or failure)	number of wayfinding errors made at decision points
Efficiency	resources/constraints (type of errors, time spend for task accomplishment, error recovery)	time needed to find a specific destination
Satisfaction	(un)favourable reviews	architectural experience; emotional and aesthetic evaluation; perceived difficulty and frustration
Learnability	time required to learn how to interact with an environment	time needed to become familiar with a building
Security	controllability/predictability of an interaction, error prevention	degree to which an environment addresses the needs of different user groups with different levels of control; (visual) access between locations

Table 1: Usability concepts and examples for building usability in the context of wayfinding (extended descriptions based on Krukar, Dalton & Hölscher, 2016; and Abran et al., 2003).

4 USING HUMAN-COMPUTER INTERACTION (HCI) METHODS AND CONCEPTS IN ARCHITECTURE

Usability has a general definition that includes all user's experience aspects during the interaction with a product, service, or environment. The CIB W111[1] is interested particularly in 'user experience' in a workplace – covering all aspects of the end-users' while interacting with an organization and its facilities as well as the design and management procedures (of the built environment) (Alexander, 2008)

Krukar et al. (2016) mentioned that one of human-artifact interaction types is human-computer interaction. HCL research is distinguished by analyzing human behavior, cognition processes and tasks that users face. Buildings can also be categorized as artifacts which humans interact with in several ways.

4.1 Usability of human-computer interactions and Building usability in psychological-architectural studies

In this field, usability means taking into account the abilities of users so that they interact and navigate easily without challenges (Krug, 2000). Ritter et al. (2014) said that to evaluate how a certain user can perform specific tasks in a specific contexts is the main purpose of the user feedback during the design-centered process. User feedback clarifies some motivations that drive users' actions. It gives an early analysis of decisions, choices, and the users' constraints during the completion of a task. As a result, user feedback facilitates the examination of potential "patterns of usage" in human-environment interaction, helping researchers to better understand why and how users do what they do when they do it (Ritter, Baxter, & Churchill, 2014). Understanding users, their tasks, and the context the interactions occurs in are some of usability important aspects.

According to Blakstad (2008), qualitative and quantitative measures combination in a mixed method approach in relation to building usage observation, standardized questionnaires, building walkthroughs, and spatial studies can improve post-occupancy evaluation benefits. Evaluations on a cross-sectional basis of particular performance analyses are focusing on "diagnostic" post occupancy evaluation (Preiser, 1995), such as wayfinding. As an example, Hölscher et al. (2006) focused on the decision-making process evaluation of the building users during the wayfinding in relation to the specific building characteristics. The reported challenges according to these researchers, were linked to the complexity of the buildings' spatial design, Signage that is difficult to read, and the individual difficulties of wayfinders while monitoring

[1] International Council for Research and Innovation in Building and Construction (CIB), W111 – Usability of Workplaces

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

landmarks. They suggested that integrating basic wayfinding ideas into the architectural design phase process as early as possible can help Architects to avoid pricey design faults (Kuliga, 2016).

5 CASE STUDY: GAMAL ABDEL-NASSER HOSPITAL

Wayfinding is considered as a challenge in healthcare facilities as a result of a variety of factors. Hospitals are large complex buildings, unfamiliar environment that may or may not have taken wayfinding into consideration during the early design phase (Devlin, 2014; Mollerup, 2009). Moreover, as hospitals are repaired and expansions are created, spatial challenges frequently develop and/or worsen (Cheng & P´erez-Kriz, 2014; Mollerup, 2009; Rousek & Hallbeck, 2011).

A hospital visit can be a stressful experience; the majority of visitors are not there by choice and are often feeling the pain, discomfort, and-or anxiety, if they require care for themselves or are visiting a sick or injured person (Berger, 2009; Mollerup, 2009). In order to reduce these feeling of discomfort and improve the user experience. Hospitals must set aside funds to improve and simplify navigation within their facilities. Effective wayfinding system utilization helps visitors to locate their destination effectively whether the navigation is in the emergency department or attending an appointment (Cooper, 2010).

5.1 Applied Methodology

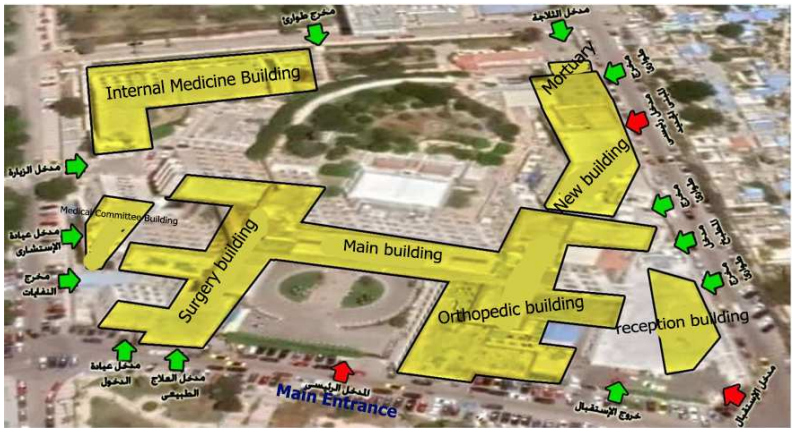


Figure 2: A satellite image of the hospital (source: Engineering authority of the hospital)

This hospital was constructed in 1943. There are 15 entrances. The red and green arrows show the entrances in Figure 2. It was selected for the study because of its complexity of functions, buildings‘ spaces, and number of entrances; another reason was that it has been uilt and designed as a hospital.

Research aimed at applying the usability concept, as derived from the standard ISO 9241/11, in the field of building design, namely hospitals. The study developed an assessment of effectiveness, efficiency and satisfaction of hospitals in Egypt by conducting a questionnaire for Gamal Abdel Nasser hospital‘s visitors with the identification of the reasons for the visit, some of the participants are doctors, pharmacists, engineers, other workers, patients, and accompanying patients. There are detailed answers from users on qualitative and quantitative types of questions. The hospital was visited with hard copies of the questionnaire. Every question helps in identifying one of the five usability aspects. 43 responses were collected. The engineers, pharmacists, patients, their escorts, and other workers werre asked about their experience in the hospital and if they could easily find their way. One question asked them to explain their experience briefly, the received answers were like: changing the familiar places and departments is very confusing and annoying, too many entrances make the experience harder; and they need to put in a clear signage system to guide the users. Another response was that, as a patient, the security men could not explain the way for me, so I got tired, while others got help from the staff so they could reach their destination.

Questions about errors and wayfinding challenges evaluate the effectiveness, while questions about the time users spend to reach their desired destination evaluate the efficiency. To evaluate the satisfaction, I asked users about their feelings towards the experience. While asking about the familiarity, and assessing the learnability, it is clear more for the hospital’s staff. Finally, the security aspect, which is about how a diversity of users can live the experience in the hospital even if they are males or females, they have disabilities or not, they work in the hospital or they are patients or their escorts.

5.2 Results

	No.	%
Q1:Gender		
Male	16	37.2
Female	27	62.8
Q2:What is the reason for your visit to the hospital?		
Patient	4	9.3
Patient escort	17	39.5
I work in the hospital	22	51.2
Q3:If you work in a hospital, what is your job? (n = 22)		
Medical team	11	50.0
Engineering authority	1	4.5
From management	4	18.2
Other - mention it	3	13.6
Nursing team	3	13.6
Q4:Do you face challenges and errors during wayfinding process?		
No- Never	17	39.5
Maybe	3	7.0
Yes sometimes	13	30.2
Yes always	10	23.3
Q5:How long does it take to get to the place you want in the hospital?		
Few minutes	24	55.8
Half an hour	10	23.3
Long time - I arrive very hard	9	20.9
Q6:How do you feel about your experience of visiting the hospital?		
Never satisfied with the experience	6	14.0
Mild feeling	26	60.5
Almost satisfied with the experience	4	9.3
Completely satisfied with the experience	7	16.3
Q7:When visiting the hospital again, do you feel familiar with the place?		
Yes	22	51.2
No	5	11.6
Maybe	16	37.2
Q8: Does having a disability make it difficult for you to find your way?		
I don't have any disabilities	38	88.4
Yes - but my disabilities don't hold me back	3	7.0
Yes - I have a movement disability	2	4.7
Q9:Do signs help you find your way into the hospital?		
Yes	13	30.2
No	9	20.9
Maybe	7	16.3
There are no enough signs in the hospital	14	32.6
Q10:Do you need the help of hospital staff to ask about the way?		
Yes	24	55.8
No	12	27.9
Maybe	7	16.3
Q11:How often do you ask about the road during your experience?		
I do not need to ask	11	25.6
Once	8	18.6
Twice	9	20.9
Three times	6	14.0
More than three times	9	20.9

Table 2: Questionnaire results (Source: Author)

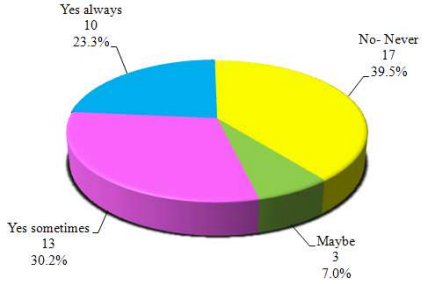


Figure 3: Distribution of the studied samples according to effectiveness Question No.4 about facing challenges

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

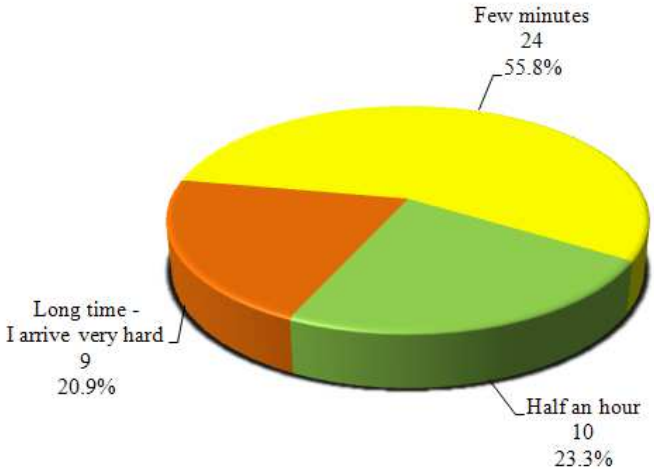


Figure 4: Distribution of the studied samples according to efficiency Question No.5 about the time

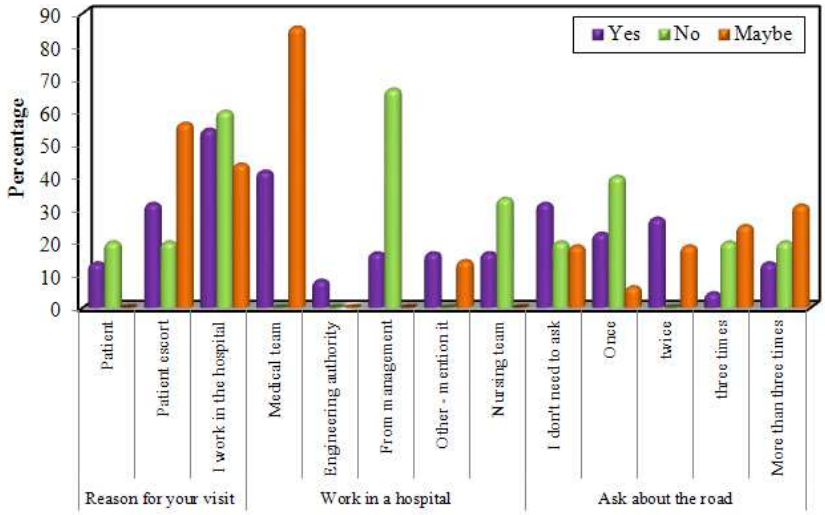


Figure 5: Relation between feeling familiar with the place with different parameters, a relation between Q2, Q3, and Q10 with the Q7

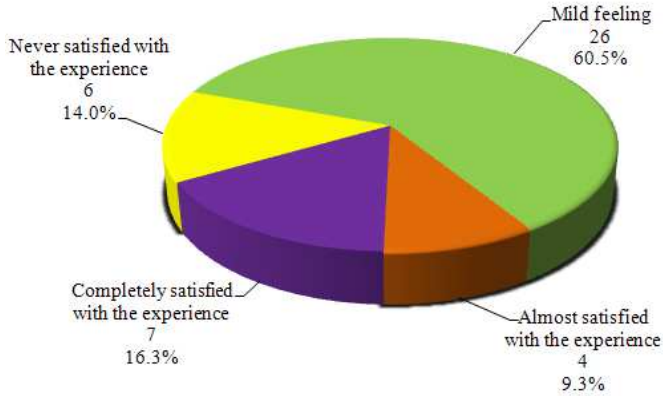


Figure 6: Distribution of the studied samples according to satisfaction Question No.6 about their feelings

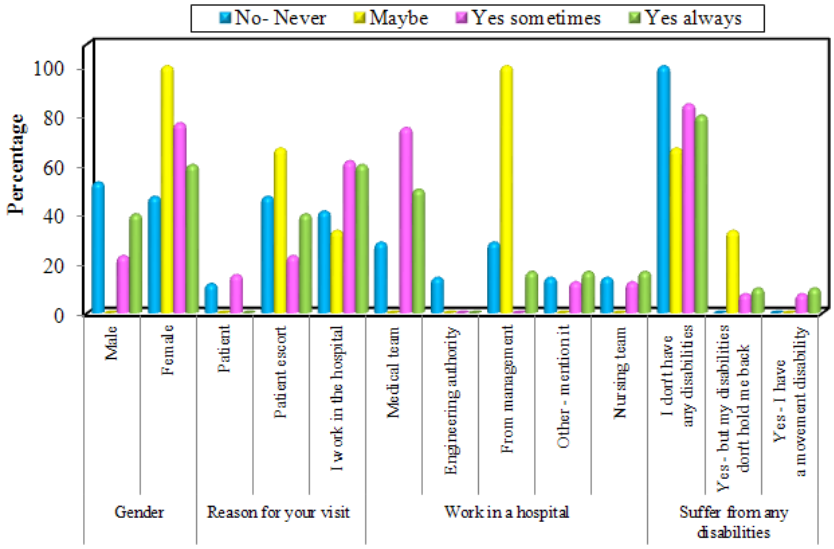


Figure 7: Relation between errors during wayfinding process with different parameters, a relation between Q1, Q2, Q3, and Q8 with Q4

	When visiting the hospital again, do you feel familiar with the place?						
	Yes (n = 22)		No (n = 5)		Maybe (n = 16)		^{MC}p
	No.	%	No.	%	No.	%	
What is the reason for your visit to the hospital?							
Patient	3	13.6	1	20.0	0	0.0	
Patient escort	7	31.8	1	20.0	9	56.3	0.276
I work in the hospital	12	54.5	3	60.0	7	43.8	
If you work in a hospital, what is your job?	(n = 12)		(n = 3)		(n = 7)		
Medical team	5	41.7	0	0.0	6	85.7	
Engineering authority	1	8.3	0	0.0	0	0.0	
From management	2	16.7	2	66.7	0	0.0	0.129
Other - mention it	2	16.7	0	0.0	1	14.3	
Nursing team	2	16.7	1	33.3	0	0.0	
How often do you ask about the road during your trip to the hospital?							
I don't need to ask	7	31.8	1	20.0	3	18.8	
Once	5	22.7	2	40.0	1	6.3	
twice	6	27.3	0	0.0	3	18.8	0.267
three times	1	4.5	1	20.0	4	25.0	
More than three times	3	13.6	1	20.0	5	31.3	

Table 4: Relation between feeling familiar with the place with different parameters (n = 43) explaining figure 5

This table explains the relation in Figure 5 which link question 2, 3 and 10 with question No.7 to evalaute the learnability aspect of usability. It all comes down to being familiar with the design. Of the 43 respondents, 22 confirmed that they are comfortable returning to the hospital. It makes sense that 12 of them, or 54.5 percent, are employed by hospitals. The majority of them work in the medical field. 31.8 percent of users who feel comfortable in the building do not need to inquire about the road during their wayfinding procedure, whereas 27.3 percent do so twice in order to get where they are going.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Even though they visit the hospital every day, some employees can't sense the familiarity, and 16 out of 43 are unsure. Although the medical professionals provided the majority of responses that they felt were familiar, they also provided 85.7% of the responses that were unsure.In other words, comparing the responses of those who say they feel familiar with those who say no or are unsure will produce results that are nearly comparable regardless of the variety of the reasons for their visits or the number of times they must inquire about their route.

	Do you face challenges and errors during wayfinding process?								
	No- Never (n = 17)		**Maybe (n =3)**		**Yes sometimes (n =13)**		**Yes always (n =10)**		**MC p**
	No.	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	
Gender									
Male	9	52.9	0	0.0	3	23.1	4	40.0	0.237
Female	8	47.1	3	100.0	10	76.9	6	60.0	
What is the reason for your visit to the hospital?									
Patient	2	11.8	0	0.0	2	15.4	0	0.0	0.656
Patient escort	8	47.1	2	66.7	3	23.1	4	40.0	
I work in the hospital	7	41.2	1	33.3	8	61.5	6	60.0	
If you work in a hospital, what is your job?	**(n = 7)**		**(n = 1)**		**(n = 8)**		**(n = 6)**		
Medical team	2	28.6	0	0.0	6	75.0	3	50.0	0.616
Engineering authority	1	14.3	0	0.0	0	0.0	0	0.0	
From management	2	28.6	1	100.0	0	0.0	1	16.7	
Other - mention it	1	14.3	0	0.0	1	12.5	1	16.7	
Nursing team	1	14.3	0	0.0	1	12.5	1	16.7	
If you suffer from any disabilities, do you face problems because of them while finding the way?									
I don't have any disabilities	17	100.0	2	66.7	11	84.6	8	80.0	0.157
Yes - but my disabilities don't hold me back	0	0.0	1	33.3	1	7.7	1	10.0	
Yes - I have a movement disability	0	0.0	0	0.0	1	7.7	1	10.0	

Table 5: Relation between errors during wayfinding process with different parameters explaining figure 7

This table explains the relation in Figure 7 which link questions 1, 2, 3, and 8 with question No.4 to evaluate the security as an aspect of evaluating the usability. 17 out of 43 said that they are not facing errors or challenges while navigating in the hospital, while 13 are facing them sometimes and 10 are facing them always, so 23 participants out of 43 are facing errors. Most of them are female. Surprisingly, most of the users who are facing challenges and errors are working in the hospital. They find it difficult to navigate more than patients and their escorts. It is surprising too that most of them are from the medical staff. Maybe that is because they are the most frequent users who are asked to navigate all the time. The majority of the participants do not have any disabilities, but most of them are facing wayfinding challenges, with 17.7% of them having movement disabilities, and said yes always and yes sometimes for facing errors in their destination.

6 NEW TECHNOLOGICAL WAYFINDING TOOLS- FUTURE STUDIES RECOMMENDATIONS

This study evaluated a hospital's wayfinding using a conventional approach. However, there are some new technological tools for wayfinding that can help users or be used to evaluate wayfinding. Any technology

that facilitates wayfinding by providing navigational information or corrective feedback while being in movement to keep the user on course may be referred to as wayfinding technology (WFT)(Hunter et al., 2016).

Some examples of advanced functionality that are available today including, touch-screen displays with voice guidance that personalise information for the user based on preferences, past usage, or social feedback. Smartphone popularity in developed nations has made it possible to gain access to GPS-tracking, realistic, virtual three-dimensional (3-D) street views, and reviews of locations from previous users. The next paragraph explains the VR technology including some examples.

These are mostly absent from the virtual environment in current VR systems, but they also present a potential for confusion because the test environment itself is probably going to include competing sensory cues, including displaced sounds or odours. While abstract or "pseudo-real" "mazes" can be used to identify wayfinding strategies (e.g., Lloyd et al. 2009 compared a simplified version of Birmingham, UK with a video game version of Nice, France), they are inherently constrained by the lack of direct comparison with the same real-world environment.

Figure 8: Comparative images of the Real Environment (RE) left, and Virtual Reality Environment (VRE) right, (source: (Ewart & Johnson, 2021)).

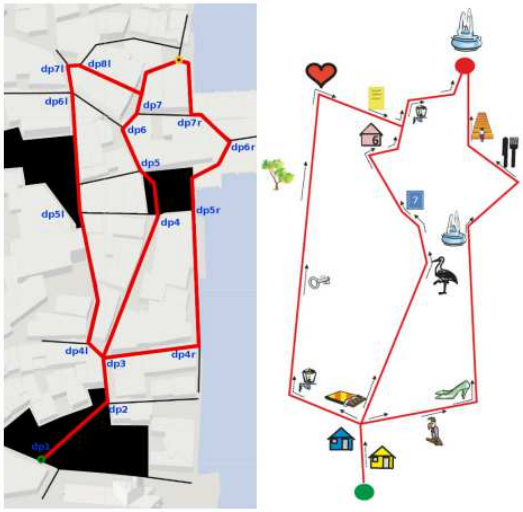


Figure 9: The experiment's region and the three paths' decision points are shown on the left side of the diagram. The participants were given the visual map on the right. (Source: Eds, 2014)

The wayfinding post-occupancy evaluation has included mobile applications. As an instance, consider the experiment that was conducted in Zurich to assess outdoor navigation in a street where cars were not permitted. Participants were handed a printed sheet measuring 28 x 28 cm at the beginning of the exercise that described the task. The map shows three different paths that could be taken to get from the starting point (the green point) to the next objective (red point). In order to get there, it was necessary. The three options for routes to the goal were explained on this abstract map, which also included symbols to denote the environment's landmarks (buildings, signs), which helped with wayfinding (Eds et al., 2014)

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

VR and mobile apps are just examples of the technological wayfinding tools to help users during their journey or to help in wayfinding evaluation.

7 CONCLUSION

One of the aims of building usability is to achieve the satisfaction of users and to meet their needs. As a result, users can consider their experience a successful user experience. This experience relies on other aspects, but in this research, we focused on the wayfinding problems. Taking hospitals as the research case study helped in the determination of the causes of feeling lost in such buildings, which the time factor can make a disaster. That was the main reason for choosing hospitals. Another reason is that people often feel stressed and nervous while visiting hospitals, whether as patients or visitors, which should be taken into consideration. Questionnaire results identified that when there is a lack of a signage system and too many changes in a complex building such as this hospital, that may result in wayfinding errors and people not feeling familiar with the building easily, even if they are part of its staff. People may make errors during their wayfinding, which is a catastrophic situation when you are in a hospital as the minute can cause a difference. The findings indicated that while the efficiency may be high, as half of the participants claimed, the building's effectiveness is not satisfying. Regrettably, they were unable to state they were satisfied with the experience in terms of satisfaction. Learnability and security prove the wayfinding problem in this building and the usability accordingly.

The study establishes a link between wayfinding and usability and demonstrates how to assess it using the five factors of usability, effectiveness, efficiency, satisfaction, learnability, and security. These factors are measured by interviewing users about their experiences with wayfinding. I advise using the latest evaluation tools, such sensors, mobile devices, and virtual reality, to assess existing structures before they are designed. Evaluation can assist in preventing wayfinding issues.or reduce them.

8 REFERENCES

ALEXANDER, k: Usability: philosophy and concepts. The Netherlands: International Council for Research and Innovation in Building and Construction., 2008.

FENKER, M: Towards a theoretical framework for usability of buildings. The Netherlands : International Council for Research and Innovation in Building and Construction , 2008.

MONTELLO, D., & Sas, C: Human Factors of Wayfinding in Navigation.. International Encyclopedia of Ergonomics and Human Factors, 2006.

NENONEN, S., Rasila, H., Junnonen, J.-M., & Kärnä, S.: Customer Journey – a method to investigate user experience. The Netherlands: International Council for Research and Innovation in Building and Construction ., 2008.

ARTHUR, P., & Passini, R: Wayfinding: People, signs, and architecture. Toronto: McGraw-Hill Bertrams., 1992/2002

BLAKSTAD, S., Hansen, G., & Knudsen , Methods and tools for evaluation of usability in buildings. International Council for Research and Innovation in Building and Construction. Netherlands : CIB General Secretariat, 2008

HEGARTY, M., Montello, D., Richardson, A., Ishikawa, T., & Lovelace, K.: Spatial abilities at different scales: Individual differences in aptitude-test performance and spatiallayout learning, Intelligence, pp. 151-176. Vienna, 2006.

KRUG, S: Don't make me think: A common sense approach to web usability. New Riders Publishing, 2000

KRUKAR, J., Dalton, R., & Hölscher, C: Applying HCI Methods and Concepts to Architectural Design (Or Why Architects Could Use HCI Even If They Don't Know It). Springer, 2016.

KULIGA, S. F: Evaluating User Experience and Wayfinding Behaviour in Complex, Architectural Environments – Towards a User-centred Approach of Building Usability, 2016.

MONTELLO, D.: Navigation. In P. Shah, & A. Miyake (Eds.), Handbook of Visuospatial Thinking. Cambridge University Press, pp. 257-294., 2005.

PREISER, W: Post-occupancy evaluation: how to make buildings work better. Facilities, Vol. 13, Issue 11, 1995.

RITTER, F., Baxter, G., & Churchill, E: Foundations for designing user-centered systems,Springer. London, 2014.

STEELE, F: Physical settings and organization development. Addison Wesley, 1973.

🏆 *reviewed paper*

Wetlands Encroachment and the Spatial Resilience of Ecosystems in Peri-Urban Areas: the Case of Budeli, Mutoti and Mphego in Nandoni, Limpopo Province, South Africa

Priscila Chioneso Banda, Trynos Gumbo, Emmaculate Ingwani

(Priscila Chioneso Banda, PhD Candidate Department of Urban and Regional Planning, Faculty of Engineering and the Built Environment, University of Johannesburg, priscbanda@gmail.com)
(Trynos Gumbo, Associate Professor and Head; Department of Urban and Regional Planning, Faculty of Engineering and the Built Environment, University of Johannesburg; tgumbo@uj.ac.za)
(Emmaculate Ingwani, Senior Lecturer; Department of Urban and Regional Planning, Faculty of Science, Engineering and Agriculture, University of Venda, ingwani@gmail.com)

1 ABSTRACT

The study examines the effects of encroachment on wetlands in peri-urban areas on the spatial resilience of peri-urban areas‘ ecosystems. This is against the background that there are continued encroachments on wetlands in peri-urban areas that are resulting in reduced size and quality of wetlands.The consequential effects include disappearance of wetlands creating an imbalance in nature that compromises the resilience of the peri-urban ecosyttems. Informed by the social-ecological systems theoretical framework, the study adopts the post-positivists philosophy and the mixed methods research approach to guide the collection of data. Key informant interviews with purposively selected spatial planners, enviromentalists and traditional leaders were used to collect data. Mapping to establish the extent of how wetlands have been affected by development was also employed. Findings reveal that various activities have affected wetlands in the respective villages severely and these include brickmaking, coversion of wetlands into farmlands and expanding residential development onto wetlands areas.These activities have led to water pollution, erosion of wetland escarpments, natural vegetation loss, reduction in wetland inhabitant species and alteration of wetland sites. Wetland designated sites have dimisinshed showing the impact of these human activities. It is recommended that sustainable practices be adopted that sustain both the community and the enviroment to reduce the impacts of wetland encroachment by human activities coupled with strong partneships by community, local leaders and local authority. Recommndations are that concerned stakeholders should work together and form strong partnerships, an intergrated or inclusive approach in land allocation issues between the local authority and the traditional leaders be adopted and practiced, incorporation of community participatory initiatives that raise awareness on wetlands importance and the extent of how human activities compromise wetland habitat quality such as Imbizo and Mayor Mahosi Forum, continual enforcement by the local authority and local community engagement on the best practices that help sustain the enviroment at the same time that meet their livelihoods.

Keywords: Peri-urban areas, Ecosystems, Spatial resilience, Encroachment, Wetlands

2 INTRODUCTION

Wetlands encroachment discourse and its effects on peri-urban fringes ecosystems characterized by extreme development has gained impetus among researchers during the last decade and needs immediate attention as its neglect may consequently lead to wetlands drying up completely leading to increase in global warming (Newton et al., 2020). McHale et al. (2013) affirms that urbanization processes in the developing world shows that projections of urbanization in Africa grossly overestimate rural to urban migration and therefore confound the true definition of urbanization. Studies have shown that permanent urban migration is decreasing; not increasing in Africa (Ferguson, 2007 & Potts, 2009) and growth in established cities is a function of higher than normal birth rates in urban areas. Angel et al (2011) projection of a 12 fold increase in urban area in sub-Saharian Africa, show that the increase in urban land area will actually be due to the reclassification of rural areas as urban areas resulting from an ever-increasing rural population. Literally, rural is the new urban. Not only is the urban or rural dichotomy inadequate for addressing the needs of the growing populations in Africa, but the rural migration occurring on the continent is overwhelmingly toward smaller cities and towns (Simon et al. 2004; Collinson et al. 2007). Peri-urban areas that is, the landscape interface between the city and rural areas is no exception to population boom dynamics exacerbated by livelihood deficient copying mechanisms (International Management Water Institute, 2018). They are considered as the transition area where activities have links with the city and exchange of products that takes place. Due to this, they are facing increasing demand of land to accommodate various development activities whose short term and long term produces detrimental effects to the surrounding ecosystem. Therefore, the

paper focuses on wetland encroachment and spatial resilience of ecosystems in peri urban areas, the case of Budeli, Mutoti and Mphego in Nandoni, Limpopo Province in South Africa. The paper starts by giving a brief introduction followed by conceptual synopsis, theoretical framework, materials and methods, results presentations and discussion and ends with the conclusion and recommendations.

3 CONCEPTUAL SYNOPSIS

Despite providing vital services, wetlands are declining at alarming rates faster than any other ecosystems (Millennium Ecosystem Assessment, 2005). Half of the world's wetlands have been lost since the beginning of the twentieth century (Davidson, 2014) and more than 60% of the remaining wetland ecosystems were being degraded or used unsustainably. As cities are increasingly challenged by rapid urbanization, population growth and the impacts of land degradation and climate change, they need to find adequate solutions for sustainable city development. As most of this development takes place in the riverside and coastal areas, the rapid loss of valuable wetland ecosystems makes our cities increasingly vulnerable to extreme weather events and climate change (Wetland International, 2019).

Wetland ecosystems are critical in making cities and towns livable through ecosystems services benefits to the people. These include provisioning services such as food, water; regulating services such as flood and disease control; cultural services such as spiritual, recreational and aesthetic benefits; and supporting services such as nutrient cycling, critical in, for example agricultural production. The vast range of ecosystem services provided by wetlands also includes the provision of water security to millions of people in rapidly growing towns and cities. Wetlands provide an essential role to the environment and natural resources through ecological, economical, socio-cultural, scientific and recreational services to the nation. Warning signals from recent international environmental reports are prompting countries and non-governmental organizations around the globe to search for ways to reorganize human activities, mitigate their ecological impacts, and reduce subsequent harmful consequences for human well-being. These developments, including both climate change and biodiversity loss, are linked to the deterioration of wetlands. African wetlands include, arguably, some of the most biologically productive systems on earth. In some instances rural economies are entirely dependent on the flow of ecosystem services that provide food, water, energy, building material, medicine, seasonal grazing and transportation. In addition, some of these wetlands are the mainstay of lucrative tourism industries that generate numerous jobs. Relative to more developed regions Africa has a high proportion of wetlands that might be considered in fairly good ecological condition. However, impacts on many are significant and pressure is increasing.

The study also focuses on the concept of ecological resilience that presumes the existence of multiple stability domains and the tolerance of the system to perturbations that facilitate transitions among stable states. Ecological resilience is defined by the magnitude of disturbance that a system can absorb before it changes stable states. Nandoni's peri-urban villages in Limpopo such as Budeli, Mutoti and Mphego have been facing similar challenges that are rapidly expanding economy and booming population, the choice between conservation of wetlands for future generations and landuse development for various uses such as residential, industrial and commercial become a difficult one. Wetland quality in the area is undergoing serious alteration or disturbance through encroachment. This is in many forms from specific village to village depending on its economic, social, environmental and political set up. The northern bank of Nandoni dam with villages Budeli, Mutoti and Mphego have the most dense vegetation and rich in species diversity. Wetland in these villages consists of riverine bushes that are being affected by overdrawing of water from them for different uses coupled with cultivation among other activities. The study sought to examine the effects of encroachment on wetlands on peri-urban areas (villages) on the spatial resilience of peri–urban areas ecosystems. These effects affect the size, character, habitat quality of these wetlands which consequently have a bearing on the spatial resilience of the surrounding ecosystems of the selected peri urban villages. National or local area policy on conservation of these wetlands in the area of Nandoni will also be investigated so as to see the missing piece of what exists in policy versus the status quo which is a continual violation through encroachment of development in these sensitive areas despite what policy has stipulated and enforced.

4 THEORETICAL FRAMEWORK

The study made use of the social-ecological systems theory. The overall drive for its adoption will make research findings more meaningful, acceptable to the theoretical constructs. The Social-Ecological Systems theory (SES) model provides a holistic perspective for examining wetlands ecosystems, the nature of their importance and what actions people can or should take in the interest of protecting the ecosystem services people enjoy from healthy, functioning wetlands wherever they are located. The theory recognises the many interrelationships and interdependencies between wetland ecosystems and people and calls for a balanced and pragmatic approach to halting and reversing the widespread loss and degradation of wetlands. It acknowledges the need to directly address tradeoffs between wetland conservation and human development needs, while ensuring ecological integrity. The SES perspective highlights the interdependencies of the coupled human and natural systems.

Change in both social and ecological systems is influenced by mitigating or amplifying feedbacks within and between these systems. Change is often uneven, with periods of relative stability pointed out by sudden change and shifts past tipping points, beyond which recovery to the earlier state is unlikely in the near term (Liu et al. 2007). The description of "human and natural systems" as coupled is an analytical distinction; humans are an indivisible part of the natural system. Human survival is utterly dependent on the benefits provided by ecosystems. Those ecosystem services are important because they provide food, water, shelter and other resources that constitute our life support system. Human activities involved in utilising these benefits have both deliberate and unintentional impacts on those very services. Ecosystems are steered by physical and biological processes; human activities are steered by individual and collective choices, although within natural constraints. On a societal level, these choices are in the form of public policy or governance structures that affect the resilience of social ecological systems. A key contributor to better ecosystem management is to develop effective governance structures that are aligned to both social and ecological factors of importance and explicit evaluation of what constitutes effective governance structures is required (Cumming et al. 2006; Guerrero et al. 2015). The challenge of reversing this rapid degradation of ecosystems while meeting increasing demands for ecosystem services will involve significant changes in policies, institutions and practices. Adaptive capacity and reorganisation play a pivotal role in the Social Ecological Systems theory as it represents the degree to which the ecosystem adapts to a disturbance in the form of human activities and reorganises or realigns itself to a stable condition or state.

In light of the study of wetland encroachment in Nandoni peri-urban villages and spatial resilience of surrounding ecosystems, the Social Ecological Systems theory is relevant in that the case study concerned involves human activities on wetlands ecosystems in peri urban villages that are causing an imbalance in the form of negative effects. Governance in the form of policy is challenged that is resulting in the gap that exists between wetland conservation policy enforcement measures versus the status quo that is a direct violation. The study involves a contestation of policy and human practices on the planning field and consequently striking a balance between ecosystem conservation and meeting the demand for ecosystem services by the local residents in Nandoni that allows the ecosystems to quickly bounce back and realigning itself.

5 STUDY AREA

The study focuses on Limpopo province South Africa, specifically Nandoni area along the Luvuvhu River. The study area is Nandoni dam (22◦5604500 S and 30◦2000700 E), whose construction was from 1998 to 2005. Nandoni dam falls under Ward 18 and 19 of Collins Chabane Local Municipality and Wards 19, 20, 26, 36, and 41 of Thulamela Local Municipality in the Vhembe District Municipality in Limpopo Province of South Africa (Figure 1).

Thulamela municipality area covers vast track of lands mainly tribal and Thohoyandou as its political, administrative and commercial centre. In terms of population it is the second largest of all the municipalities in Limpopo Province. The political leadership of the municipality is vested in the Municipal Council comprising of 81 Councillors of whom 41 are Ward or directly elected Councillors, 40 Proportional Representative (PR), representing political parties. Additional members of Council are 7 Senior Traditional Leaders or their representatives who sit on the Council as Ex-Officio representing the traditional systems of governance.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

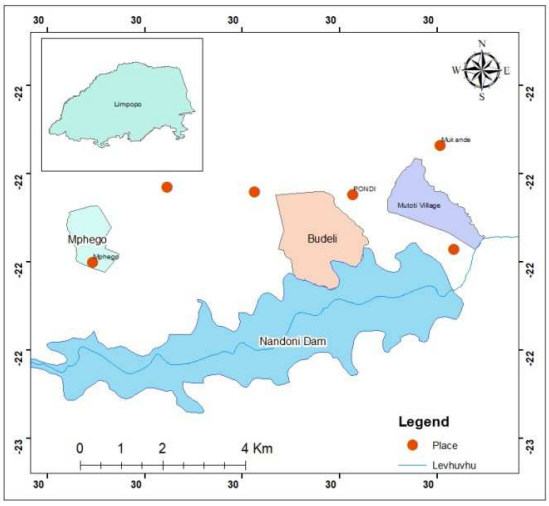


Figure 1: Map showing Nandoni Dam, Budeli, Mutoti and Mphego villages

The Nandoni Dam in terms of construction was premised by the desire of authorities to upgrade water resource management. This was paired with the wish to improve economic development through water-based recreation and tourism, a resource that had not yet been exploited in the region (Department of Water Affairs and Forestry, 2003). In other words, expectations were built amongst local communities that economic development would result from recreational utilization of the dam. It was anticipated that water-related recreation and ecotourism development in the study area would not only create employment for local communities but also improve their lives and livelihoods. In addition, the dam was also expected to act as a catalyst for new developments and initiatives in the area in poverty alleviation.

6 RESEARCH METHODOLOGY

6.1 Research design

The research paper employed the case study phenomelogical design which captures experiences of residents residing in three peri-urban villages namely, Budeli, Mutoti and Mphego in terms of engagement of wetland encroachment activities that are resulting in adverse effects. Experiences are wetland use over three spatially configured peri-urban villages.

6.2 Research approach

The paper adopted the mixed methods research approach where qualitative and quantitative are integrated to provide a more complete understanding of a research problem (Cresswell, 2018). Mixed methods research design infuses qualitative data that tend to be open-ended without predetermined responses and quantitative data that includes closed-ended responses. Mixed methods was ideal for the study on wetland encroachment and the spatial resilience of ecosystems in peri-urban areas in Nandoni, Limpopo like Budeli, Mutoti and Mphego as it integrates the qualitative and quantitative data into one database that aids in checking the validity of each database over the other. Qualitative and quantitative data identified as databases could help complement each other for example through the coupling of explanatory aspect with exploration aspect concerning the given objective, well suit research instruments in line with the given sample or population, the building of one database on other databases or alternate one database with another database back and forth during a research study.

6.3 Sampling design

The study made use of non-probability sampling that is purposive sampling to select the key informants such as spatial planners, environmentalists and chiefs using the researcher's judgment to determine the sample. Purposive sampling was used in the selection of key informants and wetland sites. The study considered eight (8) key informants consisting of four spatial planners from the Department of spatial planning, one environmentalist from the Department of Environment at Thulamela municipality and three traditional leaders from Budeli, Mutoti and Mphego villages.

6.4 Data collection instruments

The study both used primary data and secondary data sources that is, key informant interviews for spatial planners, environmentalists and traditional leaders and mapping through QGIS through Landsat satellite images. The type of data to be collected will be on wetland type, quality, size, characteristics, spatial configuration, degree of encroachment and resilience of surrounding ecosystem. Secondary data will also be used to gather data that is, documentation, archival records and internet sources.

6.5 Data analysis

The responses from key informant interviews were analysed using themes. The thematic analysis focused on nature of encroachment activities in the peri-urban villages of Nandoni, causes of wetland encroachment, effects of activities conducted on wetlands by local community villagers, extent of encroachment, policy strategies that can be employed so as to mitigate the effects of wetlands encroachment and implications on spatial resilience on ecosystems in peri-urban areas. Mapping was used in data collection as a compliment to key informant interviews ensuring data reliability and validity. Changes were mapped from 1996 after the new constitution for successive 10 year periods that is from 1996, 2006 and 2016 to 2022 to show the extent of change of wetland encroachment by development activities occurring in these peri-urban villages in Nandoni, Limpopo.

7 RESULTS PRESENTATIONS AND DISCUSSION

This section presents findings on nature of encroachment activities in the peri-urban villages of Nandoni, causes of wetland encroachment, effects of activities conducted on wetlands by local community, nature and extent of encroachment, policy strategies that can be employed so as to mitigate the effects of wetland encroachment and implications on spatial resilience on ecosystems in peri-urban areas. The research used Google earth engine (GEE) in classification and interpretation of images and key informant interviews to complement each other in data collection. GEE is a cloud based system which is capable of handling large petabytes of spatial data varying from vector to raster datasets (Noi Phan et al., 2020). GEE was preferred for classification than any other softwares because of its ability to do the whole process of image analysis and classification in cloud and then allows downloading of the images at last stage for map layout creation (Noi Phan et al., 2020). This means with GEE, you save a lot of space than rather download satellite images from earth explorer and then begin to preprocess them. Hence GEE is faster and efficient. Moreso, GEE provides level 2 and Top of the Atmosphere reflectance images, these are images which would have already gone through the process of preprocessing stages and are ready for use (Teluguntla et al., 2018). In this study Landsat satellite images with the inclusive of landsat 5 and 8 to cater for different years was used. Within the GEE environment, machine learning algorithm was chosen in a line of code and was applied to all the images for classification. In this case smileRandomForest algorithm was used due to its robustness compared to other classifiers. This algorithm then predicted or model the whole image based on the training samples provided. Classified images were exported to google drive where they were downloaded for use in ArcGIS for map layout creation.

7.1 Nature and extent of encroachment activities in the peri-urban villages of Nandoni

1. Recreational

Data collected from key informant interview responses and mapping revealed that there are recreational activities taking place on wetlands in Budeli and Mutoti villages. It was further reported that some of the wetlands consisting of recreational activities are privately owned by influential businessmen in Thohoyandou. Wetlands sites in these villages attract tourists as well as recreational events such as Flower garden festivals, wedding and corporate events that are inspired by the wetlands surrounding nature in the form of vegetation and inhabitant species.

2. Fishing

Key findings divulged that the community villagers' in Budeli and Mutoti engage in fishing activities from wetlands. They rely on acquatic life such as fish as a source of food. This is being practiced on wetland banks.

3 Retrieval of medicinal plants

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Findings reveal that in Mutoti wetland vegetation is mainly used as a source of medicinal plants by traditional herbalists as well as the local community villagers. The collection of wetland medicinal plants is used in conjuction with worship activities around the wetland area. This reveals that wetlands in this case are providing a joint function of provisioning and cultural ecosystem services.

4. Grazing of wetland pastures

Findings revealed that in Budeli there is overgrazing of wetland pastures by local community livestock such as cattle. This was sighted as leading to the deterioration of wetland vegetation quality and it is being practiced intensively.

5. Residential development

Data collected from key informants' responses and mapping revealed that Budeli, Mutoti and Mphego community have benefited through residential development that has encroached wetland sites. In Budeli some of the residential development has seen encroachment beyond the floodline. The residential development encroachments are deemed illegal by the local authority and the Traditional leaders are responsible of land allocation as far as rural or peri urban land is concerned. Through landuse landcover changes of the three per urban villages it can be seen that residential encroachment in the form of built up area has increased from 1996 up to 2022.

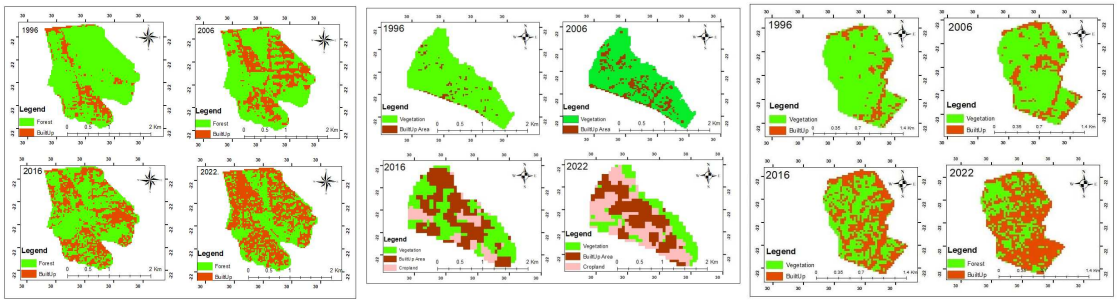


Figure 2: Landuse landcover changes for Budeli, Mutoti and Mphego in relation to residential development encroachment

Figure 2 shows land use land cover change maps for Budeli, Mutoti and Mphego and Table 1, Table 2 and Table 3 shows Land use land cover changes for Budeli, Mutoti and Mphego villages from 1996, 2006, 2016 and 2022.

1996			2006		
Class	Area	Percentage	Class	Area	Percentage
Forest	289	86.0119	Forest	230	68.4524
Built up	47	13.9881	Built up	106	31.5476
	336	100		336	100
2016			2022		
Class	Area	Percentage	Class	Area	Percentage
Forest	148	44.0476	Forest	129	38.3929
Built up	188	55.9524	Built up	207	61.6071
	336	100		336	100

Table 1: Landuse landcover changes for Budeli village from 1996, 2006, 2016 and 2022

1996			2006		
Class	Area	Percentage	Class	Area	Percentage
Forest	193	4.4554	Forest	170	15.8416
Built up	9	95.5446	Built up	32	84.1584
	202	100		202	100
2016			2022		
Class	Area	Percentage	Class	Area	Percentage
Forest	67	33.1683	Forest	60	29.7030
Built up	38	18.8119	Built up	100	49.5050
Crop	97	48.0198	Crop	42	20.7921
	202	100		202	100

Table 2: Landuse landcover changes for Mutoti village from 1996, 2006, 2016 and 2022

Table 1 illustrates how the land use and land cover changes have changed throughout successive 10 year periods from 1996 as the base year in Budeli village. Initially from 1996, forest land use gradually decreased from 1996, 2006, 2016 up to 2022. This gradual decrease is evidenced by the total area percentage from 86.0119%, 68.4524%, 44.0476% and 38.3929% respectively. In contrast to built up area which has

experienced a sharp increase from 13.9881%, 31.5478%, 55.9524% and 61.6071% respectively. This is evidence that forest area has been surpassed by development in the form of built up area. This is clear evidence that in Budeli, residential development is increasing at the expense of the natural vegetation ecosystem. If this remains unchecked may lead to disappearance of wetlands.

1996			2006		
Class	Area	Percentage	Class	Area	Percentage
Forest	108	85.71429	Forest	97	76.98413
Built up	18	14.28571	Built up	29	23.01587
	126	100		126	100
2016			2022		
Class	Area	Percentage	Class	Area	Percentage
Forest	65	51.5873	Forest	59	46.8254
Built up	61	48.4127	Built up	67	53.1746
	126	100		126	100

Table 3: Landuse landcover changes for Mphego village from 1996, 2006, 2016 and 2022

For Mutoti, illustration in Table 2 shows that built up area remained higher than forest area from 1996, 2006 and 2022 at 95.5446%, 84.1584% and 49.5050% respectively. In 2016 a new landuse area component emerged (crop) and coupled with the built up area in terms of percentage it was higher than forest area from 2016 up 2022 by a cumulative total of 66.8317% and 70.2971%. For Mphego, illustration in Table 3 showed forest landuse area having a sustained decrease from 1996, 2006, 2016 up to 2022 from 85.71429%, 76.98413% and 51.5873% up to 46.8254% for the respective years. In contrast there is a steady increase of Built up area from 1996, 2006, 2016 and 2022 from 14.28571%, 23.01587%, 48.4127% and 53.1746% respectively. The findings from the 3 villages reveal that there has been an increase in human activities with specific reference to residential development that has resulted in the alteration of the existing landscape to a new one that suits the population needs.

6. Brick molding

Findings revealed that Mphego village is witnessing a unique activity of brick-making that is benefiting that local community at the same time that is resulting in wetland encroachment within that area. Key informants highlighted that brick-making is regarded a mining activity hence deemed illegal by Thulamela local municipality. Brick making is conducted and it involves digging up of soil that is used to manufacture bricks. Water in wetland used also in brick molding.

7. Farming

Data collected from findings disclosed that in Mutoti farming activities in addition to residential development has also been an activity that is leading to wetland encroachment. This process has seen the conversion of wetland area or pastures being cleared for farming of different crops that the villagers rely on as food. The emergence of crop land can be seen in Figure 3 Landuse landcover change maps from 2016 up to 2022.This shows human intervention to the natural environment.

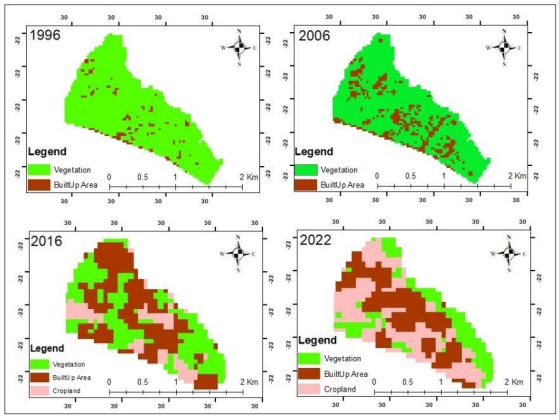


Figure 3: Landuse landcover changes for Mutoti village for 1996, 2006, 2016 and 2022.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

7.2 Causes of wetland encroachment

1. Poverty

Findings reveal that poverty is resulting in wetland encroachment as villagers are engaging in activities close to wetlands to augment their livelihood. Data collected through interviews with key informants indicate that the majority of people that reside in Budeli. Mutoti and Mphego are unemployed and have no decent sources of income, a situation that makes them poor. To earn a living, the residents turn to the environment for livelihood activities as an adaptive measure that include brick making, carpet weaving and farming. These activities sustain them but have serious effects to the environment. These activities are carried out on wetlands because of the availability of the natural resources found on wetlands such as water, soil and reed vegetation

2. Population expansion–new household formation

Findings from data collected from key sources of the study disclosed that population expansion which has led to new household formation is also a contributing factor on the cause of wetland encroachment. Historical background on the relocation of the affected households when Nandoni dam was built from 1998 to 2005 resulted in people being settled in the villages close to Nandoni dam as a proactive response. In the Nandoni land compensation case, there was no land readily available that would offer as alternative land and post the land resettlement and compensation population has increased in the peri-urban villages namely Budeli, Mutoti and Mphego. As a resulted it has created inequalities that have affected the quality of life of the locals and as a copying mechanism (wetland encroachment) to take advantage of the natural resources found within them. This comes from the background that wetlands are naturally existing, free, not owned by anyone and anyone within the village can access them for their own benefit without facing any confrontation.

3. Poor planning

Poor planning in terms of land resettlement when the Nandoni dam was built was also a finding on the cause of wetland encroachment. Key informant data collected from interviews noted that people were not supposed to be resettled close to Nandoni dam in the first place as this place is characterized by wetlands. There was need for a proper resettlement plan that would leave the area near Nandoni dam characterized by wetlands left in its natural state without any development. They also noted that because of the shortsightedness of the planning and resettlement, post the land resettlement and compensation population has increased in villages such as Budeli, Mutoti and Mphego hence it has created inequalities that have an effect in the quality of life of the locals hence as copying mechanisms wetland encroachment to take advantage of the natural resources found within them as the only way out.

4. Weak enforcement coupled with greed

Findings also revealed that weak enforcement by the local authority is also a cause of continued wetland encroachment. Data collected from key informants showed that the issue of land ownership coupled with land tenure systems that facilitates easy and cheap land transactions has increased the level of wetland encroachment in the selected villages. Traditional leaders have the mandate when it comes to rural land allocation hence the local authority have no say and hence come in to manage on what has been deliberated and end up the enemies. In the case of Mphego that involves brick-making which is a mining activity by law, the local authority issues out notices but after the third notice the issue goes into litigation and since the local authority does not have power in land allocation they lose the case and it becomes a continuous dead end cycle.

5. Lack of education on the benefits of wetlands to the environment

Lack of education or awareness about the benefits of wetlands to the environment is another identified cause of wetland encroachment according to findings by key informant. They noted that the local residents should be continuously educated on the benefits of the natural environment in contrast to development activities that lead to environmental deterioration. Key informants interviewed strongly agreed that being equipped with adequate knowledge would lead to a change in mindset that seeks to balance competing claims of livelihood demands versus the sustained use of natural resources.

7.3 Effects of activities conducted on wetlands by local community villagers

1. Alteration of size and quality wetland sites

Findings from data collected from key informants and mapping through landuse landcover changes reveal that activities carried on wetlands by the local community have detrimental effects to the surrounding ecosystems in that they are compromising the size and quality of these sensitive landscapes. Brick making in Mphego village was also noted as having consequential effects both to the surrounding ecosystem as well as the wetland itself. Effects include water pollution which affects the water quality, dredging out of soil from wetland bodies as well as escarpments leading to land wetland escarpment degradation and destruction of natural vegetation in the process of soil extraction for brick making which affects the ecosystem balance in terms of wetland vegetation inhabitant species as their food web will be disrupted. Findings from data collected also disclosed that Budeli and Mutoti is experiencing dumping of solid waste in some of its wetland bodies which affects the water quality, aquatic life and the aesthetic quality.

2. Conversion of wetland sites to other uses

Alteration of wetland sites through conversion of wetland sites to other uses such as farm land and consequently disappearance was pointed out as another effect of activities conducted on wetlands by local community villagers. Farming as a human activity in Mphego was also highlighted as leading to the conversion of some seasonal inland wetlands to agricultural land leading to the disappearance or drying up of wetlands. It has led to the introduction of new land species that may not harmoniously co-exist with natural wetland vegetation as a result it has resulted in the introduction of some invasive species in the process. The use of fertilizers in the aforementioned has affected the mineral composition of the wetland soil which affects the type of vegetation and how it copes in the new soil environment.

They also noted that in Budeli and Mutoti, land clearing to accommodate recreational facilities have destroyed the natural vegetation and some of the people that visit those areas for tourism purposes dump solid waste such as plastic and metal which may not be biodegradable hence affect the aesthetic beauty of some of these wetlands and harming or interfering with the acquatic life of these wetland systems. Grazing of livestock is another human activity that has led to instances of overgrazing hence affecting the natural vegetation state. Turnaround time for vegetation growth takes long periods of time and this affects the ecosystem in that other wetland organisms that rely on that vegetation for survival will be affected through extinction.

3. Land tenure system

Key findings revealed that land tenure system that allows for cheaper and easy land transactions in Budeli and Mutoti has seen illegal residential development that leads to the destruction and ultimate disappearance of wetlands through the use of impervious building material that prevent water seepage to their foundational structures as well as properties. They also added that some of the development taking place for residential or commercial is not following proper environmental impact assessment procedures; hence these developmental projects have more costs than benefits to the surrounding ecosystem.

7.4 Policy strategies that can be employed so as to mitigate the effects of wetlands encroachment

1. Integrated effort in stakeholder participation in land management in peri-urban villages

Findings from data sources used in the study revealed that there should be an integrated or joint effort in terms of stakeholder participation in land management in peri-urban villages of Nandoni such as Budeli, Mutoti and Mphego. Traditional leaders should work closely with the local authority land custodians such as spatial planners and environmentalists. This concerted effort would be backed up by the Spatial Planning and Landuse Management Act (SPLUMA), Landuse scheme, Spatial Development Framework (SDF), and the Integrated Development Plan (IDP) and avoid illegal land parceling on sensitive ecosystems such as wetlands whose activities that will in turn result in adverse effects that are a threat to the surrounding ecosystem.

2. Legally acceptable enforcement system

Findings revealed that legally accepted enforcement system would avoid bottleneck in enforcement of illegal wetland encroachment activities such as brick making for example which is a mining activity by law and requires certain environmental procedures that are compliant with environmental law. In the case of dispute resolution between the local authority and non compliant wetland encroachers (brick makers) in Mphego village for example regarding notice issuance for non compliance to those engaged in brick-making activities and who have violated the law in terms of an absence of a mining license. The existing litigation process was

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

seen to reach a dead end on the issuance of the 3rd notice that does not place value on the local authority's voice when it comes to law in the form of enforcement which results in the local authority losing the case.

3. Participatory forums at village level

Findings from data collected suggests that local community should engage in different participatory forums through their local traditional headsmen such as the Mayor Mahosi forum and Imbizo that preserve conservation of the environment inclusive of sensitive landscapes such as wetlands.

Implications on spatial resilience on ecosystems in peri urban areas

The findings of the study suggest that wetland encroachment on surrounding wetland ecosystems being affected to a greater extent due to various activities such as residential development, farming, brick-making and overgrazing. The spatial resilience of these surrounding wetland ecosystems is being affected adversely by the effects of encroachment activities. These activities are greatly resulting in the conversion of wetland ecosystem into new uses that lead to alteration and consequence disappearance of wetland as it is being practiced at an extensive level in the case of residential development and cropland or farmland. As wetlands are major carbon stores on the earth, their disturbance may release greenhouse gases that contribute the most to global warming. In terms of stakeholder participation, findings suggests a concerted effort between the local authority and the traditional leaders in land management so as to avoid illegal land allocations that result in the disturbance of wetland surrounding ecosystem

8 CONCLUSION AND RECOMMENDATIONS

This study concludes that encroachment of wetlands by various human activities in per urban areas is real and the spatial resilience of surrounding ecosystems is being affected greatly. Land management is an important factor in peri-urban wetland encroachment as it regulates the types of activities that are to occupy certain parcels of land and some that are sensitive such as wetlands. Recommendations made in this study are that:

- Concerted partnership is established between planners, environmentalists, traditional leaders in land allocation issues as each and every party involved works towards the preservation of the natural landscape in the form of proper planning, law enforcement and environmental feasibility.
- Direct engagement with the community in the concerted partnership set up as the community is the end user and need to be made aware of various developmental activities and their effects to the surrounding ecosystem.
- Sustainable practices be adopted that sustain both the community and the environment to reduce the impacts of wetland encroachment by human activities coupled with strong partnerships by community, local leaders and local authority.
- An inclusive approach in land allocation issues between the local authority and the traditional leaders be adopted and practiced.
- Incorporation of community participatory initiatives that raise awareness on wetlands importance and the extent of how human activities compromise wetland habitat quality such as Imbizo and Mayor Mahosi Forum.
- Continual enforcement by the local authority.
- Local community engagements on the best practices that help sustain the environment at the same time that meets their livelihoods.

9 REFERENCES

An, S., & Verhoeven, J. T. (2019). Wetland functions and ecosystem services: Implications for wetland restoration and wise use. In Wetlands: Ecosystem Services, Restoration and Wise Use (pp. 1-10). Springer, Cham.

Angel, S., Parent, J., Civco, D. L., Blei, A., & Potere, D. (2011). The dimensions of global urban expansion: Estimates and projections for all countries, 2000–2050. Progress in Planning, 75(2), 53-107.

Assessment, M. E. (2005). Ecosystems and human well-being: wetlands and water. World Resources Institute.

Collinson, M. A., Tollman, S. M., & Kahn, K. (2007). Migration, settlement change and health in post-apartheid South Africa: Triangulating health and demographic surveillance with national census data1. Scandinavian journal of public health, 35(69_suppl), 77-84.

Council, A. (2021). Conservation of Arctic Flora and Fauna (CAFF),". CAFF," available at arctic-council. Org/working group/caff.

Cumming, G. S., D. H. M. Cumming, and C. L. Redman. 2006. Scale mismatches in social–ecological systems: causes, consequences, and solutions. Ecology and Society 11(1):14. http:// dx.doi.org/10.5751/ES-01569-110114
Davidson, N. C. (2014). How much wetland has the world lost? Long-term and recent trends in global wetland area. Marine and Freshwater Research, 65(10), 934-941.
Ferguson, J. (2007). Formalities of poverty: Thinking about social assistance in neoliberal South Africa. African Studies Review, 50(2), 71-86.
Guerrero, A., Ö. Bodin, R. McAllister, and K. Wilson. 2015a. Achieving social–ecological fit through bottom-up collaborative governance: an empirical investigation. Ecology and Society 20 (4):41. http://dx.doi.org/https://doi.org/10.5751/ES-08035-200441
Gunderson, L. H. (2000). Ecological resilience--in theory and application. Annual review of ecology and systematics, 425-439.
Gunderson, L. H. 1994. Vegetation: determinants of composition. Pages 323-340 in S. M. Davis and J. C. Ogden, editors. Everglades: the ecosystem and its restoration. St. Lucie Press, Delray Beach, Florida, USA.
Gunderson, L. H., and C. S. Holling. 2002. Panarchy: understanding transformations in human and natural systems. Island Press, Washington, D.C., USA.
Holling, C. S., and G. K. Meffe. 1996. Command and control and the pathology of natural resource management. Conservation Biology 10:328-337.
Liu, W., Fedorov, A., & Sévellec, F. (2019). The mechanisms of the Atlantic Meridional Overturning Circulation slowdown induced by Arctic sea ice decline. Journal of Climate, 32, 977–996.
Mulugisi, A.M. 2015: The impact of rains on the vegetation covers in the Limpopo province of South Africa. Msc. Dissertation. North-West University: Mafikeng Campus.
Newton, A., Icely, J., Cristina, S., Perillo, G.M., Turner, R.E., Ashan, D., & Kuenzer, C. (2020). Anthropogenic, direct pressures on coastal wetlands, Font. Journal of Ecology, 8, 144–165.
Phan, T. N., Kuch, V., & Lehnert, L. W. (2020). Land Cover Classification using Google Earth Engine and Random Forest Classifier—The Role of Image Composition. Remote Sensing, 12(15), 2411.
Potts, D. (2009). The slowing of sub-Saharan Africa's urbanization: evidence and implications for urban livelihoods. Environment and Urbanization, 21(1), 253-259.
Teluguntla, P., Thenkabail, P. S., Oliphant, A., Xiong, J., Gumma, M. K., Congalton, R. G., ... & Huete, A. (2018). A 30-m landsat-derived cropland extent product of Australia and China using random forest machine learning algorithm on Google Earth Engine cloud computing platform. ISPRS Journal of Photogrammetry and Remote Sensing, 144, 325-340.
Tilman, D., Reich, P. B., & Knops, J. M. (2006). Biodiversity and ecosystem stability in a decade-long grassland experiment. Nature, 441(7093), 629-632.
Walker, B. H., C. S. Holling, S. R. Carpenter, and A. Kinzig. 2004. Resilience, adaptability and transformability in social–ecological systems. Ecology and Society 9(2):5. [online] URL: http://www.ecologyandsociety.org/vol9/iss2/art5/
Rockefeller Foundation. [Financial Statements December 31, 2020]. Retrieved 2022-07-05.
Peter N (2004) “Options for Floods and Drought Preparedness in Bangladesh”,Proceedings of the Second International Conference on Post-disaster reconstruction: Planning for Reconstruction, 22-23 April 2004, Coventry University, UK.
Rolls E T (2007) Emotion Explained, Oxford, Oxford University Press.
Sharon R (2006) Be Valuable: A Guide to Constructing Excellence in the Built Environment, London, Constructing Excellence.
Sundstrom E, Bell P, Busby P and Asmus C (1996) "Environmental Psychology."Annual Review Psychology 47: 485-512.
Warfield C (2004) The disaster management cycle, (available online http://www.gdrc.org/uem/disasters/1-dm_cycle.html [accessed on 22/12/2006])

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

🏆 *reviewed paper*

Zur Identifikation und Visualisierung von Einfamilienhausgebieten der 1950er- bis 1970er-Jahre für eine nachhaltige Raumplanung

Dominik Visca, Max Hoppe, Kevin Kaminski, Pascal Neis

(Dominik Visca, Hochschule Mainz, Fachbereich Technik, Lucy-Hillebrand-Straße 2, 55128, Mainz, dominik.visca@hs-mainz.de)
(Max Hoppe, Hochschule Mainz, Fachbereich Technik, Lucy-Hillebrand-Straße 2, 55128, Mainz, max.hoppe@hs-mainz.de)
(Kevin Kaminski, Hochschule Mainz, Fachbereich Technik, Lucy-Hillebrand-Straße 2, 55128, Mainz, kevin.kaminski@hs-mainz.de)
(Dr. rer. nat. Pascal Neis, Hochschule Mainz, Fachbereich Technik, Lucy-Hillebrand-Straße 2, 55128, Mainz, pascal.neis@hs-mainz.de)

1 ABSTRACT

Alternde Einfamilienhausgebiete sind eine Herausforderung für die nachhaltige Raumplanung. Insbesondere im ländlichen Raum führt der demografische Wandel vermehrt zu Leerständen in den Gebäudebeständen der 1950er- bis 1970er-Jahre, da der Generationenwechsel von Erstbesitzern zu jungen Familien oder neuen Eigentümern häufig problematisch verläuft. Diese Gebiete zu identifizieren ist daher von entscheidendem Nutzen, um raumplanerische Maßnahmen treffen zu können.

Anhand des Baujahres eines Gebäudes lassen sich relevante Einfamilienhausgebiete erfassen. Angaben zu Gebäudebaujahren finden sich u. a. im AFIS-ALKIS-ATKIS-Modell (AAA-Modell). In den konkreten Datensätzen fehlt diese Angabe jedoch zumeist. Daher werden in der jüngeren Forschung die bereits durch die INSPIRE-Richtlinie (Richtlinie 2007/2/EG) flächenmäßig verfügbaren Bebauungspläne behelfsweise herangezogen. Eine Auswertung hinsichtlich Festsetzungen und Datum der Rechtskraft ist hierbei jedoch nur ein Indiz für das Baujahr der Wohngebäude im überplanten Gemeindegebiet. Vor allem in schrumpfenden Regionen, in denen es oft zu Leerständen kommt, gibt es mitunter eine große zeitliche Diskrepanz zwischen dem Rechtskraftdatum eines Bebauungsplans und dem tatsächlichen Baujahr eines Gebäudes. Die Einfamilienhausgebiete lassen sich dort nicht abschließend identifizieren.

Durch die Kombination verschiedener heterogener Quellen und Disaggregation von Daten können erforderliche Baujahresklassen identifiziert werden. Diese Methode bietet sich als praktikable Vorgehensweise an, die sowohl als Grundlage für Fragen der Forschung als auch der Raumplanung herangezogen werden kann. Als Evaluation dient ein Negativabgleich mit Erhebungen von Gebäudebaujahren der vergangenen ca. 25 Jahre in einem Testgebiet.

Keywords: Identifikation, Raumplanung, Einfamilienhausgebiete, Visualisierung, Open Data

2 HINTERGRUND UND HERAUSFORDERUNGEN

In Deutschland wird die Zahl der über 80-Jährigen bei etwa 10 Millionen Menschen im Jahr 2050 liegen – gegenüber 6,1 Millionen im Jahr 2021 (STATISTISCHE ÄMTER DES BUNDES UND DER LÄNDER 2022a, 2022b, RICHTER 2020). Im gleichen Jahr werden voraussichtlich 30 Prozent der Bevölkerung über 65 Jahre alt sein (ebd.). Diese Entwicklung ist eine zentrale gesellschaftliche Herausforderung und verstärkt im Hinblick auf Umbruchsituationen bzw. den Generationenwechsel in Einfamilienhaus-Gebieten (EFH-Gebiete) der 1950er- bis 1970er-Jahre (vgl. u. a. ADAM et al. 2018, KÖHLER & SCHAFFERT 2015, KRAJEWSKI 2014, RAAB 2006). Diese Quartiere wurden mit der Absicht errichtet, Familien mit Kindern ausreichend Raum anzubieten, sowie als Alterssicherung zu dienen. In der Folge kommt es zu lebenszyklusbedingten Veränderungen: Mit dem Umzug in eine altersgerechte Wohnform oder spätestens mit dem Tod der Elterngeneration steht ein Generationenwechsel an (vgl. ebd.). Viele der älteren EFH-Objekte erfüllen die gegenwärtig nachgefragten Merkmale bezüglich Wohnflächen, Wohnungszuschnitten, Zimmergrößen oder technischer Ausstattung nicht mehr. Für Erstbesitzer ohne Investitionsbereitschaft in einem Ein- oder Zweipersonenhaushalt bedeutet dies sowohl einen Verlust an Immobilienwert als auch eine nicht mehr gerechte Wohnform, da die häufig zu große Wohnfläche nur selten den Wohnbedürfnissen entspricht (vgl. ebd.). In der Konsequenz erschwert sich besonders in ländlich-peripherer Lage und/oder in strukturschwachen Regionen der Generationenwechsel.

Um auf diese demographische Entwicklung mit angepassten städtebaulichen und raumplanerischen Maßnahmen reagieren zu können, werden neben feingranularen Daten, auf deren Basis Dynamiken unterhalb der Gemeindeebene analysiert werden können, vor allem Baujahresdaten von relevanten Gebäudebeständen benötigt. Für kleinräumige demographische Analysen kommen in Deutschland zunehmend georeferenzierte Einwohnermeldedaten zur Verwendung (vgl. u. a. LINDNER 2020, SCHONLAU et al. 2019).

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Bezüglich Baujahresdaten fällt die Informationsdichte jedoch zumeist gering aus. Durch Datendisaggregation und -anreicherung kann dieser Knappheit begegnet werden (WECK-PONTEN et al. 2018). Im Kontext verschiedener Fragestellungen werden dafür u. a. die Ergebnisse des Zensus von 2011, Bebauungspläne sowie Luft- und Satellitenbilder herangezogen. EICHHORN & SIEDENTOP (2022) verweisen beispielsweise im Zusammenhang zur Schätzung der Innenentwicklung in nordrhein-westfälischen Gemeinden zwischen 1979 und 2011 auf die Angaben zum Baujahr in den Zensusdaten von 2011, die von ihnen in Kombination mit Luftbildern genutzt werden. Für MUCKEL & OGOREK (2018) besitzen Bebauungspläne den Vorteil, dass sie neben der Art der baulichen Nutzung (vgl. § 30 BauGB) per verbindlichem Rechtskraftdatum Hinweise über das Baujahr der im Kartenausschnitt oder im Geltungsbereich sichtbaren Gebäude geben. Gleichzeitig besitzen Bebauungspläne nicht nur ein Rechtskraftdatum, sondern stellen auch ein historisches Dokument dar. IOSIFESCU et al. (2016) und CHEN et al. (2021) machen darauf aufmerksam, dass das Vektorisieren von Inhalten aus historischen Karten mit hinreichender Genauigkeit für grundlegende räumliche Abfragen möglich ist. In diesem Zusammenhang ist auch das Ableiten von Hausumringen auf Basis von Luftbildern (LI et al. 2019) historischen Satellitenbildern (WURM et al. 2011) sowie anderen Vektordatensätzen wie OpenStreetMap (FAN et al. 2014) ein in jüngerer Zeit umfangreich erforschtes Gebiet der Fernerkundung. Diese eignen sich aber nur bedingt für die Vektorisierung von Bebauungsplänen. HERRMANN (2019) und KMENT (2017) geben zu bedenken, dass sich wegen des zu kleinen Maßstabs und der meist unvollständig vorhanden Gebäudetypen keine Prognosen über zukünftige Entwicklungen der Siedlungsfläche des Einfamilienhausgebietes realisieren lassen.

Um die Einfamilienhausgebiete der 1950er-, 1960er- und 1970er-Jahre kleiner Kommunen zu ermitteln, greift dieser Beitrag Aspekte zur intelligenten Verknüpfung dieser Ansätze auf. Als Grundlage dienen die Zensusdaten der Volkszählung von 2011 aus denen sich die Dynamiken des Gebäudebestandes ableiten lassen (RUPRECHT 2014). Zur Disaggregation der Zensusdaten werden die gemäß INSPIRE-Richtlinien flächenmäßig verfügbaren Bebauungspläne verwendet, die laut WECK-PONTEN et al. (2018) Hinweise zu Gebäudebaujahren enthalten können.

Dazu wird im folgenden Abschnitt eine halb-automatisierte Methode vorgestellt. Im Anschluss werden Methode und Ergebnisse kritisch diskutiert, um hiernach die Ergebnisse auf Basis einer großangelegten Erhebung der amtlichen Hausumringe und darin enthaltener Baujahre der letzten ca. 25 Jahre zu evaluieren. Der Beitrag schließt mit einem Ausblick.

Codierung im Datensatz	**Merkmalsbeschreibung**
1	Vor 1919
2	1919 – 1948
3	1949 – 1978
4	1979 – 1986
5	1987 – 1990
6	1991 – 1995
7	1996 – 2000
8	2001 – 2004
9	2005 – 2008
10	2009 und später

Tab. 1: Merkmalsausprägungen des Attributs Baujahr im Datensatz „Gebäude um 100 Meter-Gitter“ (STATISTISCHE ÄMTER DES BUNDES UND DER LÄNDER 2022c).

3 METHODIK

3.1 Datengrundlage

Als Grundlage für die Ermittlung und anschließende Visualisierung der Einfamilienhausgebiete dienen die offenen Daten der Zensus 2011-Volkszählung (STATISTISCHE ÄMTER DES BUNDES UND DER LÄNDER 2022c). Seit der Änderung des Bundesstatistikgesetzes im Jahr 2013 liegt ein großer Teil der für den Zensus 2011 erhobenen Daten in aggregierten 100m-Gitterzellen vor (NEUTZE 2015). Eines der

erhobenen Merkmale ist das klassifizierte Baujahr der jeweils in einer Gitterzelle enthaltenen Wohngebäude. Tabelle 1 zeigt die im Zensus 2011 vorhandenen Merkmalsausprägungen des Attributes „Baujahr“.

Aus der Auflistung ist ersichtlich, dass die Klassifizierung der Baujahre vor allem ab dem Jahr 1987 eine hohe zeitliche Auflösung aufweist. Der für diese Arbeit relevante Zeitraum der 1950er- bis 1970er-Jahre wird im Groben hingegen von nur einer Klasse „1949 – 1978“ abgedeckt. Diese Klasse erlaubt eine Abgrenzung von Gebäuden zu jüngeren und älteren Gebäuden, allerdings keine Abgrenzung nach z.B. Jahrzehnten innerhalb dieser Klasse. Das Fehlen des Jahres 1979 und das zusätzliche Vorhandensein des Jahres 1949 ist in Ermangelung einer bundesweit verfügbaren Alternative räumlich hochauflösender Baujahresdaten zu vernachlässigen.

3.2 Identifizierung von Wohngebäuden

Die Baujahresklassen der Zensusdaten sind angelehnt an PAJARES et al. (2021) und VISCA et al. (2022) auf die Wohngebäude zu disaggregieren, um eine genauere Ebene als die bereitgestellten 100m-Gitterzellen zu erhalten. In einem ersten Schritt ist die Identifizierung von Wohngebäuden notwendig. Dafür werden die Hausumringe des amtlichen Liegenschaftskatastersystems (ALKIS) verwendet (siehe Abbildung 1). Um Nebengebäude (z.B. Garagen oder nachträgliche Anbauten) vorzufiltern, erscheinen nur diejenigen Gebäudepolygone nützlich, die mindestens eine, ebenfalls aus ALKIS stammende, georeferenzierte Gebäudeadresse beinhalten. Anschließend findet eine Filterung nach Wohngebäuden durch einen Abgleich einerseits mit den ebenfalls in ALKIS vorgehaltenen Nutzungsarten, andererseits mit OpenStreetMap-Gebäudepolygonen die ein „amenity“-Tag aufweisen, welche eine entsprechende wohnliche Gebäudenutzung ausschließen. Dafür werden pro Zensus-Gitterzelle Adress- und Gebäudedaten aus OpenStreetMap (OSM) über die Overpass API von OLBRICHT (2015) extrahiert und die Ergebnisse mit den amtlichen Hausumringen verschnitten. Ausschließlich gewerblich, industriell oder landwirtschaftlich genutzte Gebäude werden so aus dem Datensatz entfernt.

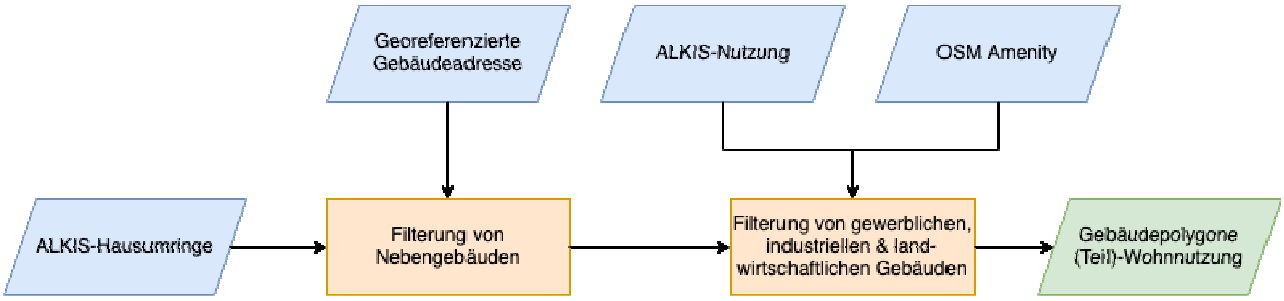


Abb. 1: Schematische Darstellung der Vorverarbeitung des ALKIS-Hausumringe.

Um die rein tabellarisch vorliegenden Baujahresklassen auf die korrekten Gebäudepolygone disaggregieren zu können, sind Informationen aus sekundären Datensätzen notwendig. Zentral sind dabei die rechtskräftigen Bebauungspläne der Kommunen. Unabhängig vom konkreten Geltungsbereich eines Bebauungsplans liefert der gesamte Kartenausschnitt des Planwerks Hinweise zum Vorhandensein von Gebäuden zum Zeitpunkt des Rechtskraftdatum bzw. des angegebenen Datums der verwendeten ALKIS-Daten. Auch die Abwesenheit eines Bebauungsplans liefert einen Hinweis auf die Baujahresklasse. Das Planungsinstrument des verpflichtenden Bebauungsplans entstand erst mit der Verabschiedung des Bundesbaugesetzes (BBauG) im Jahr 1960, bebaute aber nicht überplante, größere Gebiete müssen dementsprechend älter sein (SCHRÖTELER-VON BRANDT 2018). Für die überplanten Gebiete ist eine systematische Auswertung des in den Bebauungsplänen sichtbaren Gebäudebestands notwendig.

3.3 Vektorisierung von Bebauungsplänen

Die bereitgestellten Bebauungspläne liegen i.d.R. nur als gescanntes Plandokument im PDF-Format vor, ggf. zusätzlich auch als georeferenziertes und auf den Geltungsbereich zugeschnittenes Rasterbild. Abhängig vom Alter des Bebauungsplans und der daraus folgenden Datengrundlage verfügen die in Geoportalen bereitgestellten Bebauungspläne über exportierbare Vektor-Ebenen. Dies ermöglicht bei jüngeren Plänen auf CAD-Basis den Import des PDFs und das Abgreifen der georeferenzierten Vektordateien in einem Geoinformationssystem. Bei Scans unterzeichneter Originale oder einem älteren Bebauungsplan ist diese Möglichkeit nicht gegeben. Daher ist es erforderlich, die Bebauungspläne zu vektorisieren, um über eine räumliche Abfrage das Vorhandensein der im aktuellen ALKIS-Bestand vorhandenen Gebäudepolygonen

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

mit den historischen Gebäudepolygonen aus ALKIS, der automatischen Liegenschaftskarte (ALK) bzw. der Flurkarte abzugleichen (siehe Abbildung 2).

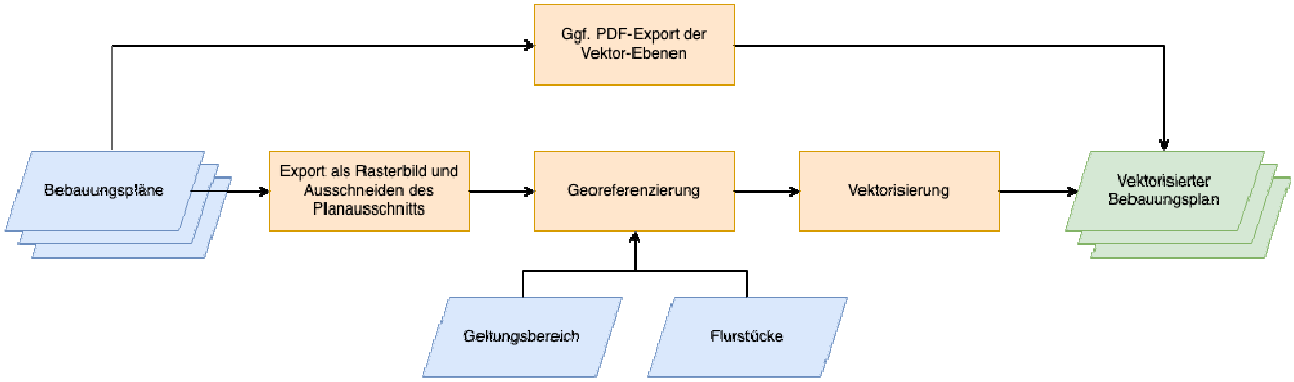


Abb. 2: Verarbeitungsschritte: Vektorisierung der Bebauungspläne.

Die Anforderung an möglichst akkurate, rechtwinklige Gebäudepolygone ist nicht notwendigerweise erforderlich für die Abfrage, ob zu zwei (oder mehr) unterschiedlichen Zeitpunkten ein Gebäude vorhanden ist oder nicht. Die Bebauungspläne werden vektorisiert und mit einem Zeitstempel des Rechtskraftdatums bzw. dem ALKIS-Datenstand versehen.

3.4 Abgleich von Hausumringen mit Bebauungsplänen

Entsprechend der Darstellung in Abbildung 3 sind anschließend von den eingangs gefilterten Hausumringen mit (Teil-)Wohnnutzung Zentroide innerhalb des jeweiligen Polygons zu bilden. Um das frühste Vorhandensein des Gebäudes in einem Bebauungsplan zu identifizieren und den jeweiligen Zeitstempel an das Gebäudepolygon anzuhängen, wird iterativ in chronologischer Reihenfolge für jeden Bebauungsplan überprüft, ob die gebildeten Zentroide innerhalb eines flächenmäßig ähnlichen Polygons aus einem vektorisierten Bebauungsplan vorliegen. Dementsprechend ist eine möglichst nahe Abbildung des Hausumrings nicht notwendig, solange die ungefähre Geometrie und Lage erhalten bleibt. Am Ende aller Iterationen liegt für jedes Gebäudepolygon das Datum des frühsten Auftretens und des letzten „Nicht-Auftretens“ in einem Bebauungsplan, bzw. „keine Angabe“ vor, wenn das Gebäude in keinem Bebauungsplan-Kartenausschnitt sichtbar ist. Die so entstehende Zeitspanne entspricht dem Zeitfenster, in dem das Gebäude fertiggestellt wurde.

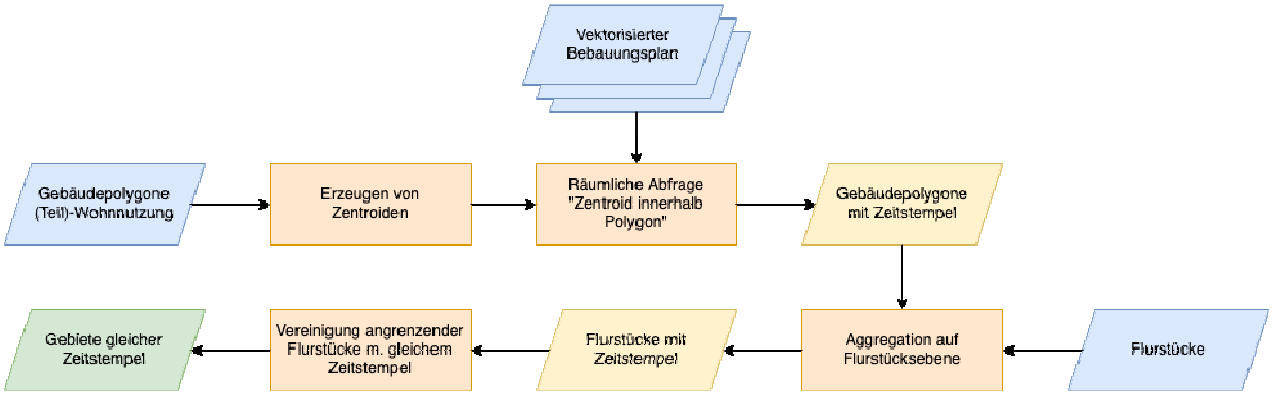


Abb. 3: Abgleich des Vorhandenseins von Gebäuden in historischen Bebauungsplänen.

3.5 Disaggregation der Zensusdaten

Die Zeitstempel der Gebäudepolygone werden anschließend auf Flurstückebene aggregiert, wobei stets auf das älteste Gebäude pro Flurstück zurückgegriffen wird. Alle angrenzenden Flurstücke mit dem gleichen Zeitstempel sind dann zu vereinigen, um größere Gebiete gleicher Baujahres-Hinweise zu erhalten. Diese Flächen dienen als primäres Verteilungsmerkmal zur Disaggregation der Zensusdaten.

Pro Zensus-Gitterzelle wird die eigentliche Disaggregation der Baujahresklassen durchgeführt. Für jede in einer Gitterzelle enthaltene Merkmalsausprägung des Attributes „Baujahr“ wird eine dreistufige Verteilung auf alle innerhalb der Gitterzelle liegenden Gebäude aus dem gefilterten Gebäudepolygon-Datensatz vorgenommen. Zuerst werden alle Baujahresklassen auf diejenigen Gebäude verteilt, die sich in einem für

die Baujahresklasse passenden Gebiet gleicher Baujahres-Hinweise befinden. Dabei ist der spezifischere Zeitrahmen anzuwenden (d.h. „jünger als 1985 und älter als 2002“ ist spezifischer als „älter als 2003“). Sollte die Verteilung nicht abschließend sein, wird die relative Entfernung zu bekannter historischer Bausubstanz als Indikator für ein Gebäudealter hinzugezogen. Klassische Points of Interest (POIs) in diesem Sinne sind Kirchen, Rathäuser oder der Marktplatz als Indikator für den historischen Ortskern. Entsprechend der Entwicklung von Siedlungserweiterungen sind jüngere Gebäude tendenziell weiter von diesem historischen Ortskern entfernt als ältere. Können Baujahresklassen weiterhin keinem Gebäude zugeordnet werden, müssen diese auf alle übrigen Gebäude in der Gitterzelle randomisiert verteilt werden.

3.6 Identifizierung von Einfamilienhäusern

Die Ermittlung von Einfamilienhausgebieten macht darüber hinaus die Differenzierung von Einfamilien- und Mehrfamilienhäusern notwendig. Zu diesem Zweck werden die über die Overpass API extrahierten Gebäudedaten entsprechend der Vorgehensweise nach VISCA et al. (2022) auf Basis des Attributes „Gebäudetyp (Größe)“ bzw. der Grundfläche und Stockwerkszahl mit den Gebäudepolygonen verschnitten. Analog zur Aggregation der Baujahreshinweise der Bebauungspläne zu Gebieten gleicher Baujahreshinweise ist eine schrittweise Aggregation der Einfamilienhäuser auf Flurstücke und dann eine Vereinigung auf Basis dieser Baujahresklassen hin zu Einfamilienhausgebieten identischer Baujahresklassen vorzunehmen (siehe Abbildung 4).

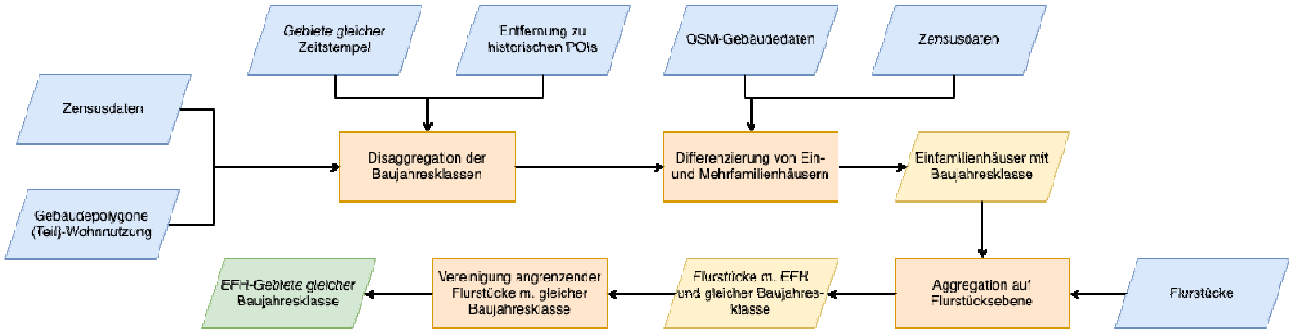


Abb. 4: Disaggregation der Zensusdaten, Identifizierung von Einfamilienhäusern und Aggregation zu Einfamilienhausgebieten identischer Zensus-Baujahresklassen.

4 ERGEBNISSE & DISKUSSION

Die Stadt Otterberg (Verbandsgemeinde Otterbach-Otterberg, Rheinland-Pfalz, Deutschland) diente als Testgebiet. Ihr Siedlungsgebiet umfasst eine Fläche von ca. 2,20 km2 und enthält laut ALKIS 3.369 amtliche Hausumringe, aus denen Nebengebäude und nicht wohnlich genutzte Gebäude auf 1.756 Hausumringe gefiltert wurden. Ein manuelles Aussortieren von Grundstücken u.a. im Außenbereich wurde nicht vorgenommen. Der erzeugte Datensatz stellt die Grundlage der nachfolgenden Auswertungen dar.

Im Untersuchungsgebiet sind 22 Bebauungspläne rechtskräftig und im Internet veröffentlicht (Stand: Juli 2022). Das Rechtskraftdatum erstreckt sich dabei von 1987 bis 2019. Insgesamt sind 1.081 der 1.756 wohnlich genutzten Gebäude von mindestens einem Bebauungsplan überplant. Weitere 45 Gebäude sind außerhalb eines Bebauungsplan-Geltungsbereich, allerdings im sichtbaren Kartenausschnitt mindestens eines Bebauungsplans enthalten. Es ergeben sich für 1.126 Gebäude Informationen zur späteren Disaggregation.

Die 22 Bebauungspläne wurden auf den Kartenausschnitt zugeschnitten, georeferenziert und vektorisiert. Bei älteren Plänen bestehen die größten räumlichen Abweichungen, da deren Datengrundlage noch die Flurkarte ist. Der mitunter schlechte Planzustand erschwerte die Georeferenzierung. Aufgrund der sich veränderten Aufteilung der Flurstücke sind die die Referenzpunkte zum aktuellen Kataster schwer zu finden. Weiterhin weicht die Datengrundlage der Flurkarte auch innerhalb eines Plans räumlich zueinander ab, was ein Entzerren und Drehen einzelner Planausschnitte notwendig macht. Insbesondere die alten Bebauungspläne erfordern daher ein hohes Maß an manueller Vorbereitung. Die eigentliche Vektorisierung ist aufgrund der sehr heterogenen Ausgestaltung der Bebauungspläne nicht gleichermaßen zufriedenstellend. Insbesondere Bebauungspläne, die viele Schraffuren enthalten, erzeugen häufig für jeden Schraffur-Innenraum einzelne Polygone, die in einem Nachbearbeitungsschritt wieder zu generalisieren sind.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Abbildung 5 zeigt die 605 roten Hausumringe mit einem Baujahr jünger als 1987, die nicht als Einfamilienhausgebiete der 1950er- bis 1970er-Jahre in Betracht kommen. Die 521 grünen Hausumringe könnten im gesuchten Zeitraum liegen. Häufig sind die Baujahreshinweise allerdings sehr grob, wie in Tabelle 2 zu sehen.

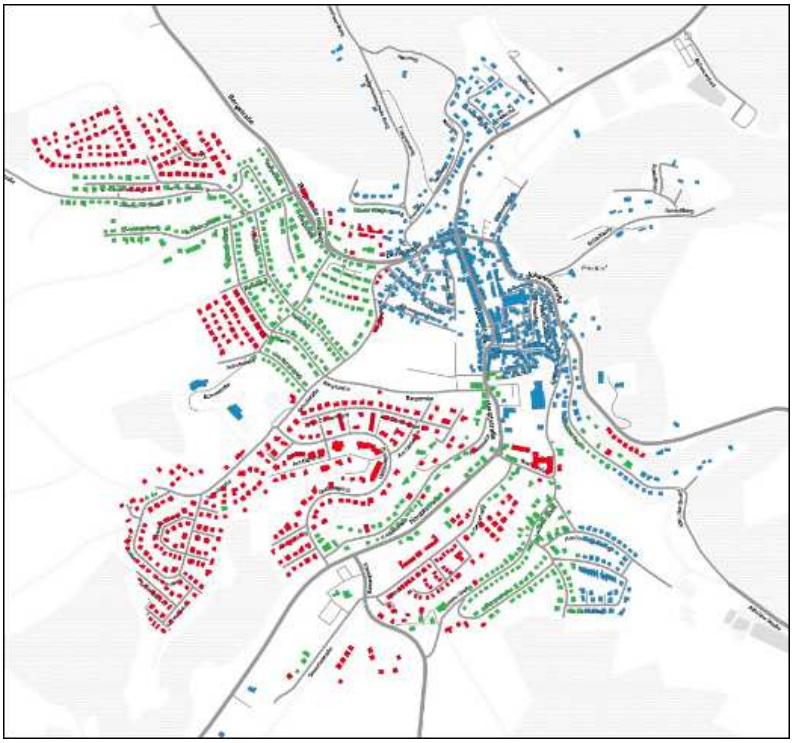


Abb. 5: Rechtskräftige Bebauungspläne, Map Tiles von Stamen Design, CC BY 3.0. Daten von OpenStreetMap, ODbL.

Bei den blauen Hausumringen handelt sich um 630 Gebäude im unbeplanten Innenbereich deren Baujahre älter als 1960 sind. Diese Gebäude könnten in der frühen Phase der Siedlungsentwicklung nach 1945 entstanden sein. Zum großen Teil handelt es sich um Bausubstanz des vor 1919 errichteten historischen Ortskern.

Baujahreshinweise laut Bebauungsplan	Gebäudeanzahl
Älter als 2017	2
Älter als 2015	12
Älter als 2003	312
Älter als 2002	1
Älter als 2001	112
Älter als 2000	13
Älter als 1989	8
Älter als 1987	58

Tab. 2: Baujahreshinweise der 521 relevanten Hausumringe

Die Disaggregation der Zensusdaten zeigt, dass die Wohngebiete der 1950er- bis 1970er-Jahre aufgrund der homogenen Siedlungsstruktur einen hohen Deckungsgrad mit der Vorauswertung der Bebauungspläne besitzen. Abbildung 6 zeigt ein Neubaugebiet, welches nach dem Stichtag des Zensus 2011 geplant und bebaut wurde. Die blau eingefärbten Hausumringe im rechten Kartenausschnitt bedeuten, dass keine Angaben in den Zensusdaten zu einem Baujahr existieren, während die roten Hausumringe im linken Kartenausschnitt aus den Bebauungsplänen stammen und die Baujahre nach 1970 repräsentieren. Rechts unten konnten Baublöcke aus den Jahren 1949 bis 1978 identifiziert werden. Summenbildungen in den Zensusdaten über einzelne Attribute hinweg sind nicht immer deckungsgleich mit den tatsächlichen Gegebenheiten. Die Auswirkungen des Anonymisierungsverfahrens lassen sich oben im Bild erkennen: Laut Bebauungsplänen sind die dortigen Gebäude älter als 2003 (grün, links), im Zensus von 2011 hingegen sind keine Angaben (blau, rechts) zu diesen Gebäuden zu finden.

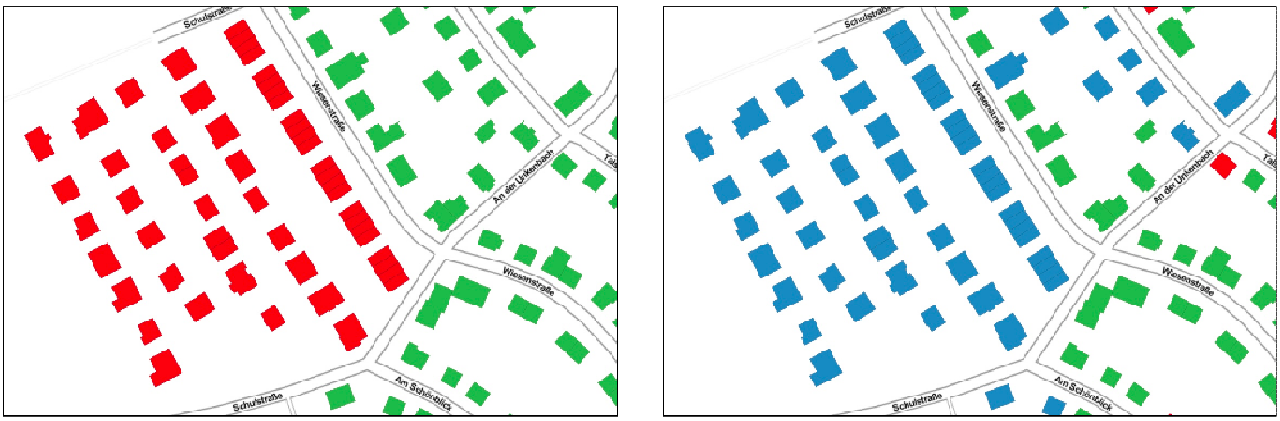


Abb. 6: Gegenüberstellung aus Bebauungsplan-Auswertung (links) und Zensus-Disaggregation (rechts), Map Tiles von Stamen Design, CC BY 3.0. Daten von OpenStreetMap, ODbL.

Im unbeplanten, dicht bebauten Innenbereich des historischen Ortskerns erzeugt die Methode nur wenig nachvollziehbare Ergebnisse. In der exemplarischen Gitterzelle hält der Zensusdatensatz zu 35 Gebäuden aus sechs Baujahresklassen bereit (siehe Abbildung 7). Aufgrund der fehlenden Angaben aus der Bebauungsplan-Auswertung und der ähnlichen Distanz der Bebauung zum Ortskern, bzw. zu POIs wie der Kirche (unten rechts im Bild), ist nur eine Zufallsverteilung möglich. Eine gebäude- oder flurstückscharfe Zuteilung von Baujahresklassen ist ohne weitere Informationen ausgeschlossen. Im Kontext der Zielsetzung, Einfamilienhausgebiete abzugrenzen lässt sich der gezeigte Kartenausschnitt trotz allem als möglicher Kandidat ausschließen. Zwar konnte am linken Rand der Gitterzelle eine Bebauung (siehe grüne Fläche) disaggregiert werden, allerdings kann hier schwerlich von einem Einfamilienhausgebiet die Rede sein. Die gelben Hausumringe im rechten Kartenausschnitt zeigen die erwartete, historische Bausubstanz aus den Jahren 1949 und früher an.

Abb. 7: Beispiel verbesserungsfähiger Disaggregation (links Bebauungsplan-Auswertung, rechts Zensusdisaggregation), Map Tiles von Stamen Design, CC BY 3.0. Daten von OpenStreetMap, ODbL.

Die Analyse verdeutlicht, dass zur Bestimmung des Baujahres auch die Ermittlung der einzelnen Einfamilienhäuser nötig ist. Ein Abgleich nach Gebäudeart über OpenStreetMap verspricht aufgrund der tendenziell eher mangelnden Datenvollständigkeit im ländlichen Raum dabei wenig Erfolg. Eine Disaggregation der Gebäudetypen aus dem Zensusdatensatz ist daher nur randomisiert möglich, wobei innerhalb der relativ homogenen Siedlungserweiterungsgebiete auch die Aggregationsebene der 100m-Gebiete hinreichende Genauigkeit liefern kann. Weder notwendig noch zielführend stellt die Berücksichtigung jedes einzelnen Ausreißers, ob des Baujahres oder des Gebäudetyps, dar. Die Einfamilienhausgebiete charakterisiert eine Durchmischung des Baubestandes durch Nachverdichtung oder Neubauten. Daher müssen sie unabhängig von einzelner nicht zur Definition passenden Bausubstanz in Gänze zu betrachtet werden. Das Ergebnis der daraus folgenden Aggregation zu größeren Einfamilienhausgebieten der 1950er- bis 1970er-Jahre ist für die Stadt Otterberg in Abbildung 8 zu sehen.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

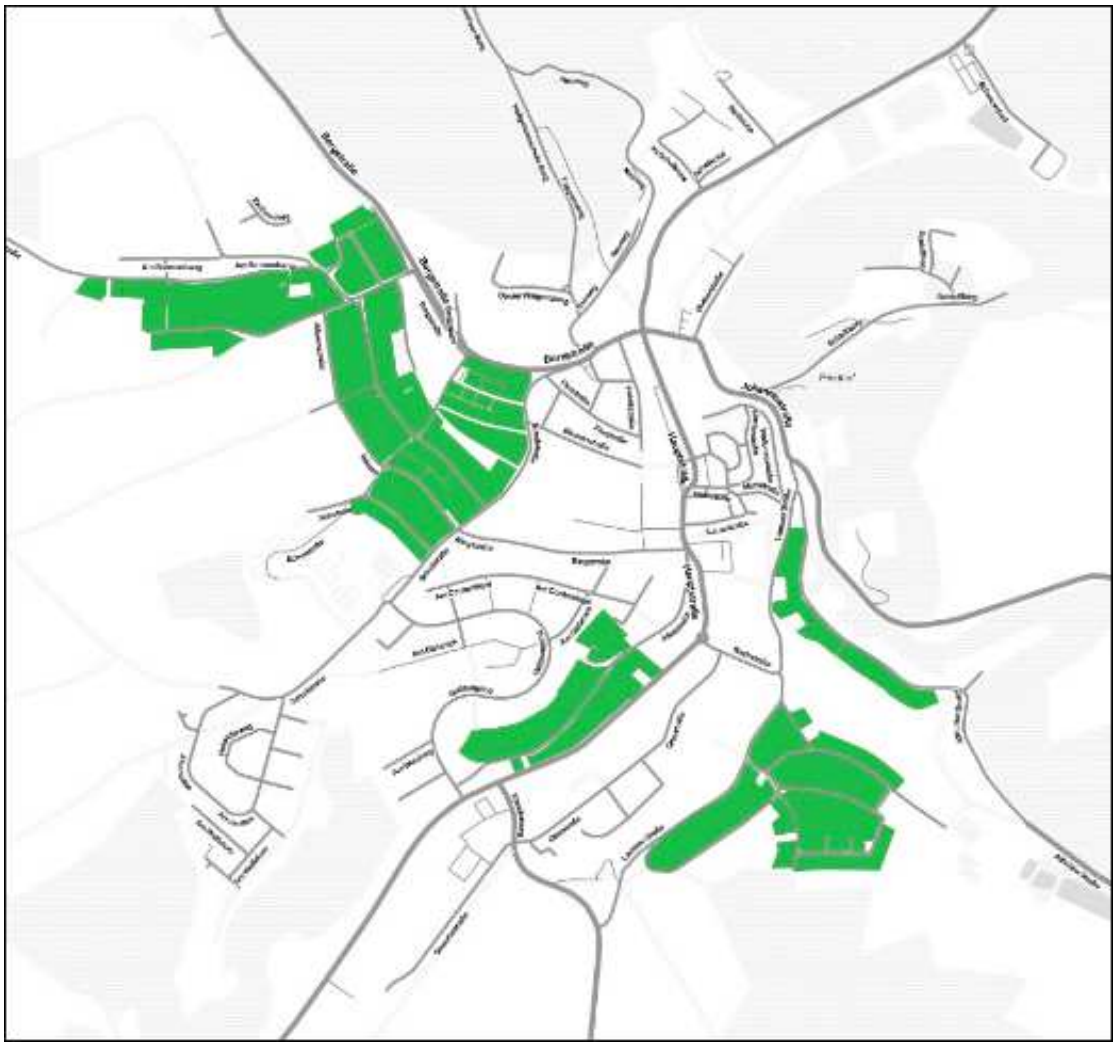


Abb. 8: Einfamilienhausgebiete der 1950er- bis 1970er-Jahre, Map Tiles von Stamen Design, CC BY 3.0. Daten von OpenStreetMap, ODbL.

Zur Validierung der Ergebnisse wird ein Datensatz der amtliche Hausumringe des Landesamts für Vermessung und Geobasisinformation des Landes Rheinland-Pfalz verwendet, der im Zuge eines großangelegten Erhebungsverfahrens die Baujahre der letzten ca. 25 Jahre ergänzt. Zwar lassen sich damit die fraglichen Einfamilienhausgebiete nicht identifizieren, die Angaben sind jedoch als Negativabgleich zur Evaluierung der hier präsentierten Methodik hilfreich. Von den 1.756 amtlichen Hausumringen wurden für 347 Baujahre zwischen 1957 und 2021 ergänzt, wobei nur 10 Baujahre älter als 1998 sind. Mit ca. 44% wurde ein großer Teil der Hausumringe nicht von der Disaggregation berücksichtigt. Überwiegend handelt es sich dabei um Neubauten nach dem Stichtag des Zensus 2011, die für die Fragestellung keine Relevanz besitzen. Von den verbliebenen 56% hat für ca. 19% der Fälle die Disaggregation der Hausumringe eine nicht dem tatsächlichen Gebäudebaujahr entsprechende Baujahresklasse zugewiesen. Hingegen für ca. ca. 81% aller relevanten Fälle hat die Methode die korrekte Baujahresklasse den Hausumringen zugeordnet.

5 AUSBLICK

Mit Blick auf zukünftige Verbesserungen von Aktualität, Tiefe, Übertragbarkeit sowie generelle Verfügbarkeit von Daten lässt sich festhalten, dass mit der Veröffentlichung der Ergebnisse des Zensus 2022 aktualisierte Baujahresklassen verfügbar sein werden. Das ermöglicht einen Abgleich mit den Zensusergebnissen 2011 wodurch mögliche Lücken aufgedeckt werden können, die u. a. dem Anonymisierungsverfahren geschuldet sind. Dadurch ließe sich eine feinere Disaggregation der Baujahre nach Jahrzehnten vornehmen, um relevante Einfamilienhausgebiete spezifischer betrachten zu können. Auch für zukünftige demographische Entwicklungen sind genaue Angabe aktueller und zukünftiger Bebauung obligatorisch.

Die Daten der Liegenschaftskataster haben zwar den Vorteil, dass sie einer auf alle Bundesländer abgestimmten ALKIS-Modellierungsvorschrift unterliegen, aufgrund der dezentralen Führung in über 400 Liegenschaftsämtern gibt es jedoch erkennbare Unterschiede zwischen den Datenprodukten. Auch sind sie nicht in allen Bundesländern frei verfügbar (vgl. MEINEL 2020, FINA 2021). Eine weitere Harmonisierung und eine flächendeckende Öffnung der Datenbestände würden zur besseren Übertragbarkeit der aufgezeigten Methode beitragen. Die Daten aus dem OpenStreetMap-Projekt profitieren von einer laufenden Aktualisierung durch Mitwirkende, die sich auch in einer zunehmenden Tiefe und Verfügbarkeit von Informationen in ländlichen Gebieten bemerkbar macht (vgl. HECHT et al. 2013). Werden falsche oder irrtümliche Informationen beachtet, ist ein verbesserter Datenabgleich bezüglich der Nutzungsarten potentiell möglich (vgl. NEIS & ZIELSTRA 2014). Um einen zusätzlichen Mehrwert für die Auswertung von sichtbaren Gebäudebeständen in Bebauungsplänen zu erhalten, hilft der Zugang zu nicht mehr rechtskräftigen Plänen. In der Praxis gestaltet sich der Umgang jedoch schwierig, da gemäß INSPIRE-Richtlinie (Richtlinie 2007/2/EG) eine webbasierte Bereitstellung nur für Bebauungspläne ab Dezember 2013 vorgesehen ist. Eine Historisierung älterer Bebauungspläne wäre wünschenswert.

6 LITERATURVERZEICHNIS

ADAM, B., ARING, J., BERNDGEN-KAISER, A., HOHN, U., JOCHEMSEN, K., KÖTTER, T., & WIESS, D.: Ältere Einfamilienhausgebiete im Umbruch – Eine unterschätzte planerische Herausforderung. Situation in Nordrhein-Westfalen. Positionspapier ARL. 2018.

CHEN, Y., CARLINET, E., CHAZALON, J., MALLET, C., DUMÉNIEU, B. & J. PERRET: Vectorization of Historical Maps Using Deep Edge Filtering and Closed Shape Extraction. In: Document Analysis and Recognition – Lecture Notes in Computer Science, Aufl. 12824. Springer, Cham, 2021.

EICHHORN, S., & SIEDENTOP, S.: Innen vor Außen? Eine Schätzung der Innenentwicklung in nordrhein-westfälischen Gemeinden, 1979 bis 2011. Raumforschung Und Raumordnung | Spatial Research and Planning.2022.

FAN, H., ZIPF, A., FU, Q. & NEIS, P.: Quality assessment for building footprints data on OpenStreetMap. International Journal of Geographical Information Science 28. S. 700–719. 2014.

FINA, S.: Stadtgrün unter Druck: Vergleichswerte zur urbanen Grünraumversorgung in deutschen Städten.
Stadtforschung und Statistik: Zeitschrift des Verbandes Deutscher Städtestatistiker, 34(2), S. 17-23. 2021.

HECHT, R., KUNZE, C., HAHMANN, S.: Measuring Completeness of Building Footprints in OpenStreetMap over Space and Time. ISPRS Int. J. Geo-Inf., 2, S. 1066-1091. 2013.

HERRMANN, A.: Die Reduzierung der Flächeninanspruchnahme durch das Bauplanungsrecht. Juristische Geltung und Realisierung im sozialen System. Nomos Verlagsgesellschaft mbH & Co. KG. Baden-Baden, 2019.

IOSIFESCU, I., TSORLINI, A., & L. HURNI: Towards a comprehensive methodology for automatic vectorization of raster historical maps. 2016.

KMENT, M.: Öffentliches Baurecht. Band I Bauplanungsrecht – Schriftenreihe der Juristischen Schulung. 107(7). C.H. Beck, München, 2017.

KÖHLER, T., SCHAFFERT, M.: Building Measures in the Face of Population Decline. In: Challenges for governance structures in urban and regional development = Fragen zur Steuerung von Stadt- und Regionalentwicklung, S. 195–208. Zürich, 2015.

KRAJEWSKI, C.: Was wird aus den Traumhäusern? – Teil 1: Zum Umgang mit Einfamilienhaussiedlungen analysiert am Beispiel von Altena und Finnentrop in Südwestfalen. In: INSTITUT FÜR GEOGRAPHIE WESTFÄLISCHE WILHELMS-UNIVERSITÄT MÜNSTER (14). Münster, 2014.

LI, W., HE, C., FANG, J., ZHENG, J., FU, H., YU, L.: Semantic Segmentation-Based Building Footprint Extraction Using Very High-Resolution Satellite Images and Multi-Source GIS Data. Remote Sens. 11, 403. 2019.

LINDNER, A.: Kommunales Monitoring. KomMonitor: Ein digitales Planungswerkzeug für die Stadtentwicklung. 47(3), S. 76-87. 2020.

MEINEL, G.: Herausforderung Flächenmonitoring: Datenquellen für ein Flächeninformationssystem und was sie leisten können. Stadtforschung und Statistik: Zeitschrift des Verbandes Deutscher Städtestatistiker, 33(1), S. 107-114. 2020.

MUCKEL, S. & OGOREK, M.: Öffentliches Baurecht - Grundrisse des Rechts. C.H. Beck, München, 2018.

NEIS, P. & ZIELSTRA, D.: Recent Developments and Future Trends in Volunteered Geographic Information Research: The Case of OpenStreetMap. Future Internet, 6, S. 76-106. 2014.

NEUTZE, M: Gitterbasierte Auswertungen des Zensus 2011. In: Stadtforschung und Statistik, S. 64-67, 2015.

OLBRICHT, R. M.: Data Retrieval for Small Spatial Regions in OpenStreetMap (2015). In: Jokar Arsanjani, J., Zipf, A., Mooney P. & Helbrich M. (eds) OpenStreetMap in GIScience. Lecture Notes in Geoinformation and Cartography, S. 101-122, 2015.

PAJARES, E., MUÑOS NIETO, R., MENG, L., & WULFHORST, G.: Population Disaggregation on the Building Level Based on Outdated Census Data. In: ISPRS Int. J. Geo-Inf., 10, S. 662. 2021.

RAAB, A.: Nachfrageorientierte Innenentwicklung und Flächenmanagement – Zukunftsausgabe bei Stadt- und Dorfumbau. In: Mitteilungen DVW Bayern, 65(4). S. 547-563. 2006.

RICHTER, E.: Seniorendemokratie: Die Überalterung der Gesellschaft und ihre Folgen für die Politik. Berlin, Deutschland: Suhrkamp Verlag. 2020.

RUPRECHT, M.-I.: Kleinräumige Siedlungsanalysen zur Abbildung von Veränderungen: Vom Nutzen baulich-räumlicher Daten für die Planung. In: Raumforschung und Raumordnung 72, S. 227–238. 2014.

SCHONLAU, M., DANOWSKI-BUHREN, C., GUTH, M., KLEIN, U. & LINDNER, A.: Integriertes Monitoring als Werkzeug einer nachhaltigen Stadtentwicklung. IS THIS THE REAL WORLD? Perfect Smart Cities vs. Real Emotional Cities.

Proceedings of REAL CORP 2019, 24th International Conference on Urban Development, Regional Planning and Information Society. S. 453-462. 2019.

SCHRÖTELER-VON BRANDT, H.: Geschichte der Stadtplanung. In: ARL – Akademie für Raumforschung und Landdesplanung (Hrsg.): Handwörterbuch der Stadt- und Raumentwicklung, S. 805-821. 2018.

STATISTISCHE ÄMTER DES BUNDES UND DER LÄNDER: Bevölkerungsvorausrechnung. Abgerufen von: https://www.destatis.de/DE/Themen/Gesellschaft-Umwelt/Bevoelkerung/Bevoelkerungsvorausberechnung/_inhalt.html. 2022a

STATISTISCHE ÄMTER DES BUNDES UND DER LÄNDER: Bevölkerungsstand: Amtliche Einwohnerzahl Deutschlands. Abgerufen von: https://www.destatis.de/DE/Themen/Gesellschaft-Umwelt/Bevoelkerung/Bevoelkerungsstand/_inhalt.html. 2022b.

STATISTISCHE ÄMTER DES BUNDES UND DER LÄNDER: Ergebnisse des Zensus 2011 zum Download - erweitert. o.O, o.J. Abgerufen von: https://www.zensus2011.de/DE/Home/Aktuelles/DemografischeGrunddaten.html. 2022d.

VISCA, D., HOPPE, M. & NEIS, P.: Generating a Pseudo Resident Registration Register by Using Open Data. In: GEOProcessing 2022: The Fourteenth International Conference on Advanced Geographic Information Systems, Applications, and Services. Porto, 2022.

WECK-PONTEN, S., BECKER, R., HERLE, S., BLANKENBACH, J., FRISCH, J., & v. TREECK, C.: Automatisierte Datenaggregation zur Einbindung einer dynamischen Gebäudesimulation in ein Geoinformationssystem. 2018.

WURM, M., TAUBENBÖCK, H., GOEBEL, J., ESCH, T. & WAGNER, G.: Zensus der Zukunft? - Erdbeobachtung zur räumlichen Abschätzung der Bevölkerungsverteilung. In: Standort - Zeitschrift für angewandte Geographie 35, S. 169–175. 2011.

Einführung von Kapazitätsgrenzen als Kriterium der urbanen Versorgungsqualität

Johanna Schmitt, Günter Gruber

(Johanna Schmitt, RSA FG iSPACE, Schillerstraße 25, Salzburg, johanna.schmitt@researchstudio.at)
(Günter Gruber, RSA FG iSPACE, Schillerstraße 25, Salzburg, guenter.gruber@researchstudio.at)

1 ABSTRACT

Dieses Paper stellt einen GIS-basierten Ansatz zur Berechnung der Versorgungsqualität verschiedener Einrichtungen (z.B. Kindergärten, Schulen und Erholungsflächen) basierend auf kapazitätssteuernden Eigenschaften wie Größe oder Ausstattung vor. Es handelt sich um einen Ansatz, der räumlich übertragbar ist und für verschiedene Fragestellungen und Anwendungsfälle der Stadt- und Raumplanung flexibel angewandt werden kann. Die Methode wird anhand des Beispiels Spielplätze in der Stadt Salzburg vorgestellt und diskutiert.

Keywords: Raumplanung, Lebensqualität, Kapazitäten, Versorgung, GIS

2 EINLEITUNG

Aufgrund der fortschreitenden Urbanisierung ist die Entwicklung von nachhaltigen und lebenswerten Städten ein aktuelles Thema. Dafür ist auch die flächendeckende Versorgung mit Einrichtungen des täglichen Lebens wie Kindergärten, Schulen oder Erholungsflächen essentiell. Im Hinblick auf ökologische Faktoren und eine hohe urbane Lebensqualität sollten derartige Einrichtungen von möglichst vielen Personen zu Fuß gut erreichbar sein. Daher ist die Analyse der Versorgung mit bestimmten Einrichtungen auch in der Raum- und Stadtplanung von hoher Bedeutung. Aus der Perspektive der Geoinformatik können mit Hilfe von klassischen Netzwerkanalysen Einzugsgebiete berechnet werden, um Versorgungsdisparitäten sowie Entwicklungsbedarfe abzubilden. Oftmals jedoch ist die Distanz das alleinige Kriterium und Größe oder weitere Eigenschaften einer Einrichtung werden nicht berücksichtigt.

Dieses Paper stellt eine GIS-basierte Methode zur Berechnung von Grenzen der Versorgungsqualität vor, die auf Größe, Ausstattung und weitere kapazitätsbestimmende Merkmale bestimmter Einrichtungen Bezug nimmt. Auf diese Weise können aktuelle Versorgungsgrade bestimmt und Einrichtungen, bei denen die Gefahr einer zeitweisen Überlastung besteht, identifiziert werden. Auf dieser Grundlage lassen sich Entwicklungsbedarfe und Potentiale ableiten. Die Methode wird beispielhaft anhand verschiedener Annahmen für Spielplätze in der Stadt Salzburg diskutiert.

3 HINTERGRUND

Es existiert eine große Anzahl von Konzepten zum Themenfeld Lebens- und Versorgungsqualität in der Stadt, welche eine wichtige Basis für die angewandte Forschung in der Raum- und Stadtplanung liefern und eine Grundlage für die in dieser Publikation präsentierte Methode darstellen.

So zielt beispielsweise das Konzept der Stadt der kurzen Wege, welches aus der Diskussion um die nachhaltige Entwicklung von Städten entstand, auf eine effiziente und dezentrale Siedlungsgestaltung mit kompakten Strukturen ab, bei der die wohnungsnahe Versorgung mit Einrichtungen des täglichen Lebens eine wichtige Rolle spielt. Besonders hervorgehoben wird u.a. die Bedeutung der fußläufigen Erreichbarkeit von Einrichtungen der Nahversorgung und Erholung im Bereich des Wohnstandorts. Auf diese Weise können ökologische, ökonomische und soziale Vorteile geschaffen und die städtische Lebensqualität und somit die Attraktivität der Stadt als Wohn- und Aufenthaltsort verbessert werden (Deutsches Institut für Urbanistik 2011). Aufgegriffen wird diese Idee auch in anderen Konzepten, z.B. der 15-Minuten-Stadt, in der alle wichtigen Einrichtungen für die Bevölkerung in max. 15 Minuten ohne Auto erreicht werden können. Dies entspricht etwa einem Radius von 3-4 km mit dem Fahrrad oder 1-1,5 km zu Fuß. Um dieses Konzept umsetzen zu können, müssen Stadt- und Verkehrsplanung eng verknüpft sein. Jeder Stadtteil muss eine Multifunktionalität vorweisen und wie eine eigene Stadt funktionieren, um die Bevölkerung mit allen Einrichtungen des täglichen Lebens versorgen zu können. Verschiedene Städte, beispielsweise Paris, Oslo und Madrid, befinden sich mit Stand 2020 bereits auf dem Weg zu einer 15-Minuten-Stadt (Steude 2021).

Weiterhin verweisen auch Smart City Strategien v.a. im Sinne von Smart Environment sowie Smart Living auf das Thema urbane Lebensqualität und Versorgung. Betrachtet werden u.a. Umweltschutz, Klima, Grünflächen sowie die Lebensqualität im Hinblick auf Kultur, Gesundheit und Wohnen (TU Wien 2007). Es

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

finden sich zudem verschiedene Indikatorsysteme mit Bezug zu Städten, Smart Cities und nachhaltiger Stadtentwicklung, die sich mit verschiedenen Themenbereichen des urbanen Lebens befassen. Dazu gehört beispielsweise eine Gruppe von ISO Standards. Teil davon ist der Standard ISO 37120 zum Thema „Sustainable cities and communities – Indicators for city services and quality of life", welcher Städte in ihrer nachhaltigen Entwicklung unterstützen soll. Die zugehörigen Indikatoren sind nach Themenfeldern zusammengefasst und behandeln u.a. Wirtschaft, Bildung, Umwelt, Klimawandel und Stadtplanung (ISO 2018).

Im städtischen Kontext wird v.a. in den letzten Jahren oft der Begriff Livability verwendet, zu welchem aufgrund seiner hohen Komplexität keine allgemeingültige Definition existiert. Beispielsweise kann Livability als Qualität gebauter und natürlicher urbaner Umgebungen mit ihrer Infrastruktur und ihrer Funktionalität im Sinne einer Mensch-Umfeld-Beziehung beschrieben werden. Livability ist zudem stark subjektiv und daher schwierig zu messen, jedoch werden z.B. Siedlungsstruktur und Mobilitätsaspekte als wichtige Faktoren der Bewohnerinnen- und Bewohnerzufriedenheit untersucht (Kovacs-Györi et al. 2019).

4 METHODIK

Die Grundidee dieses Papers besteht darin, Kapazitätsgrenzen von Einrichtungen mit Versorgungsauftrag (z.B. Spielplätze, Kindergärten, Krankenhäusern, Nahversorger etc.) basierend auf ihren Eigenschaften zu bestimmen und auf diese Weise einen flexiblen, tatsächlichen Versorgungsgrad zu errechnen, welcher der Planung eine Grundlage für die Identifikation von Defiziten und Entwicklungspotentialen über einfache distanzbasierte Erreichbarkeitsanalysen hinausgehend liefert. Es lässt sich dabei beliebig festlegen, welche Eigenschaften einer Einrichtung betrachtet werden sollen. Je nach Ziel der Analyse oder abhängig von vorhandenen Datengrundlagen können Parameter ergänzt oder entfernt werden. Somit lässt sich dieser Ansatz auch auf einfache Weise räumlich übertragen. Die Idee basiert auf einem indikatorbasierten Ansatz zur Grünflächenbewertung im urbanen und suburbanen Raum der Stadt Salzburg und ihrer Umgebung. Dieser stützt sich auf ein Indikatorensystem für die Bewertung unterschiedlicher Flächenarten. Damit kann u.a. die Erholungsqualität von Parks und Spielplätzen im Hinblick auf verschiedene Eigenschaften bestimmt werden. Die definierten Indikatoren für Erholungsflächen werden den Bereichen Natur, Ausstattung und Erreichbarkeit zugeordnet, welche zu einem Gesamterholungswert verrechnet werden. Der Ansatz kann durch eine Erweiterung und Anpassung des Indikatorensets außerdem flexibel auf andere Grünflächenarten übertragen werden (Schmitt & Gruber 2018).

Eine weitere Grundlage für die in diesem Paper vorgestellte Methode stellt eine Studie dar, deren Ergebnisse als Planungsgrundlage für die Stadtplanung der Stadt Salzburg dienen. Dabei wurden mit Hilfe einer klassischen Netzwerkanalyse fußläufige Versorgungsgebiete von Spielplätzen und Erholungsflächen basierend auf Zugangspunkten berechnet und darauf aufbauend Gebiete mit Entwicklungsbedarf identifiziert. Als Kriterium wurde die Distanz vom Wohnstandort zu den genannten Flächen betrachtet, wohingegen ihre Eigenschaften (z.B. Größe oder Ausstattung) nicht berücksichtigt wurden. Dieser Ansatz wurde für für die vorliegende Publikation aufgegriffen und erweitert.

Die Eingangsdaten aus der genannten Studie wurden beibehalten. Es handelt sich um das Straßennetzwerk der GIP (Graphenintegrations-Plattform), aus dem zur Abbildung fußläufiger Erreichbarkeiten u.a. Autobahnen, Schnellstraßen und Eisenbahntrassen eliminiert wurden sowie ein aktuelles Bevölkerungsraster der Bewohnerinnen und Bewohner mit Hauptwohnsitz mit einer Auflösung von 100 m von der Statistik Austria mit Datenstand 1.1.2021. Da Altersklassen als Datenprodukt nur ab 250 m Auflösung vorliegen, wurde die Zahl der Unter-20-Jährigen als Hauptzielgruppe von Spielplätzen, anteilsmäßig auf die 100 m Rasterzellen heruntergerechnet (räumliche Disaggregation). Außerdem wurden als Einrichtungen beispielhaft Spielplätze der Stadt Salzburg gewählt und deren Größe und die Eigenschaft, ob sie in einen Park eingegliedert sind, als Attributfelder aufgenommen. Auf Basis dieser kapazitätssteuernden Attribute wurde unter Zuhilfenahme des QGIS Graphic Modeller und der Erweiterung QNEAT3 ein Modell erstellt, das auf Basis von Eingabeparametern iterativ für beliebig viele Einrichtungen individuelle netzwerkbasierte Versorgungszusammenhänge als Polygone errechnet. Es wurden für Spielplätze, die nicht in einem Park liegen, 500 m als Einzugsgebiet definiert, da sie in der Regel weniger Attraktionen für Jugendliche bieten. Für Spielparks wurde das Einzugsgebiet allerdings auf 1000 m ausgeweitet, da es sich dabei üblicherweise um besonders attraktive Flächen handelt, die ein größeres Publikum anziehen und für die oft ein etwas weiterer Weg in Kauf genommen wird.

In einem nächsten Schritt wurden diejenigen Gitterzellen des Bevölkerungsrasters (gefiltert auf Unter-20-Jährige) selektiert, welche die Versorgungszusammenhänge schneiden. Dadurch erhält man einen theoretischen Grad der fußläufigen Versorgung der Bevölkerung mit Spielplätzen und zugleich einen Überblick der gänzlich unversorgten Regionen. Schließlich wurde ein direkt in QGIS ausführbares Python-Skript geschrieben, das alle Versorgungszusammenhänge iterativ durchgeht, die enthaltenen Gitterzellen nach Distanz zur Einrichtung sortiert und auf Basis des Kapazitätskriteriums diejenigen Zellen selektiert, die unterhalb der errechneten Kapazitätsgrenze liegen. Dieses Skript erlaubt flexible Änderungen, mit deren Hilfe z.B. die Kapazitätsgrenzen sowie weitere Kriterien zur Bewertung der Einrichtungen rasch angepasst werden können.

Abb. 1 zeigt die methodische Abfolge schematisch und nennt auch Entwicklungsziele und Planungskonzepte (vgl. Kapitel 3) als strategischen Hintergrund.

Abb. 1: Workflow zur Berechnung von Kapazitätsgrenzen

Im vorliegenden Beispiel wurde eine Kapazitätsgrenze von 15 Personen je 100 m² angenommen. Die errechneten Ergebnisse wurden kartographisch aufbereitet und zusätzlich mit etwas höher und niedriger angesetzten Kapazitätsgrenzen verglichen.

5 ERGEBNISSE

Abb. 2 zeigt die Ergebniskarte des im Methodenteil beschriebenen Szenarios für die Stadt Salzburg. Man erkennt in den südlichen und südöstlichen Stadtteilen eine weitreichende Unterversorgung mit fußläufig erreichbaren Spielplätzen nahezu unabhängig von Kapazitätsgrenzen, sprich die generelle Verteilung von Spielplätzen und nicht die potenzielle Überfüllung dient als Hinweise für die Stadtplanung. Wohlgemerkt handelt es sich um Gebiete mit hohem Einfamilienhaus- und Gartenanteil, wodurch die Defizite in der Praxis kaum ins Gewicht fallen dürften. In den dichter bevölkerten Gebieten im zentrumsnahen Norden und Osten der Stadt sind hingegen fast alle Kinder und Jugendliche fußläufig versorgt, weite Teile davon allerdings über der fiktiven Kapazitätsgrenze. Sie müssen zu Hochphasen der Spielplatznutzung mit starker Auslastung und Konkurrenz rechnen. Abhilfe könnte durch die Anlage weiterer Spielplätze oder den Ausbau sowie die Verbesserung der Ausstattung bestehender Spielplätze geschaffen werden.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

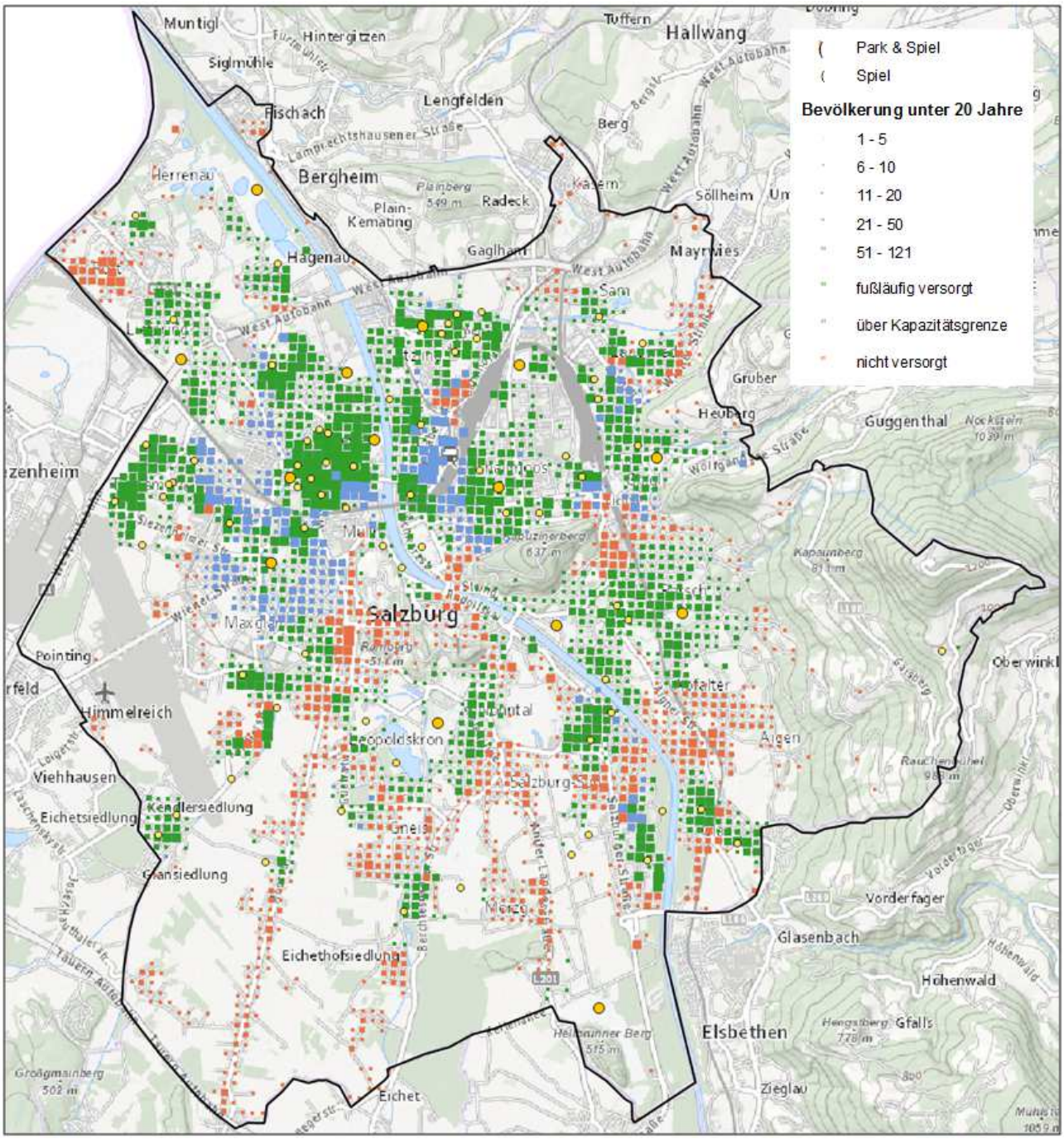


Abb. 2: Versorgungsqualität von Unter-20-Jährigen mit Spielplätzen in Salzburg unter Annahme einer Kapazitätsgrenze von 15 Personen pro 100 m² Spielplatzfläche

Szenarien	**10 Personen/100 m²**	**15 Personen/100 m²**	**20 Personen/100 m²**
Unter-20-Jährige gesamt	26.942	26.942	26.942
... davon fußläufig versorgt (nur Einzugsgebiet ohne Berücksichtigung von Kapazitätsgrenzen)	21.048	21.048	21.048
... davon innerhalb Kapazitätsgrenze	15.367	17.424	18.557
Anteil der eingeschränkt Versorgten (unversorgt und versorgt über Kapazitätsgrenze)	43,0%	35,3%	31,1%

Tabelle 1: Vergleich der Ergebnisse der drei Szenarien

Tabelle 1 fasst die Versorgungsqualität der Kinder und Jugendlichen unter diesen Modellannahmen für die Gesamtstadt statistisch zusammen und enthält zum Vergleich auch die Szenarienrechnungen für eine etwas

niedriger und höher angesetzte Kapazitätsgrenze mit 10 und 20 Personen je 100 m². Man sieht einerseits, dass nahezu 80 % der unter-20-jährigen Stadtbevölkerung einen Spielplatz in unmittelbarer Wohnortnähe erreichen können, andererseits ist je nach Kapazitätskriterium etwa ein Drittel bis über 40 % der Personen nur eingeschränkt versorgt.

6 DISKUSSION UND AUSBLICK

Bei der vorgestellten Methode handelt es sich um einen generischen Ansatz, der für diverse Anwendungsfälle erweiterbar und räumlich übertragbar ist. Es handelt sich um Prozessroutinen, die unter Anpassung von Parametern und Eingangsdaten komplett in QGIS durchführbar und beliebig reproduzierbar sind. Verschiedene Fragestellungen der Versorgungsqualität und -sicherheit lassen sich untersuchen und hochrechnen, etwa die Erreichbarkeit von Krankenhäusern unter Berücksichtigung der vorhandenen Bettenkapazität oder die wohnortnahe Versorgung mit Kindergartenplätzen. Es lassen sich somit gut versorgte sowie defizitäre Gebiete identifizieren.

Besonders relevant wird der Ansatz, wenn eine kurze Distanz zu den betreffenden Einrichtungen von entscheidender Bedeutung ist. Andernfalls können auch weiter entfernt gelegene Einrichtungen die gewünschte Rolle einnehmen. Dieses Ausweichen auf Alternativen bei Erreichen der Kapazitätsgrenze wurde hier (noch) nicht berücksichtigt und ist ein potentielles Defizit der Vorgehensweise. Andererseits ist die wohnortnahe mobilitätsarme Alltagsversorgung der Bevölkerung ein zentraler Baustein nahezu aller räumlichen Entwicklungskonzepte (z.B. 15-Minuten-Stadt) wodurch das Denken in einzelnen Versorgungszusammenhängen seine Berechtigung erhält.

Weiterhin hilft der vorgestellte Ansatz dabei, Einrichtungen zu identifizieren, bei denen die Gefahr einer Überlastung durch die Überschreitung der Kapazitätsgrenzen besteht. Im Falle des hier vorgestellten Beispiels der Bewertung der Spielplatzsituation kann eine zu starke Auslastung zu verschiedenen Problemen führen, da überfüllte Spielplätze in ihrer Attraktivität sinken und somit für Besucherinnen und Besucher weniger Erholungswert bieten. Darüber hinaus können auch für Anwohnerinnen und Anwohner negative Folgen entstehen, z.B. eine starke Lärmbelastung. Beides sind Faktoren, die Einfluss auf die Livability nehmen.

Ein weiterer Diskussionspunkt ist die zeitliche Variabilität von Nachfrage, sprich viele Spielplätze (oder andere Einrichtungen) sind abhängig von Wochentag, Uhrzeit oder Wetter völlig unterschiedlich ausgelastet. Darauf muss die fiktive Kapazitätsgrenze Rücksicht nehmen, indem man sie ggf. an Wochenenden höher ansetzt. Unter Zuhilfenahme von Beobachtungen, Messungen oder Erfahrungen lassen sich entsprechend verschiedene Szenarien rechnen. Auch eine räumliche Differenzierung der Modellparameter kann sinnvoll sein. In ländlichen oder locker bebauten Strukturen sollten womöglich größere Versorgungszusammenhänge angenommen werden, wohingegen speziell in verdichteten Räumen gut durchdacht werden sollte, welche maximale Auslastung im Hinblick auf ein lebenswertes Wohnumfeld als vertretbar angenommen wird und ab wann man zusätzliche Kapazitäten für die Bevölkerung schaffen möchte. Die Einführung eines Kapazitätskriteriums gibt der Planung und Regionalentwicklung jedenfalls ein flexibles Werkzeug zur Erweiterung und Flexibilisierung von Analysen der Versorgungsqualität in die Hand und erlaubt es, Raumentwicklungsszenarien im Einklang mit strategischen Zielen durchzuspielen.

7 REFERENZEN

DEUTSCHES INSTITUT FÜR URBANISTIK: Leitkonzept – Stadt und Region der kurzen Wege. Gutachten im Kontext der Biodiversitätsstrategie, 2011, https://www.umweltbundesamt.de/sites/default/files/medien/461/publikationen/4151.pdf. Aufgerufen am 12.08.2022.

ISO: ISO 37120:2018 Sustainable Cities and Communities. Indicators for City Services and Quality of Life, 2018, https://www.iso.org/obp/ui/#iso:std:iso:37120:ed-2:v1:en. Aufgerufen am 10.08.2022.

KOVACS-GYÖRI, A., Cabrera-Barona, P., Resch, B., Meha, M.: Assessing and Representing Livability through the Analysis of Residential Preference. In: Sustainability 2019, 11, 4934.

SCHMITT, J., Gruber, G.: Assessment of Recreational Green Spacy Quality and Supply. In: GI_Forum 2018, 2, pp. 294-301.

STEUDE, A.: Sollte Bochum zur 15-Minuten-Stadt werden?, 2021, https://die-stadtgestalter.de/2021/01/10/sollte-bochum-zur-15-minuten-stadt-werden/. Aufgerufen am 22.08.2022.

TU WIEN: Smart Cities. Ranking of European Medium-sized Cities, 2007, http://www.smart-cities.eu/download/smart_cities_final_report.pdf. Aufgerufen am 09.08.2022.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Entwicklung eines elektrischen Carsharing-Angebots für den ländlichen Raum

Jan Silberer, Patrick Müller, Thomas Bäumer

(M.Sc. Jan Silberer, Hochschule für Technik Stuttgart, Schellingstr. 24, 70191 Stuttgart, jan.silberer@hft-stuttgart.de)
(Prof. Dr. Patrick Müller, Hochschule für Technik Stuttgart, Schellingstr. 24, 70191 Stuttgart, patrick.mueller@hft-stuttgart.de)
(Prof. Dr. Thomas Bäumer, Hochschule für Technik Stuttgart, Schellingstr. 24, 70191 Stuttgart, thomas.baeumer@hft-stuttgart.de)

1 ABSTRACT

Carsharing hat deutschlandweit das Potenzial, einen Beitrag zur Verringerung der Treibhausgase im Tansportsektor leisten zu können. Dabei ist es fraglich, ob sich erfolgreiche Carsharing-Angebote auch für den ländlichen Raum entwickeln lassen. Um herauszufinden, welche besonderen Herausforderungen aus Sicht der Nutzerinnen und Nutzer im ländlichen Raum bestehen, wurde in einem Partizipationsprozess mit Bürgerinnen und Bürger einer Ortschaft im ländlichen Raum ein elektrisches Carsharing-Angebot entwickelt. Wichtige Einflussfaktoren für die Nutzung des Carsharing-Angebots waren laut einer Umfrage mit 190 Bürgerinnen und Bürgern die Nützlichkeit im Alltag, der Spaß an der Nutzung und die Erreichbarkeit des Standorts. Qualitative Interviews mit 21 Bürgerinnen und Bürgern bestätigten diese Ergebnisse und lieferten Details zu deren Hintergründen. Zudem wurde die Fokussierung auf bestimmte Zielgruppen als wichtig gesehen. In anschließenden Workshops mit Bürgerinnen und Bürgern wurden darauf aufbauend konkrete Ideen für passende Carsharing-Modelle entwickelt. Dabei wurde unter anderem eine App mit einer Funktion zum Angebot von Mitfahrgelegenheiten gewünscht, um das Gemeinschaftsgefühl bei der Nutzung des Carsharing zu fördern. Insgesamt zeigt sich, dass es einige spezielle Anforderungen der Bürgerinnen und Bürger im ländlichen Raum hinsichtlich eines Carsharing-Angebots gibt, denen vor allem eine soziale Ausrichtung gemein ist. Um die größten Erfolgschancen mit einem Carsharing-Angebot im ländlichen Raum zu haben, sollten diese Wünsche mit maßgeschneiderten Lösungen adressiert werden.

Keywords: Ländlicher Raum, Elektrisches Carsharing, Nachhaltige Mobilität, Akzeptanz, Nutzerzentrierte Entwicklung

2 EINFÜHRUNG

Der Verkehrssektor verursacht in Europa ungefähr 25 % der Treibhausgase (European Environment Agency, 2020). Elektrisches Carsharing kann einen Beitrag dazu leisten diese Problematik einzudämmen.

Die Anzahl der Carsharing-Kunden in Deutschland ist in den letzten zehn Jahren von 0,26 Millionen auf 3,39 Millionen stark angestiegen (Bundesverband CarSharing, 2022). Zudem ist der Anteil an Elektrofahrzeugen in deutschen Carsharing Flotten von 2020 bis 2022 von 18,0 % auf 23,3 % gestiegen (Bundesverband CarSharing, 2022). Im ländlichen Raum gibt es jedoch besondere Herausforderungen wie weite Reisewege und eine geringe Populationsdichte für die Implementierung nachhaltiger Mobilitätslösungen wie ein elektrisches Carsharing (Cottrill, Brooke, Mulley, Nelson & Wright, 2020; Næss, Xue, Stefansdottir, Steffansen & Richardson, 2019).

Um diesen Herausforderungen gerecht zu werden, wurde im Projekt Smart2Charge (https://www.hft-stuttgart.de/forschung/projekte/aktuell/smart2charge) eine für den ländlichen Raum angepasste Lösung für elektrisches Carsharing unter partizipativer Einbindung relevanter Stakeholder-Gruppen mit Hilfe einer Umfrage, Interviews und Workshops entwickelt. Umgesetzt wurde das Projekt in der Gemeinde Wüstenrot in Süddeutschland mit 6600 Einwohnerinnen und Einwohnern. Dabei ging es um die Frage, welche besonderen Anforderungen bei einem Carsharing-Angebot im ländlichen Raum berücksichtigt werden sollten. Im Folgenden werden die zentralen Ergebnisse zu dieser Frage aus Umfrage, Interviews und Workshops vorgestellt und diskutiert.

3 UMFRAGE

Ziel der Umfrage war es, einen Überblick über die spezifischen Anforderungen der Bürgerinnen und Bürger einer Gemeinde im ländlichen Raum an ein elektrisches Carsharing zu gewinnen.

Es wurden 190 Bürgerinnen und Bürger befragt, die zu 68 % männlich und 32 % weiblich waren. Das Durchschnittsalter lag bei 53,6 Jahren (SD=14,6; range = 17-87). Es bestand ein mittelhohes Vorwissen zu Carsharing[1] (M=3,0; SD=1,1). Zudem gaben die Bürgerinnen und Bürger an, dass ihnen Nachhaltigkeit[2]

[1] Auf einer Skala von 1 (sehr niedrig) bis 5 (sehr hoch).

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

wichtig sei (M=4,2; SD=1,0) und sie gleichzeitig für den Weg zur Arbeit (82 %) sowie für den Weg zu Freizeitaktivitäten (83 %) am häufigsten das eigene Auto mit Verbrennungsmotor nutzen.

Grundlage für die Befragung war das weit verbreitete Technologieakzeptanzmodell Unified Theory of Acceptance and Use of Technology 2 (UTAUT 2) von Venkatesh, Thong und Xu (2012). Befragt wurden die Bürgerinnen und Bürger zu ihrer Nutzungsabsicht für elektrisches Carsharing, Nützlichkeit von Carsharing im Alltag, Einfachheit der Nutzung, sozialen Einflüsse auf die Nutzung, Erreichbarkeit der Stationen, Spaß an der Nutzung, sowie Vertrauen in die Verfügbarkeit, Reichweite und Ladedauer. Alle zuvor genannten Fragen wurden auf einer Skala von 1 (stimme überhaupt nicht zu) bis 5 (stimme vollkommen zu) beantwortet.

Um die Bedeutung der einzelnen Faktoren für die Nutzungsabsicht zu bestimmen, wurde eine multiple Regression gerechnet. Es zeigte sich, dass die Nützlichkeit von elektrischem Carsharing im Alltag der Bürgerinnen und Bürger ($\beta = .617$, $p < .01$) den höchsten Einfluss auf die Nutzungsabsicht für elektrisches Carsharing hatte. Der Spaß an der Nutzung ($\beta = .206$, $p < .01$) und der Erreichbarkeit der Stationen ($\beta = .079$, $p < .01$) hatten ebenfalls einen signifikanten Einfluss auf die Nutzungsabsicht, der aber vergleichsweise schwächer war.

Die auf der fünfstufigen Skala angegebene Nutzungsabsicht für das elektrische Carsharing war gering (M=2,2; SD=1,3). Zudem wurden die Nützlichkeit im Alltag (M=2,2; SD=1,2) von den Bürgerinnen und Bürgern als gering eingeschätzt. Die Erreichbarkeit der Stationen (M=2,9; SD=1,7) und der Spaß an der üNutzung (M=2,6; SD=1,2) wurden mittelhoch bewertet. Eine Zusammenfassung der Ergebnisse aus der Umfrage ist in Tabelle 1 zu finden.

Anforderungen	Nützlichkeit im Alltag	Spaß an der Nutzung	Erreichbarkeit
Wichtigkeit	Hoch	Mittel	Gering
Erfüllungsgrad	Gering	Mittel	Mittel

Tabelle 1: Zusammenfassung der Ergebnisse aus der Umfrage.

Obwohl die Bürgerinnen und Bürger nur ein mittelhohes Vorwissen zu Carsharing haben, sind die Voraussetzungen für ein elektrisches Carsharing grundsätzlich positiv in der Modell-Gemeinde. Die Mehrheit der Bürgerinnen und Bürger gab an, eigene PKWs mit Verbrennungsmotor für den Weg zur Arbeit und zu Freizeitaktivitäten zu nutzen, jedoch gleichzeitig das Thema Nachhaltigkeit im Mobilitätskontext sehr wichtig zu finden.

Die Bedeutung von Anforderungen an ein elektrisches Carsharing scheint im ländlichen Raum ähnlich zu sein wie im urbanen Raum. Es wurden bereits ähnliche Ergebnisse für die Nützlichkeit des Carsharings im Alltag (Curtale, Liao & van der Waerden, 2021; Müller, 2019; Tran, Zhao, Diop & Song, 2019), den Spaß an der Nutzung (Tran et al., 2019) und die Erreichbarkeit der Stationen (Shaheen & Cohen, 2013) im urbanen Raum gefunden. Dies unterstreicht die grundsätzliche Umsetzbarkeit eines solchen Angebots für den ländlichen Raum. Nichtsdestotrotz sollte berücksichtigt werden, dass das elektrische Carsharing in Wüstenrot zum Zeitpunkt der Umfrage nur als Konzept vorlag und noch nicht für die Bürgerinnen und Bürger verfügbar war. Es können je nach Marktreife eines Produkts unterschiedliche Anforderungen von Bürgerinnen und Bürgern gestellt werden (Adell & Várhelyi, 2008).

15 % der Bürgerinnen und Bürger gaben eine hohe Nutzungsabsicht[3] für das elektrische Carsharing an. Im deutschlandweiten Vergleich ist das etwas höher als der Durchschnitt von 13 % (IfD Allensbach, 2019). Die Nützlichkeit des Carsharings im Alltag und der Spaß an der Nutzung wurden (noch) als gering bewertet, wohingegen die Erreichbarkeit des Standorts als mittelhoch eingestuft wurde. Nach diesen Erkenntnissen entsprach das in der Umfrage vorgestellte Konzept des elektrischen Carsharings für den ländlichen Raum nur zum Teil den Ansprüchen der Bürgerinnen und Bürger bzw. war nur für eine Teilgruppe der Bürgerinnen und Bürger in Wüstenrot interessant. Was hierzu die genauen Hintergründe waren, wurde durch qualitative Interviews genauer untersucht, die im Folgenden vorgestellt werden.

[2] Auf einer Skala von 1 (stimme überhaupt nicht zu) bis 5 (stimme vollkommen zu).
[3] 4 oder 5 auf einer Skala von 1 (stimme überhaupt nicht zu) bis 5 (stimme vollkommen zu).

4 INTERVIEWS

Ziel der qualitativen Interviews war es, die Hintergründe der Anforderungen an ein elektrisches Carsharing im ländlichen Raum genauer zu ergründen und daraus Treiber und Barrieren abzuleiten.

Insgesamt wurden 21 Interviews mit Bürgerinnen und Bürgern durchgeführt. Von diesen waren sieben Mitarbeitende der Gemeinde Wüstenrot, sowie vier Mitarbeitende bzw. Geschäftsführende von örtlichen Unternehmen. Das Durchschnittsalter der Stichprobe betrug 44,0 Jahre (SD = 11,12, range = 21-62).

Hinsichtlich der Nützlichkeit des Carsharings im Alltag gaben die Bürgerinnen und Bürger an, dass diese nur bei bestimmten Zielgruppen gegeben sei. Die meisten Bürgerinnen und Bürger berichteten ein privates Fahrzeug zu besitzen und somit grundsätzlich keinen Bedarf für ein zusätzliches elektrisches Carsharing zu sehen. Jedoch konnten sie sich folgende Zielgruppen für ein elektrisches Carsharing vorstellen: Junge Menschen mit Führerschein aber (noch) ohne eigenes Fahrzeug, Haushalte mit einem Bedarf an einem kostengünstigen Zusatzfahrzeug für bestimmte Gelegenheiten, sowie Touristen und Geschäftsleute mit kurzfristigem Aufenthalt im ländlichen Raum. Beim Spaß an der Nutzung gaben die Bürgerinnen und Bürger an, besonders im neuartigen Antrieb von elektrischen Fahrzeugen eine reizvolle Produkteigenschaft des Carsharing-Angebots zu sehen. Die Erreichbarkeit von Stationen stellt laut Bürgerinnen und Bürgern eine mögliche Einschränkung dar, das elektrische Carsharing zu nutzen. Da die Gemeinde Wüstenrot sehr weitläufig ist und aus mehreren Ortsteilen besteht, müssten viele Bürgerinnen und Bürger ein weiteres Verkehrsmittel (z.B. öffentliche Verkehrsmittel oder das eigene Auto) nutzen, um zur Carsharing-Station zu kommen. Die öffentlichen Verkehrsmittel hätten hierfür eine zu geringe Taktung und das eigene Auto stelle einen gewissen Widerspruch zur wahrgenommenen Nachhaltigkeit des Mobilitätsangebots dar. Tabelle 2 fasst die Ergebnisse aus den qualitativen Interviews zusammen.

Anforderungen	Nützlichkeit im Alltag	Spaß an der Nutzung	Erreichbarkeit der Stationen
Treiber	Vorübergehender Bedarf an einem Auto	Interesse am Elektroantrieb	Carsharing-Station in Gehweite
	Bedarf eines kostengünstigen Zusatzfahrzeuges	-	-
Barrieren	Autobesitz	-	Betriebsfrequenz der öffentlichen Verkehrsmittel
	-	-	Anfahrt mit dem eigenen Auto nicht nachhaltig

Tabelle 2. Zusammenfassung der Ergebnisse aus den qualitativen Interviews.

Die Nützlichkeit des elektrischen Carsharings im Alltag ist aus Sicht der der Bürgerinnen und Bürger im ländlichen Raum nur bei bestimmten Zielgruppen gegeben. Dass Carsharing-Angebote für einzelne Zielgruppen eine höhere Relevanz besitzen, zeigt sich auch in Studien im urbanen Raum. So wurden Familien, die eines ihrer Fahrzeuge durch Carsharing ersetzen wollen, im urbanen Raum ebenfalls als Zielgruppe hervorgehoben (Burghard & Dütschke, 2019; Cantelmo et al., 2022). Auch Touristen (Danielis, Rotaris & Valeri, 2012) und Geschäftsleute (Burkhardt & Millard-Ball, 2006) wurden in früherer Forschung bereits als Zielgruppen genannt. Eine Zielgruppe, die speziell im ländlichen Raum eine besondere Rolle spielen könnte, sind junge Menschen mit Führerschein aber (noch) ohne eigenes Fahrzeug. Aufgrund der eingeschränkten Mobilitätsalternativen im ländlichen Raum im Vergleich zum urbanen Raum, könnte in dieser Gruppe eine hohe Nachfrage an einem Carsharing-Angebot bestehen. Ein elektrisches Carsharing für den ländlichen Raum auf die Bedürfnisse einer oder mehrerer der genannten Zielgruppen auszurichten, könnte die Nützlichkeit im Alltag für die Bürgerinnen und Bürger erhöhen. Der Spaß an der Nutzung durch den elektrischen Antrieb wurde ebenfalls im urbanen Raum schon von Ryghaug und Toftaker (2014) berichtet. Hier könnten Möglichkeiten, das elektrische Carsharing zu testen, den Spaß an der Nutzung erlebbar machen. Dass ein Carsharing zu Fuß oder mit öffentlichen Verkehrsmitteln erreichbar sein sollte, wurde auch für den urbanen Raum bereits von Roblot, Boisjoly, Francesco und Martin (2021) berichtet. Die Taktung von öffentlichen Verkehrsmitteln im ländlichen Raum sollte hier in Kooperation mit den lokalen Verkehrsbetrieben an die Anforderungen der Bürgerinnen und Bürger so weit wie möglich angepasst

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

werden. Zudem sollte die Erreichbarkeit der Carsharing-Fahrzeuge für so viele Bürgerinnen und Bürger wie möglich gewährleistet werden, was bei der Auswahl der Stations-Standorte berücksichtigt werden muss.

Um aus den zuvor genannten Erkenntnissen konkrete Ideen für die Umsetzung des Carsharing-Angebots zu generieren, wurden im nächsten Schritt Workshops mit Bürgerinnen und Bürgern durchgeführt.

5 WORKSHOPS

Ziel der Workshops war es, ein konkretes Konzept orientiert an den Anforderungen der Bürgerinnen und Bürger für elektrisches Carsharing im ländlichen Raum zu entwickeln. Insgesamt 17 Bürgerinnen und Bürger nahmen an den Workshops teil. Der Teilnehmerkreis war hierbei bewusst heterogen zusammengesetzt, um möglichst viele Sichtweisen mit zu berücksichtigen. So nahmen Mitarbeiterinnen, Mitarbeiter, Inhaberinnen und Inhaber lokaler Unternehmen, Mitarbeiterinnen und Mitarbeiter der Stadtverwaltung, Vertreterinnen und Vertreter des Vereins für Elektromobilität, Besitzerinnen und Besitzer von Elektrofahrzeugen, Pendlerinnen, Pendler, Rentnerinnen und Rentner an den Workshops teil. Das Durchschnittsalter der Stichprobe betrug 44,18 Jahre, war aber bewusst breit gestreut (SD = 14,52; Spanne = 20-76).

Im ersten Schritt gab es einen Rückblick auf die Ergebnisse aus der Umfrage und den Interviews, um den Fokus auf die Anforderungen der Gesamtheit der Bürgerinnen und Bürger in der Gemeinde zu lenken. Zudem wurden vier bestehende Carsharing-Modelle vorgestellt: Free-floating (ohne feste Stationen), stationsbasiert (mit Stationen in jedem Ortsteil), hosting[4] und gebietsbezogen[5]. Dann konnten die Bürgerinnen und Bürger in Gruppen gemeinsam ein Modell nach ihren Anforderungen entwickeln und nach gegenseitiger Vorstellung ihrer Modelle das bevorzugte Modell wählen. Tabelle 3 zeigt die von den Bürgerinnen und Bürgern entwickelten Modelle zum elektrischen Carsharing im ländlichen Raum.

	Modell 1	Modell 2	Modell 3
Typ	Stationsbezogen	Hosting	Stationsbezogen
Anforderungen	Abholung und Zustellung von Fahrzeugen Verschiedene Fahrzeugtypen	Video-Bewerbungswettbewerb für interessierte Gastgeber	Testfahrten Ermäßigungen Prämienpunkte Abholservice für Fahrzeuge Mitfahrgelegenheits-Funktion

Tabelle 3. Zusammenfassung der Ergebnisse des Workshops (n = 17).

Nach gegenseitiger Vorstellung wählten die Teilnehmerinnen und Teilnehmer das Modell 3 zu ihrem bevorzugten Modell. Es enthält größtenteils im urbanen Raum übliche Anforderungen, aber auch manche Anforderungen, die im ländlichen Raum als wichtiger gesehen werden könnten. Übliche Anforderungen für den urbanen Raum sind feste Standorte für die Fahrzeuge, Ermäßigungen und Prämienpunkte. Dies kann bestehenden Carsharing Angeboten wie Stadtmobil (Stadtmobil, 2022) oder Share Now (Share Now, 2022) entnommen werden. Sie könnten eine gute Basis für ein Carsharing im ländlichen Raum bieten. Ebenso wurde ein Abholservice für Fahrzeuge, der nach Beendigung der Fahrt einen Rücktransport arrangiert, bereits unter dem Begriff One-Way Carsharing im urbanen Raum diskutiert (Boyacı & Zografos, 2019). Durch eine Umsetzung könnte eine höhere Nützlichkeit im Alltag erreicht werden, da hiermit auch Fahrten ohne baldigen Rückweg wie beispielsweise der Weg zur Arbeit oder Tagesausflüge attraktiver wären. Eine Mitfahrgelegenheitsfunktion integriert in die Buchungs-App des elektrischen Carsharings könnte eine Anforderung sein, die im ländlichen Raum stärker priorisiert wird als im urbanen Raum. In der Gemeinde Wüstenrot gibt es beispielsweise bereits eine „Mitfahrbank“, auf der sich Bürgerinnen und Bürger setzen können, um von Privatpersonen im Auto mitgenommen zu werden. Dies passt auch zur Arbeit von Rotaris und Danielis (2018), die hervorheben, dass Carsharing im ländlichen Raum sozialer ausgerichtet sein muss als im urbanen Raum. In diesem Sinne kann in den Workshops auch die Idee eines „privaten“ Car-Sharings

[4] Einzelne registrierte Mitglieder sind als „Host“ für ein Auto und dessen Stellplatz verantwortlich und erhalten im Gegenzug Vergünstigungen bei der Nutzung des Fahrzeugs

[5] Fahrzeuge können innerhalb eines eng umgrenzten Areals an einem beliebigen freien Stellplatz abgestellt werden

auf, bei dem sich eine feste Gruppe an Bürgerinnen und Bürgern ein Auto teilt und sich auch gemeinsam um das Auto und den Stellplatz kümmert.

6 DISKUSSION

Für eine Modell-Gemeinde im ländlichen Raum wurde ein elektrisches Carsharing-Angebot unter partizipativer Beteiligung unterschiedlicher Stakeholder-Gruppen entwickelt. Dabei sollte herausgefunden werden, ob und welche spezifischen Anforderungen an ein solches Carsharing-Angebot im ländlichen Raum bestehen. Zusammenfassend kann gesagt werden, dass die Anforderungen an ein elektrisches Carsharing im ländlichen Raum denen im urbanen Raum überwiegend gleichen. Die Nützlichkeit im Alltag ist dabei ein besonders wichtiger Aspekt, aber auch der Spaß an der Nutzung und die Erreichbarkeit der Fahrzeuge spielen eine bedeutsame Rolle[6]. Um die Nützlichkeit im Alltag für die Bürgerinnen und Bürger zu erhöhen, könnte es sinnvoll sein, bestimmte Zielgruppen vor allem in der Kommunikation besonders zu berücksichtigen: Bürgerinnen und Bürger mit einem Bedarf für ein kostengünstiges Zusatzfahrzeug, sowie Touristen und Geschäftsleute sind sowohl im urbanen als auch im ländlichen Raum relevant. Spezifisch für den ländlichen Raum könnte die Gruppe junger Menschen sein, die als Fahranfänger zwar einen Führerschein aber (noch) kein eigenes Auto besitzen. Eine Fokussierung auf die Anforderungen und die gezielte Ansprache der genannten Zielgruppen könnte erfolgsversprechend sein. Beispielsweise wäre es denkbar, innerhalb von Fahrschulen auf das Carsharing Angebot in der Gemeinde hinzuweisen und so spezifisch junge Fahranfänger als Nutzerinnen und Nutzer zu gewinnen. Zur Steigerung des Spaß an der Nutzung kann das Interesse der Bürgerinnen und Bürger am elektrischen Antriebssystem genutzt werden. Dieser Treiber für elektrisches Carsharing ist auch im urbanen Raum zu finden. Testfahrten könnten hierbei erlebbar machen, dass ein elektrisches Carsharing aufgrund des neuen Fahrgefühls besonderen Spaß machen kann. Bei der Erreichbarkeit der Fahrzeuge sind, ebenfalls wie im urbanen Raum, Stationen in Gehweite eine Anforderung der Bürgerinnen und Bürger. Dies stellt allerdings im ländlichen Raum aufgrund der geringen Bevölkerungsdichte eine Herausforderung dar. Bei der Wahl eines Carsharing Modells gibt es einige Aspekte, die im urbanen wie im ländlichen Raum gleichermaßen relevant sind. Ein stationsbasiertes Carsharing Modell mit Ermäßigungen und Prämienpunkten könnte vom urbanen Raum übernommen werden. Anforderungen spezifisch für den ländlichen Raum sind dabei eine Mitfahrgelegenheitsfunktion integriert in die Buchungs-App und ein Service zur Abholung der Fahrzeuge nach Beendigung der Fahrt. Eine Mitfahrgelegenheitsfunktion könnte den Spaß an der Nutzung steigern, da es Spaß machen könnte, sich mit anderen Bürgerinnen und Bürgern während der Fahrt zu unterhalten. Ein Service zur Abholung der Fahrzeuge nach Beendigung der Fahrt könnte auch Fahrten ohne baldige Rückfahrt wie beispielsweise der Arbeitsweg oder Tagesausflüge attraktiver für die Bürgerinnen und Bürger machen und somit die Nützlichkeit des elektrischen Carsharings im Alltag der Bürgerinnen und Bürger erhöhen. Als Nebenbefund hat sich die Idee eines “privaten” Carsharing als zusätzliches Angebot gezeigt. Dies könnte eine besondere Form des Carsharings für den ländlichen Raum darstellen, die zu den gemeinschaftlichen Ansprüchen der Bürgerinnen und Bürger passt.

Zusammengefasst zeigen die Ergebnisse, dass Carsharing auch im ländlichen Raum ein umsetzbares Angebot darstellt, das die bisherigen Mobilitätsangebote ergänzen kann. Bei der Umsetzung kann man sich hinsichtlich vieler Aspekte an den Erfahrungen aus dem urbanen Raum orientieren. Zusätzlich sollte man aber die Besonderheiten des ländlichen Raums mitberücksichtigen. Zum einen sollte man hier verstärkt die Zielgruppen adressieren, für die Carsharing vor allem nützlich ist (z.B. junge Fahranfänger ohne eigenes Auto). Zum anderen sollte man sozial-gemeinschaftliche Aspekte (z.B. über Mitfahrgelegenheitsfunktion in Buchungs-App) berücksichtigen, die im ländlichen Raum die Attraktivität des Angebots erhöhen können. Somit stellt Carsharing auch im ländlichen Raum eine sinnvolle Ergänzung dar, die zur Verringerung der Treibhausgase im Tansportsektor beitragen kann.

7 LITERATURVERZEICHNIS

Adell, E. & Várhelyi, A. (2008). Driver comprehension and acceptance of the active accelerator pedal after long-term use. Transportation Research Part F: Traffic Psychology and Behaviour, 11(1), 37–51. https://doi.org/10.1016/j.trf.2007.05.006

[6] Dabei muss berücksichtigt werden, dass das elektrische Carsharing in der aktuellen Gemeinde nur auf einer konzeptionellen Ebene präsentiert wurde und sich die Anforderungen nach ersten Nutzungserfahrungen noch ändern können.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Boyacı, B. & Zografos, K. G. (2019). Investigating the effect of temporal and spatial flexibility on the performance of one-way electric carsharing systems. Transportation Research Part B: Methodological, 129, 244–272. https://doi.org/10.1016/j.trb.2019.09.003

Bundesverband CarSharing. (2022). Anteil der Elektrofahrzeuge an den Carsharing-Flotten in Deutschland in den Jahren 2020 bis 2022 (in Prozent). Zugriff am 22.08.2022. Verfügbar unter: https://de.statista.com/statistik/daten/studie/695105/umfrage/anteil-der-elektrofahrzeuge-an-carsharing-flotten-in-deutschland/

Burghard, U. & Dütschke, E. (2019). Who wants shared mobility? Lessons from early adopters and mainstream drivers on electric carsharing in Germany. Transportation Research Part D: Transport and Environment, 71, 96–109. https://doi.org/10.1016/j.trd.2018.11.011

Burkhardt, J. E. & Millard-Ball, A. (2006). Who is Attracted to Carsharing? Transportation Research Record, 1986(1), 98–105. https://doi.org/10.1177/0361198106198600113

Cantelmo, G., Amini, R. E., Monteiro, M. M., Frenkel, A., Lerner, O., Tavory, S. S. et al. (2022). Aligning users' and stakeholders' needs: How incentives can reshape the carsharing market. Transport Policy, 126, 306–326. https://doi.org/10.1016/j.tranpol.2022.07.009

Cottrill, C. D., Brooke, S., Mulley, C., Nelson, J. D. & Wright, S. (2020). Can multi-modal integration provide enhanced public transport service provision to address the needs of vulnerable populations? Research in Transportation Economics, 83, 100954. https://doi.org/10.1016/j.retrec.2020.100954

Curtale, R., Liao, F. & van der Waerden, P. (2021). User acceptance of electric car-sharing services: The case of the Netherlands. Transportation Research Part A: Policy and Practice, 149, 266–282. https://doi.org/10.1016/j.tra.2021.05.006

Danielis, R., Rotaris, L. & Valeri, E. (2012). Carsharing for tourists. Rivista Italiana di Economia, Demografia e Statistica, LXVI(2), 103–119. Verfügbar unter: https://www.researchgate.net/profile/eva-valeri/publication/236951038_carsharing_for_tourists

European Environment Agency. (2020). Transport: increasing oil consumption and greenhouse gas emissions hamper EU progress towards environment and climate objectives. Verfügbar unter: http://resp.llas.ac.cn/c666/handle/2xk7jswq/251535

IfD Allensbach (Statista, Hrsg.). (2019). Anzahl der Personen in Deutschland, die Carsharing nutzen oder sich dafür interessieren, in den Jahren 2015 bis 2019 (in Millionen). Zugriff am 22.08.2022. Verfügbar unter: https://de.statista.com/statistik/daten/studie/257867/umfrage/carsharing-interesse-und-nutzung-in-deutschland/

Müller, J. M. (2019). Comparing Technology Acceptance for Autonomous Vehicles, Battery Electric Vehicles, and Car Sharing—A Study across Europe, China, and North America. Sustainability, 11(16), 4333. https://doi.org/10.3390/su11164333

Næss, P., Xue, J., Stefansdottir, H., Steffansen, R. & Richardson, T. (2019). Second home mobility, climate impacts and travel modes: Can sustainability obstacles be overcome? Journal of Transport Geography, 79, 102468. https://doi.org/10.1016/j.jtrangeo.2019.102468

Roblot, M., Boisjoly, G., Francesco, C. & Martin, T. (2021). Participation in Shared Mobility: An Analysis of the Influence of Walking and Public Transport Accessibility to Vehicles on Carsharing Membership in Montreal, Canada. Transportation Research Record, 2675(12), 1160–1171. https://doi.org/10.1177/03611981211032221

Rotaris, L. & Danielis, R. (2018). The role for carsharing in medium to small-sized towns and in less-densely populated rural areas. Transportation Research Part A: Policy and Practice, 115, 49–62. https://doi.org/10.1016/j.tra.2017.07.006

Ryghaug, M. & Toftaker, M. (2014). A Transformative Practice? Meaning, Competence, and Material Aspects of Driving Electric Cars in Norway. Nature and Culture, 9(2), 146–163. https://doi.org/10.3167/nc.2014.090203

Shaheen, S. A. & Cohen, A. P. (2013). Carsharing and Personal Vehicle Services: Worldwide Market Developments and Emerging Trends. International Journal of Sustainable Transportation, 7(1), 5–34. https://doi.org/10.1080/15568318.2012.660103

Share Now. (2022). Zugriff am 22.08.2022. Verfügbar unter: https://www.share-now.com/de

Stadtmobil. (2022). Zugriff am 22.08.2022. Verfügbar unter: https://www.stadtmobil.de/

Tran, V., Zhao, S., Diop, E. B. & Song, W. (2019). Travelers' Acceptance of Electric Carsharing Systems in Developing Countries: The Case of China. Sustainability, 11(19), 5348. https://doi.org/10.3390/su11195348

Venkatesh, Thong & Xu. (2012). Consumer Acceptance and Use of Information Technology: Extending the Unified Theory of Acceptance and Use of Technology. MIS Quarterly, 36(1), 157. https://doi.org/10.2307/41410412

8 DANKSAGUNG

Diese Studie wurde im Rahmen des Projekts Smart2Charge durchgeführt, welches vom Bundesministerium für Wirtschaft und Klimaschutz (BMWK) im Rahmen des 7. Energieforschungsprogramms Innovationen für die Energiewende unter der Nummer 03EN3009A gefördert wurde.

Exploring the Spatial Impact of MRT Gentrification by Different Processes: Taipei City MRT Station as an Example

Li Shan Su, Tzu-Ling Chen

(Li Shan Su, University of Taipei,voukry@gmail.com)
(Tzu-Ling Chen, University of Taipei,G11050007@gmail.com)

1 ABSTRACT

In recent years, the tod model of urban development driven by public transportation systems has emphasized public transportation to achieve the concept of green transportation and sustainable development. It has been proven in the literature that MRT stations can reduce air pollution and energy consumption, improve transportation efficiency, accessibility, and land value, etc. However, these changes have led to higher local affordability costs, attracting affordable communities and businesses to develop and replace existing households or small and medium-sized enterprises, resulting in academic discussions of MRT-induced gentrification. This study investigates the impact of MRT station gentrification and the surrounding space, and examines the spatial and temporal effects of MRT station gentrification in Taipei City from 2012 to 2019. The study uses the area around the MRT stations in Taipei City as the target population, and distinguishes the early, middle, and late gentrification patterns in Taipei City through the ratio of residential housing price increase, education level, and household income, and further examines the demographic structure of the significant area.

Keywords: transit-oriented development, neighbourhood, changes, gentrification, urban planning

2 INTRODUCTION

In the field of land research, the term "gentrification" was first introduced in 1964 by the British sociologist Ruth Glass, who observed that the middle class in London, England, had replaced the areas formerly inhabited by the working class and thus changed the characteristics of the area, resulting in the renovation and beautification of the buildings in the area, the revival of the formerly decaying areas, and the change of social characteristics due to the change of class structure. This phenomenon is called "gentrification". This phenomenon has a negative impact on the disadvantaged groups and is usually accompanied by the relocation of families to the suburbs, increased cost of living, and social conflicts, which has led to a lot of international studies and discussions on gentrification. New York (Freemam & Bracoin, 2004), Seoul (Ha, 2004), Istanbul (Ergun, 2004), Stockholm (Millard-Ball, 2004), Mexico (Jones & Varley, 1999), and several cities in South Africa (Visser, 2002). The study of gentrification has also extended to various gentrification research directions, including humanities, ecology and social culture, quality of public facilities, political and economic perspectives, and housing market. For example, Sims (2021) and Qian (2018) confirmed that urban renewal areas have changed the demographic characteristics, showing that more residents and businesses move out every 200 meters; Boterman (2020), Candipan (2020) and Pearman (2020) confirmed that school choice increases the percentage of gentrification. However, as urban transit systems improve, Bardaka (2018), Chava (2021), and Deka (2017) confirm that transit systems have led to socioeconomic changes around transit, such as higher household income, higher housing prices, and an increase in whiteness.

After World War II, many emerging cities began to develop their public transit systems to achieve transportation efficiency and sustainable urban development. In East Asia, mass transit systems were built in Beijing (1969), Pyongyang (1973), Seoul (1974), Hong Kong (1979), Singapore (1987), Shanghai (1993), Kuala Lumpur (1996), Taipei (1996), Guangzhou (1997), and Bangkok (2004), and their regional spatial impacts include LeRoy (1983) was the first to suggest the impact of transportation innovations on gentrification, showing that transportation innovations lead to changes in the location of households of different incomes. This is reflected in the fact that households will consider income, rent, and transportation costs as the main factors for their residential location. Based on the above theories, transportation-induced gentrification is beginning to be supported worldwide, such as Lin's 2002 study on the impact of Chicago's rapid transit on gentrification. In the past literature, the impact of gentrification on urban areas was mostly focused on urban regeneration, such as Kovács, Z. (2013), who studied urban regeneration in the inner city of Budapest, and Ha, S.K. (2004), who focused on the contribution of urban regeneration to the development

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

of residents and communities in Seoul. Therefore, this study uses the example of MRT stations in Taipei City, Taiwan, to investigate the relationship between MRT-induced gentrification.

According to the literature, Jyothi Chava & John L. Renne (2021) studied the negative impact of the construction of new light rail stations on black and low-income households, and the data showed that the proportion of blacks in the nearby census tracts decreased due to the entry of the new light rail, and the corresponding proportion of whites increased significantly. Lin (2002) uses LeRoy's (1983) model to analyze changes in land values over a three-year period, confirming evidence of increased land values due to the presence of MRT stations; Zheng & Kahn (2013) argue that investors who advance the construction of a new light rail station in an area that has not yet been served by the MRT will be able to afford it. Brown (1993) argues that accessibility is considered to be one of the main factors in determining the location of businesses. With the increase of MRT operating years, the impact of MRT-induced commercial gentrification tends to expand, and the impact of MRT-induced commercial gentrification varies with the change of land use in the stations. Therefore, this study focuses on the spatial effects around the MRT stations in terms of housing value and population characteristics changes.

In the above literature, the research results support the argument of transportation-induced gentrification, however, it is clear from the literature that the changes of transportation-induced gentrification change over time, and the scope of impact also varies with the distance and land use of the stations. (2010) compared the gentrification index of 12 transit stations using census data from 1990 to 2000; Feinstein & Allen (2008) studied data from 1970 to 2000 and compared the gentrification change index of Boston transit census tracts and other census tracts; Brown (2016) compared the gentrification index of the Orange Line in Los Angeles to the gentrification index of 10 TODs opened before 2012. Brown (2016) compared the change in demographic indicators within 2 and 5 village of the stations, using 10 stations opened by 2012 as targets. Therefore, to support the spatial impact of MRT-induced gentrification, this study collected data from 2012 to 2019, and divided Taipei City MRT stations into three zones according to different operating periods to compare the demographic changes of stations at different distances.

The purpose of the study is:

(1) Development Stage of Taipei City MRT Gentrification

(2) Spatial Influence of MRT Gentrification in Taipei City

(3) Spatial and Temporal Influences of MRT Gentrification in Taipei City

3 RESEARCH FRAMEWORK

3.1 Classification principles of gentrification stage

When the development potential of an area is underestimated, i.e., the socio-economic indicators need to be lower than the regional average, and investors or high-income residents realize the development potential of the area, the phenomenon of gentrification occurs. With the increase of the upper class population, the vulnerable population cannot afford the higher housing market, resulting in the displacement of the vulnerable population from their homes or to the less accessible suburban areas. Therefore, the definition of gentrification stages should be classified according to "vulnerable population", "demographic change" and "real estate value", and the data should be compared with the city average and classified into different gentrification stages according to real estate prices and demographic conditions.

(1) Gentrification-prone stage

I. The area contains a high vulnerable population, i.e., the population with low education and household income; the area does not have a population replacement phenomenon, i.e., the demographic change with low increase in education and household income; the area has a low real estate price and is near a high value, i.e., the real estate price is low to medium and is near a high housing price area.

(2) Early gentrification

I. The area contains a high vulnerable population, i.e., a population with low education and low household income; the area does not experience population replacement, i.e., demographic changes with low increases in education and household income; the area's real estate prices show II. accelerated appreciation, i.e., real estate prices increase at a high rate but remain at a low to medium rate.

The area begins to attract the middle-class population, i.e., the population with high education and income starts to increase, but still contains a highly vulnerable population; the area also begins to experience population replacement, i.e., demographic changes in education and household income with medium to high rates of increase; the area's real estate prices show I. low values and are close to high values, i.e., the area's real estate prices are still medium to low and are surrounded by areas with high housing prices.

(3) Mid-term gentrification stage

I. The area begins to attract the middle class population, i.e., the population with high education and income starts to increase, but still contains a high vulnerable population; the area begins to experience population replacement, i.e., the demographic change of education and household income population with medium to high increase; the real estate price of the area shows II. accelerated appreciation, i.e., the real estate price increases at a high value but the real estate price remains at a medium to low value.

(4) In the late stage of gentrification

I. The area already contains more middle class population, i.e., the area contains high education and income population and no longer has high vulnerable population; the area has experienced population replacement, i.e., the rate of increase of education and household income population is medium-high; the area's real estate price shows III. continuous appreciation, i.e., the rate of increase of real estate price is high and the real estate price is still high.

II. Due to the limitation of the study period, the earliest data is obtained in 2012, so the early and late II areas of the study already contain more middle class population, i.e., they contain high education and income population and no longer have high vulnerable population; the real estate prices of the areas show IV. both high values, i.e., the real estate prices of both the early and late areas of the study are high.

3.2 Classification of MRT Stations

The Center for Transit Oriented Development (CfTOD) (2008) in the U.S. refers to the relationship between the value of transit facilities at different stages of operation. In the value curve of transportation, housing prices are affected by the announcement of transportation construction plans, the start of operation, and changes in residential investment and business patterns in the vicinity after the construction. Therefore, this study analyzed the socio-economic changes of Taipei City MRT stations according to their operating years, and classified them into three categories: early operating stations, mid-operating stations, and late operating stations, using five-year intervals. The early operating stations are Muzha Line, Danshui Line, Xindian Line, Zhonghe Line, Nangang Line, and Banqiao Line; the mid-operating stations are extended in nature (MRT lines); and the late operating stations are Wenhu Line and Xinyi Line.

3.3 Principles of selecting variables for the effect of MRT gentrification areas

This study focuses on the spatial effects of the gentrification of MRT. Referring to the review of literature on demographic changes and real estate price changes, the study should focus on demographic changes in addition to education level and household income variables, and should go deeper into the variables of the vulnerable population who are vulnerable to displacement, including the elderly population and youth groups, population density, low-income households, and migrating population. However, the affordability of housing in the area should also be included in the variables, including the rent-to-income ratio of housing prices. Therefore, in order to investigate the spatial effects of MRT gentrification, in addition to housing prices, the physical properties of housing should include age, building type (condominiums, luxury buildings, etc.), building size, and rent.

(1) Rent

The rent gap theory was first proposed by Smith (1979), and many studies have further extended it, for example, Clark (1988) provided a basic explanation for gentrification from a Marxist perspective. The land rent gap is the difference between the level of potential land rent and the actual land rent capitalized under current land use. The theory states that investment in the real estate market will only take place when there is a sufficient rent gap. The rent gap increases rents and the supply of real estate, which in turn leads to migration between different classes. In Taiwan, ping is the commonly used unit of area (3.3m2). These two results are also used in previous gentrification studies, including Badcock (1989), Yung & King (1998), Feinstein & Allen (2011), Cavers & Patterson (2015), Kahn (2007), and Zheng & Kahn (2013).

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

(2) Real estate prices

Su et al. (2021) explain the conceptual framework affecting real estate prices using the characteristic price model (Rose, 1974) and the TOD neighborhood structure. Real estate prices are affected by changes in the surrounding environment through factors such as (1) residential physical attributes, (2) accessibility attributes, and (3) environmental characteristics (Goodman,1989; Williams,1991), where residential physical attributes include building age, gross floor area, lot size, type of materials and finishes, neighborhood size, number of rooms, maintenance conditions, and structural condition (In addition, environmental characteristics include socioeconomic, external factors, local government (Chin&Chau, 2003), and public facilities (Roe et al., 2004). The value of the area varies greatly depending on the attributes. In addition, the impact of different stations in a region varies, with stations having little or no impact on housing prices in some areas, but a large impact in others (Wardrip, 2011).

4 RESEARCH METHODOLOGY

(1) LandSuitabilityAnalysis

LandSuitabilityAnalysis refers to the process of analyzing the relationship between the current land use status and nature, the natural environment, and the human environment before the land use plan is prepared, in order to analyze the potential and limitations of the natural environment on various land uses. The purpose is to ensure that development is compatible with environmental conservation objectives and to effectively allocate resources in the most appropriate spatial manner. The analysis covers a wide range of aspects of the original suitability of the various lands and uses within the area, including existing and possible future use restrictions and potentials. Among the factors considered, emphasis is placed on the types and intensity of various land uses and other opportunities, i.e., the suitability and unsuitability of a particular use or type of use are considered in the analysis.

(2) The Analysis of Variance

One-way analysis of variance (ANOVA) is a statistical method used to determine the difference between the means of three or more groups when the analysis contains a single independent variable or factor and the objective is to check whether the variables or different degrees of factors have a measurable effect on the corresponding variables. ANOVA is a statistical method for detecting the null hypothesis (H0), which assumes that three or more parent means are equal, and the alternative hypothesis (Ha), which assumes that at least one of the means is not equal.

$$H_0: \mu_1 = \mu_2 = \cdots = \mu_K$$

$$H_a: \text{not all means are equal}$$

One-way analysis of variance (ANOVA) is used to compare the mean differences between multiple groups, in the method of comparing whether the means are the same. The total variance formula is as follows.

$$\text{SST} : \text{SSB+ SSW}$$

$$\text{TSS} : \sum_i \sum_j (Y_{ij} - \bar{Y})^2$$

$$\text{BSS} : \sum_i n_i \, (\bar{Y}_i - \bar{Y}_{toatal})^2$$

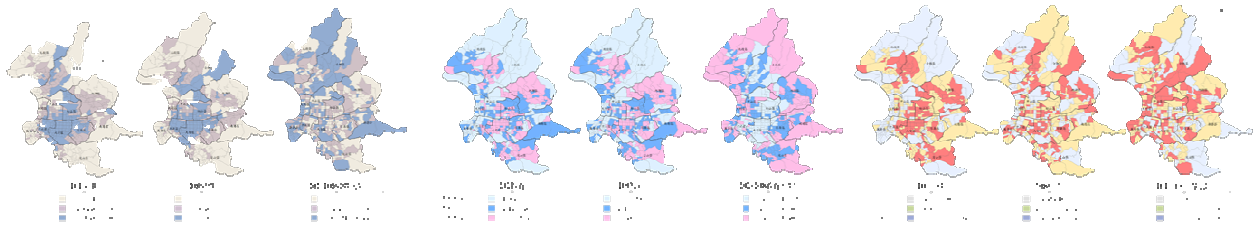
$$\text{WSS} : \sum_i \sum_j (Y_{ij} - \bar{Y}_i)^2$$

5 PRELIMINARY RESULTS

In measuring the gentrification stage variables, the housing price indicators were selected for analysis, and the housing price information in the real price register was used to select residential use as the data for analysis; the year of completion of the original column was replaced by the variable housing age as the data for analysis; the transactions of friends, relatives, employees, or other special relationships, and the transactions of rough housing that affect the housing price were removed from the real price register variables. Due to the classification principle of the gentrification stage, the real estate price data are divided into three categories of data: (1) the tertile of real estate price in 2012, (2) the tertile of real estate price change in 2019, and (3) the ratio of real estate price increase in 2012 to 2019. The data are presented in detail according to the type of data.

Among the variables measuring the gentrification stage, educational attainment indicators were selected for the analysis, and the number of people who graduated from tertiary institutions or above was screened out. Due to the classification principle of the gentrification stage, the educational attainment data are divided into the following three data categories: (1) tertile of educational attainment in 2012, (2) tertile of change in educational attainment in 2019, and (3) ratio of increase in educational attainment from 2012 to 2019. The data are presented in detail according to the type of data.

In measuring the gentrification stage, the median household income of each mile was used as the indicator of household income for analysis. Due to the classification principle of the gentrification stage, the household income data are divided into the following three data categories: (1) the tertile of household income in 2012, (2) the tertile of household income change in 2019, and (3) the ratio of household income increase from 2012 to 2019. The data are presented in detail according to the type of data.



(1) Gentrification-prone stage

There are a total of 14 villages in the gentrification stage, and the neighborhoods are mainly located in the following administrative districts: Shihlin District contains 3 villages, Daan District contains 3 villages distributed in, Zhongzheng District contains 1 village, Wenshan District contains 1 village, Beitou District contains 1 village, Songshan District contains 3 villages, and Wanhua District contains 1 village.

(2) Early gentrification

In the early gentrification stage I, there were 5 villages, and each neighborhood was mainly located in the following administrative districts: Hsinyi District contained 1 village, Chungcheng District contained 1 village, Wanhua District contained 1 village, Shilin District contained 1 village, and Beitou District contained 1 village.

During the Early Gentrification Stage II, there were a total of 83 village, which were mainly distributed in the following administrative districts: 2 village in Songshan District, 6 village in Xinyi District, 8 village in Zhongshan District, 1 league in Zhongzheng District, 9 village in Datong District, 11 village in Wanhua District, 10 village in Wenshan District, 5 village in Nangang District, 13 village in Neihu District, 5 village in Shilin District, and 13 village in Beitou District.

(3) Mid-term gentrification stage

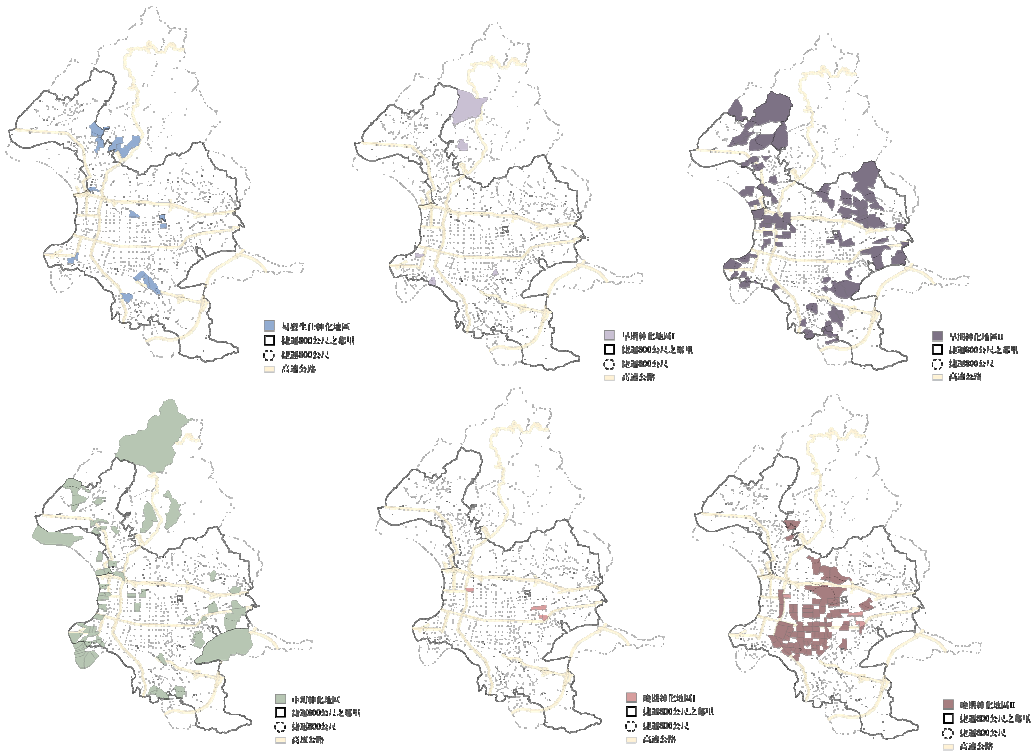
There are a total of 58 village in the mid-term gentrification stage, and the neighborhoods are mainly located in the following administrative districts: Xinyi District contains 2 village, Daan District contains 1 village, Zhongshan District contains 4 village, Zhongzheng District contains 2 village, Datong District contains 5 village, Wanhua District contains 18 village, Wenshan District contains 3 village, Nangang District contains 5 village, Neihu District contains 2 village, Shilin District contains 8 village, and Beitou District contains 8 village.

(4) In the late stage of gentrification

In the Late Gentrification Stage I, there are 4 village, and each neighborhood is mainly located in the following administrative districts: Hsinyi District contains 2 village, Songshan District contains 1 village, Zhongshan District contains 1 league, and Hsinyi District contains 1 village.

In the Late Gentrification Stage II, there are 75 leagues, and the neighborhoods are mainly located in the following administrative districts: Hsinyi District contains 3 leagues, Songshan District contains 12 leagues, Xinyi District contains 1 league, Daan District contains 33 leagues, Zhongzheng District contains 9 leagues, Neihu District contains 1 league, and Shilin District contains 4 leagues.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER



6 CONCLUSION

In this study, we used "vulnerable population", "population change" and "real estate value" to classify the gentrification process in Taipei City, and compared the data with the city average. From the results of the gentrification process in Taipei City, the areas prone to gentrification are mainly in Shilin and Beitou, while the early and middle stages of gentrification are mainly in the outer administrative areas of Taipei City, and the late stages of gentrification are in the city center of Taipei City. By examining the results of the gentrification process, we can prioritize the policy to prevent the problem of dislocation brought by gentrification.

7 REFERENCES

(Baker & Lee, 2019; Booi & Boterman, 2020; Candipan & Brazil, 2020; Cervero & Landis, 1997; Chava & Renne, 2022; Ergun, 2004; Jandl, Asmussen, Omé, & Ohnson, 2006; Lees, 2014; Lewis-Workman & Brod, 1997; Louvet et al., 2005; Nassif et al., 2017; Visser, 2002; 李承嘉, 2000)

Baker, D. M., & Lee, B. (2019). How does light rail transit (LRT) impact gentrification? Evidence from fourteen US urbanized areas. Journal of Planning Education and Research, 39(1), 35-49.

Booi, H., & Boterman, W. R. (2020). Changing patterns in residential preferences for urban or suburban living of city dwellers. Journal of Housing and the Built Environment, 35(1), 93-123.

Candipan, J., & Brazil, N. (2020). The neighborhood context of school openings: Charter school expansion and socioeconomic ascent in the United States. Journal of Urban Affairs, 1-26.

Cervero, R., & Landis, J. (1997). Twenty years of the Bay Area Rapid Transit system: Land use and development impacts. Transportation Research Part A: Policy and Practice, 31(4), 309-333.

Chava, J., & Renne, J. L. (2022). Transit-Induced Gentrification or Vice Versa? A Study of Neighborhoods Around Light Rail Stations From 1970–2010. Journal of the American Planning Association, 88(1), 44-54.

Ergun, N. (2004). Gentrification in Istanbul. Cities, 21(5), 391-405.

Jandl, R., Asmussen, K., Omé, M., & Ohnson, D. (2006). The Role of Forests in Carbon Cycles. Sequestration, and Storage, IUFRO Newsletter(4-2006).

Lees, L. (2014). Gentrification in the global south? The Routledge handbook on cities of the global south (pp. 528-543): Routledge.

Lewis-Workman, S., & Brod, D. (1997). Measuring the neighborhood benefits of rail transit accessibility. Transportation Research Record, 1576(1), 147-153.

Louvet, C., Labianca, R., Hammel, P., Lledo, G., Zampino, M., André, T., . . . Taieb, J. (2005). Gemcitabine in combination with oxaliplatin compared with gemcitabine alone in locally advanced or metastatic pancreatic cancer: results of a GERCOR and GISCAD phase III trial. Journal of Clinical Oncology, 23(15), 3509-3516.

Nassif, H., Ozbay, K., Deka, D., Lou, P., Zhu, Y., Na, C., . . . El-Awar, A. (2017). Performance measures to assess resiliency and efficiency of transit systems: University Transportation Centers Program (US).

Visser, J. (2002). Why fewer workers join unions in Europe: A social custom explanation of membership trends. British Journal of Industrial Relations, 40(3), 403-430.

Impact Assessment of Disruptive Technologies on Electronic Identities (eID) for the Improvement of Digital Public Services for Citizens

Bertille Auvray, Madlen Schmudde, René Lindner, Diana Silvestru, Jaime Loureiro Acuna, Xavier Martinez, Jiri Musto, Stepan Bakhaev, Nicholas Martin

(Bertille Auvray, Pôle TES, 8 rue Léopold Sedar Senghor 14460 Colombelles (France), bertille.auvray@pole-tes.com)
(Madlen Schmudde, René Lindner, Deutsches Institut für Normung, e.V., Burggrafenstraße 6, 10787 Berlin (Germany), madlen.schmudde@din.de, rene.lindner@din.de)
(Diana Silvestru MA, Agency for European Integration and Economic Development, Bräunerstraße 11a, 1010 Vienna (Austria), diana.silvestru@aei.at)
(Jaime Loureiro Acuna, Xavier Martinez, Gradiant, Carretera do Vilar, 56-58 36214 Vigo, Pontevedra (Spain), jloureiro@gradiant.org, xmartinez@gradiant.org)
(Jiri Musto, Stepan Bakhaev, LUT University, Yliopistonkatu 34, 53850 Lappeenranta (Finland), jiri.musto@lut.fi, stepan.bakhaev@lut.fi)
(Dr. Nicholas Martin, Fraunhofer Institut für System and Innovationsforschung ISI, Breslauer Straße 48, 76139 Karlsruhe (Germany), nicholas.martin@isi.fraunhofer.de)

1 ABSTRACT

Public services are increasingly being transformed into smart public services, also known as digital public services or eGovernment. In several cases, access to specific services is personal and non-transferable, thus requiring secure and trustful identification as well as management of the so called “digital identities”. In this context, it is obvious that citizens and public services in particular would benefit greatly from digital identity management technology, as new and emerging technologies have strong potential to empower existing eID systems. Yet, while opportunities enabled by these technologies are undeniable, challenges also exist, including technological and social implications, as well as barriers, risks and limitations. In addition, the establishment of standards for these ecosystems and compliance with framework conditions, including national and European regulations are essential points that must be considered. Based on these observations, the IMPULSE (Identity Management in PUblic SErvices) project, funded under the Horizon 2020 programme, was launched in early 2020. IMPULSE aims to perform a multidisciplinary evaluation of the disruptive transformation of electronic identity (eID) management in public services enabled by Distributed Ledger Technology (DLT) and Artificial Inteligence (AI). Overall, this paper will present the research pathway set up to answer the question of how a single adaptive eID solution can be useful to the whole city ecosystem, from the micro-citizen level to the macro-governmental perspective, by focusing on the main achievements of the IMPULSE project so far.

Keywords: digital innovation hub, public services, disruptive technologies, electronic identities, smart city

2 INTRODUCTION

IMPULSE aims to develop a method for evaluating eID management, more specifically the identification of individuals when accessing online public services, using distributed ledger technology (blockchain) and artificial intelligence. This evaluation covers not only the benefits, but also the risks to be considered, the costs to be borne and the limitations that this new eID solution may have. In addition, the potential socio-economic, legal, ethical and operational impacts will also be considered, while taking into accoung the current framework conditions, at European or national level (e.g. GDPR, existing national e-identity systems and standards, etc.). In order to achieve this, it combines the bottom-up approach of co-creation with the need for a universal vision of digital identity ethics by drawing up a user-centric multi-stage method. To this end, IMPULSE brings together a range of experienced partners, including six case studies in public administrations in five different countries, as well as other key players, in line with its ambition to conduct its research in an open form. Ultimately, the research will result in specific and actionable outcomes. The first one is a framework for a holistic integration of AI and blockchain technology to support secure and privacy-preserving eID management by public services, having been deployed and assessed in diferent countries to complement existing EU identity schemes. The second is the drafting and dissemination of actionable roadmaps for the adoption, escalation and sustainability of advanced eID technology by public services in the European ecosystem, in different countries and at different levels (local, regional, national, and cross-border) and supported by Digital Innovation Hubs (DIHs) all around Europe.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

3 SELECTED TECHNOLOGIES

IMPULSE intends to be a novel eID system to be integrated into online public services as a new and alternative eID option. Unlike other centralized eID systems like the ones based on user/password or federated identities (i.e., Facebook, Google, LinkedIn…), IMPULSE proposes a secure and privacy preserving alternative for existing eID management systems, the self-sovereign identity (SSI) concept (Mühle et al., 2018) being at the core of the user-centric IMPULSE eID approach.

3.1 Artificial Intelligence and Blockchain in the SSI context

IMPULSE combines disruptive technologies such as Artificial Intelligence and Blockchain with the goal of transforming the two critical processes of the whole eID system, which are needed to get a secure and privacy preserving access to online public services: the enrolment and authentication processes.

Enrolment is the process of registering a user in the system. In IMPULSE, this process is conducted by following an AI-based digital onboarding process. To verify citizens' identities, IMPULSE runs a combination of AI algorithms – based on deep Convolutional Neural Networks (CNNs) – which involves both the validation of the identification documents and the facial recognition of the citizens. Additionally, security measures are duly applied to avoid both presentation attack and document tempering attempts. If the onboarding results in success, a verifiable identity credential (ID-VC) is issued by the Public Administration to the citizens. Such a credential can be used for authentication purposes in online public services.

Unlike centralised identity systems, in IMPULSE the citizens' credentials are verified in a blockchain network, in particular in the European Blockchain Service Infrastructure (EBSI) (EC, 2018) and following the self-sovereign identity model defined on the European Self-Sovereign Identity Framework (ESSIF).

3.2 Concrete implementation – building blocks

The building blocks of the solution can be grouped into three domains depending on the location and the controller of each one: the user domain handled through an Android device, the Public Administration (PA) domain located in the public administration's backend, and the blockchain infrastructure domain which corresponds to the EBSI network.

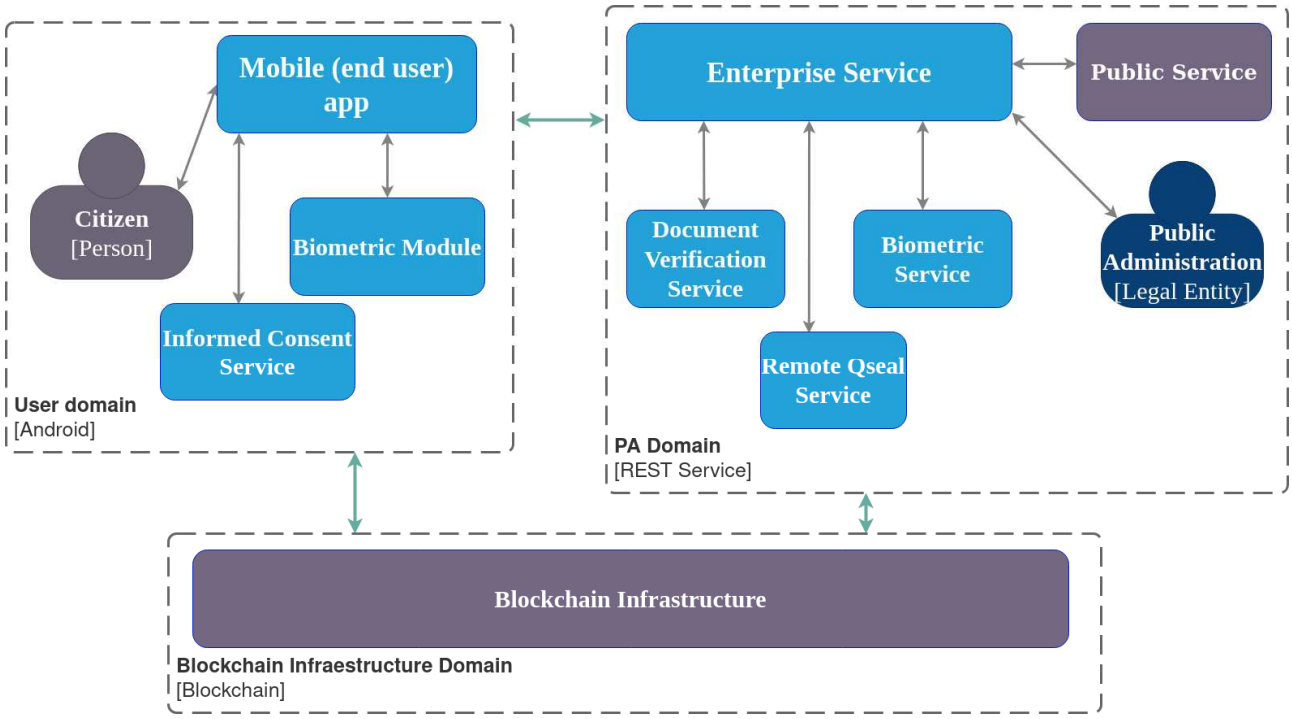


Fig. 1: IMPULSE solution building blocks

Regarding the user domain, the functional blocks are the following:

- Mobile app: the IMPULSE application that holds the digital wallet and interacts with the user, the modules inside the same domain and with other domains.

- Biometric module: a facial recognition module with the capability to create a local biometric profile of the user, using a selfie. This biometric profile is used to protect the access to the credentials.
- Informed Consent Service: A service that can register informed consent in a public blockchain using Smart Contracts.

Regarding the PA domain, the functional blocks are:

- Enterprise Service: the deployable core component of the solution that interacts with all the modules within the public administration domain and with other domains. This element is integrated with the PA service enabling IMPULSE for the public administration.
- Document Verification Service: a service that can validate the authenticity of an ID document submitted by the user.
- Remote Qualified Seal (Qseal) Service: a service that can sign the credentials with a qualified signature.
- Biometric Service: a service that can match the faces of a selfie and the ID document of a user.
- Public Service: the online public administration service that is integrated with the IMPULSE solution.

Regarding the blockchain infrastructure domain, there is one functional block: the European Blockchain Services Infrastructure (EBSI) which is a blockchain network oriented towards the creation of cross-border services for citizens of public administrations within the European Union (EU).

3.3 Opportunities and challenges

There are several opportunities and challenges that emerged during the implementation of the IMPULSE project. Among them, the following stand out:

- Simplifying the integration and instantiation processes of the solution by public administrations.
- Complying with current European legislation, such as eIDAS 1, eIDAS 2 and GDPR.
- Standardizing Self-Sovereign Identities for both natural and legal persons.
- Designing the solution with careful consideration for inclusion and accessibility.

4 OPEN COMMUNITY OF STAKEHOLDERS

The integration and engagement of stakeholders, whether internal or external are crucial points for a project to be successful. Internal stakeholders are those who are directly and actively involved in the project, while external stakeholders are individuals or groups outside the project, who can influence it or be influenced by it.

4.1 Internal actors

Internal actors are mainly understood to be the members of the project consortium. They reflect the multidimensional approach set up for the project and thus enable a holistic view which enriches the project efforts, quality and outcomes. The gathering of diverse and interdisciplinary expertise and experience is an obvious strength of the consortium which has been built to provide a balanced participation of interested parties, covering all the roles needed to develop the eID solution. In order to help fostering knowledge transfer and the exploitation of IMPULSE, a strong public-private partnership has been established between 16 partners from 9 EU countries including: 6 public administrations acting as local testbeds; 1 Digital Innovation Hub managing the stakeholder community and ensuring the transferability of the project; 2 Research and Technology Organisations (RTOs), one of which is focusing on the evolution of existing blockchain-based identity management solutions for integration into the public sector, while the other is analysing the socio-political and socio-economic effects and implications of the solution; 1 university working on co-creative design and piloting of the IMPULSE solution together with end-users, approaching the project from the “public service demands” side; 4 SMEs respectively leading the analysis and verification of the digitised documents provided by the citizens during the registration process, as well as experimenting with and transferring the practical use of the eID management approach to public service providers and providing ethical and legal assessment that will lead to recommendations for decision makers on privacy,

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

ethical and legal issues in the eID field, 1 large company overseeing the innovation and exploitation management, dissemination and communication, and 1 standardisation body working on the initiation of standardisation activities, for the development of new standards.

4.2 External actors

To achieve meaningful impacts, gain acceptance and promote the adoption of disruptive eID concepts in public services, collaboration with external stakeholders is considered at the core of IMPULSE. As part of the project activities, a stakeholders community has been set up. It is understood as the gathering of actors around a common interest: to jointly explore the notion of eID management for public services. This community is also thought as being open. The opportunity is given to each of its participants to contribute to help determine the direction and outcomes of the project. Each stakeholder brings its own expertise, opinions, needs, expectations and concerns, allowing a global view of the context in which the project was undertaken. For IMPULSE, the considered stakeholders and their specificities are: any additional public administration providing an even broader and richer perspective of the EU's public context; end-users (general public) perfecting the solution by sharing their views on which solution would best meet their needs; innovative SMEs, entrepreneurs, GovTech providing perspectives on public-private partnership as well as their view for the market introduction of the solution; policy makers having the actual capacity and means to influence the transformation of public services; other established networks taking on the role of IMPULSE advertisers to reach even more stakeholders; and finally Digital Innovation Hubs (DIHs) as well as European Digital Innovation Hubs (EDIHs). A strong emphasis was placed on the latter. What has been highlighted, when defining the partnership with DIHs, was their capacity to act as enablers and facilitators. They can reach and connect different actors in the innovation ecosystem by playing a brokering role not only at local but also at European level. Therefore, they can act as a bridge between the project and various ecosystems allowing for fruitful exchanges of knowledge and good practice. Moreover, they have the necessary infrastructure to provide testing grounds for the solution expansion. In a nutshell, the significant assets of DIHs made their involvement in the IMPULSE project more than relevant, especially in ensuring the transferability of the project effectively for the benefit of all.

4.3 Opportunities and challenges

Bringing these two types of stakeholders together creates both opportunities and challenges to be considered. In terms of opportunity, it is the possibility to define the framework as well as identifying and understanding the needs as comprehensively as possible, coupled with the ability to improve the solution through co-creation, leading more confidently to a solution implementation with a higher reliability and takeover rate. However, different stakeholders are often heterogeneous in their logics, values, goals, capacities and power, as well as their fields of activity, experiences and interests. This is a key point to take into account when setting up an open collaborative approach, in particular when it comes to getting similar types of actors to work not only together, but also with those from other fields of work to create new synergies.

5 METHODOLOGY

At its core, the project is based on a demand-driven co-creative research process in which public administrations carry out pilot experiments with the system-agnostic IMPULSE solution. Through two piloting phases, the objective will be to assess what this eID solution brings out in terms of benefits, but also risks and limitations, taking into account possible socio-economic, ethical and operational impacts, as well as alignments between European and national framework conditions.

To achieve the co-creation and evaluation of the IMPULSE solution, the project employs the action design research (ADR) method. The ADR method features an iterative design process of building, intervention and evaluation (BIE-cycle) that is helpful for solving open-ended research problems in information systems. The ADR method supports collaboration between the researchers, developers and end-users, which is vital for a co-creation process (Sein et al., 2011).

BIE-cycles allow a continuous improvement of the IMPULSE solution during pilot experiments as both piloting phases will go through one cycle. By using an iterative improvement process, the end-users will be more involved in the co-creation of the solution and their opinions are better considered in the development process.

5.1 Pilot experiments

Pilot experiments are used in IMPULSE at the core of the research, throughout the project lifetime. On this basis, different areas were chosen as exemplifying applications of the use of selected disruptive technologies to be piloted in public services. Thus, a set of six case studies in five different countries has been set up:

- City of Aarhus (Denmark): provide vulnerable citizens with secure storage for identity documents to ensure equal access to digital services for all citizens.
- Police Department of Ertzaintza (Spain): make the issuing of complaints fully digital to increase police efficiency and citizen safety.
- Gijón City Council (Spain): demonstrate the advantages of new identification systems for the Gijón Citizen Card, dedicated to municipal services for citizens.
- Municipality of Peshtera (Bulgaria): provide a more secure and GDPR-compliant digital system for civil registration & certification to citizens.
- Union Camere & Info Camere (Italy): design and implement the necessary infrastructure to provide an enterprise digital drawer for business leaders to access public/private services online.
- City of Reykjavik (Iceland): test of an eID solution that will enable citizens with physical impairments to authenticate on Reykjavik's participatory democracy platform "Better Reykjavik".

The piloting process of the project is divided into four phases consisting of the pre-piloting phase, the first piloting phase, iteration and the second piloting phase. During the pre-piloting phase, software requirements, needs and concerns are collected from the literature as well as from stakeholders through surveys, workshops and interviews. The collected set of functional and non-functional requirements are evaluated by the researchers and developers to create the initial prototype of IMPULSE.

During the first piloting round, the IMPULSE prototype is tested by end-users and the existing requirements are modified based on feedback received. Afterwards, the prototype is improved to implemend the new requirements and the second version of IMPULSE is tested during the second round of pilots. After the pilots are over, IMPULSE is finalized within the scope of the project.

5.2 Impact assessments

5.2.1 Standardization

In terms of standards implications, there is a gap in transferring successfully research results into practice, as most dissemination and exploitation activities only lead to the development of publication or patents (Blessing and Seering, 2016). Standardization is one answer to tackle this challenge. The European Commission is therefore fostering the integration of standardization in their Framework Programme projects in the last years (EC, 2018). IMPULSE is one of these projects that integrates standardization throughout the whole project duration. As a first step, the project has intensively assessed the relevant standardization landscape. The top 10 standards have their origin in Germany, Spain, as well as at European and international level. Especially the Spanish standard UNE 71307-1 "Digital Enabling Technologies. Part 1: Reference Framework" has high relation to the project activities. Therefore, IMPULSE has already established a partnership with the standardization committee. Further so-called liaisons are planned to interact with the relevant standardization committees at European and international level. Within these committees, a variety of organisations are involved which supports the outreach of the project results to external stakeholders to enhance, validate and promote them. Thus, the impact that the standardization activities have on the IMPULSE solution can be rated as very high. There is on the one hand interest in the standardization world to get the results of IMPULSE, and on the other hand the standardization tool provides an appropriate way to actively disseminate and exploit the project solutions into practice via standardization.

5.2.2 Socio-economic, socio-political impact analysis and ethical implications

Further questions increasingly arise in IMPULSE, related to the socio-economic and socio-political contexts: first, what end-users want, expect, and need when it comes to new self-sovereign identity schemes, innovative eID solution and the online identity, and second, what are the impacts of novel ID systems for public services. To this end, IMPULSE aims to assess the social acceptability of its solution, discover which

public services would derive significant societal benefits from the use of eID technology and determine the specific economic benefits for public systems with eID technologies in selected contexts. Some of the drivers for adoption and acceptance that our social science anchored analysis (literature review, qualitative interviews with pilot experiments owners, stakeholder survey) has highlighted so far refer to the quality and size of accessible services in a broader eGovernment ecosystem (Aztori, 2015; EC 2020b), usability and security issues related to the used technology (Doerk, 2020; Ehrlich et al. 2021; Pöhn et al., 2021), personal and demographic characteristics of the user (Feher, 2019; EC 2020a), as well as the economic rationality of the novel eID solution (van Dijck, 2020) and contextual legal-organizational environment of the public institutions in question (Doerk et al. 2020). Larger societal, economic and political benefits from the use of eID technology mainly focus on efficiency and convenience gains (EC 2020b), time savings for both final and end-users of the eID solutions and public administrations (WBG 2018a, 2018b; Nortal, 2020), potential reduction of fraud, interoperable activity resulting from potential wallet features (Addo & Senyo, 2021) and new business models. Envisioning the socio-economic and political analysis, IMPULSE will promote in its final stage the adoption of eID technologies in public services considering relevant stakeholder groups and potentially divergent perspectives as well as specify case-related business models for the IMPULSE solution.

This raises the question of the IMPULSE solution ethical implications. Arguably, the most important benefit it promises is facilitating access and therefore hopefully increasing the uptake of digital services, especially for less privileged parts of the population. It does this by substituting biometric recognition to the standard current authentication technologies (username/passwords, PINs, etc.), rendering the registration process faster and less complicated. Surveys indicate that a substantial number of people find it difficult to use multiple digital identities and authentication means in parallel and that the less advantaged and educated are most suffering from this (Initiative D21, 2019). For similar reasons, digital processes for service access can be more inclusive their offline counterparts (less travel/waiting time, fewer papers to keep track of, etc.). Nevertheless, like all technologies, the IMPULSE solution comes with potential risks, the two most important ones being facilicating surveillance and increasing the digital divide. Although it is designed to increase users‘ control over their data by requiring their active consent to make said data available to third parties, the very presence of this data can entice service providers to require an excessive amount of it in return for access to their service.

6 CONCLUSION

IMPULSE is an ambitious project inscribing itself within the logic of the smart and sustainable city. Indeed, it uses disruptive technologies to create a solution aiming at making the access to digital public services easier, but also more secure and respectful of citizens‘ private data. In order to achieve that, the project partners are creating a community including all stakeholders that can be involved in the implementation of such a solution with a double objective: feeding the IMPULSE project with their needs and perspectives, but also fostering other innovative initiatives that could complement IMPULSE’s work (actionable roadmaps based on the experience of the 6 pilot experiments will be developed to help support such initiatives).

Although some risks have been identified, these are less a question of the solution itself, but more of ist governance and in particular the presence or absence of institutional safeguards. This is why IMPULSE partners also intend to produce guidelines and recommendations involving input from relevant policy makers.

7 REFERENCES

MÜHLE, Alexander; GRÜNER, Andreas; GAYVORONSKAYA, Tatiana; MEINEL, Christoph: A survey on essential components of a self-sovereign identity. In: Computer Science Review, Vol. 30, pp. 80-86, ISSN 1574-0137, 2018. Available online: https://www.sciencedirect.com/science/article/abs/pii/S1574013718301217?via%3Dihub

European Commission, European Blockchain Service Infrastructure, 2018. Available online: https://ec.europa.eu/cefdigital/wiki/display/CEFDIGITAL/EBSI

BLESSING, Lucienne; SEERING, Warren: Preparing for the Transfer of Research Results to Practice: Best Practice Heuristics. In Impact of Design Research on Industrial Practice; Chakrabarti, A., Lindemann, U., Eds.; Springer: Cham, Switzerlands, 2016.

European Commission. 2018/0224 (COD) Proposal for a Regulation of the European Parliament and of the Council establishing Horizon Europe the Framework Programme for Research and Innovation, Laying Down Its Rules for Participation and Dissemination. 2018. Available online: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2018:0435:FIN

SEIN, Maung K.; HENFRIDSSON, Ola; PURAO, Sandeep; ROSSI, Matti; LINDGREN, Rikard: Action Design Research. In MIS Quarterly, Vol. 35, No 1, pp. 37-56, 2011. Available online: https://www.jstor.org/stable/23043488

ADDO Atta; SENYO P.K.: Advancing E-governance for development: Digital identification and its link to socioeconomic inclusion. In Journal Government Information Quarterly. Corpus ID: 233186604, 2021.

ATZORI, Marcella: Blockchain technology and decentralized governance: Is the State still necessary? In Social Science Research Network, 2015. Available online: https://ssrn.com/abstract=2709713

DOERK, Adrian: The growth factors of self-sovereign identity solutions in Europe. Thesis, October 2020. Available online: ResearchGate DOI: 10.6084/m9.figshare.14182586

DOERK, Adrian; HANSEN, Patrick; JÜRGENS, Georg; KAMINSKI, Moritz; KUBACH, Michael; TERBU, Oliver: Self Sovereign Identity Use Cases – von der Vision in die Praxis. Bundesverband Informationwirtschaft, Telekommunkation und neue Medien e. V., 2020. Available online: https://www.bitkom.org/Bitkom/Publikationen/Self-Sovereign-Identity-Use-Cases

EHRLICH, Tobias; RICHTER, Daniel; MEISEL, Michael; ANKE, Jürgen: Self-Sovereign Identity als Grundlage für unversell einsetzbare digitale Identitäten. Springer, 2021. Available online: https://doi.org/10.1365/s40702-021-00711-5

European Commission (Ghent University, CEF Digital) (2020b): ESBI Social Assessment Report. Available online: https://ec.europa.eu/digital-building-blocks/wikis/display/EBSIDOC/%5Barchived%5DSocial+and+Economic+Assessment+Reports?preview=/555222096/555222100/EBSI_Social_assessment_report.pdf

European Commission (TNO, CEF Digital) (2020a): EBSI Economic Assessment Report. Available online: https://ec.europa.eu/digital-building-blocks/wikis/display/EBSIDOC/%5Barchived%5Dsocial+and+Economic+Assessment+Reports?preview=555222096/555222100/EBSI_Social_assessment_report.pdf

FEHER, Katalin: Digital identity and the online self: Footprint strategies – An exploratory and comparative research study. In SAGE Journal of Information Science 1-14, 2019. Available online: https://journals.sagepub.com/doi/abs/10.1177/0165551519879702

NORTAL: How Electronic Identity can reduce government spending. White paper, 2020. Available online: https://nortal.com/wp-content/uploads/2020/09/wp_-how_eid_can_reduce_government_spending-.pdf

PÖHN, Daniela; GRABATIN, Michael; HOMMEL, Wolfgang: eID and Self-Sovereignty Identity Usage: An Overview. Electronics 2021, 10, 2811. Available online: https://doi.org/10.3390/electronics10222811

VAN DIJCK, José: Electronic identity services as sociotechnical and political-economic constructs. In New Media & Society, Vol. 22(5), pp. 896-914, 2020.

World Bank Group (2018a): Private Sector Economic Impacts from Identification Systems: World Bank.

World Bank Group (2018b): Public Sector Savings and Revenue from Identification Systems: Opportunities and Constraints: World Bank.

Kooperativer Planungsprozess zur Transformation der Zinzendorfgasse in Graz in eine Begegnungszone

Barbara Hammerl, Gosia Stawecka, Karlheinz Gürtl, Gabriele Herzog, Michael Deutsch

(Mag. Barbara Hammerl, CSE, StadtLABOR Innovationen für urbane Lebensqualität GmbH 1, Griesgasse 40, 8020 Graz, barbara.hammerl@stadtlaborgraz.at)
(Gosia Stawecka, MA, StadtLABOR Innovationen für urbane Lebensqualität GmbH 1, Griesgasse 40, 8020 Graz, gosia.stawecka@stadtlaborgraz.at)
(Karlheinz Gürtl, MA, StadtLABOR Innovationen für urbane Lebensqualität GmbH 1, Griesgasse 40, 8020 Graz, karlheinz.guertl@stadtlaborgraz.at)
(DI Gabriele Herzog, BSc, Stadt Graz – Abteilung für Verkehrsplanung, Europaplatz 20, 8020 Graz, gabriele.herzog@stadt.graz.at)
(DI Michael Deutsch, BSc, Stadt Graz – Stadtplanungsamt, Europaplatz 20, 8020 Graz, michael.deutsch@stadt.graz.at)

1 ABSTRACT

Als eine Konsequenz des in den 1970er-Jahren vorherrschenden Planungsparadigmas der autogerechten Stadt ist der Großteil des öffentlichen Verkehrsraums dem PKW vorbehalten. In vielen europäischen Städten fordern die Menschen bereits seit mehreren Jahren eine Zurückeroberung der Straßen und Plätze für Fußgängerinnen, Fußgänger, Radfahrerinnen und Radfahrer und damit eine gleichberechtigtere Nutzung des knappen Gutes Verkehrsraum. Der öffentliche Raum wird im Bewusstsein der Menschen verstärkt zum verlängerten "Wohnzimmer", das im Idealfall flexible, vielfältige Nutzungen und mehr Platz für Begegnung, Interaktion, Kommunikation oder Spiel bietet. Auch der Klimawandel macht eine Umgestaltung von Verkehrsräumen in Richtung mehr Grünflächen notwendig.

Die Stadt Graz setzt seit einigen Jahren auf Basis bestehender Strategien (Mobilitätsstrategie, Klimawandelanpassungsstrategie, etc.) erste sichtbare Schritte in der Umgestaltung des Stadtraums. Neben der konsequenten Pflanzung von Bäumen im Straßenraum, neuen Grünflächen, dem Ausbau des ÖV-Netzes werden auch vermehrt Begegnungszonen umgesetzt. Das sind verkehrsberuhigte Straße, *„deren Fahrbahn für die gemeinsame Nutzung durch Fahrzeuge und Fußgänger bestimmt ist*" (§2 Abs. 1 Ziffer 2a StVO). Dadurch entsteht ein neuer attraktiver Straßenraum, in dem alle Verkehrsteilnehmerinnen und Verkehrsteilnehmer einander gleichberechtigt auf Augenhöhe begegnen. Großes Augenmerk wird auf die Aufenthaltsqualität gelegt – durch neue Baumstandorte, Sitzgelegenheiten, konsumfreie Zonen oder Wasser als spielerisches Element.

Aktuell laufen die Planungen für die Umsetzung einer Begegnungszone in der Zinzendorfgasse, die eine zentrale Verbindungsachse zwischen dem Stadtzentrum/Stadtpark und dem Uni-Viertel darstellt. Bei diesem Projekt liegt ein Fokus auf der Einbindung von Bürgerinnen, Bürgern, Wirtschaftstreibenden, dem Bezirksrat und den benachbarten Institutionen. Auf Basis eines bereits vorliegenden Vorentwurfs für die Begegnungszone wurden über vier Monate vielfältige und inklusive Beteiligungsangebote geschaffen, um möglichst alle Nutzerinnen und Nutzer der Gasse anzusprechen und einzubinden.

Mit diesem sehr stark kooperativen Planungsansatz kann die Akzeptanz des Vorhabens von Beginn an gestärkt und insbesondere auch die Qualität der Planungen erhöht werden. In dem Paper werden erste Zwischenergebnisse und Learnings aus dem umfassenden Beteiligungsprozess dargestellt und auch die Eignung bzw. Qualität der Outputs der verschiedenen Formate diskutiert. Weiters wird ein Ausblick auf mögliche Beteiligungsangebote während der Umsetzung der Begegnungszone gegeben.

Keywords: kooperative Planung, Beteiligungsprozess, Begegnungszone, Transformation, öffentlicher Raum

2 KOOPERATION UND BETEILIGUNG ALS BASIS FÜR ERFOLGREICHE URBANE TRANSFORMATIONSPROZESSE

Die frühzeitige Einbindung relevanter Stakeholder in städtische Vorhaben sowie Governance im Sinne offener, transparenter und partizipativer Entscheidungsfindungsprozesse werden in europäischen Strategiedokumenten mehrfach explizit gefordert[1]. Sie werden aber auch seitens der Entscheidungsträger in Kommunen zunehmend als erfolgsrelevantes und qualitätssteigerndes Kriterium für Transformationsprozesse

[1] siehe u.a. EU-Städteagenda, Leitfaden für die Mitgliedstaaten zu integrierten nachhaltigen Stadtentwicklung bzw. ältere Dokumente wie die Aalborgh-Charta und die Leipzig-Charta zur nachhaltigen europäischen Stadt

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

erkannt. Internationale Vorreiter wie Jan Gehl (Dänemark) betonen in ihren Projekten die Bedeutung der „human dimension“ für eine qualitätsvolle Stadt(teil)entwicklung[2].

Um einen professionellen und transparenten Beteiligungsprozess aufzubauen ist darauf zu achten, dass alle betroffenen Nutzerinnen und Nutzergruppen im Planungsprozess frühzeitig eingebunden werden. Dabei ist es zentral, niederschwellige und attraktive Beteiligungsangebote zu schaffen, welche die vielen konstruktiven Ideen, Lösungsansätze und das lokale Wissen der Menschen und Unternehmen vor Ort einbeziehen. Neue Lösungen entstehen oftmals durch Impulse von außen und wenn Akteure in ungewohnten Konstellationen zusammentreffen. Es macht daher Sinn, Beteiligung und Kooperation in der Stadtentwicklung verstärkt auch aus dem Blickwinkel von Innovationsprozessen zu betrachten, um den notwendigen gesellschaftlichen Wandel und Transformationsprozess hin zu nachhaltigen und lebenswerten Städten zu unterstützen.

Durch diesen Austausch kann ein Planungsvorhaben bereits zu einem frühen Zeitpunkt, durch lokales Wissen aus dem Bezirk, durch Anregungen aus verschiedenen Zielgruppen, durch die Erfahrungen der Bewohnerinnen und Bewohner und durch konkrete Gestaltungsideen angereichert werden. Diese Vorgehensweise stellt einen maßgeblichen Baustein eines kooperativen Entwicklungsprozesses dar.

3 STRATEGIEN DER STADT GRAZ FÜR EINE NACHHALTIGE, KLIMARESILIENTE UND MENSCHENGERECHTE STADT

3.1 Mobilitätsstrategie der Stadt Graz

Die Stadt Graz setzt seit vielen Jahren in ihrer Verkehrspolitik auf die „Sanfte Mobilität". In der aktuellen Mobilitätsstrategie der Stadt Graz, die von 2011 bis 2015 erstellt wurde, wurden die Mobilität-Zielwerte bis zum Jahr 2021 definiert. Per Grundsatzbeschluss[3] des Gemeinderates der Stadt Graz wurde die Weiterverfolgung der 2021-Ziele bis zur abgeschlossenen Weiterentwicklung der aktuellen Strategie fixiert. Die überarbeitete Strategie wird als Sustainable Urban Mobility Plan (SUMP) erstellt werden und versteht sich als Kerninstrument zur Erreichung der europäischen Ziele.

Mit dem Gemeinderatsbeschluss der „Verkehrspolitischen Leitlinie 2020" wurden die Grundsätze der Verkehrspolitik in Graz definiert. Diese lauten: 1) Nachhaltigkeit steht im Mittelpunkt, 2) Graz als Stadt der kurzen Wege, 3) Mobilität ist in ihrer Gesamtheit zu betrachten, 4) Mobilität im urbanen Raum bedeutet Vorrang für die Sanfte Mobilität, 5) Graz als Teil einer Region setzt auf Kooperation[4].

Die Forderung nach mehr „Sanfter Mobilität“ soll für die Gestaltung des öffentlichen Raums herangezogen werden. Dies führt situationsbedingt zu anderen Prioritäten bei konkreten Neu- und Umgestaltungen des Verkehrsraumes: mehr Platz und Vorrang für Fuß- und Radverkehr (breitere Gehsteige und Radwege) und weniger für den MIV. Die Radverkehrsstrategie 2025 sieht z.B. eine Verdoppelung des innerstädtischen Fahrradverkehrs vor (derzeit rund 19% lt. Modal Split). Ebenso werden die „sanften“ Mobilitätsmaßnahmen für eine „Walkable City“ und der Ausbau des Öffentlichen Verkehrs weiter vorangetrieben.

In „Nebenstraßen“ sollen die Straßenquerschnitte für den Kfz-Durchzugsverkehr unattraktiv und nur die minimal erforderlichen Breiten dem fließenden Kfz-Verkehr zur Verfügung gestellt werden. Damit soll eine Entlastung der Wohngebiete von gebietsfremden Verkehr erreicht werden, die Verkehrssicherheit für die Anrainerinnen und Anrainer und den Fuß- und Radverkehr erhöht und der Straßenraum durch Möblierung und Begrünungsmaßnahmen attraktiver gestaltet werden sowie zu einer höheren Aufenthaltsqualität führen.

3.2 Begegnungszonen als wichtige Maßnahme zur Verkehrsberuhigung und Förderung der Lebensqualität im urbanen Raum

Eine weitere Maßnahme, die vermehrt in Graz umgesetzt wird, sind sog. Begegnungszonen. Das sind verkehrsberuhigte Straßen, *„deren Fahrbahn für die gemeinsame Nutzung durch Fahrzeuge und Fußgänger bestimmt ist“* (§2 Abs. 1 Ziffer 2a StVO)[5]. Dadurch entsteht ein neuer attraktiver Straßenraum, in dem alle Verkehrsteilnehmerinnen und Verkehrsteilnehmer einander gleichberechtigt auf Augenhöhe begegnen.

[2] siehe Gehl, J. Cities for People, 2010
[3] GZ: A10/8-3256/2021/0001, 21.1.2021
[4] https://www.graz.at/cms/beitrag/10191191/8038228/Mobilitaetsstrategie_der_Stadt_Graz.html
[5] https://www.ris.bka.gv.at/GeltendeFassung.wxe?Abfrage=Bundesnormen&Gesetzesnummer=10011336

Großes Augenmerk wird auf die Aufenthaltsqualität gelegt – durch neue Baumstandorte, Sitzgelegenheiten oder konsumfreie Zonen. Gestaltete öffentliche Räume werden außerdem als Grundlage für Kommunikation, sowie für den alltäglichen Austausch und Begegnungen zwischen Stadtbewohnerinnen und Stadtbewohnern gesehen, die das soziale Gefüge in einer Stadt unterstützen. Der Ausbau und die Sicherung einer hohen Gestalt- und Aufenthaltsqualität des öffentlichen Raums bildet somit die Grundlage einer zukunftsgerechten Entwicklung und unterstützt maßgeblich die positive Entwicklung einer Stadt und deren Bewohnerinnen und Bewohnern.

Aktuell laufen in Graz die Planungen für die Umgestaltung der Zinzendorfgasse – eine zentrale Verbindungsachse zwischen dem Grazer Stadtzentrum/Stadtpark und dem Uni-Viertel – zu einer Begegnungszone. Die Einbindung von Bürgerinnen, Bürgern, Wirtschaftstreibenden, dem Bezirksrat und den benachbarten Institutionen ist ein wichtiger Aspekt in diesem Vorhaben. Dieses Planungsvorhaben sowie erste Ergebnisse aus den Beteiligungsformaten werden im Kapitel 4 beschrieben.

3.3 Klimawandelanpassung und Klimaschutz

Im Stadtentwicklungskonzept der Stadt Graz sind viele wichtige verbindliche Vorgaben im Bereich der Klimawandelanpassung und des Klimaschutzes verankert, wie etwa Vorgaben zur Begrünung von Dächern oder zu Versiegelungsgraden. Speziell für den Klimaschutz und der klimaneutralen Versorgung der Stadt Graz wurde unlängst der Grazer Klimaschutzplan (Teil 1) beschlossen.

Aus der bisherigen Stadtklimaanalyse entwickelt sich KIS – das Klimainformationssystem, das aussagekräftige Prognosen liefert und damit die wissenschaftliche Basis für gezielte Maßnahmen der Stadt im Umgang mit den Folgen des Klimawandels. Dazu wurde eine städtische Arbeitsgruppe aus unterschiedlichen Fachabteilungen gebildet, die von Kooperationspartnern aus Land Steiermark, Wissenschaft und Wirtschaft unterstützt wird. Neue Methoden der Modellierung und Simulation nach internationalen Klimaszenarien (IPCC) werden für das Grazer Stadtklima prognostiziert und angewandt. In einzelnen Case-Studies werden spezielle mikroklimatische Analysen durchgeführt, wie zum Beispiel in der Zinzendorfgasse. Es wurden dafür zusätzlich mit einer speziellen Drohne Befliegungen mit hochauflösenden Wärmebildkameras durchgeführt. Dadurch können Hot Spots erkannt und Aussagen über die gefühlte Temperatur abgeleitet werden. In einem weiteren Schritt werden Green Szenarios für die Zinzendorfgasse erstellt und durchgespielt. Diese Auswertung ermöglicht es mögliche Szenarien einer Gestaltung in der Gasse auf seine klimarelevanten Schwerpunkte zu prüfen und Verbesserungen in der Planung zu bewirken.

4 BETEILIGUNGSPROZESS IM RAHMEN DES PROJEKTS BEGEGNUNGSZONE ZINZENDORFGASSE IN GRAZ

Auf Basis eines bereits vorliegenden Vorentwurfs für die Begegnungszone Zinzendorfgasse wurden über vier Monate vielfältige und inklusive Beteiligungsangebote geschaffen, die vom StadtLABOR im Auftrag der Stadt Graz koordiniert und durchgeführt wurden. Ziel war es, über den Vorentwurf zu informieren und Anliegen, Ideen und Anregungen der Bürgerinnen und Bürger, Wirtschaftstreibenden und lokalen Einrichtungen zu sammeln. Die gesammelten Ideen, Anregungen und Anliegen werden im Anschluss an die Beteiligungsphase von den Abteilungen für Verkehrsplanung und der Stadtplanung sowie den beauftragten Planungsbüros fachlich und wirtschaftlich geprüft und wenn möglich in den Planungen berücksichtigt.

Insgesamt haben bisher ca. 200 Menschen an den Beteiligungsformaten teilgenommen. Infotermine mit den Wirtschaftstreibenden in der Gasse finden Ende August/Anfang September 2022 statt. Mit diesem kooperativen Planungsansatz sollen die Akzeptanz des Vorhabens von Beginn an gestärkt und insbesondere auch die Qualität der Planungen erhöht werden. In den folgenden Kapiteln werden die einzelnen Beteiligungsformate beschrieben und erste Zwischenergebnisse und Learnings aus dem bisherigen Beteiligungsprozess dargestellt.

4.1 Beteiligungsformate im Rahmen des Projekts Begegnungszone Zinzendorfgasse

- Mobiler Info- und Beteiligungspoint im Rahmen des Straßenfestes „Zinzengrinsen“

Das erste Beteiligungsformat fand im Rahmen des Straßenfestes „Zinzengrinzen“ statt. An einem Samstag wurde die Gasse für einen Tag zu einer autofreien Zone mit einem bunten Mix aus Spiel, Spaß, Musik und Kulinarik. Das StadtLABOR war mit einem Lastenrad als mobiler Infopoint vor Ort in der Gasse und konnte das Projekt sowie das Konzept einer Begegnungszone niederschwellig vermitteln. Erste Ideen und Anliegen

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

wurden gesammelt und Stimmungsbilder eingeholt. Mit ca. 50-60 Besucherinnen und Besuchern wurden persönliche Gespräche geführt, die nahezu ausschließlich positive Rückmeldungen zur Begegnungszone brachten.

- „Dialog-Abend“ mit Vertreterinnen und Vertretern aus Politik, Verwaltung und Planung

Knapp 100 Anrainerinnen, Anrainer, Unternehmen, Studierende und interessierte Bürgerinnen und Bürger sind zum offiziellen Auftakt der Bürgerinnen- und Bürger-Beteiligung zur Begegnungszone Zinzendorfgasse der Einladung der Stadt Graz gefolgt. Im Rahmen der Veranstaltung wurden erste planerische Überlegungen sowie der Vorentwurf der Planungsbüros präsentiert. Hervorgehoben wurde, dass es sich zu diesem Zeitpunkt, um grundsätzliche Gestaltungsideen handelt, die durch Anregungen und Ideen aus dem Beteiligungsprozess vertieft und präzisiert werden sollen.

Am Ende der Veranstaltung wurde via Mentimeter ein Stimmungsbildes unter den Anwesenden eingeholt. Die allgemeine Resonanz für die Begegnungszone fiel dabei sehr positiv aus. Die meisten Teilnehmerinnen und Teilnehmer haben sich durch den Dialogabend auch durchaus gut informiert gefühlt.

Fig. 1: Abfragen des Stimmungsbildes zur Begegnungszone Zinzendorfgasse beim Dialog-Abend

- Workshop und Gassenspaziergang mit Jugendlichen eines benachbarten Gymansiums

Der öffentliche Raum erfüllt für Kinder und Jugendliche wichtige Funktionen als Ort der Sozialisation und Identitätsentwicklung. Möglichkeiten, die Planung und Gestaltung des öffentlichen Raums mitzugestalten, sind jedoch gerade für diese Gruppe oftmals nicht gegeben. Im Sinne der UN Kinderrechtekonvention[6] wurden daher bewusst auch die Meinungen und Ideen zur Begegnungszone von Schülerinnen und Schülern aus einem benachbarten Gymnasium stellvertretend für die jungen Menschen eingeholt. Nach einem kurzen Kennenlernen und einer Einführung in das Thema Begegnungszone, unternahmen 15 Schülerinnen und Schüler zwischen 11 und 16 Jahren – mit Planmaterial ausgestattet – einen Spaziergang durch die Zinzendorfgasse. Die Schülerinnen und Schüler wurden aufgefordert attraktive und weniger ineressante Orte in der Gasse auf den Plänen einzutragen und konkrete Gestaltungsmaßnahmen für die Begegnungszone zu überlegen.

- Temporäre 3-wöchige Planungsaustellung in einem Café in der Zinzendorfgasse

Das StadtLABOR konzipierte und entwickelte die temporäre Planungsausstellung „Die Zinzendorfgasse auf dem Weg zur Begegnungszone", die im Zeitraum vom 27. Juni bis zum 13. Juli 2022 im Gastraum eines Cafés in der Zinzendorfgasse während der Öffnungszeiten besucht werden konnte. Zusätzlich gab es insgesamt 9 Informations-Termine, an denen Mitarbeiterinnen und Mitarbeiter des StadtLABORs, der Stadt Graz und – an einem Termin – auch des Planungsbüros vor Ort anwesend waren und für Fragen und Anliegen zur Verfügung standen. Neben dem Dialog und dem unmittelbaren Feedback auf den ausgestellten Planungsentwurf gab es auch die Möglichkeit, Postkarten mit weiteren Ideen und Anregungen auszufüllen und abzugeben.

Knapp 40 Besucherinnen und Besucher während der Info-Termine und ca. 30 weitere Personen, die mit dem mobilen Info-Stand am Lastenrad vor dem Cafe erreicht wurden, konnten durch dieses Format angesprochen werden. Darüber hinaus wurden auch zahlreiche Besucherinnen und Besucher des Cafés „nebenbei“ für das Vorhaben sensibilisiert.

[6] https://www.unicef.de/informieren/ueber-uns/fuer-kinderrechte/un-kinderrechtskonvention

- Online-Beteiligungsmöglichkeit auf der Online-Plattform der Stadt Graz

Für den Zeitraum der Ausstellung wurde außerdem von der Stadt Graz eine Online-Beteiligungsmöglichkeit auf der Plattform https://mitgestalten.graz.at geschaffen, auf welcher Bürgerinnen und Bürger sich mit Ideen und Hinweisen beteiligen und diese auf einer interaktiven digitalen Karte der Zinzendorfgasse verorten konnten. Insgesamt wurden 41 Rückmeldungen über die Online-Plattform eingeholt.

- One-to-one-Infotermine mit allen Wirtschaftstreibenden der Gasse

Darüber hinaus wurden One-to-one-Info-Termine mit den in der Zinzendorfgasse ansässigen Betrieben organisiert, um Gestaltungselemente und Straßenraumplanung bestmöglich mit ihren Bedürfnissen abzustimmen. Nach einer gemeinsamen Inspektion des Ist-Zustandes direkt vor dem Geschäftslokal wurden anhand von einem Schemamodell konkrete Wünsche und Vorschläge für die Gestaltung des Raumes vor dem Lokal mit den Planungsbüros diskutiert und visualisiert. Im nächsten Schritt werden diese Vorschläge von den Planungsbüros fachlich geprüft.

Fig. 2: Beteiligungsformate im Rahmen des Projekts Begegnungszone Zinzendorfgasse

4.2 Zwischenergebnisse – Überblick über die am häufigsten genannten Ideen und Anregungen

Die Zwischenergebnisse aus den bisherigen Beteiligungsformaten zeigen vielfältige Bedürfnisse und Wünsche verschieneder Nutzerinnen- und Nutzergruppen. Die eingebrachten Themen reichten von mehr Sicherheit für Fußgängerinnen und Fußgänger, Beibehaltung der Ladezonen, Sorgen um Ruhestörungen bis zu konkreten Gestaltungsideen für die Gasse. Grundsätzlich besteht ein großer Wunsch nach mehr Begrünung, natürlicher Beschattung und Wasserelementen, um das Mikroklima und die Luftqualität in der Gasse zu verbessern sowie die Aufenthaltsqualität zu steigern. Die Bepflanzung mit großkronigen Bäumen und begleitende Grünstreifen könnten auch einen positiven Effekt zur Lärmminderung haben.

Es gab einige Bedenken, vor allem von den Anrainerinnen und Anrainern, in Bezug auf mögliche Verkehrsverlagerungen, Lärm und Verschmutzung. Überraschenderweise fiel die Resonanz auf die Reduktion der Kfz-Parkplätze größtenteils positiv aus. Dennoch gibt es auch die Befürchtung, dass nach der Umgestaltung zu wenig Parkplätze für Anrainerinnen und Anrainer zu Verfügung stehen werden.

Die konkreten Gestaltungsideen für die Begegnungszone reichten von Nebelduschen und kleinen Wasserfällen, begrünten Fassaden und Hanggärten über die Schaffung von Leseinseln und einer Zonierung der Gasse mit verschiedenen Belägen (Längsrichtung/Querrichtung) bis hin zu einer besonderen Gestaltung der „Eingangssituation“ zur neuen Zinzendorfgasse. Es besteht weiters ein großer Wunsch nach konsumfreien Aufenthaltsmöglichkeiten, um zufällige Begegnung und die soziale Interaktion zu fördern. Die Barrierefreiheit und Sicherheit aller Nutzerinnen und Nutzer spielt dabei eine große Rolle.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Die gesammelten Ideen, Anregungen und Anliegen werden im Anschluss an die Beteiligungsphase von den Abteilungen für Verkehrsplanung und der Stadtplanung sowie den beauftragten Planungsbüros fachlich und wirtschaftlich geprüft und wenn möglich in den Planungen berücksichtigt.

Ein wichtiger Aspekt am Ende des Beteiligungsprozesses wird es sein, transparent darzustellen und darüber zu informieren, welche konkreten Ideen umgesetzt wurden und welche aus welchen Gründen nicht. Zu diesem Zweck ist unter anderem eine öffentliche Informationsveranstaltung zur Präsentation der finalen Planungen vorgesehen.

Fig. 3: Word cloud mit den Ideen und Anliegen für die Begegnungszone Zinzendorfgasse

5 LESSONS LEARNT UND CONCLUSIO

- Wie in vielen Beteiligungsprozessen hat sich auch hier gezeigt, dass eine frühzeitige, transparente und vielfältige sowie kontinuierliche Information viele Menschen gut abholen und die Akzeptanz für ein Vorhaben unterstützen kann. Neben den oben beschriebenen Beteiligungsformaten wurde auch auf der Website der Stadt Graz laufend über das Vorhaben informiert. Die Seite wurde bis dato 570 Mal aufgerufen und scheint bei vielen Menschen den Informationsbedarf gedeckt zu haben. Das StadtLABOR stand auch als Kontaktstelle für Anfragen und Anliegen zur Verfügung, dieses telefonische Kontaktangebot wurde von einigen Interessierten zufriedenstellend genutzt.
- Beim Dialogabend – als größtes Beteiligungsformat – wurden seitens der eher skeptischen Anrainerinnen und Anrainer wiederholt und durchaus emotional Bedenken zur Begegnungszone geäußert. Die Mentimeter-Auswertung am Ende des Abends hat jedoch ein mehrheitlich sehr positives Stimmungsbild für das Vorhaben gezeigt. Das unterstreicht die Erfahrung, dass diejenigen die sich zwar laut und vehement einbringen, oftmals nicht die Mehrheit repräsentieren. Eine weitere Erkenntnis ist, dass Befürworter eines Vorhabens sich nicht im selben Ausmaß inhaltlich und zeitlich in einen Beteiligungsprozess einbringen, wie die zahlenmäßig eher kleine Gruppe der Gegnerinnen und Gegner.
- Erwartungsgemäß ist der Wunsch, sich einzubringen, bei den direkt Betroffenen (Bewohnerinnen, Bewohner und Unternehmen der Gasse) und jenen Menschen mit einem höheren Leidensdruck am größten.
- Bisherige Ergebnisse zeigen vielfältige Bedürfnisse und Wünsche. Die drei wichtigsten Themen für einen qualitätsvollen öffentlichen Raum sind Begrünung (die meisten Nennungen), Verkehrsberuhigung und eine hohe Aufenthaltsqualität (kommerziell und konsumfrei) sowie die

Berücksichtigung von Gesundheits- und Sicherheitsaspekten für alle Verkehrsteilnehmerinnen, Verkehrsteilnehmer, Altersgruppen sowie gefährdete Gruppen (Ältere, Kinder, Menschen mit Behinderungen).

- Trotz der vielfältigen On- und Offline-Beteiligungsangebote blieb die Anzahl konkreter und verorteter (Gestaltungs)Ideen ein wenig hinter den Erwartungen zurück. Das kann damit zusammenhängen, dass es in Graz bis dato noch sehr wenige Begegnungszonen gibt, der Begriff für viele Menschen neu ist und daher noch keine intensive Auseinandersetzung mit dem Konzept stattgefunden hat.
- Der Infopoint beim „Zinzengrinsen-Fest“, der Dialogabend sowie der Gassenspaziergang mit den Jugendlichen brachten mit einem relativ geringen bzw. mittlerem Vorbereitungs- und Organisationsaufwand eine hohe Teilnehmerfrequenz und teils sehr intensive Gespräche mit den Interessierten. Die Planungsausstellung mit den Info-Nachmittagen waren in der Vorbereitung durchaus zeitintensiv und in Bezug auf die Besuchszahlen nicht ganz so zufriedenstellen (mit Ausnahme des Termins mit dem Planungsbüro). Hier könnte für die Zukunft durch eine komprimiertere Form und mehr Info-Termine mit den Planungsbüros optimiert werden. Gleichzeitig wurde der niederschwellige Zugang zu Informationen in einem Cafe direkt in der Gasse als sehr positiv wahrgenommen und konnte sicher auch zahlreiche Gäste des Cafés ansprechen.
- Für die Entwicklung konkreter Gestaltungsideen können zukünftig auch interaktive Workshopformate (z. B. nach der Design-Thinking-Methode) angeboten werden.

Fazit 1: Die Transformation des öffentlichen Raumes muss behutsam unter Einbindung von (direkt) Betroffenen und Interessierten erfolgen, um die gewünschte Akzeptanz zu erzielen. Beteiligung beginnt mit einer umfassenden, frühzeitigen, transparenten und kontinuierlichen Information über ein Vorhaben, die bereits sehr viele Menschen abholt bzw. zufriedenstellt. Darüber hinaus können durch unterschiedliche Beteiligungsangebote konkrete Anregungen und Ideen abgeholt werden, die eine qualitätsvolle und bedarfsgerechte Planung unterstützen.

Fazit 2: Um sicherzustellen, dass die Umgestaltung der Zinzendorfgasse zu einer Begegnungszone von allen Nutzerinnen und Nutzern gut angenommen wird, bedarf es nicht nur eines intensiven Beteiligungsprozesses in der Planungsphase, sondern auch während der Phase der Umsetzung. Neben umfassenden und frühzeitigen Informationen zur zeitlichen und räumlichen Abwicklung der Baustelle (insbesondere zur Gewährleistung eines reibungslosen Geschäftsbetriebs für die Gewerbetreibenden) könnten in diesem Prozess beispielsweise auch Spielregeln eines guten Zusammenlebens zwischen allen Nutzerinnen- und Nutzergruppen gemeinsam erarbeitet werden, um von Anfang an einen respektvollen Umgang zu leben und Konflikte zu vermeiden. Die Neugestaltung der Zinzendorfgasse kann somit als eine Chance gesehen werden, um von einem Neben- zu einem positiven Miteinander zu kommen.

6 REFERENCES

GEHL, Jan: Cities for People. Copenhagen, 2010. GEHL, Jan: Cities for People. Copenhagen, 2010.
https://www.graz.at/cms/beitrag/10191191/8038228/Mobilitaetsstrategie_der_Stadt_Graz.html
https://www.unicef.de/informieren/ueber-uns/fuer-kinderrechte/un-kinderrechtskonvention
https://www.ris.bka.gv.at/GeltendeFassung.wxe?Abfrage=Bundesnormen&Gesetzesnummer=10011336

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Landside/airside – Airports als Schnittstelle für die Energie- und Verkehrswende in der Luftfracht?

Heinz Dörr

(Dipl.-Ing. Dr. Heinz Dörr, arp-planning.consulting.research, 1090 Wien, Postfach 15, heinz.doerr@arp.co.at)

1 ABSTRACT

Der hochurbane Charakter einer Airport City hat viele Facetten auch in Hinblick auf die Mobilitätsformen angenommen. Die landseitige Verkehrsanbindung ist eine laufend thematisierte Angelegenheit, weil sie als infrastrukturelle Vorleistung die Attraktivität des Flughafenstandortes wesentlich vorausbestimmt. Gewonnen wird die Wettbewerbsfähigkeit für die verschiedenen Kundenkreise sowohl auf den traditionellen Kernmärkten der Luftfahrt als auch auf den Sekundärmärkten der Forwarding-Logistik, der Immobilienansiedlungen, des Einzelhandels, der Gastronomie und der Landverkehrsdienste. Somit ergibt sich ein Kerngeschäft und nicht minder wichtig stellen sich mittlerweile die Geschäftsfelder der Annexeinrichtungen dar. Sie machen die Airport Cities sowohl für die mit dem Luftfahrtbetrieb verbundenen Beschäftigten als auch für jene in Geschäftsfeldern, die die Standortgunst der globalen Erreichbarkeit genießen, zu einem bunten Arbeitsplatzschwerpunkt. Dem Flughafen benachbarte Wirtschaftsparks übernehmen als ausgelagerte Business Centres Teilfunktionen der Inner Cities im Ballungsraum. Für die Raumordnung ist die Airport City daher ein hochrangiger Zentraler Ort der regionalen wie auch der globalen Funktionsteilung. So mancher Tower signalisiert als Landmarke die Bedeutung der Airport City.

Ein Flughafen ist nur so attraktiv, wie sein Hinterland es ist. Daher ist dieses in Hinblick auf seine airaffinen Stärken und Schwächen ständig zu „beackern“. Dies gilt umso mehr, als es eine sehr hohe Dichte an Airports in Kerneuropa gibt – u.a. als ein Erbe des Kalten Krieges des vorigen Jahrhunderts, deren Luftwaffen-Flugplatzstandorte keine ökonomisch motivierte Wahl waren. Die Road Feeder Services (Straßenersatzverkehre mit Flugnummer) für Air Cargo haben mittlerweile ein die „Hinterländer“ übergreifendes Netz ausgebildet. Die Ausgangsflughäfen im Schwerpunkt von Wirtschaftsregionen bedienen oft hauptsächlich mit ihren Air Cargo Centres eine Umschlagfunktion im Land-Land-Verkehr. Denn „Belly Load“ (im Unterdeck der Pax-Flugzeuge) wird von den Fluggesellschaften, denen es um die Knapphaltung der Turnaround-Zeiten ihrer Passagier-Flüge geht, nicht so gerne mitgenommen, auch weil sie am interkontinentalen Hub-Airport, das Ground Handling Aircraft to Aircraft eher vermeiden wollen.

Eine verkehrslogistisch-organisatorische Voraussetzung ist des Weiteren, dass es sich zumeist um Kontraktlogistik handelt, die regelmäßige Air Cargo-Transportketten durch spezialisierte Speditionen auf den Land- und Luftweg bringt. Das ist ein wichtiger Ansatzpunkt, weil dabei auch die Luftfrachtkunden ein Wörtchen mitzureden haben. Im kontinental-europäischen Luftfrachtverkehr spielt der Landweg jedenfalls eine immer größere Rolle, was die Transportweite und die Dichte der Fuhren hauptsächlich im Autobahnnetz betrifft.

Keywords: New2Air, H2-Trucks, Landverkehr, Air Cargo, Airport City

2 DER FLUGHAFEN ALS „GLOBAL-ZENTRALER ORT“

2.1 Die Airport City als unvollständige Stadt

Der hochurbane Charakter einer Airport City hat viele Facetten auch in Hinblick auf die Mobilitätsformen angenommen. Die landseitige Verkehrsanbindung ist eine laufend thematisierte Angelegenheit, weil sie als infrastrukturelle Vorleistung die Attraktivität des Flughafenstandortes wesentlich vorausbestimmt. Gewonnen wird die Wettbewerbsfähigkeit für die verschiedenen Kundenkreise sowohl auf den traditionellen Kernmärkten der Luftfahrt als auch auf den Sekundärmärkten der Forwarding-Logistik, der Immobilienansiedlungen, des Einzelhandels, der Gastronomie und der Landverkehrsdienste. Somit ergibt sich ein Kerngeschäft und nicht minder wichtig stellen sich mittlerweile die Geschäftsfelder der Annexeinrichtungen dar. Sie machen die Airport Cities sowohl für die mit dem Luftfahrtbetrieb verbundenen Beschäftigten als auch für jene in Geschäftsfeldern, die die Standortgunst der globalen Erreichbarkeit genießen, zu einem bunten Arbeitsplatzschwerpunkt. Dem Flughafen benachbarte Wirtschaftsparks übernehmen als ausgelagerte Business Centres Teilfunktionen der Inner Cities im Ballungsraum. Für die Raumordnung ist die Airport City daher ein hochrangiger Zentraler Ort der regionalen wie auch der globalen Funktionsteilung. So mancher Tower signalisiert als Landmarke die Bedeutung der Airport-City.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

So gesehen ist die Airport City eine unvollständige, jedoch hochspezialisierte Stadt jenseits der üblichen Siedlungshierarchie. Denn sie ist ein Arbeitsplatzmagnet als hochgradiges Einpendlerzentrum ohne ständige Wohnfunktion und mit nur wenigen Wohnfolgeeinrichtungen und fungiert als Inkubator für die Regionalentwicklung in ihrem Umkreis, die so manche Disparitäten in der Wirtschaftsentwicklung der umgebenden Regionen abseits des namengebenden Ballungsraumes auszugleichen vermag. Längst clustern sich nicht nur direkt mit der Luftfahrt verbundene Wirtschaftszweige im Windschatten der Einflugschneisen und Luftfahrtsicherheitzonen rund und auch inmitten der Airport City, die die Fühlungsvorteile, das Standortimage und die indirekt wirkenden Umgebungsfreiheiten (großzügige Flächenangebote außerhalb des Wohnbaulandmarktes und der lokalen Bewohnersensibilitäten) nützen.

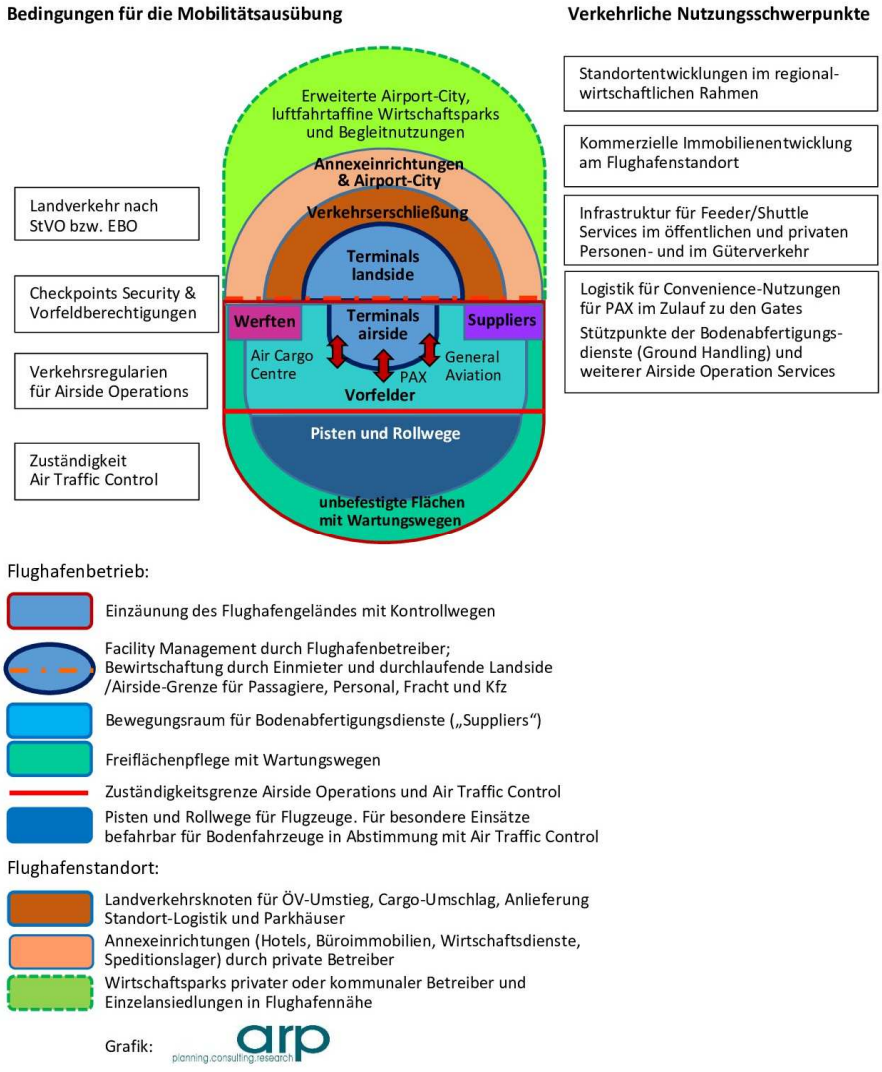


Abb. 1: Flächenorganisationsmodell eines Hub-Airports nach Sicherheitszonen und Verfügungsrechten (Quelle: Romstorfer/Dörr, 2018

2.2 Zonierung in Funktionsstandorte nach Sicherheitsanforderungen

Ausgehend von der Kernfunktion der Luftfahrt stellt sich die Airport City als „Inselgruppe“ mit Grenzübertritten zwischen heterogenen abgestuften Sicherheitszonen dar, wie sie heutzutage zum „Werksschutz“ vieler Betriebe gehören, wodurch die öffentliche Zugänglichkeit kontrolliert und kanalisiert wird. Der funktionell hochangereicherter Standort, der ein vielfältiges globales Eingangstor (Gateway) bildet, macht hohe Sicherheitsstandards unabdingbar, die die Raumorganisation, die Zugangsberechtigungen und Kontrollmechanismen determinieren. Diese betreffen insbesondere auch das Air-Cargo-Business, wozu zu gewährleisten sind, die:

- Sicherheit vor terroristischen Angriffen (auf Personal, Passagiere, Fracht, Infrastruktur, Fluggeräte)
- Sicherheit vor kriminellen Eingriffen (Diebstahl, Schmuggel, Drogen, Erpressung)

- Sicherheit vor Einschleppungen (von Krankheitserregern, Insekten u.ä.)
- Sicherung der Funktionalitäten des Betriebes (Funkverkehr, Ground Handling, Air Operations)

Diesbezüglich haben sich zur Security verschiedene Berufsbilder behördlicherseits (wie Polizei oder Zoll), und als private Dienstleister (Objektschutz, Personencheck) ausgeprägt. Die Airport City ist von ihrer Kernfunktion der Luftfahrt ausgehend ein streng reglementierter öffentlicher Ort, die sie von einer traditionellen Inner City unterscheidet und die Aufenthaltsqualität beeinflusst. Eine gewisse Hektik ist meistens spürbar. Als Treffpunkt der Ethnien und Kulturen ist sie einzigartig, aber dennoch ein sehr flüchtiger Ort. Auch, wenn manches Airport-Hotel als globaler Ort für geschäftliche Zusammenkünfte und Tagungstreffen aus allen Himmelsrichtungen sich positioniert hat. Abbildung 1 stellt in einem generellen Flächenfunktionsmodell eines Hub-Flughafens die Innovationsfelder für die Dekarbonisierung (nicht nur) der Mobilität je nach Verfügungs- und Nutzungsrechten dar.

2.3 Der Flughafen als Potenzialstandort

Betrachtet man jeden Flughafen – unbeschadet der Konkurrenzverhältnisse – als Standort für sich, so kann das Potenzial für den Luftfrachtverkehr eines Verkehrsflughafens mit drei Dimensionen beschrieben werden, nämlich durch:

(1) das Hinterlandpotenzial der Nachfrage der luftfrachtaffinen Wirtschaft, (2) das Destinationspotenzial des Angebotes an Flugverbindungen des Flughafens als Hub (s. Abb. 2), (3) das Standortpotenzial (Kapazitätsangebot und Dienstleistungsqualität) des Flughafens in räumlicher und verkehrlicher Hinsicht als Hub und Konsolidierungszentrum.

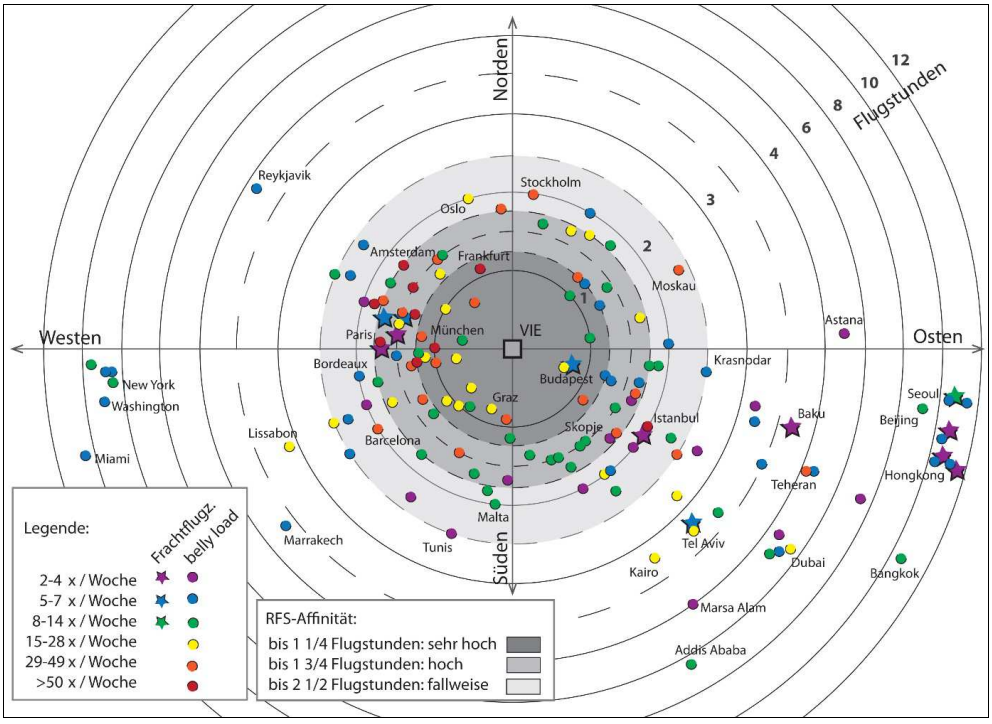


Abb. 2: Destinationen und Flugdistanzen am Beispiel Vienna Airport (VIE) (aus ACCIA, 2016, Grafik: Y. Toifl, Quelle: VIENNA AIRPORT: Flugpläne des Flughafens Wien 2015/2016

Es hat sich herausgestellt, dass nicht mehr unbedingt von einer besonderen Affinität von Branchen oder Warengruppen ausgegangen werden kann, auch wenn es Leitkundschaft gibt, die Kontraktlogistik an Luftfrachtspediteure als Integratoren vergibt, wie die Elektronik- oder die Pharmaindustrien, die für eine Grundauslastung in nachgefragten Relationen sorgen. Selbst geringwertige, verderbliche oder verwelkende Güter, wie Blumen, werden über tausende Kilometer eingeflogen. Sogar der Transport lebender Tiere zwischen den Kontinenten ist durchaus üblich geworden. Dazu kommt, dass Luftfracht – nicht zuletzt durch E-Commerce – für alle Bevölkerungsgruppen und alle Wirtschaftszweige gleichermaßen zugänglich ist. Selbst in so manchem Lastenfahrrad stecken Päckchen mit Luftfrachtsendungen. Spotmärkte im B2B-Bereich sind ebenso zum alltäglichen Geschäft geworden wie Spontanversendungen im B2C-Bereich. Die

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

große Vielfalt der Luftfrachtgüter und der Sendungsgrößen macht die Luftfrachtprozesse anspruchsvoll und kompliziert in der Abwicklung, womit das Engagement der involvierten Personale gefordert ist.

3 DIE VERKEHRSLOGISTIK DER LUFTFRACHTTRANSPORTKETTE

3.1 Die Sequenzen im Landverkehr und im Luftverkehr

Die Luftfrachttransportketten sind von einer Vielzahl an Akteuren, einem hochkompetitiven Marktumfeld und einer Vielfalt von logistischen Qualitätsanforderungen seitens der Kunden geprägt. Als Luftfracht werden heutzutage nahezu alle Güter geflogen, sofern sie nicht die Massenleistungsfähigkeit der Luftfahrzeuge übersteigen. Die versendende und empfangende Luftfrachtkundschaft ist branchenmäßig und regional breit gestreut, wiewohl sich Leitverlader mit hohem Sendungsaufkommen mittels Kontraktlogistik geradezu symbiotisch mit Spezialisten aus der Speditionswirtschaft und mit Fracht-Fluggesellschaften zusammenfinden. Damit hat die Frachtbeiladung (Belly Load) im Unterdeck der Passagierflugzeuge ebenso wie die Beförderung in Frachtflugzeugen ihre wirtschaftliche Zweckmäßigkeit, dabei bedienen erstere auch Destinationen abseits der globalen Wirtschaftsschwerpunkte und erlauben spontane Sendungswege. Allerdings sind die Fluggesellschaften vor allem im Kurz- und Mittelstreckenverkehr bestrebt, die Turn-around-Zeiten auf den Flughäfen kurz zu halten und nehmen daher nicht immer Luftfrachtsendungen als Belly Load mit, die dann stattdessen auf dem Landweg entweder als Road Feeder Service das Air Cargo Center wiederum oder als Zulaufverkehr zu einem Hub-Airport den Speditionsstützpunkt verlassen.

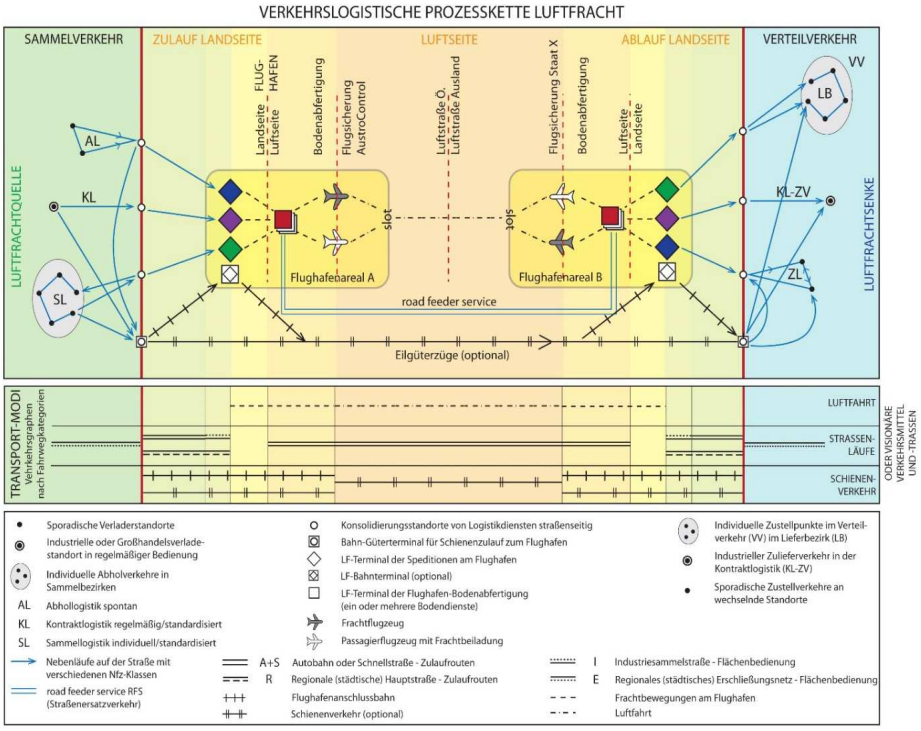


Abb. 3: Die Verkehrslogistik der Luftfrachttransportkette nach Sequenzen (Quelle: ACCIA, 2016)

3.2 Das Air Cargo Center als Verkehrsdrehscheibe

Ein Air Cargo Center ist meist ein vom Passagierterminal und seiner Vorfahrt separierter Teil der Airport City, weil der zu- und abströmende Nutzlastverkehr möglichst nicht den öffentlichen Bus- und den individuellen Autoverkehr zu den Parkhäusern tangieren soll. So kommt es, dass bei vielen Hub-Airports getrennte Autobahnabfahrten für den Cargo-Verkehr angelegt sind und die Cargo-Positionen am Vorfeld samt den Cargo-Empfangshallen einen Flughafen innerhalb des Flughafengeländes bilden. Im Cargo-Centre selbst werden nach Destinationen geordnet die Unit Load Devices auf Blechpaletten aufgebaut bzw. abgebaut oder spezifische an den Flugzeugkörper angepasste Container hergerichtet. Das kann Stunden dauern, sodass Gefahrengüter eigens gesichert zwischengelagert oder temperaturgeregelte Lager(hallen) zur Aufrechterhaltung der Kühlkette, etwa bei Pharmazeutika, frequentiert werden müssen. Bei Importen gilt es nicht nur zollrechtliche Kontrollen durchzuführen, sondern auch phytohygienische Anforderungen (Einschleppungen von Schädlingen oder Pflanzensamen) sind zu überprüfen. Auch Vetrinäre müssen manch-

mal tätig werden. Das Air Cargo Center ist somit ein hoch organisierter Brennpunkt des Welthandels auf vergleichsweise kleinstem Raum. Aber nicht nur interkontinentale Airports, wie sie aus der Passagierluftfahrt prominent sind, sondern auch Airports mit geringerem Passagieraufkommen mischen als Nischen-Player im Cargo-Umschlag zum Luftweg mit. Dabei ist deren Anfahrbarkeit vielleicht nicht so sehr stauanfällig zu Luft und auf der Straße und die Abwicklung vor Ort spielt sich kollegial entspannter ab.

Abb. 4 (links): Zufahrt zum Cargo Center des Flughafens Aachen-Maastricht (MST) im Dreiländereck (D, B, NL). Abb. 5 (rechts): Der Europa-Hub eines KEP-Carriers am Flughafen Köln-Bonn (CGN)

Über die durch die Frequentierung von Air Cargo Centers erzeugten Verkehrsströme gibt es keine veröffentlichten Daten. Zwar könnten an den Gates zu den Rampen Zählungen vorgenommen werden, aber Datenschutz und ein allgemeines Desinteresse schieben dem einen Riegel vor, sodass eine sinnvolle Zuflußsteuerung meist unterbleibt und das Wartemanagement weitgehend den Lkw-Fahrern überlassen bleibt. An unternehmenseigenen Logistikstandorten mag das jedoch anders gehandhabt werden.

Allerdings kann der dem Air Cargo Center zuströmende und abgehende Nutzfahrzeugverkehr modellhaft aus den Daten der Luftfahrtstatistik abgeleitet werden (s. Abb. 4). Dabei müssen die dem Air Cargo Center zuströmenden und abgehenden Tonnagen im Export und im Import auf ein zu bestimmendes Mix von Nutzfahrzeugmustern unter der Berücksichtigung der Besonderheiten von Luftfracht einerseits und den wirtschaftsstrukturellen Eigenheiten des Einzugsgebietes andererseits aufgeteilt werden, wobei unvermeidbare Leerfahrten und einschränkende Auslastungsfaktoren, die mit den Abflugterminen und den Vorlaufzeiten am Flughafen-Cargo-Terminal zusammenhängen, zu bedenken sind.

Abb. 6 u. 7: Die Cargo City Süd für die Speditionswirtschaft im Grüngürtel der Metropolregion Frankfurt-Rhein-Main mit Anschluss an FRAPORT CARGO SERVICES jenseits der Passagier-Terminals mit eigenen Rollwegen zu den Pisten

Zwar ist die Straßenlastigkeit im kontinentalen Landverkehr der Luftfracht unübersehbar, gleichzeitig muss aufmerksam gemacht werden, dass jede Tonne Nutzlast im Straßenverkehr um ein Vielfaches emissionsärmer befördert werden kann als im Lufttransport. So kann es keine ernsthafte Verlagerungsdebatte zum Luftweg geben, es sei denn, dass Belly-Load-Kapazitäten bei Linienflügen regelmäßig unterausgelastet bleiben, aber stattdessen im Landtransport Routen in immissionsträchtigen Siedlungsräumen passiert werden.

4 ANGRIFFSPUNKTE FÜR DIE DEKARBONISIERUNG DER LUFTFRACHTMOBILITÄT IM LANDVERKEHR

4.1 Luftfrachtransporte im Straßennetz als Nebenläufe

Da die Bahn bzw. sonstige Verkehrsträger bei Luftfrachttransporten im Landverkehr keine erkennbare Rolle spielen, ist es bislang der Verkehrsträger Straßengüterverkehr, der verschiedene Verkehrszwecke zu den Gütersenken der Versender und Empfänger erfüllt. Dazu finden im Wesentlichen folgende vier Arten von Straßenverkehren statt:

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

- Luftfrachtersatzverkehre (Road Feeder Services, RFS) im Fernverkehr in der Regel zwischen Spoke-Flughäfen und Hub-Flughäfen in Verantwortung einer Fluggesellschaft, manchmal auch direkt vom Standort eines bekannten Versenders zu einem Hub. Solche intermodalen Verkehre sind übrigens von einigen zeitlichen Verkehrsbeschränkungen als Terminalzuläufe ausgenommen.

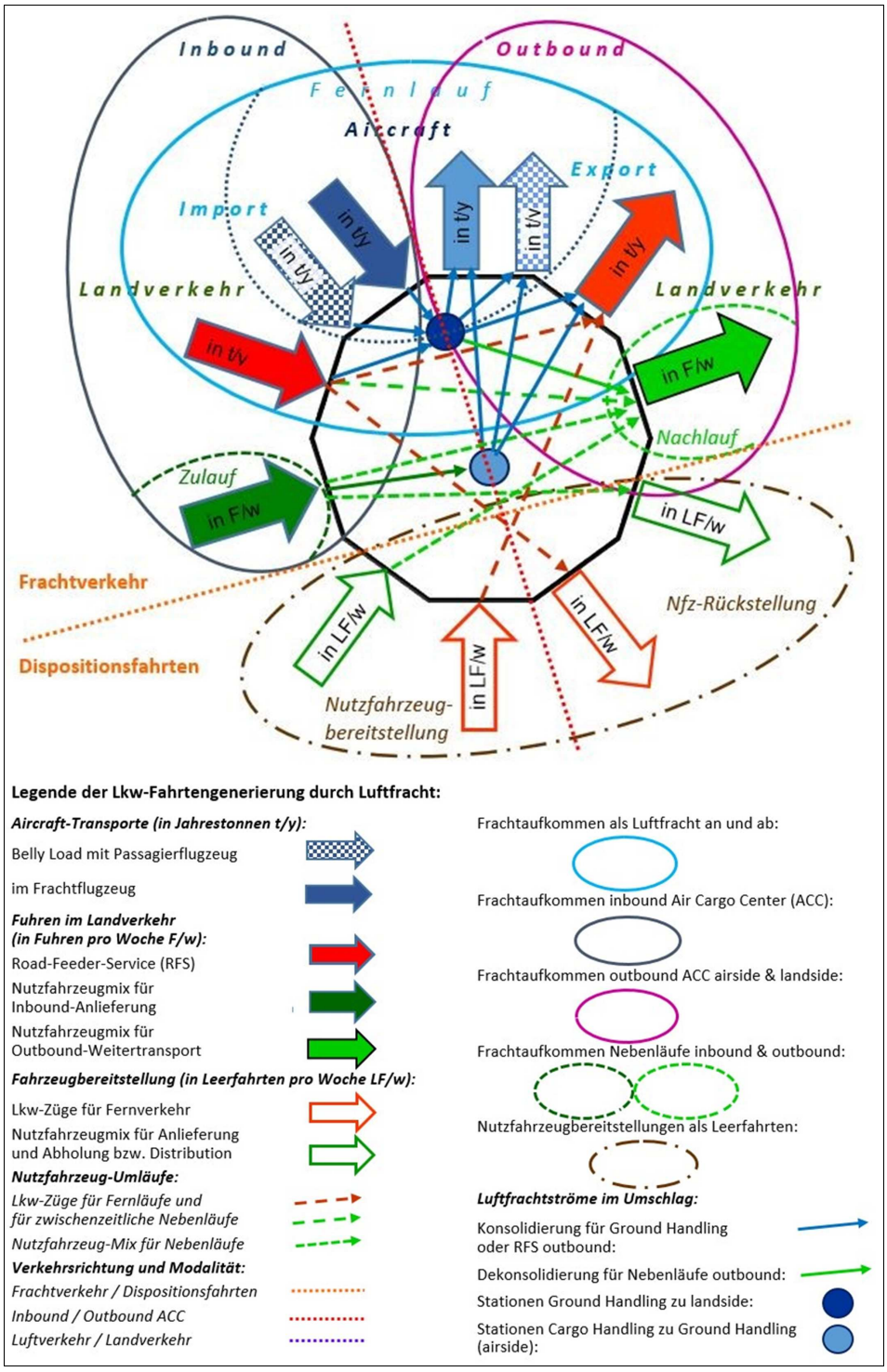


Abb. 8: Die Frachtströme und Verkehrsmitteleinsätze eines Air Cargo Centers (Grafik: Dörr, aus ACCIA 2016)

- Zubringer- und Konsolidierungs- sowie Verteilverkehre mit dem Hinterland im herkömmlichen Straßengüterverkehr durch Speditionen im Kundenauftrag B2B
- Konsolidierungs- und Logistik-Pendelverkehre im regionalen Umkreis des Ballungsraumes als Zwischenverkehre zwischen Logistik-Zentren oder als Expressdienste B2C
- Lokale Frachtüberstellverkehre im Flughafengelände auf der Landseite und aus der Nachbarschaft

Die Erfassung dieser Straßenverkehre (RFS und die Nebenläufe) ist gegenwärtig unmöglich, da es keinerlei punktuelle Verkehrszählungen oder Datenerhebungen dazu gibt. Daher bleibt vorderhand nur eine Annäherung über Modellhypothesen unter Verwendung fragmentierter Datenbestände, aus denen solche Verkehre nach Plausibilität abgeleitet und in den Größenvergleich mit amtlichen Verkehrserhebungen gestellt werden, um einen ersten Eindruck von der Verkehrsteilnahme der Luftfrachttransportläufe im Straßenverkehr zu erhalten (s. Abb. 4).


Abb 9 u. 10: Das Air Cargo Center landside und airside am Aéroport du Luxembourg (LUX)

4.2 Road Feeder Services (RFS) als landgestützter Luftfrachtverkehr

RFS-Transportläufe sind mit einer Flugnummer eines Ausgangsflughafens (outbound) versehen und bereits sicherheitsmäßig entsprechend behandelt worden. Sie werden daher in der Luftfahrtstatistik erfasst und scheinen daher nicht in der Straßenverkehrsstatistik auf („Flughöhe null“). RFS-Transportläufe können in bestimmten, speziell geeigneten Fällen, wenn es sich um einen sogenannten „bekannten Versender“ handelt, der im Rahmen der Kontraktlogistik mit einem „reglementierten Beauftragten“ Luftfrachttransportketten abwickelt, bereits an einem Versandstandort beginnen. Dazu kann ein ULD-Aufbau auch schon am Versandstandort stattfinden, womit ein zeitsparender ULD-Durchlauf über die Landside-Airside-Grenze zum Ground-Handling des Flugzeugs (meist Frachter) ermöglicht wird. Dadurch bietet sich der Vorteil, die aufeinander eingespielten Akteure in ein Umstellungskonzept einbinden zu können und in der Transportpraxis die Einsparungs-, Entlastungs- und Kosteneffekte einem begleitenden Monitoring zu unterziehen.

Die Zulauf-Ketten bis zum Abflug umfassen verschiedenen Transport-Sequenzen beginnend an einem der vielen Versandorte mit einem beliebigen Straßentransporteur (werkseigene Flotte, beauftragter Transporteur oder Abholverkehr organisiert durch eine Spedition) über ein näher oder ferner des Abflughafens gelegenes Cross-Docking-Lager eines Verkehrsdienstleisters zur flugplangerechten Konsolidierung der Sendungen. Von wo der Weitertransport mit einem Straßentransporteur seiner Wahl oder durch Abholung durch einen Ground Handling Agent zur Anlieferung an ein Air Cargo Center an der Landside-Airside-Grenze zur flugnummerngerechten Bepackung einer flugzeugmustergerechten Palette oder eines Containers (“Unit Load Devices”) erfolgt. Sodann werden die Luftfrachtsendungen vom Ground Handling im Rahmen des Load-Mastering (z.B. in Hinblick auf die Ausbalancierung im Flugzeugkörper „weight & balancies“) von einem Ground-Handling-Supplier in den Frachtraum eines Flugzeuges entweder als Belly Load im Unterdeck eines Passagierfluges oder in ein Frachtdeck eines Frachtflugzeuges verbracht.


Abb. 11 u. 12: Die Befrachtung eines Frachtflugzeuges B 747F mit ULDs auf dem Cargo-Vorfeld

4.3 Die Verkehrsbewegungen am Flughafenstandort und am Vorfeld im Ground Handling

Je größer und bedeutender ein Hub-Airport ist, desto weiter sind die flughafeninternen Wege und desto höher sind die erbrachten Verkehrleistungen, sodass sie auch ein lohnender Angriffspunkt für die Dekarbonisierung darstellen. Wie eingangs erwähnt ergeben sich an einem Flughafenstandort verschiedene

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Innovationsfelder in Korrespondenz mit den dort initiativen Akteuren für eine CO2-neutrale und schadstoffarme Flächen-nutzung und Mobilität. Über die Effekte alternativer Antriebsformen in Hinblick auf die Primärenergie-bilanzen, die Wirkungsgrade und die Einsparpotenziale bei den Emissionen gibt es eine kontroversielle, von Interessen geprägte Diskussion, auf die hier nicht im Detail eingegangen wird. Vielmehr wird das Vorfeld als Mobilitätsraum ins Bild gerückt, das wenig Beachtung findet, weil es zwar intensiv frequentiert, aber nicht öffentlich frei benutzbar ist. Ausgangspunkt der Betrachtung sollen daher die günstigen Randbedingungen für eine Umstellung auf eine nachhaltige Mobilität am Vorfeld sein, ehe die antriebstechnologischen Optionen dann im jeweiligen Einzelfall zu behandeln sein werden. Als vorteilhaft erweisen sich im Vergleich zur Mobilität in den öffentlichen Verkehrsnetzen folgende verkehrslogistische Faktoren:

- Das Vorfeld als Infrastruktur steht in Verantwortung des Flughafenbetreibers
- Es handelt sich um relativ kurze Wege
- Die Relationen führen zu Stützpunkten am Gelände zurück
- Es herrscht eine brauchbare Planbarkeit der Einsätze
- Die Gewichtscharakteristik der Vorfeldtransporte über kurze Strecken ist im Normalfall im Zentner- bis niedrigen Tonnenbereich angesiedelt.

Alles in allem sind das nahezu ideale bodenbezogene Voraussetzungen für eine Umstellungsstrategie, die man sich anderswo im Ballungsraum wünschen würde. Dazu sind aber viele am Vorfeld sich bewegende Akteure „an Bord“ zu holen, deren Verkehrsmittel eine bunte Vielfalt auszeichnet, Deswegen müssen sowohl die verkehrslogistisch bedingten Bewegungsmuster als auch die Fahrzeugmassen genau erhoben werden, um zu beurteilen, welche Antriebskonfigurationen den Nachhaltigkeitszielen am besten entsprechen. Denn für eine Umstellung sind für den Fuhrparkbetreiber airside die örtlichen Möglichkeiten und Kapazitäten der Energieversorgung ebenso zu bedenken wie die Folgeeinrichtungen für die Wartung und Reparatur.

4.4 Antriebskonzepte je nach Einsatzzweck

Die Nachhaltigkeitsziele sind mit den betrieblichen Zielen der Operabilität für den jeweiligen Flughafen abzuwägen, womit sich nicht automatisch eine Verteufelung herkömmlicher fossiler Antriebe verbindet. So ist für bestimmte Bodendienste die verlässliche jederzeitige Einsatzfähigkeit (Pusher, Enteisung, Winterdienst, Feuerwehr, Guidance) sicherzustellen, weil solche Spezialfahrzeuge auch nicht in Überzahl vorgehalten werden können. Schließlich sind auch widrige Witterungsverhältnisse mit zu bedenken.

In der Hauptsache stehen folgende Antriebskonzepte zur Auswahl, wobei die externe Energieversorgung der Fahrzeugflotte und die Energiespeicher im Fahrzeug immer dazugehören:

- Diesel- oder Benzin betriebene Verbrennungskraftmotoren (VKM)
- Erdgasbetriebene Verbrennungskraftmotoren (CNG, LNG)
- Batteriebetriebene Elektrofahrzeug (BEV)
- Wasserstoffbetriebene Elektrofahrzeuge (FCEV)
- Hybride Kombinationen dieser Antriebe

Erdgasgestützte Fahrzeuge erfreuen sich einer gewissen Beliebtheit, weil zu ihnen reichliche Betriebserfahrungen vorliegen. Ihr Betrieb reduziert die klimaschädlichen Emissionen geringfügig. Sie kommen außerdem in hybriden Antriebskombinationen in Frage, was für den Landeinsatz in der erweiterten Airport-City-Region spricht.

Bei der reinen Elektromobilität ist der lokale Entlastungseffekt klarerweise am höchsten, die Knackpunkte liegen beim Lastmanagement der Stromversorgung und der Einrichtung einer genügenden Anzahl von Ladestationen, die am Gelände dezentralisiert werden könnte. Zudem ist unter günstigen Umständen die konduktive Ladetätigkeit (über Kabel oder Pantograph) um induktive Standplätze (also berührungsfrei über Magnetspulen) indoor oder an Abstellplätzen ergänzbar. Die Reichweite sollte über den Tageseinsatz am Vorfeld oder in der Airport City gewährleistet sein. Die Anfahrzugkraft ist je nach Einsatzzweck ein Thema, das faktische Geschwindigkeitsniveau entspricht dem einer Wohnanliegerzone und von der Rekuperation der

Bremsenergie darf nicht allzuviel erwartet werden. Die zentralen Stützpunkte erlauben ferner einen raschen Batterientausch, sodass nicht unbedingt schnell oder langdauernd das BEV-Fahrzeug geladen werden muss.

Bei der Brennstoffzelle (Fuel Cell) ist der Entlastungseffekt wie vorhin. Der Knackpunkt liegt bei der Anlage der aufwändigen Wasserstofftankstelle, die aber an der Landside-Airside-Grenze zur Betankung beiderseits positioniert werden kann, sodass sie von der Auslastung des allgemeinen Landverkehrs profitieren könnte. Aufgrund der Reichweite des H2-Tanks sind die Erreichbarkeit und die Frequenz der Tankvorgänge kein Problem. Die Sicherheit gilt heute als gewährleistet. Übrigens kann Wasserstoff auch in einem VKM eingesetzt werden, was eine Adaptierung im Bestand erfordert, die technische Reife hat aber noch nicht den Markt erreicht. Die den Einsatz limitierenden Faktoren der batteriegestützten Elektrofahrzeuge stellen sich bei den H2-betriebenen Fahrzeugen nicht ein, sodass sie ein breiteres Anwendungsspektrum abdecken.

Je näher die benötigten Fahrzeugmuster an der Marktnachfrage angesiedelt sind, desto leichter fällt eine Investitionsentscheidung zugunsten CO2-reduzierter bzw. -neutraler und schadstoffarmer bzw. -freier Boden-fahrzeuge bei der Nachbeschaffung. Dabei können auch hybride Antriebslösungen ihre Chance bekommen, wenn analoge Fahrzyklen im Landverkehr, was regelmäßige Tagesfahrleistungen, etwa von Taxi-, Shuttle- und Liefer-Services, anbelangt, zum Vergleich herangezogen werden können. Koordinierte Beschaffungen der Fuhrparkbetreiber innerhalb des Flughafenstandortes oder im Flughäfen-Verbund könnten günstigere Konditionen erzielen und nach außen die Umstellung positiv signalisieren.

4.5 Umstellung im Überlandverkehr als Perspektive

Eine Umstellung im Landtransport auf emissionsfreie Antriebe, wie auf Wasserstoff-Brennstoffzellen, könnte viel früher und einfacher zu bewerkstelligen sein als auf dem Luftweg. Die Flugzeugmuster für emissionsgeminderte Triebwerke, sei es durch synthetische Treibstoffe oder biogene Beimischungen zum Kerosin, sind noch im Experimentierstadium, ganz abgesehen von der Entwicklung spezieller Fluggeräte nur für Air Cargo. Derzeit ist die Nachnutzung bzw. der innere Umbau von in die Jahre gekommenen Passagier-Fliegern noch üblich (wie „747-F“). Da der Lkw-Transport im RFS-Modus, erstens ein spezielles Equipment im Trailer braucht (Roller beds), zweitens aber die Nutzlast der Luftfracht in ULDs (ca. 9 t NL gesamt) verladen kaum an die Nutzlastgewichtsgrenze der Lkw heranreicht, steht für die Unterbringung der Energiespeicher (H2-Tank, Batterien für Rekuperation, allenfalls Range Extender) genügend Spielraum für die Truck- und Trailerentwicklung der nächsten Fahrzeuggeneration offen. Die Verkehrslogistik bietet folgende Vorteile:

- Die Routen sind durch die vorherrschende Kontraktlogistik zwischen den Airports und den zugeordneten Cargo-Logistik-Stützpunkten gut planbar.
- Die Sammel- und Verteilverkehre der Luftfrachtsendungen im Vorlauf und Nachlauf können auf geeignete emissionsarme Verkehrsmittel verlagert werden. Dabei sollte auch die Bahn auf Dauer in der Transportkette nicht außer Acht bleiben, wenn es sich um Punkt-zu-Punkt-Zugläufe handelt.
- Die Nutzfahrzeuge im Überlandverkehr bilden spezielle Flotten, die mit der turnusmäßigen Fuhrparkerneuerung umgestellt werden können, sofern auch Flughäfen als Infrastrukturpartner für die Betankungsstationen sorgen und eine Auswahl an H2-Trucks am Markt angeboten werden.

So bildet sich eine Transport-Prozesskette heraus, deren Sequenzen auf Angriffspunkte für klimafreundliche Restrukturierungsmaßnahmen hin untersucht werden sollte. Freilich ist dabei immer Bedacht auf die Energieerzeugungskette der Kraftstoffe zu nehmen, damit nicht die Elektrolyse für die Wasserstoffproduktion aus der Braunkohleverstromung gespeist wird. Ein Unsicherheitsfaktor darf nicht unbeachtet bleiben und das ist der Preis für einen Kilogramm Wasserstoff. Die Preisentwicklung wird vermutlich eng mit jener der anderen Energieträger korreliert sein, aber davon abgekoppelte Erzeugungsstrukturen wären denkbar.

Die Betriebskosten in der Kette der Vorleistungserbringung Well to Tank, sprich Windenergie – Elektrolyse – Zwischenspeicherung – Tankstellenbelieferung, sind dabei heikle Punkte, wenn die Betreibermodelle dafür nicht als Vorfragen abgeklärt werden. Die aufwendige Errichtung der Tankstellen – diesfalls als Infrastrukturanlagen der Flughäfen – kann mit öffenlichen Förderungen bedacht werden. Die Tankstellen können sodann für die Versorgung air-affiner wie auch anderer Kundenkreise geöffnet werden, wenn sie an der Schnittstelle und Grenze zwischen Landside und Airside eingerichtet worden sind.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER



Abb. 13, 14 und 15: Windkraft als Primärenergie, H2-Trucks als Verkehrsmittel (Prototyp gesehen bei der ITS-World Conference 2021 in Hamburg 2021) und flaches Autobahnnetz in Mitteldeutschland


Abb. 16 u. 17: Noch wenig für Air Cargo genutzter Luftfrachtbahnhof im Vorfeld des Europa-Hubs von DHL Global Forwarding am Flughafen Leipzig-Halle (LEJ)

4.6 Ausblick auf eine Projektinitiative NEW2AIR (No Emissions on the Way to the Aircraft)

Die Abbildungen 12-16 sollen einen ersten Eindruck von der angedachten Projektinitiative NEW2AIR vermitteln, wofür die Zeit nun reif wäre. Die Börden Norddeutschlands (hier bei Magdeburg) liefern den durch Windenergie erzeugten Strom für die „grüne“ Elektrolyse zur Wasserstoffbetankung der Fuel-Cell-Trucks. Das flache Autobahnnetz begünstigt hohe Reichweiten und erlaubt vielleicht das Platooning (automatisiert verkettetes Fahren im Konvoi) zur Steigerung des Wirkungsgrades, da die Routen und Ankünfte inbound klar ausgewiesen werden können. Fuhrpark-Umstellungen werden auf mittelfristige Sicht vorbereitet, sobald der Fahrzeugmarkt überzeugende Angebote macht. Für gebündelte Transporte zu den Logistiklägern sollte auch die Bahn ins Visier genommen werden. Jedenfalls ist ein „Vieleck“ von operativen Akteuren an Bord zu holen, die versuchen wollen, solche zukunftsfähigen Transportketten aufzubauen.

5 QUELLENHINWEISE

ACCIA (2016): F&E-Potenziale in den Luftfrachtprozessen in Österreich. Forschungs- und Entwicklungs-dienstleistung für das Bundesministerium für Verkehr, Innovation und Technologie (BMVIT), bearbeitet von arp-planning.consulting.research (H. DÖRR, V. MARSCH, A. ROMSTORFER, Y. TOIFL), DHL Global Forwarding Austria (R. FRIEDREICH, A. PACESKI, O. THUNHART) und der Flughafen Wien AG (P. DE LEEUW, S. PETERA). Verfügbar unter: www.researchgate.net oder www.ffg.at

DÖRR, H.; MARSCH, V. und ROMSTORFER, A. (2017a): FTI-Potenziale an Schnittstellen für Air Cargo. Schnittstellen zwischen Logistik, Landverkehr und Luftfahrt entlang der Air Cargo Transportketten. In: Internationales Verkehrswesen (69) 2 /2017. 28-32

INTERNATIONAL TRANSPORT FORUM (ITF: (2021): “Decarbonising Air Transport: Acting Now for the Future”, International Transport Forum Policy Papers, No. 94, OECD Publishing, Paris

ROMSTORFER, A; DÖRR, H.; MARSCH, V. (2017b): RTI-Capabilities of Air Cargo Transport Chains by Evaluating Processing Interfaces and Actor´s Responsibilities. In: 4th Internationale Physical Internet Conference IPIC 2017 in Graz. Edited by University of Technology Graz

ROMSTORFER A.; DÖRR, H. (2018): Die Airside-Mobilität eines Hub-Flughafens. Innovationspotential am Vorfeld für nachhaltige Mobilität. In: Internationales Verkehrswesen (70) 4 / 2018. S. 44-48

Alle Grafiken vom arp-Team. Alle Bilder von © Dörr im Beisein autorisierter Personen aufgenommen.

Mixed Use in Practice: Über- und Einblick in gemischt genutzte Immobilienprojekte

Herbert Bartik, Uschi Dorau, Michael Rosenberger

(Mag. Herbert Bartik, Urban Innovation Vienna, Abteilung Quartiere und Immobilien, 1040 Wien Operngasse 17-21, bartik@urbaninnovation.at)
(DI Uschi Dorau, Urban Innovation Vienna, Abteilung Quartiere und Immobilien, 1040 Wien Operngasse 17-21, dorau@urbaninnovation.at)
(DI Michael Rosenberger, Magistrat der Stadt Wien, Abteilung MA 18 - Stadtentwicklung und Stadtplanung, 1010 Wien Rathausstraße 14-16, michael.rosenberger@wien.gv.at)

1 ABSTRACT

Die Ermöglichung von Mixed-Use-Projekten gehört zu den Zielen der Wiener Stadtplanung, wie sie u.a. im Stadtentwicklungsplan 2025 und den STEP Fachkonzepten festgelegt sind. Nutzungsmischung spielt unter anderem im Hinblick auf kurze Wege, Ressourcenschonung, Klimaschutz, Verkehrsreduktion und soziale Gerechtigkeit eine Rolle. Anspruch und Wirklichkeit klaffen jedoch vielfach (noch) auseinander, denn in der Praxis scheuen sich viele Entwicklerinnen und Entwickler vor einer Umsetzung. Die Gründe dafür sind vielschichtig, höhere Baukosten, Koordinations- und Planungsaufwand sind einige davon. Die vorliegende Analyse ausgewähler Mixed-use-Projekte inkludiert einen umfassenden Blick auf Rahmenbedingungen und Entstehung, ökonomische Parameter, Entwicklerinnen- und Entwickler-Interessen, Rolle und Instrumente der Stadtverwaltung, die zur Entwicklung beitrugen, und schließlich auf die Bewährung der Projekte am Markt.

Keywords: Quartiersentwicklung, produktive Stadt, Marktentwicklung, Nutzungsmischung, Immobilien Markt.

2 ZIELSETZUNG

2.1 Vorgehensweise

Im Rahmen des Projektes „Mixed-Use in Practice“ wurde analysiert, welche Mixed-Use-Typologien am Markt umgesetzt werden und welche Parameter eine erfolgreiche Entwicklung befördern können. Zunächst erfolgte eine Einschätzung der Marktentwicklung von Mixed-Use Projekten. Die daraus gewonnen Erkenntnisse bildeten die Grundlage für eine detaillierte Funktionsbewertung von 14 ausgewählten Mixed-Use-Projekten. Betrachtet wurden grundsätzlich unterschiedlichste Formen von Nutzungsmischung (Gewerbe-Wohnen, Büro-Wohnen, Büro-Gewerbe-Appartements, Büro-Einzelhandel etc.). Die methodische Annäherung erfolgte über einen Mix aus Desktop- und Literatur-Recherche und Gesprächen mit Projektverantwortlichen.

Mixed-Use-Blocks	High-rise	Transformation
• Baufeld D13 Aspern, Wien • BLOX, Kopenhagen • Caxton Works, London • Frizz23 (Baugruppe), Berlin • Gründerinnenhof, Wien • LIVING Garden, Wien • MIO Quartiershaus, Wien • MISCHA, Wien • SEEPARQ, Wien • SEEHUB, Wien • Sirius, Wien • Strathcona Village, Vancouver • The Student Hotel, Wien • Wohnprojekt Nordbahnhof, Wien	• Bałtyk Tower, Poznan • De Rotterdam, Rotterdam • Four Frankfurt, Frankfurt am Main • L’Arbre Blanc, Montpellier • Marina One, Singapur • Omniturm, Frankfurt am Main • Toranomon Hills Mori Tower, Japan	• Abattoir, Brüssel • Breakout Kreativzentrum, München • Brooklyn Navy Yard, New York City • CREA Creative Cluster Margareten, Wien • LAVAZZA, Turin • Linden Karree, Gelsenkirchen • Malzfabrik Schultheiss, Berlin • Monopolis, Lodz • RDM, Rotterdam • Toni Molkerei, Zürich • VW Gläserne Manufaktur, Dresden • WeiberWirtschaft, Berlin • Werkspoorfabriek, Utrecht

Tabelle 1: Übersicht der untersuchten Mixed-Use Projekte.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Die untersuchten Projekte umfassen eine breite Palette an Nutzungstypen, Gebäudeensembles sowie Eigentümerstrukturen und wurden zwecks besserer Strukturierung der Funktionsbewertung in drei Typen eingeteilt:

- Mixed-Use-Blocks. Die gängigste Form von Mixed-Use Projekten bei Neuentwicklungen. Horizontale Kombination von Nutzungsformen in einem Gebäudekomplex oder mehreren separaten Gebäuden.
- High-rise. Hochhausprojekte, meist in zentraler Lage mit hohem architektonischem Anspruch. Kombination verschiedener Nutzungen in der Vertikalen.
- Transformation. Revitalisierung und Erweiterung von Brownfields zu gemischtgenutzten Quartieren.Die Analyse der einzelnen Cases folgte einem strukturierten Analyseraster entlang der Kriterien:
- Ausgangsbedingungen, Hintergrund, Besonderheiten.
- Ökonomische Parameter. Finanzierung, Förderungen, Betrieb, Mietpreise, Nachfrage / Marktsituation, Entwicklerrationalität hinter der Nutzungsmischung
- Perspektive der Stadt. Rolle der Stadtverwaltung, Instrumente der Stadtentwicklung, die zur Entstehung bzw. Entwicklung des Projektes beitrugen
- Funktionsbewertung. Wie bewährt sich das Projekt im Betrieb, Auslastung, Management und Qualitätssicherung, Eigentümer- und Nutzerzufriedenheit
- Schlüsselakteure im Entwicklungsprozess

3 MIXED-USE-BLOCKS

Mixed-Use-Blocks stellen die gängigste Form der Mischnutzung dar. Verschiedene Nutzungen werden in einem Gebäudekomplex oder mehreren separaten Gebäuden nebeneinander kombiniert. Die Kombination der Nutzungen ist vielfältig. Oft gibt es eine bzw. wenige klare Hauptnutzungsformen, wie z.B. Wohnen (inkl. Student Housing, Micro- oder Co-Living), Büronutzung (inkl. Co-working), Produktion, Gewerbe, Hotelnutzung (inkl. Serviced Apartments), Forschungs- oder Bildungseinrichtungen. Diese werden durch Dienstleistungsangebote zur Unterstützung der Hauptnutzer, wie Geschäfte und Handwerker, Sport- und Freizeiteinrichtungen, Gastronomie, öffentliche Einrichtungen, Kultur- oder Bildungsangebote ergänzt. Diese Nutzungsform wird zunehmend in den neuen Stadtentwicklungsgebieten umgesetzt. Jüngere Projekte auch als Baugruppenmodelle.

3.1 Entwickler-Perspektive(n)

Unterschiedliche Developer. Projekte in dieser „Assetklasse“ werden sowohl von rein gewerblichen Developern umgesetzt als auch durch gemeinnützig orientierte Träger (z.B. Baugruppen, Genossenschaften). Daraus ergeben sich unterschiedliche Interessenlagen und Projektakzentuierungen (z.B. im Hinblick auf hochpreisige Wohnungen), allerdings sind auch Parallelitäten sichtbar (z.B. Aufbau einer Business-Community, Bereitschaft zu flexiblen Preismodellen bei der Miete).

Hochpreisiges Wohnungsangebot. Ein Unterschied ist sehr deutlich: Profit-orientierte Developer setzen auf ein hochpreisiges Wohnungs-/Appartement-Angebot zur Gesamtfinanzierung des Projektvorhabens. Als besonders relevant scheint das aus Developer-Sicht bei der Mischung Wohnen/Produktion zu sein. Die hierbei schlagend werdenden höheren Baukosten sollen so refinanziert bzw. moderate Preise für gewerblicher Mieterinnen und Mieter solcherart querfinanziert werden. Öffentliche Vorgaben zu Anteil von Sozialwohnungen werden entsprechend kritisch gesehen.

Öffnung zum Quartier. Eine Gemeinsamkeit ist wiederum das Bestreben, Mixed-Use-Blocks zum Quartier hin zu öffnen. Aus Sicht der Privaten wird dadurch ein positives Branding und eine positive Entwicklungsdynamik am Standort erleichtert, bei nicht-gewerblichen Bauträgern kommen noch gemeinwohlorientierte Überlegungen hinzu.

Flexible Preismodelle. Flexible Preismodelle kommen sowohl im gewerblichen wie auch im Non-Profit-Bereich zum Einsatz. Die Rationalität ist in den beiden Fällen ähnlich: innovative Unternehmen sollen die

Möglichkeit haben, sich in einer Frühphase der Projektentwicklung anzusiedeln und so zu einer Belebung und Positionierung des Standortes beitragen.

Funktionsänderungen ermöglichen. Für den Fall, dass sich der geplante Nutzungsmix nicht bewährt, sollten Funktionsänderungen flexibel und ohne Mehrkosten realisiert werden können. Dafür wird in der Planung durch Raumhöhen, Struktur (Stützen statt Wände) und Haustechnik (Ringleitungen statt Wohnungsschächte) Vorsorge getragen

3.2 Instrumente & Rolle der Stadt

Grundstücke im städtischen Besitz nutzen. Developer betreten vielfach mit Mixed-Use Projekten Neuland (insbesondere mit der Mischung von Produktion und Wohnen oder mit innovativen partizipativen Konzepten wie Baugruppenmodellen). Über moderate Verkaufspreise bzw. über günstige Konditionen bei einer Vergabe im Baurecht von städtischen Grundstücken können Städte solche Entwicklungsvorhaben unterstützen bzw. überhaupt erst ermöglichen.

Rechtliche Vereinbarungen. Über entsprechende Widmungskategorien oder übergeordnete Vorgaben zu Anteilen von leistbaren Wohn- und/oder Gewerbeflächen nehmen Städte auf Mixed-Use-Blocks Einfluss. Den stärksten Hebel bilden freilich vertragliche Festschreibungen beim Grundstücksverkauf bzw. bei der Vergabe in Baurecht (Voraussetzung dafür: es handelt sich um Grundstücke im öffentlichen Besitz oder es werden entsprechende Vereinbarungen mit dem Liegenschaftseigentümer getroffen).

Vorgaben zu leistbarem Wohnen. Mixed-Use-Blocks befinden sich an gut erschlossenen Standorten, die eine Wohnnutzung ermöglichen und somit eine Wertsteigerung des jeweiligen Grundstücks begründen. Städte haben die Haltung, dass die Wertsteigerung nicht vollständig beim (privaten) Developer verbleiben soll. Das Mittel um das zu erreichen, können einerseits städtebauliche Verträge sein oder etwa Vorgaben zum Anteil des leistbaren Wohnens.

3.3 Risiken & Stolpersteine

Höhere Baukosten. Die Baukosten steigen durch die Nutzungsmischung. Insbesondere industrielle Nutzungen haben bautechnische Anforderungen (Systeme zur Vermeidung von Geruchs- und Lärmbelästigung, große Räume ohne Säulen und tragenden Wänden), die mit entsprechenden Kosten verbunden sind, die an anderer Stelle verdient werden müssen.

Schwierige Finanzierung. Insbesondere für die Non-/Limited-Profit-Projekte im Sample erwies sich die Projekt-Finanzierung als herausfordern. Banken und andere Kapitalgeberinnen und Kapitalgeber forderten Vermietungs- bzw. Vorvermietungszusagen, die bei solchen Projekten insbesondere für die gewerblichen Nutzungen schwierig zu bekommen sind. Die gewerblichen Developer konnten mit dieser Problemstellung besser umgehen, etwa weil sei bereits über die entsprechenden Geschäftsverbindungen bzw. ein etabliertes Finanzierungs- und Businessmodell verfügten oder weil sie über die Errichtung hochpreisiger Wohnungen/Appartments den Business-Case verdeutlichen konnten.

Marktdynamiken. Schließlich wirken insbesondere bei Mixed-Use-Blocks mit hohem öffentlichen, gemeinwohlorientierten Anspruch Marktdynamiken vielfach gegen die Projektziele (etwa im Hinblick auf Nutzungen und Kosten). In der Praxis wird hier versucht durch spezifische Organisationsmodelle (Baugruppe, Genossenschaften) und striktes Controlling/Monitoring dagegen zu halten.

4 HIGH-RISE

Hier sind die Nutzungen in der Vertikalen angeordnet. Die Hauptnutzungsformen sind Wohnungen, Büros oder Hotelnutzung (inkl. Serviced-Appartments), die oft durch Einkaufszentren, Gastro- oder Entertainmentangebote (in den untersten oder obersten Geschossen) ergänzt werden. Diese Mischnutzungsform ist in den USA und Asien weit verbreitet, gewinnt jedoch zusehendes auch in Europa an Bedeutung. Oft handelt es sich um Luxusobjekte in zentralen Lagen mit hohem architektonischem Anspruch.

4.1 Entwickler-Perspektive(n)

Nutzungsmischung en vogue. Die Analyse-Cases reihen sich in den allgemein konstatierten Trend zu Nutzungsmischung im Hochhaus ein. Dahinter steht eine Verwertungsrationalität, Nutzungsmischung mit einhergehender Nutzungsflexibilität sind ein Instrument der Risikostreuung in einem zunehmend volatilen

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Markt. Dazu kommt, ein abnehmender „Prestigefaktor“ bei der Hochhausentwicklung: Während in der Vergangenheit große Konzerne stärker als Bauherr für „ihr“ HQ auftraten, stehen heute hinter der Hochhausentwicklung in der Regel Fonds und Kapitalgesellschaften als Financiers, die ihren Anlegern eine entsprechende Sicherheit und Rendite liefern müssen – beides heute ein Argument für kluge Mischkonzepte.

Finanzierungskonzept mit High-End Angebot. Die Wohnungen in Hochhäusern gehören ebenso wie die Büros oft zu den teuersten der Stadt. Das hohe Preisniveau ist wesentlich für ein funktionierendes Finanzierungskonzept. Dass die Finanzierung von kostspieligen Hochhausprojekten gelingt, hängt wesentlich mit einem dynamischen Immobilienmarkt und steigenden Preisen zusammen. Selbst hohe Investitionssummen können über einen Verkauf nicht refinanziert werden, sondern die Realisierung von beachtlichen Profiten wird möglich. Die analysierten Projekte bilden insofern einen allgemeineren Trend gut ab, als die enormen Preissteigerungen in diesem Sektor des Immobilienmarktes sichtbar werden.

4.2 Instrumente & Rolle der Stadt

Die hohe Dynamik am Immobilienmarkt und dessen Attraktivität als Kapitalanlage bringen es mit sich, dass die Anzahl der Hochhausprojekte insgesamt und auch solche mit gemischter Nutzung weltweit zunehmen. Dementsprechend sind Städte gefragt, sich diesem Trend gegenüber zu positionieren. Sie tun dies, indem sie Instrumente auf einer Skala von regulativ-beschränkender bis incentivierend-unterstützend zur Umsetzung bringen.

Aufteilung Bodenwertsteigerung. In den letzten Jahren wurden (insbesondere in westeuropäischen) Städten unterschiedliche Modelle des Planwertausgleichs etabliert bzw. weiterentwickelt. Gerade im Falle von Hochaushausprojekten ist eine Aufteilung der Wertsteigerung und der aus dem Projekt entstehenden Kosten vielfach Voraussetzung für einen positiven Planungsbescheid. Im Falle Frankfurts können bis zu zwei Dritteln der planungsbedingten Bodenwertsteigerung als Leistungen für die Allgemeinheit vereinbart werden und so verpflichtend in Maßnahmen wie Erschließung, soziale Infrastruktur, Klimaschutz oder Grünflächen investiert werden.

Instrumente der Raumordnung. Klassisches Instrument der Raumordnung ist die Festlegung von prioritären/geeigneten Zonen für Hochhausbebauungen wie das Frankfurt mit dem Hochhausentwicklungsplan macht. Zentraler Verdichtungsraum soll demnach das Bankenviertel mit seinen umgebenden Hauptverkehrsachsen sein. Festgelegt wird darüber hinaus, dass Hochhausstandorte zukünftig verstärkt zu einer positiven Quartiersentwicklung beitragen, sie sollen keine abgeschlossenen Orte sein, sondern sich zur Stadt hin öffnen. Bei weiteren Hochhausentwicklungen soll demnach der öffentliche Raum in besonderem Maße fokussiert werden. Insbesondere gemischt genutzte Hochhäuser sollen forciert werden.

Reduktion des Vermietungsrisikos. Die Entwicklung von gemischt genutzten Hochhausprojekten kann im Hinblick auf Finanzierung und Vermarktung schwierig sein. Höhere Baukosten sind ein Faktor, eine gewisse Zurückhaltung der Finanzmärkte bei der Finanzierung solcher Projekte ein anderer. Frühzeitige Vormietungszusagen helfen maßgeblich dabei, Finanzierungspartner zu überzeugen, sind aber gleichzeitig in einer sehr frühen Projekt-Planungsphase von privaten Marktteilnehmerinnen und Marktteilnehmern kaum zu bekommen. Durch frühzeitige Mietzusagen der öffentlichen Hand können jene Sicherheiten geschaffen werden, die institutionelle Investorinnen und Investoren einfordern.

4.3 Risiken & Stolpersteine

Herausfordernde Finanzierungskonstruktion. Der Nutzungsmix im Hochhaus bringt zusätzliche Komplexität in den Entwicklungsprozess und ist für die Immobilienwirtschaft noch ein Novum. Finanzierungskonstruktionen umfassen in der Regel intensive Abstimmungsprozesse mit einer Vielzahl an Finanzierungspartnern.

Verdrängungseffekte. Großprojekte wie Hochhausvorhaben sind bisweilen umstrittene Projekte – neben Fragen der Architektur und städtebaulichen Maßstäblichkeit spielen dabei auch mögliche negative Effekte auf Bestandsobjekte eine Rolle.

5 TRANSFORMATION

Bei der Revitalisierung und Transformation ehemaliger Industrieareale wird zunehmend auf Mixed-Use Typologien gesetzt. Meist werden bestehende Gebäude umgenutzt und durch moderne Neubauten erweitert.

Die vielfach historisch bedeutsamen Gebiete machen eine behutsame Synergie von Tradition und Moderne in Planung und Betrieb notwendig. Die Eigentümerinnen- und Eigentümerstrukturen sind vielfältig: je größer die Quartiere sind, desto seltener ist die Entwicklung rein privat, aufgrund des sensiblen Charakters der Gebiete nimmt die öffentliche Hand meist eine starke Rolle ein, oft in Form komplexer PPP Modelle. Prädestinierte Nutzungen für diese besonderen Standorte sind Kultur- und Kreativeinrichtungen, Start-Up Inkubatoren oder publikumsbezogene Nutzungen. Mitunter entwickeln sich innovative wissenschaftliche Vorzeigeprojekte, wie z.B. im Bereich der Kreislaufwirtschaft oder der urbanen Landwirtschaft. Die Projekte haben hohe Strahlkraft in die Nachbarschaft.

5.1 Entwickler-Perspektive(n)

Nutzungs-Layout und Managementstrukturen Neuland für Investorinnen und Investoren. Alle analysierten Projekte zeigen: Die Finanzierungsform musste erst gefunden werden. Zum Nutzungsmix kommt hier noch der Aspekt der Revitalisierung dazu - für dieses Portfolio gibt es (noch) wenig Erfahrung bei Banken, Investorinnen und Investoren. Als Schlüssel zum Erfolg erwiesen sich – bei kleinen wie auch bei großen Projekten – langjährig aufgebaute und gut etablierte Geschäftsbeziehungen.

Triple Helix für Innovation. Ehemalige historisch bedeutsame Industrie- und Gewerbegebiete verkörpern Innovationsgeist. Dieser kann durch Nutzungskombinationen von Wissenschaft, öffentlicher Hand und Wirtschaft wiederbelebt werden. Die Areale bieten durch ihre lange Tradition des technischen Fortschritts einen fruchtbaren Boden, um Innovation anzuregen. So können Industrieerbe in zentraler Lage gehalten werden und zu Standorten für kreative Unternehmer entwickelt werden.

Von Mono zu Mixed-Use. Nutzungsmischung wird zu einem Bestandteil modernerer Produktionsareale. Um aus ehemals monofunktionalen oder leerstehenden Arbeiterwohnquartieren oder Industriestandorten vielfältig genutzte, moderne Immobilien, Produktions- und Gewerbeareale zu machen, benötigt es Flächen mit unterschiedlichen Charakteristika und Nutzungsmöglichkeiten. In unterschiedlichen Projekten wird dieses Verständnis beispielhaft umgesetzt.

Innovation als Imagefaktor & Attraktor. Modellprojekte, die Themen adressieren die auf der politischen Agenda weit oben stehen (z.B. soziale Gerechtigkeit, Klima, Energie, etc.) sichern die öffentliche Unterstützung, machen die Mieträume attraktiv und sind auch ein wesentliches Element der Außenkommunikation der angesiedelten Firmen.

5.2 Instrumente & Rolle der Stadt

Steuerung über Liegenschaftsmanagement. In den untersuchten Projekten wurden PPPs in unterschiedlichen Konstellationen entwickelt: In einigen Fällen befindet sich das Grundstück im Besitz der Stadt bzw. hat die Stadt die Liegenschaften an eine Non-Profit Organisationen übertragen. Bei anderen Beispielen blieb das Grundstück ebenfalls im Besitz der Stadt, während jedoch private Investorinnen und Investoren als Manager auftreten. Schließlich gibt es auch Fälle, wo private Investoren das Grundstück kauften und dieses langfristig an die Stadt vermieten.

Forcierung eines Non-Profit Ansatz. Öffentliche, Non-Profit-Organisationen agieren nicht wie „normale“ Marktakteure, sondern handeln stark missions-orientiert. Sie können eine Nachfrage kleiner, innovativer Unternehmen adressieren, die (noch) nicht jene Preise zahlen können, die am freien Markt für entsprechende Immobilien verlangt werden. Diesen Unternehmen können Flächen unter Marktpreisniveau und gleichzeitig „spaces to grow“ angeboten werden.

Öffentliche Investitionen und finanzielle Unterstützungen. In der Brooklyn Navy Yard initiierte die Stadt durch die Finanzierung umfangreicher Upgrades der grundlegenden Infrastruktur ein starkes Wachstum der Zahl der Unternehmen. Durch parallel durchgeführte Nachhaltigkeitsinitiativen der BNYDC konnte so ein schnell wachsendes Cluster grüner Hersteller etabliert werden. In vielen deutschen Städten werden Unterstützungen durch Angebote der Gemeinde, den Sanierungsaufwand steuerlich geltend zu machen (Sanierungssatzung), gewährt. Von den Investitionen profitiert die Stadt letztendlich, denn die Neuansiedelungen bringen Gewerbesteuer- und Einkommensteuereinnahmen und initiieren vielfältige Wertschöpfungsketten. Ein Gesamtsystem wirtschaftlicher und sozialer Initiativen belebt nicht nur die Transformationsgebiete selbst, sondern strahlt auch in die Nachbarschaft aus und steigert den Wert der umgebenden Immobilien.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

5.3 Risiken & Stolpersteine

Kombination von Produktion und Wohnen. Die Integration von Wohnnutzungen in traditionell als Gewerbegebiete genutzte Areale stellt eine besondere Herausforderung dar. Einerseits müssen die Managementstrukturen für den Immobilienbetrieb oft erst aufgebaut werden. Andererseits gestaltet sich die Umsetzung auch baulich herausfordernd, denn Lärmemissionen durch Logistik und Lieferverkehr machen umfangreiche Lärmschutzmaßnahmen nötig. Damit sind beträchtliche Kosten und Abstimmungsaufwände im Umsetzungsprozess verbunden, die nicht unterschätzt werden dürfen.

6 RESÜMEE

Das Thema Mixed-Use wurde und wird seit einigen Jahren von Marktteilnehmerinnen und Marktteilnehmern, von der Wissenschaft und von öffentlichen Akteurinnen und Akteuren vermehrt in den Blick genommen und intensiv diskutiert. Aus der Analyse der ausgewählten Fälle und ausgewählter Dokumente (Marktberichte, Reports, Expert-Interviews, Fachpaper) lassen sich folgende Beobachtungen zusammenfassen:

Städte verändern die Spielregeln. Zahlreiche Städte haben in den vergangenen Jahren strategische Zielsetzungen und rechtliche Rahmenbedingungen angepasst, um Nutzungsmischung zu erleichtern. Vielfach wird dabei auch danach gestrebt, produktive Tätigkeiten in den Nutzungsmix zu integrieren.

Urbane Nachfragemuster forcieren Nutzungsmischung. Es wird konstatiert, dass es gerade bei der jüngeren Bevölkerung in Städten eine wachsende Nachfrage nach vielfältigen, urbanen Quartieren gibt. Gemischte Nutzungen werden zum Asset, auch die Akzeptanz lärmintensivere Nutzungen (wie z.B. Produktion) sei vielfach höher als in der Vergangenheit.

Begrenztes Flächenangebot. Die Immobilienbranche reagiert auf eine Marktsituation, die vielfach durch eine zunehmende Flächenknappheit und damit einhergehende Preissteigerungen gekennzeichnet ist.

Mixed-Use als Instrument der Risikostreuung. Aus immobilienwirtschaftlicher Sicht ist Mixed-Use auch ein Element der Risikostreuung und unter den gegebenen Marktbedingungen daher eine rationale Vorgehensweise.

Mixed-Use in Hochhäusern nimmt zu. Dass in den vergangenen Jahrzehnten die Zahl der weltweit errichteten Hochhäuser massiv zugenommen hat, ist angesichts von Urbanisierung und Wachstum wenig verwunderlich.[1] Interessant ist, dass auch hier ein verstärkter Trend Richtung Mixed-Use sichtbar wird.

Hürden bleiben bestehen. Es gibt aber im Hinblick auf Mixed-Use nicht nur Optimismus –wesentliche Umsetzungshürden, wie Schwierigkeiten beimVerkauf, gebäudetechnische Herausforderungen oder erhöhter Koordinationsaufwand bleiben bestehen.

7 REFERENCES

CAG Consults, London Industrial Land Demand (2017)
Catella Property GmbH, Urbane Quartiere und Mixed-Use-Immobilien – Neue Elemente und Strategien der Immobilienentwicklung (2020)
Christie & Co.; Hotels in Mixed-Use-Konzepten – Hoch hinaus statt nebenan? (2017)
EY & Urban Land Institute, Future of Work - A global real estate player's point of view on the Future of Work and its impact on real estate, (2020)
EY; The Attractiveness of Global Business Districts report The Challenge to Remain Competitive (2020)
JLL, Readiness, Resilience and Responsibility - City Governance and Real Estate in a Post-COVID World (2020)
McKinsey & Company, The future of the high-rise: Creating peoplecentric spaces (2020)
Otto Immobilien, Büro-Marktbericht Herbst 2020
PWC; Emerging Trends in Real Estate: An uncertain impact, (2021)
ULI (G. Clark & T. Moonen); Technology, Real Estate, and the Innovation Economy (2015)

[1] Laut dem „The Council on Tall Buildings and Urban Habitat" gelten Gebäude ab einer Höhe von 150 Meter als Hochhäuser, diese Kategorisierung steht hinter diesen Zahlen. Mixed Use wird dabei wie folgt definiert: „A mixed-use tall building contains two or more functions (or uses), where each of the functions occupies a significant proportion (15 percent or greater of either) of the tower's total space."

Mo.Hub – Co-Developing Cooperative Mobility Hubs in Vienna

Aurelia Kammerhofer, Katharina Leeb, Christoph Singelmann, Martin Berger

(Dipl.-Ing. Aurelia Kammerhofer, TU Wien, Research Unit Transportation System Planning, Karlsgasse 11, AT-1040 Vienna, aurelia.kammerhofer@tuwien.ac.at)
(Dipl.-Ing. Katharina Leeb, MO.Point – Mobilitätsservices GmbH, Niederhofstraße 30/13, A-1120 Vienna, katharina.leeb@mopoint.at)
(Dipl.-Ing. Christoph Singelmann, UIV Urban Innovation Vienna GmbH, Operngasse 17-21, AT-1040 Vienna, singelmann@urbaninnovation.at)
(Univ.Prof. Dipl.-Ing. Dr.-Ing. Martin Berger, TU Wien Research Unit Transportation System Planning, Karlsgasse 11, AT-1040 Vienna, martin.kp.berger@tuwien.ac.at)

1 ABSTRACT

Cities face the challenge that urban public spaces are often dominated by moving and parked motorised vehicles. In particular in existing neighbourhoods, the question arises as to where space for active mobility, greening and recreation can be taken from and how public space can be redesigned to meet users' needs.

The availability of diverse mobility solutions - as concentrated at mobility hubs - promotes inter-modal and multi-modal, seamless mobility and helps to reduce motorisation (Villareal 2018; Pais 2019; Claasen 2020). Thus, mobility hubs are used in some European cities, to concentrate different mobility options and functions of the public urban space spatially and digitally concentrate (Villareal 2018; Pais 2019; Claasen 2020). The implementation of such mobility hubs has often taken place in new neighbourhoods and is organised in a top-down manner by transport companies, city administrations or developers.

The research project Mo.Hub (https://mohub.at) aims to tackle the challenge of implementing mobility hubs in existing neighbourhoods by co-developing and implementing three mobility hubs with a cooperative and co-creative approach for a pilot phase of six months in Vienna.

The mobility hubs combine demand-oriented (shared) mobility offers in close distance to public transport and a jointly designed recreational area, in the form of a parklet. Thereby public space regained by transforming the behaviour from private car use to multi-modal mobility behaviour is made visible. A higher user acceptance is expected by involvement not only in the implementation process but also by testing new operating models that build upon active participation and self-organization.

Keywords: transformation, public space, co-creative, cooperative, mobility hub

2 INTRODUCTION: NEIGHBOURHOOD-BASED MOBILITY HUBS

2.1 Motivation and background

Currently, urban public spaces are often dominated by moving and particularly parked motorised vehicles. The availability of diverse mobility solutions promotes inter-modal and multi-modal, seamless mobility and helps to reduce motorisation (Villareal 2018; Pais 2019; Claasen 2020). For example, one shared car can replace up to 20 privately owned cars (bcs 2016) – with 12.5 m² of parking space per car (on average), this means an enormous gain in public space (Kopp 2015; Eisenmann 2018). Mobility hubs are already seen as a suitable concept in numerous European cities and regions, as they concentrate different mobility options and functions of the public urban space (such as a higher quality of stay and green space) (Villareal 2018; Pais 2019; Claasen 2020).

Up to now, the implementation of such mobility hubs has often taken place in new neighbourhoods and is organised in a top-down manner by transport companies, city administrations or developers in corporations with sharing mobility operators.

While changes in mobility behaviour and thus the acceptance of innovative mobility measures may be favoured in new-build neighbourhoods due to the change of residential location, the implementation of mobility hubs in existing neighbourhoods is more difficult.

A community-based implementation of mobility hubs with the involvement of interested neighbourhoods in a co-creative process offers the opportunity to raise awareness for sustainable mobility, to increase user sustainable mobility, user acceptance and changes toward sustainable, multi-modal mobility. In addition, the participatory approach enabling mobility hubs can also be implemented at locations where no potential is

seen top-down, but where committed residents justify the local need. This supports a faster and area-wide roll-out of mobility hubs with regard to climate protection goals.

2.2 Objectives

The research project Mo.Hub (https://mohub.at), funded within the research funding programme Mobility of the Future of the Austrian Research Promotion Agency (FFG), aims to enable multi-modal and seamless mobility, reduce car density and free up public spaces, that can be used in different flexible ways. Having these objectives in sight we want to increase the accessibility of residential neighbourhoods and contribute to reducing mobility poverty. Active user involvement within a cooperative and neighbourhood-based approach is expected to lead to demand-oriented mobility services, higher acceptance of the mobility services and thus to a transformed mobility behaviour.

The aim is to test different approaches to the design of the participation processes as well as different location qualities and design features of the mobility stations within three different neighbourhoods in Vienna (Neubau, Alsergrund and aspern Seestadt). This will be accompanied by impact and process evaluation to assess the acceptance of the mobility stations and learn from the processes. By implementing the hubs, the aim is to gain knowledge about cooperative neighbourhood-based approaches, and to develop a transferable overall package of Mo.Hub.

2.3 Typology of neighbourhood mobility hubs

Neighbourhood mobility hubs are important for mobility to and from the residential location as well as to and from the workplace on the one hand, and for upgrading the public space in the neighbourhood on the other. This is achieved by valorising the existing qualities of the public space and providing new opportunities to stay. (Vianen 2022; Van Gerrevink 2021)

Recommended features of neighbourhood hubs include (Vianen 2022; Van Gerrevink 2021):

- Walking: direct pedestrian connections where possible, traffic-safe location and recognition value.
- Cycling: Cycle parking facilities, cycle service station where appropriate, connection to main cycle routes, e-charging station, safe location and recognition value.
- Public transport: pedestrian connection to bus or tram stops, ideally within sight of them.
- Shared mobility: car-sharing, bike-sharing, possibly other shared vehicles such as mopeds, scooters, cargo bikes
- Private motorised vehicles: parking spaces, e-charging station,
- Open space: quality of public space, densely populated area, close to workplaces.
- Services: Information points or similar, possibly shops and restaurants, possibly parcel boxes.

3 METHODOLOGY

The research project Mo.Hubs aims to gain further knowledge on cooperative implementation processes of neighbourhood-based mobility hubs through literature and good-practice research and an experimental research design by co-developing, co-implementing and co-facilitating mobility hubs in Vienna and deriving knowledge by complementary summative and formative evaluation.

Based on the literature research good practice examples were investigated and assessed within an analysis matrix. Further, selected projects were analysed in-depth by qualitative interviews focussing on important process steps, actors, drivers and barriers.

The assessment of the needs of potential users and the involvement of relevant stakeholders and target groups have already been identified as key success factors for implementation in literature and good practice (Pais 2019; Holland et al. 2018; Dorner/Berger 2017; Dorner et al. 2020). In the collective, engagement is strengthened (Fritsche et al. 2018; Reese 2019), thus offers can be realised in locations where top-down implementation might not be feasible (Dorner/Berger 2017). Mo.Hub, therefore, implements a co-creative process to develop suitable mobility tools for shared use. As each of the pilot locations differs in terms of building and social structure, different cooperative process designs are developed within the project for each pilot location (see chapter 4.2).

An evaluation is carried out to accompany the co-creative process, gather learning experiences to improve processes (formative evaluation) and to improve the measures (summative evaluation) (cf. Chen 1996:163). Thus, the evaluation aims to capture the effects and impacts of the implemented mobility hubs on the mobility behaviour of users and the use of public space regarding user acceptance, user behaviour, characteristics of users and non-users, as well as satisfaction of different target groups (residents, traders, passers-by). Further interest lies on how co-creative processes and their relevant process steps can take place. Hereby, potential fostering and hindering aspects should be identified. A complementary combination of qualitative and quantitative methods (cf. Stifter 2005) is applied both within formative and summative evaluation (cf. Chen 1996:163).

4 REFLECTION: FIRST RESULTS OF MO.HUB IMPLEMENTATION PROCESSES

By July 2022 the first Mo.Hub is operating at full service in the 9th district, a further hub in the 7th district is partially implemented, expecting all three hubs to be operating in autumn. Following, the first results of the implementation process are outlined and discussed regarding fostering and hindering aspects.

4.1 Site definition and formal site-approval

4.1.1 Site definition

An iterative approach was developed for site selection based on quantitative and qualitative criteria and coordination with relevant public stakeholders. Further, the site definition was embedded in formal structures and procedures of the City of Vienna.

The quantitative analysis determined an initial basic selection of building blocks that are suitable in principle for a Mo.Hub location. The location criteria were developed cooperatively based on data availability, feasibility and relevance to the project goals. Building blocks with a higher density, a lower degree of motorization and existing infrastructure (especially for e-cars) were taken into consideration. Public transport connections and the availability of other mobility services were also evaluated, although there was little variation within the areas.

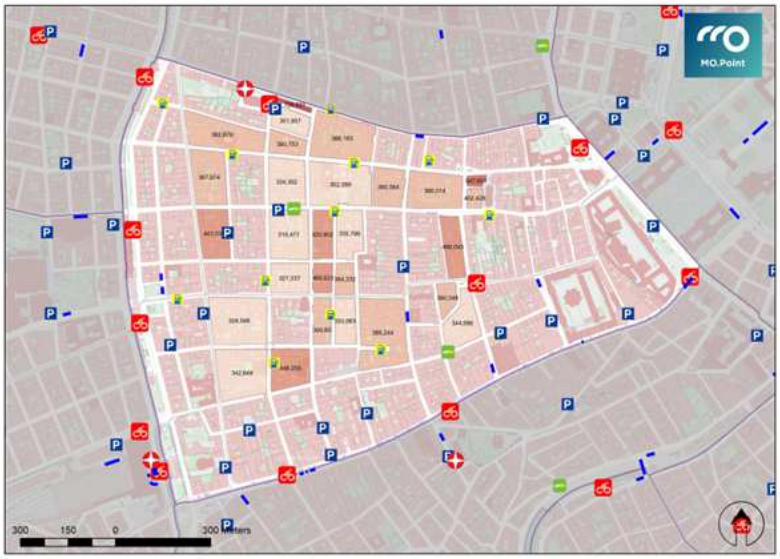


Fig. 1 Quantitative analysis result, MO.Point, 2021

The building blocks meeting the minimum requirements were subsequently explored through city tours in a qualitative process considering the quality of the public space, the availability of recreational areas and public space for car-sharing. Further, information on connecting points such as local initiatives, associations, shops and restaurants where gathered and relevant actors contacted regarding a cooperation. In addition, surveys were conducted in the respective districts to indicate the potential to build an active community for co-designing and co-facilitating the mobility hub. The identified locations were subsequently discussed with Wiener Linien and local politicians, in order not to compete with existing or planned station-based services and to consider local conditions, such as planned construction sites and short-term streetscape redesigns.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

4.1.2 Formal site approval

Based on a framework agreement with the City of Vienna, Wiener Linien as the municipal transport operator is authorised to allocate car-sharing spaces on public ground via contracting to shared mobility providers. In a contract between Wiener Linien and the operators, locations and conditions for use are specified. The approved shared mobility spaces are former parking spaces which with the conversion (at least for the period of the contract) is intended only for use by the contracted operator for its offers.

In the process of approval, Wiener Linien acts as a coordinating body and contractual partner towards the third parties and forwards the application documents to the relevant municipal departments that must approve the plan (e.g. MA 28) and the representatives of the respective district. In the following, the already streamlined process of Wiener Linien for the approval of its WienMobil hubs is compared to the approval process within the project Mo.Hub. In the case of the 9th district an existing but unused shared mobility parking space could be reactivated, in the 7th district the shared mobility parking space will be newly created together with a WienMobil hub, therefore the approval process is more time consuming.

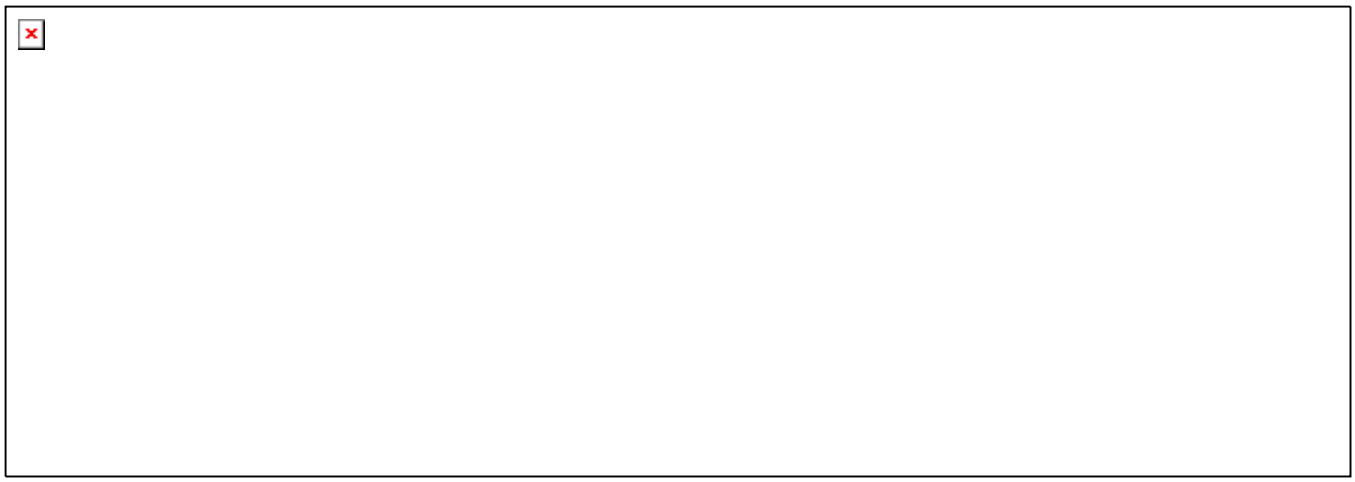


Fig. 2 Streamlined formal process for site approval for WienMobil in comparison to the approval process in Mo.Hub for the 9th district.

Wiener Linien is also obligated to go through the same approval procedure for their current expansion of the mobility hubs from 16 operating so-called WienMobil hubs to 100 by 2025. Due to the existing framework agreement with MA 28, which already defines specifications on, for example, uniform signage for carsharing parking spaces, as well as the experience of former and on-going site approval process, an efficient routine for the process could be developed.

4.2 Co-planning and participation

At each Mo.Hub a different process design for activation, participation and co-creation with local residents was developed. In general three phases of participation were applied: (1) Initial activation - recruiting interested locals for co-creating a Mo.Hub, (2) co-creation - developing and designing a Mo.Hub and (3) on-going activation - recruiting (potential) users.

Within the initial activation process, mailings were sent out including general information on the project and a short survey to indicate the potential to build an active community for co-designing and co-facilitating the mobility hub. As the response rate was low, direct interviews on site were conducted in the 7th district and the project was introduced within a local event in 9th district. Thereby contact lists were gather of people, who wanted to be informed about upcoming events, opportunities to participate and the project's progress.

In the co-creation phase the design of the mobility hub, relevant vehicles, the operation model and the design of the open space were focused on. The corona pandemic being a main obstacle to the participation, co-creation had to be carried out hybrid or online very soon. To foster awareness and active participation informative flyer and a mobile installation in the public space were created. In the 9th district, cooperation with the local initiative Agendagruppe Lichtental - striving to improve the quality of public spaces in their neighbourhood - could be arranged. The Agendagruppe Lichtental developed and created the open space together with the Mo.Hub team. In the 7th district, active participation appeared to be more difficult, thus

variants of possible open space designs were developed by the project team and sent out via the contact list and website for voting.

The last activation phase is still ongoing, as the pilot phase just started. During this phase, people in the neighbourhood are informed via mailings about the new mobility offer. Also, the open space design is used to create attention for the shared mobility service and recruit people as sharing users, for example through local events.

4.3 Business and operating models

All existing sharing services were surveyed and analysed in the three Viennese neighbourhoods. Most of the provided sharing services in those areas are B2C, some of them also offer a B2B option. Only one service is organised in a C2C structure. The business models of many existing sharing services are quite similar and differ mostly in the structure of the tariffs and the business area, whereby most of them focus on the inner city, dense areas.

	Angebot	Betreiber	Finanzierung			Organisationsform				Betriebsform		Gebiet		
			Public	Private	Subventioniert	B2C	B2B	P2B/C	C2C	Freefloating	Stationsbasiert	7. Bezirk	9. Bezirk	Seestadt
Car Sharing	STADTAUTO by greenmove	Greenmove			X	X	X				X	X	X	X
	ÖBB Rail and Drive	ÖBB	X		X	X	X				X	(X)		X
	Elfride Car Sharing Verein	Verein für nachhaltige Mobilität und Carsharing		X					X		X	X		
	Share Now	BMW & Daimler		X		X	X			X		X	X	
	E-Loop	Caroo Mobility GmbH		X		X				X		X	X	
	Seestadtauto	Verein zur Förderung des Carsharings in der Seestadt		?		?					X			X
	Wien Mobil Car Sharing	Wiener Linien/Greenmove	X		X	X	X				X	X	X	
Bike Sharing	City Bike	Gewista			X	X		X			X	X	X	X
	Seestadt Flotte	Aspern Stadtteilmanagement Aspern mobil			?	?					X			X
	Lime Bike	Neutron Holdings Inc		X		X				X		X	X	
Kickboards	Tier	Tier Mobility GmbH		X		X				X		X	X	
	Lime	Neutron Holdings Inc		X		X				X		X	X	
	Wheels	Wheels Ride Safe		X		X				X		X	X	
	Bird	Bird Rides, Inc.		X		X				X		X	X	
	Link	Link Your City, Inc		X		X				X		X	X	
	KiwiRide	DW Sharing GmbH (KiwiRide)		X		X				X		X	X	?
Moped Sharing	easy way	ÖAMTC		X		X				X		X	X	X
	goUrban	goUrban e-Mobility GmbH		X						X		X	X	
	mo2drive	mo2drive GmbH		X		X				?		X	X	X
	SCO2T	TSS GmbH		X		X				?		X	X	X

Fig. 3 Overview of sharing services (1070, 1090, Seestadt), MO.Point, 2021

Based on the analyses and first discussions with interested people, three scenarios for operation- and cooperation models were developed whereby those differed in:

- Service- level
- Ownership structures of the vehicle
- Financial risk distribution

4.3.1 Classic station-based car sharing

The classic station-based car sharing is the most common operation model, where the operator provides a vehicle at a fixed location. After a registration process, everybody can use the offered vehicles for a fixed price, which can be defined by the operator. All revenues are returned 100% to the operator, as he also covers the economic and financial risks 100%.

4.3.2 Bottom-up sharing

The bottom-up sharing is more of a community/ cooperation model, where a group of people (main user group) acquires a vehicle together. The ongoing fixed costs of the vehicle (e.g. leasing rate/insurance, …) are covered by the main user group. However, to keep the costs as low as possible and the utilization of the vehicle high, the vehicle is also made available to third parties (open user group). The revenue of the trips is

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

returned to the main user group. The economic and financial risks are taken by the main user group. The service levels can be covered by the main user group itself or by an external operator. An external operator provides the reservation and booking platform, as well as the billing platform, to ensure practical handling of the vehicle.

4.3.3 Sharing through vehicle transfer

The third operation model "sharing through vehicle transfer" can be applied when a person is willing to share his/her privately owned car with others. Therefore, a vehicle transfer agreement is necessary. Within this agreement, the vehicle owner entrusts the vehicle to an external operator for a defined period. For the vehicle to be integrated into a sharing operation, it must be equipped with appropriate hardware. To generate high usage and utilization of the vehicle, the vehicle can be used by anyone (open user group). Through an external operator, who takes over the reservation/booking/billing, users can be checked and controlled (driver's license validation for sharing operation necessary), so that traceability and security can be guaranteed. Revenues generated by the use of others are returned to the vehicle owner on a pro-rata basis. The liability risk remains with the vehicle owner, who must seek suitable insurance. A residual risk due to the loss of value of the vehicle also remains for the vehicle owner.

With the three operating models developed, an attempt was made to show a wide variety of implementation options. Despite many information and exchange events, no group could be found that was willing to actively engage with the project in the long term.

To implement a new sharing operating model, a very elaborate accompaniment and support are necessary. In the districts, where it was possible to connect to already existing initiatives, more active participation was possible, whereas, in the 7th district, where a rather young, sharing-affine audience can be found, consistent and active participation was difficult. For the development and implementation of new sharing operating models, mutual trust, long-term commitment, and the contribution of resources (both financial and timewise) are necessary, which partly contradicts the setting of a research project (temporal component vs. long-term implementation).

4.4 Learnings regarding drivers and barriers to cooperative implementation of neighbourhood-based mobility hubs

Site definition appeared to be an ongoing process, especially in the district Neubau, as there are many constructions areas due to a new metro line and coordination with all relevant stakeholders is very time-consuming. Within in the process qualitative and quantitative criteria was important, although decisions had to be derived in a practical way in coordination with the local politics and municipal transport operators. It appeared, that in case of temporary implementation process experiences and general conditions regarding contracts are not yet given.

Site definition based on the feedback of local residents through short surveys was seen as the ideal, however in reality it was very difficult to communicate with local residents on the rather abstract subject of "mobility hubs". An unclear vision and too many options turned out to be hindering the activation and participation process. Thus, it was necessary to visualise ideas, narrow down options and prepare examples that could be discussed and further developed with residents.

Further, a participative process (for temporary implementation) contradicts current formal process structure as formal process structures require a clearly defined location and vehicle offer in order to be approved. Whereas a co-creative approach would require a defined location for easier communication with residents and co-developing the offer. In general, the complex formal process and approval structures appear to be hindering private and non-commercial actors to implement station-based mobility sharing in public space in Vienna.

Within the participative process many residents showed interested in the idea and potential results of Mo.Hub, but did not want to engage in the co-development. This corresponds with the findings of the qualitative interviews, which also stated that there was hardly any commitment to participate in the implementation. However, as soon as the services were implemented more residents engaged in facilitating and there is high demand of the services.

In the case of Mo.Hub the temporary character seemed to be a further obstacle to user commitment. Whereas, building upon existing groups of engaged residents in activation and participation and on existing infrastructure within Mo.Hub were identified as relevant driving forces for the implementation.

Interview results showed, that bottom-up initiatives for mobility sharing aim to improve accessibility, in some cases economic and ecological aspects were relevant. Regarding Mo.Hub accessibility is already on a quite high level in all districts, thus main arguments in the communication were focused on economic and ecological aspects. Within this context, interviewees emphasized the influence of a building structure that promotes social interaction.

5 CONCLUSION

Implementing mobility hubs as pilots using a co-creative and cooperative approach together with residents of existing neighbourhoods, as done in the project, has longer lead times than for standardised processes. The formal approval process for mobility hubs in Vienna is not designed for experimental processes so far. Whereas in some other cities (such as Munich), the implementation of pilot projects or temporary mobility hubs is approved more quickly in order to allow for "quick" experimentation. Another conclusion, which is also in line with experiences from comparable projects, is that residents who are participating in the process need a certain degree of knowledge of specifications and options for the design and equipment of mobility hubs to which they can orient themselves or on the basis of which offers can be further developed and shaped (e.g. indicating which vehicle types satisfy which needs or which elements a mobility hub can contain).

The requirement for participating residents to make a commitment and also to contribute financially to the future offer even before a mobility hub is implemented is difficult to achieve without a concrete implementation.

6 REFERENCES

CHEN, Huey-Tsyh: Epilogue: Synthesizing Formative/Summative Evaluation Issues and Beyond. In: Evaluation Practice, Vol. 17, Issue. 2, pp. 163-167. 1996.

CLAASEN, Yorick (2020): Potential effects of mobility hubs Intention to use shared modes and the intention to reduce household car ownership. Masterarbeit: University of Twente.

DORNER, Fabian, DÖRRZAPF, Linda, BERGER, Martin: Grätzlrad Wien: Nutzerinnen-und Nutzerstruktur und Nutzungsverhalten in host-basiertem Lastenrad-Sharing. In: REAL CORP 2020: SHAPING URBAN CHANGE Livable City Regions for the 21st Century – Aachen, Germany. Proceedings/Tagungsband 15-18 September 2020, S.391-400. 2020.

DORNER, Fabian, BERGER, Martin: Kombiniertes Carsharing und Ridesharing: eine gemeinschaftsbasierte Mobilitätslösung für den ländlichen Raum?. In: REAL CORP 2017–PANTA RHEI–A World in Constant Motion. Proceedings of 22nd International Conference on Urban Planning, Regional Development and Information Society. S.319-328. 2017.

EISENMANN, Christine: Mikroskopische Abbildung von Pkw-Nutzungsprofilen im Längsschnitt. In: Schriftenreihe des Instituts für Verkehrswesen (KIT) Band 74. Dissertation: KIT Scientific Publishing. Karlsruhe, 2018.

HOLLAND, Ben, HOUSE, Heather, RUCKS, Greg (2018): Reimagining the Urban Form: Austin's Community Mobility Hub. Rocky Mountain Institute, 2018. URL: www.rmi.org/insight/reimagining-the-urbanform (31.09.2020).

KOPP, Johanna Petra: GPS-gestützte Evaluation des Mobilitätsverhaltens von free-floating CarSharing-Nutzern. Dissertation: ETH Zürich. Zürich, 2015.

PPAIS, Renita Ravina: A Tale of Three Cities. An attempt to improve multimodality in Rostock, Vilnius and Pskov through mobility points. Masterarbeit: Technische Universität Berlin, Berlin, 2019.

REESE, Gerhard: Soziale Identitäten in einer globalisierten Welt Herausforderungen und Möglichkeiten gemeinsamen Handelns. Präsentation im Rahmen des IPU Kongress 2019, Zürich, am 8.3.2019.

STIFTER, Matthias: Quantiative Analyse des Besucherverhaltens. Evaluierung der Ausstellung medien.welten des Technischen Museums Wien mittels automatisch protokollierten Besucherinteraktionen. Diplomarbeit: Technische Universität Wien. Wien, 2005.

VAN GERREVINK, Iris: Ex-post evaluation of neighbourhood shared mobility hubs. A qualitative research on the facors of influencing the usage and effects of mobility hubs. Master Thesis: Delft University of Technology. Delft, 2021.

VIANEN, J.C. (Jarco): A design approach to determine the locations in combination with amenities for neighbourhood hubs, based on user profiles. Qualitatively researching the users, amenities, and locations for neighbourhood hubs. Master Thesis: Delft University of Technology. Delft, 2022.

VILLAREAL, Montserrat Miramontes: Assessment of mobility stations Assessment of mobility stations. Success factors and contributions to sustainable urban mobility. Dissertation: Technische Universität München. München, 2018.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Resilience Assessment of Mountain Settlements Isolation Effects in Extreme Climate Change

Shih-Min Hsu, Tzu-Ling Chen

(Shih-Min Hsu, University of Taipei 1, No. 101, Sec. 2, Zhongcheng Rd., Shilin Dist., Taipei City, pipi23433470@gmail.com)
(Supervisor Tzu-Ling Chen, University of Taipei 1, No. 101, Sec. 2, Zhongcheng Rd., Shilin Dist., Taipei City, skylight@mail2000.com.tw)

1 ABSTRACT

It's been a while since people have awareness of the environmental impact of climate change, especially in mountain settelements of Taiwan. Extreme heavy precipitation event was very rare in the past, we rarely saw a disaster occurrence that affect the daily life of human beings. However, due to the impact of climate change, the occurs of extremely heavy precipitation events in Taiwan are more and more frequent in the past 20 years. From once every few years to nearly a dozen times a year, including heavy rain and typhoon every summer and autumn. Taiwan has special geographical factors: narrow land, densely populated, and a high density of streams. If the slope is greater than 5 degrees or the elevation is greater than 100m, the region is regarded as a mountain area. Such an area occupies about 70% lands of Taiwan, and there are many old settlements and aboriginal tribes living here. The best-known disaster event was the typhoon Morakot in 2009, it caused serious flooding, mountain crashing, and landslides in many areas of Taiwan. These disasters in mountain settlements are the most serious, including road blockage, house inundation, water and food shortages, etc. After the typhoon Morakot, People refer to "the situation in which mountain settlements are blocked due to climate phenomena" as an "isolation effect" due to plenty of news reports. Mountain settlements that have an isolation effect are like inhabitants of isolated islands on the sea. It's difficult for local residents to save themselves, and it is hard to obtain external rescue resources. Because of the natural landform and special socio-economic environment of mountain settlements, we need to pay attention to such problems occur.

The collection of "isolation effect" data is from domestic news reports, from 2000 to October 2021. A total of 326 disasters had occurred in 151 villages(The level is larger than that of the settlement because the news media mostly reported the disaster situation in the village as a unit). The severity of the disaster ranges from mild to severe, there were also many villages where the isolation effect had repeatedly occurred in different years.

This study attempts to integrate and analyze the weights of the isolation effect from past studies, at this stage, the historic isolation effect villages have been split into 270 historic isolation effect settlements. The indicators include general isolation effect, hazard, exposure, and vulnerability. Then, the weight of the analyzed indicators is used to determine the other 360 mountain settlements in Taiwan. Looking forward to clarifying the potential degree of isolation effect that may occur in the future, and providing it to the public. It is hoped that such a demonstration will allow the government to carry out more disaster reduction measures for mountain settlements, and local residents can also have considerable disaster awareness in their homes. In the future, climate change will be more abrupt, but mountain settlement residents can also live and work in peace.

Keywords: climate change, disasters, resilience, isolation effects, mountain settlements

2 INTRODUCTION

The Intergovernmental Panel on Climate Change (IPCC) revealed in its sixth report on climate change that it compared with pre-industrial standards. The global surface temperature from 2011-2020 has risen by 1.07 degrees, including more severe polar ice melt, extreme rainfall, and marine heat waves, which can be described as an "era of climate emergency." (Portner, Roberts, Trisos, & Simpson, 2022) For every 1°C increase in global warming, the global extreme daily rainfall event is estimated to increase by about 7%. The global proportion of severe tropical cyclones and the maximum wind speeds of the strongest tropical cyclones are projected to increase. Heavy rainfall and associated flooding events are expected to become more intense and frequent across the Pacific Islands and many parts of North America and Europe. (TCCIP, 2021) Disaster events derived from extreme climates, especially heavy rains, have a severe impact on mountain settlements. However, due to the limitation of various factors, the benefits brought by disaster management strategies in mountain settlements are often challenging to quantify, resulting in ineffective

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

implementation.(Vorhies, 2016) The typhoon Morakot in 2009 caused many mountain settlements to collapse, the roads were interrupted, and the settlements needed to evacuate immediately.

The term "isolation effect" is precise because, after the 2009 Morakot typhoon, many news media used the term "isolated island" to describe the isolated and helpless mountain settlements in Taiwan. Even after the 2015 typhoon Soudelor hit the mountain settlements in Taiwan hard again, research and discussions on Taiwan have launched one after another: disaster identification and countermeasures and strategies in isolation effect areas. There is no complete definition of "isolation effects" in academics. For example, Pan (2016) defines it as an "isolation effect" when the external roads and bridges in a specific area are interrupted or closed and cannot pass through; Ting (2012) proposed that this area has an isolation effect where communications are interrupted, roads are damaged, and broken bridges; Lee (2012) pointed out that when a settlement is in a disaster, roads, bridges, or communications with the outside world cannot be used or interrupted, making it impossible for the settlement to communicate with the outside world. Based on the above description, the "isolation effect" is the occurrence of six situations: circuit breakage, water cutoff, power cutoff, signal cutoff, credit cutoff, and out of food.

Furthermore, in addition to discussing the identification of isolation, there should also be differences in the investment sequence between "isolation effects" and "disaster isolation effects." Mountain settlements, isolated and helpless due to road interruptions, unable to receive immediate assistance or lack temporary self-rescue ability, that is, the "disaster isolation effect." The isolation effect event refers to the identification mentioned above, which belongs to the "external intermedium damage" other than the settlement itself. In contrast, the disaster isolation effects refer to the disaster and damage to the settlement itself and the damage to the external intermedium. The urgency of investment in "disaster isolation effects" is more significant than "isolation effects" because the situation of further one is prone to direct damage such as industrial impact and residents' safety concerns due to their social and economic vulnerability and the relative disadvantage of the natural environments. Therefore, under the identification of these two types of isolation, their respective isolation effects indicators and corresponding climate change strategies are also different.

Under the threat of extreme weather, there are three areas in Taiwan that are likely to face higher disaster risks, including: urban communities with high population density and rapid development, coastal vulnerable and severely subsided rural communities, and highly vulnerable and sensitive mountain settlements. (Technology, 2014) Mountainous settlements are located in the border areas of human life circles. In addition to high environmental disaster exposure, they also have relatively fragile social and economic resilience and are more affected by climate change than other regions. Therefore, how to adjust measures to local conditions for highly vulnerable and sensitive situations such as mountain settlements is a topic that should be discussed and acted upon urgently in Taiwan in the near future.

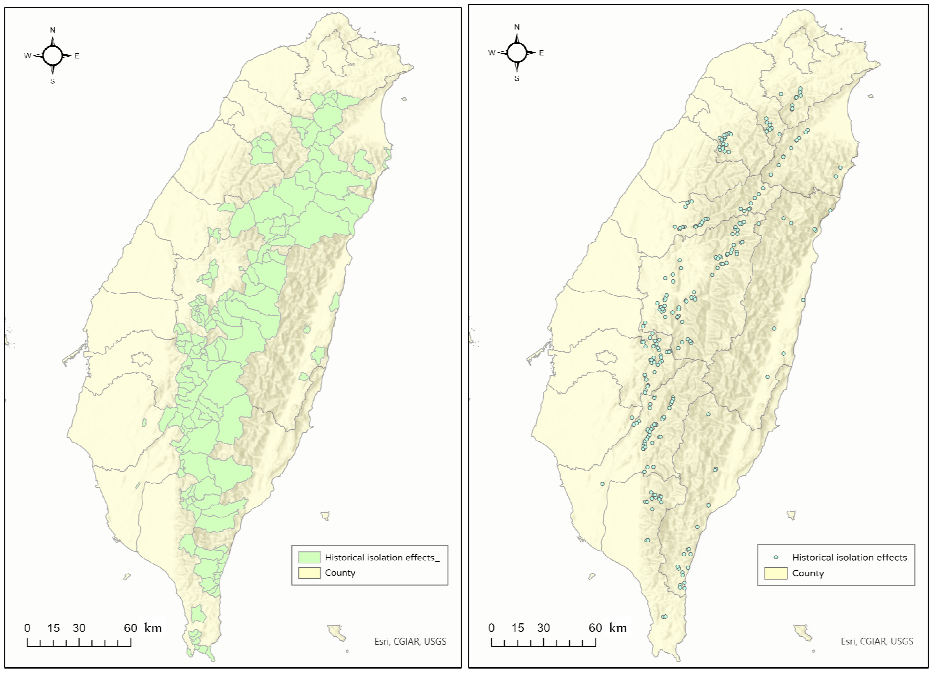


Fig. 1: Historical isolation effects (151 villages). Fig. 2: Spatial distribution of historical isolation effects (270 settlements).

3 HISTORICAL ISOLATION EFFECTS AND EVALUATION METRICS

This study collects past research (Pan, 2016)and online news about the isolation effect incidents in Taiwan from January 2001 to October 2021. Further, analyze the causes of disasters in historical isolation effects events and the socio-economic and natural conditionsbo of the neighborhood to which the isolation effect belongs. There were 326 spots that happened isolation effects and distributed in 151 villages. Overview them, With an overview, we found that from 2001 to 2007, there were three isolation effect incidents each in Lishan village and Boai village in the Heping District of Taichung; 2008 to 2014, there were five isolation effects incidents each in Shenmu village in the Xinyi District of Nantou and Fuxing village, Qinhe village, Tangaanua village of Kaohsiung; 2015 to 2021, there were seven isolation effects incidents each in Fuxing village, Lavulan village, and Meishan village of Kaohsiung.

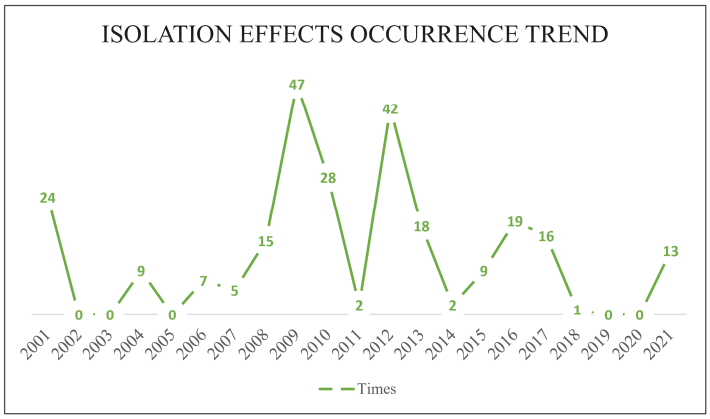


Fig. 3: Isolation effects occurrence trend for years.

Lishan village and Boai village in Taichung City were respectively affected by Typhoon Mindulle, Typhoon Krosa, and one torrential rain. They caused isolation effects. The disasters are mainly in the form of debris flow and landslides, causing broken bridges, roadbeds hollowing out, and falling rocks.Shenmu village of Nantou and Fuxing village, Qinhe village, and Tangaanua village of Kaohsiung were affected by Typhoon Morakot, Typhoon Parma, Typhoon Soulik, Typhoon Usagi, Typhoon Saola, and some torrential rains. The disasters were dominated by landslides, floods, and the destruction of access roads, bridges, houses, roads, etc. occurred one after another.Fuxing village, Lavulan village, and Meishan village of Kaohsiung were affected by Typhoon Nepartak, Typhoon Chanthu, and numerous torrential rains. The forms of disaster include floods, debris flows, and skyrocketing streams, including the continuous washing out of important connecting bridges, hollowing of roadbeds, falling rocks, and resource interruptions.

This study collects past research on isolation effects or mountain disasters, including National Fire Agency (2021), (Wu & Huang, 2018), Tsai (2016), Chen (2017), Pan (2016), (Chang & Wang, 2015), Huang (2014), Lin (2008), and Yang et al. (2010). Roughly, the island index can be divided into six dimensions, slope and elevation, disaster, road and bridge, critical infrastructure, social economy, and others. Since the spatial scale unit of this study is set as "settlement", considering the limitation of data acquisition, this study selects five dimensions to evaluate the potential location of isolation effects, as well as the disaster isolation effects that comprehensively accommodate the risk drivers of hazard, exposure, and vulnerability.

4 RESEARCH DESIGN

4.1 Research Conception

First of all, it summarizes the "isolation effect" evaluation indicators based on historical isolation effect events and brings risk dimensions to construct disaster isolation effect assessment indicators. Then, set high, medium, and low potential standards based on historical isolation effect events, based on the entire mountain settlements in Taiwan, overlap the disaster isolation effect index, and find out where will become disaster isolation effect settlements. The purpose of this research is to interpret high-potential disaster isolation effect mountain settlements based on historical isolation effect event as a reference for future disaster management, mitigation, and adaptation key areas.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

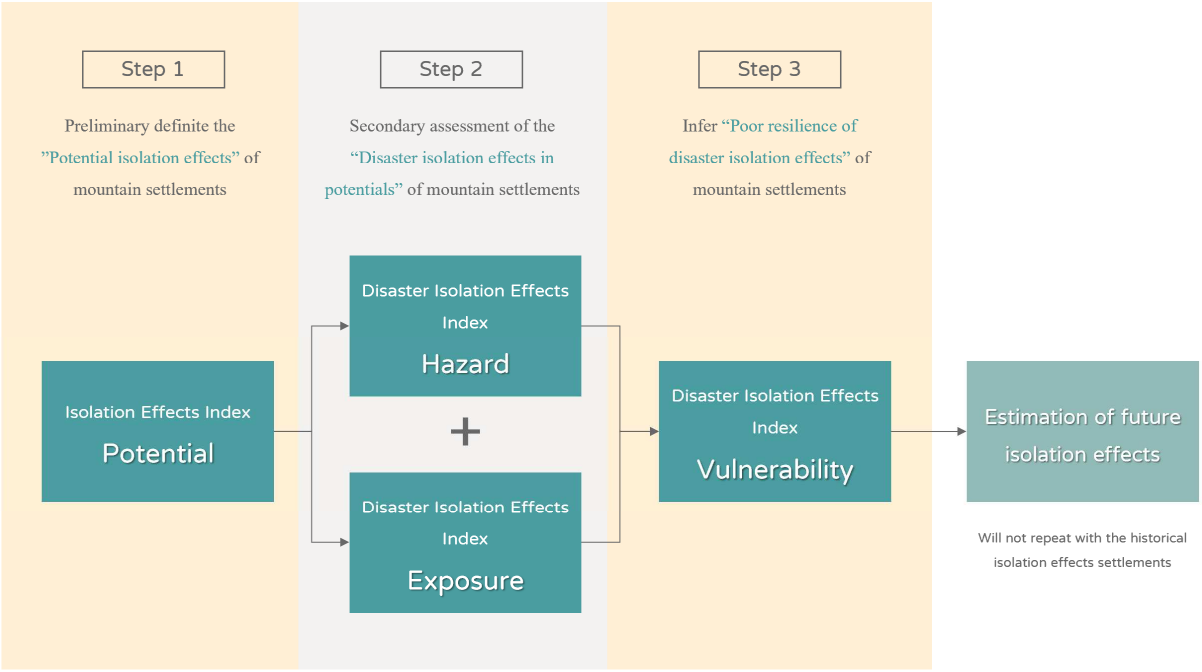


Fig. 4: Research process.

4.2 Study Area- Mountain Settlements

Taiwan is located at the intersection of Northeast Asia and Southeast Asia. Due to the mutual extrusion of the Eurasian plate and the Philippine Sea plate, orogeny has developed. The area of the mountains is larger than that of the plains, and its area ratio is about 7:3. Although the plains are suitable for human habitation and development, there are still many residents and aboriginals living in mountainous settlements for many years. (Tsai, 2016) According to article 3 of the "Slope Land Conservation Regulations", a hillside land is an area with an elevation of more than 100 meters or an area with an elevation of fewer than 100m and an average gradient of more than 5%. „Settlement“ generally refers to the aggregate of many residential houses in the hillside area or the distribution area where the population lives in a concentrated manner, which includes infrastructure, and life-sustaining pipelines, and is sufficient to provide the living resources of the residents in the settlement. (Chang & Wang, 2015)

Consequently, This research refers to the principles mentioned earlier of mountain settlements: areas with an elevation above 100m or an elevation less than 100m and an average slope of more than 5%; an aggregate composed of many residential houses in a hillside area, or population agglomeration areas.

4.3 Index of Isolation Effects

Internationally, disaster risk is defined as the possibility that a hazardous event will cause negative impact or to a place or a system. The size of disaster risk depends on factors such as hazard, exposure, vulnerability and adaptation capacity, while the probability and possibility of occurrence are implicit in the three factors above. That is to say, a place, system, or object must be expose to a hazard event, it has the characteristics of being vulnerable to adverse effects, and incapable of responding to this hazard event. All the three conditions must be met to cause a disaster to occur.

Based on historical isolation effect events and isolation effect indicators proposed by previous researches, this study aggregates and constructs "general isolated island index" and "disaster isolated island index", and further subdivides the disaster isolated island index into three major categories: hazard, exposure, and vulnerability according to the risk structure. Types to evaluate key indicators of island incidents.

Potential isolation effects index	Evaluation standards	Based on	Selection
Average slope	>5 degrees	Slopeland conservation and utilization act	Definite" Mountain settlements"
Mean elevation	>100m		
The number of the access roads	=1	K-means 1 of historical isolation effects	Definite the" Potential isolation effects" of mountain settlements
The number of streams pavement&bridges	≧2	K-means 1 of historical isolation effects	

Table 1: Potential isolation effects index.

Hazard index	Evaluation standards	Based on	Selection
The ratio of slope disaster potentials to the settlement area	High potential: >0.1083606080% Low potential: >0.0132916953%	K-means of historical isolation effects	Standard of low potential hazard isolation effects: conform any one of the low potential assessment criteria Standard of high potential hazard isolation effects: conform any one of the high potential assessment criteria If none of settlement meet any one of criteria, it is "nonpotential"
The ratio of geologically sensitive areas to the settlement area	High potential: >0.7223782528% Low potential: >0.0754282799%	K-means of historical isolation effects	
The ratio of flood potential areas to the settlement area	High potential: >0.0022938737% Low potential: >0.0000022209%	K-means of historical isolation effects	
The ratio of potential debris flow torrents to the settlement area	High potential: >0.0555677995% Low potential: >0.0287269599%	K-means of historical isolation effects	

Table 2: Disaster isolation effects index (Hazard).

Exposure index	Evaluation standards	Based on	Selection
The number of slope disasters	>2	Average of historical isolation effects	Standard of low potential exposure isolation effects: conform any one of the low potential assessment criteria Standard of high potential exposure isolation effects: conform any two of the high potential assessment criterias If none of settlement meet any one of criteria, it is "nonpotential"
The number of protected residents	>14	Average of historical isolation effects	
The number of access road points exposed to landslide risks	>5	Mode of historical isolation effects	

Table 3: Disaster isolation effects index (Exposure).

Vulnerability index	Evaluation standards	Based on	Selection
Old age dependency ratio(Village)	>23.07611111%	Average of historical isolation effects	Standard of low potential vulnerability isolation effects: conform any three of the criterias If none of settlement meet any three of criteria, it is "nonpotential"
Household income per year(Village)	<682.5087778	Average of historical isolation effects	
Shelters(700m)	=0	K-means of historical isolation effects	
Shelters suitable for weakness	=0	K-means of historical isolation effects	

Table 4: Disaster isolation effects index (Vulnerability).

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

5 RESULTS

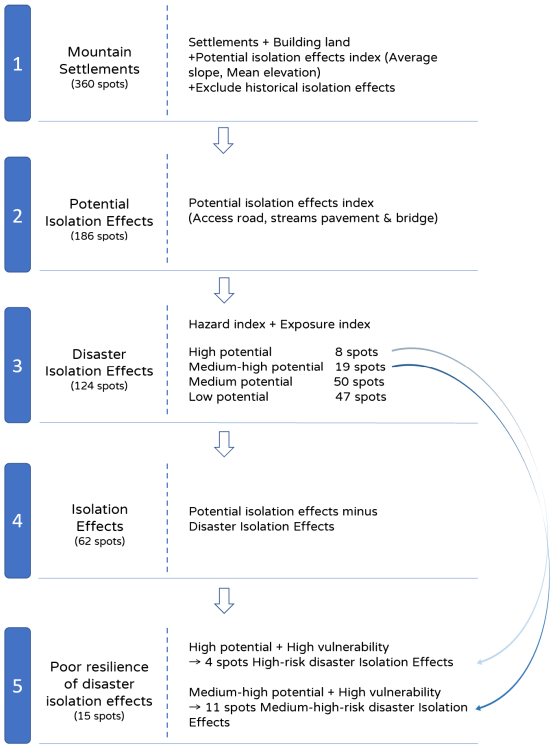


Fig. 5: Evaluation process of isolation effects.

This study uses the average slope and mean elevation to determine whether a settlement belongs to the mountain settlement identified by this research. The preliminary result is that there are 360 mountain settlements in non-historic isolation effects in Taiwan. Further based on the screening indicators of isolation effects: the number of the access roads and the number of streams pavements and bridges. Finally, a total of 186 potential isolated islands are obtained.

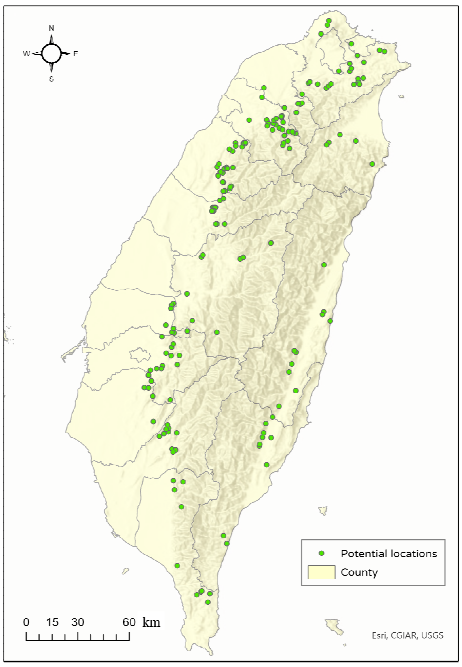


Fig. 6: Potential locations of isolation effects.

The study found that there are 8 settlements with high potential disasters, most of which are located in mountainous areas such as Hsinchu County, Miaoli County, and Pingtung County; 19 settlements with medium-high potential disasters, mainly in Jianshi Township, Hsinchu County, and Tai'an Township, Miaoli County. In addition, there is also Datong Township in Yilan County.

Last, 47 settlements with low potential disasters are mostly distributed in the mountainous areas of New Taipei City. There are also distributed in Fuxing District, Taoyuan City, Jianshi Township, Hsinchu County, and Dongshi District, Taichung City. Settlements that are not mentioned in the preceding paragraph are general isolation effect spots, with a total of 62 settlements.

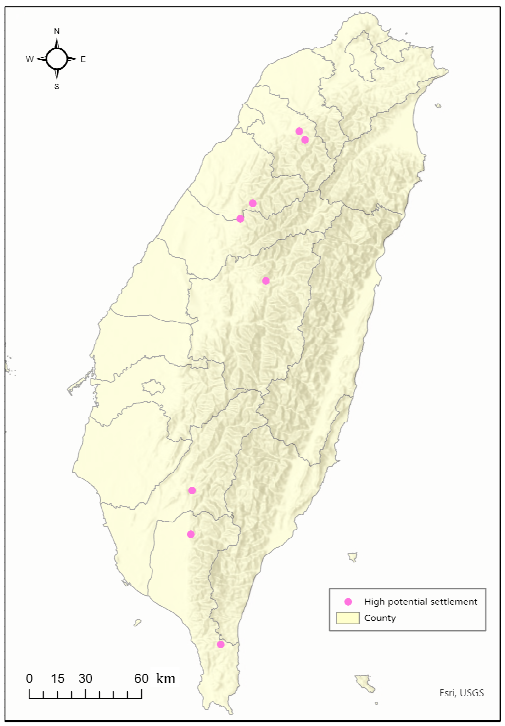


Fig. 7: High potential disaster isolation effects.

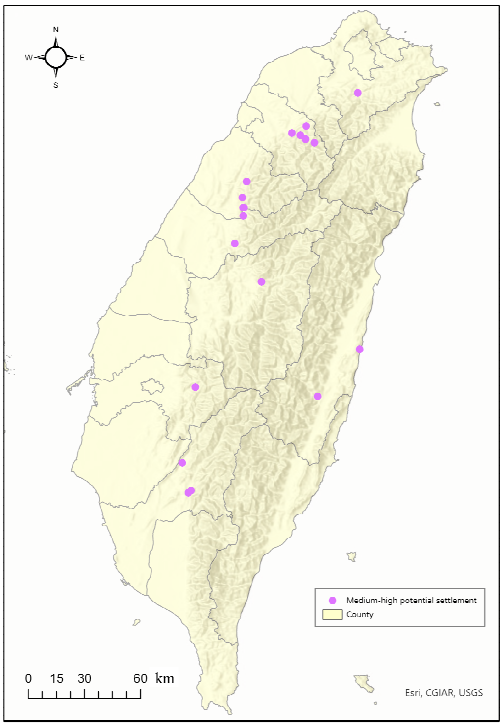


Fig. 8: Medium-high potential disaster isolation effects.

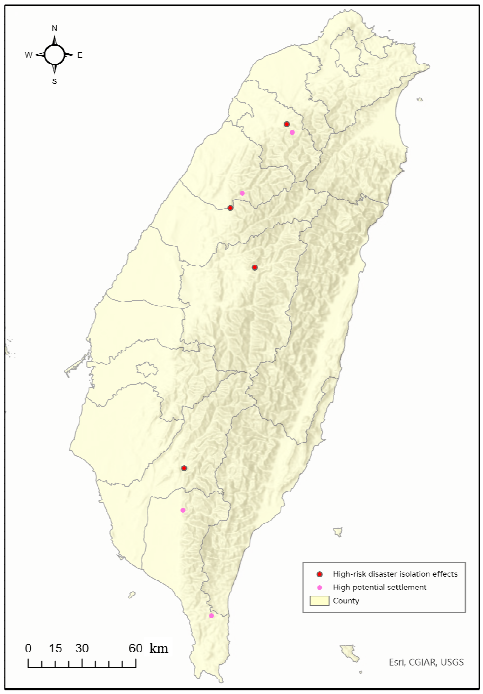


Fig. 9: High-risk disaster isolation effects.

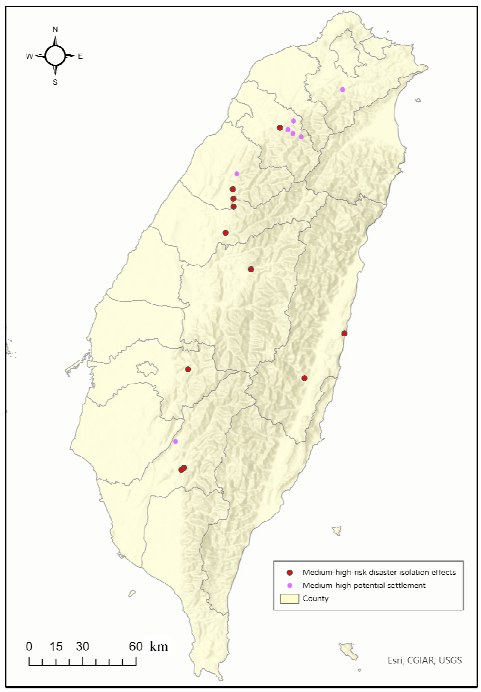


Fig. 10: Medium-high-risk disaster isolation effects.

At the end of this study, "vulnerability" was used to analyze the resilience of isolated islands. The results showed that 4 isolated islands with high potential disasters and 11 isolated islands with medium and high potential disasters had low resilience. A total of 15 settlements need to be given an overall review immediately within a certain period of time. What kind of response mechanism does it have to deal with the threats brought by climate change disasters? For example, have they signed an opening contract for road maintenance? The residents of the settlement have Have they all received education and training related to disaster prevention and relief? What are the residents' awareness and attitudes towards climate change

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

disasters? Does the settlement have appropriate airdrop points and helicopter landing sites? Does the settlement have food and drinking water reserves, etc?

6 CONCLUSION

This study attempts to use the potential isolation effects index, hazard index, exposure index, and vulnerability index to evaluate mountain settlements. The research shows that there are 8 high potential disaster isolation effects areas, most located in the mountains of Hsinchu, Miaoli, and Pingtung County; medium-high potential disaster isolation effects areas are about 19 settlements, mainly distributed in Jianshi Township, Hsinchu County, and Tai'an Township, Miaoli County. Comprehensively analyzing the "Vulnerability" of isolation effects shows that 4 settlements with high-risk disaster isolation effects and 11 settlements with medium-high-risk disaster isolation effects have low resilience. Therefore, it is necessary to conduct a comprehensive review of these 15 mountain settlements in order to mitigate the impact of extreme disasters caused by climate change on mountain settlements.

The scale of the study area is mainly based on settlements to explore a more realistic aspect angle on isolation effects in this study. However, it is difficult to collect data at the settlement level at the present stage, especially the vulnerability index; data is relatively limited.

Once the isolation effect occurs in mountain settlements, it will significantly impact the local area due to its high disaster exposure and relatively fragile social economy. Thence, applying "Co-benefit" can help to enhance the additional benefits of Disaster Risk Management (DRM), such as the natural environment, human settlement environment, and economy.

7 REFERENCES

Chang, C.-H., & Wang, Y.-T. (2015). Establishing Hill Tribe Disaster Environmental Indicators and Application Security Assessment. [Establishing Hill Tribe Disaster Environmental Indicators and Application Security Assessment]. Journal of Chinese Soil and Water Conservation, 46(2), 123-132. doi:10.29417/JCSWC.201506_46(2).0007

Chen, Y.-H. (2017). An Evaluation of the Isolation Effects in Mountain Community. (master), National Taipei University of Education, Taipei City, Taiwan. Retrieved from https://hdl.handle.net/11296/x7gxb6

Huang, C.-H. (2014). A Study of Isolated Area Identification Model for Natural Disaster Prevention based on Prim Algorithm. (master), National Taitung University, Taitung County, Taiwan. Retrieved from https://hdl.handle.net/11296/5ce9d8

Lee, C.-C. (2012). Community independent discussion on disaster-preparedness promotion –Mau forest Wanshan tribes of the city as an example. (master), National Kaohsiung University of Applied Sciences, Kaohsiung City, Taiwan. Retrieved from https://hdl.handle.net/11296/34x2kx

Lin, H.-L. (2008). Establishing the Mechanism and Guidelines for Safe Construction of Land in Disaster-prone Areas (Phase 1). Taipei City, Taiwan: Urban and Rural Development Branch, Construction and Planning Agency

National Fire Agency, M. o. t. I. (2021, 05/30). Disaster Prevention and Relief in Isolation Effects Areas in 2021. Retrieved from https://www.nfa.gov.tw/cht/index.php?code=list&flag=detail&ids=1524&article_id=10375

Pan, Y.-X. (2016). Discussion of the Rural Settlements Isolation Effects Occurs. (master), National Taipei University of Education, Taipei City, Taiwan. Retrieved from https://hdl.handle.net/11296/jwa9bj

Portner, H.-O., Roberts, D., Trisos, C., & Simpson, N. (2022). Summary for Policymakers: Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. doi:10.1017/9781009325844.001

TCCIP. (2021, 09/22). IPCC Sixth Assessment Report--Basics of Physical Science Summary for Policymakers Translation. Retrieved from https://tccip.ncdr.nat.gov.tw/km_abstract_one.aspx?kid=20210922175643

Technology, M. o. S. a. (2014). Disaster Sector Action Programme 2013-2017. Taipei City, Taiwan: Ministry of Science and Technology

Ting, S.-F. (2012). Study the concept of disaster risk and vulnerability analysis at Taitung County hillside fields. (master), National Dong Hwa University, Hualien County, Taiwan. Retrieved from https://hdl.handle.net/11296/92nqu7

Tsai, Y.-F. (2016). Sediment Disaster Risk Evaluation and Adaptation Study in Isolated Community(I). Retrieved from Taipei City, Taiwan:

Vorhies, F. (2016). Co-Benefits of Disaster Risk Management. World Bank Working Paper. doi:10.1596/1813-9450-7633

Wu, F.-J., & Huang, C.-N. (2018). Study on the Impact of Critical Infrastructure of Rural Settlements Island-A Case Study of Pingtung County, New Taipei City, Taiwan.

Yang, S.-R., Shih, Z.-Y., Huang, C.-M., Jheng, J.-T., Huang, W.-J., & Chen, J.-Y. (2010). Isolated Effect Induced by Typhoon Morakot in Laonong River Basin. Paper presented at the Taiwan Rock Engineering Symposium, Kaohsiung City, Taiwan.

The Transport Challenges in one of the Most Beautiful Micro Regions of Hungary

László Jóna

(Dr László Jóna, Széchenyi István University, Faculty of Architecture, Civil Engineering and Transport Sciences, Department of Transport, Hungary, 9026 Győr, Egyetem tér 1., jona.laszlo@sze.hu; Centre for Economic and Regional Studies Institute for Regional StudiesWest-Hungarian Research Department, Hungary 9022 Győr, Liszt Ferenc utca 10., jona.laszlo@krtk.hu)

1 ABSTRACT

The Szigetköz is one of the most beautiful areas in Hungary, which is located in Western Transdanubia. However, in recent years more and more people have moved out of the region, mainly from the City of Győr, which due to their traffic has increased significantly. All this is the result of Győr's growing industry and economy, which has had a major impact on the growth of real estate prices. Therefore besides with the people of higher income also the people with lower income has been settled in one of the settlements of the Szigetköz. However, in the typical way of suburbanisation, people living in the area still go to work and study in the city, so there are serious congestions, especially in the morning and afternoon rush hours. These congestions not only affect the city of Győr, but can already be felt in several settlements of the Szigetköz. Therefore, in my study I present how the traffic of the Szigetköz has increased in recent years, how its green space has changed, and what transport-related development is planned in each settlement. At the end of the study, I suggest what what kind of development could be used to make liveable the traffic of the area.

Keywords: sustainability, Szigetköz, microregion, Hungary, traffic

2 INTRODUCTION

The history of the Szigetköz started in that age when the place of the dried up Pannon see began to fill the ancestors of the river Danube, Moravian, and Nitra with sediment. In the beginning, this area was a large island, which was marked on old maps as "Insula Magna". However, in the 16th century, the flow of the main Danube branch changed and cut this large island in two. From then on, the southern part was called Szigetköz, and the northern part Csallóköz. The Szigetköz which is located between the Mosoni-Danube and the Great-Danube, has a northwest-southeast axis of approximately 52.5 km and a width of 6-8 km. (Alexay, 2018)

In our country, suburbanization started in the second half of the 80s, but the process accelerated from the 2000s. In the case of the city of Győr, most people have moved to the agglomeration in recent years, and in high rate to the more distant settlements which are located in the Szigetköz. The reason for this is primarily due to the fact that Győr's growing industry and economy had a significant effect on the increase in real estate prices. Therefore beside of the richer stratum a significant number of those has moved to the Szigetköz who cannot afford the family house in the city area. (Hardi – Nárai, 2005)

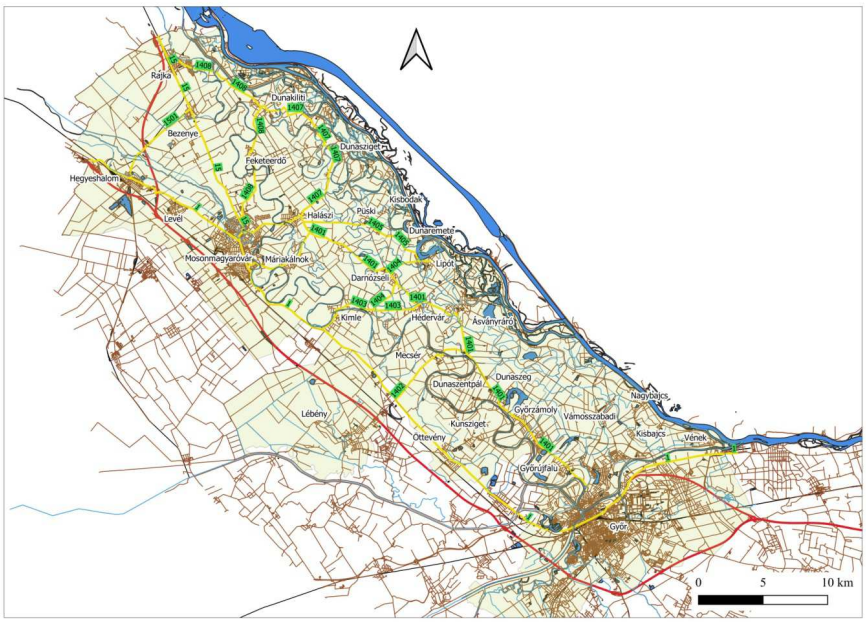


Fig. 1: The road network of the Szigetköz

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

One of the negative effects of suburbanization, which can also be observed in the case of those living in Szigetköz and in Győr, is the change in transportation needs and the significant increase of passenger car traffic. Especially during the morning and afternoon peak periods, significant congestion occurs along the main roads leading to Győr (main roads 1, 14, 81, 82, 83). All of this is also true for the "Szigetköz" connecting road number 1401, which through people coming from Szigetköz want to reach the Industrial Park and the city center on highway 14. Such a large increase in passenger car traffic is clearly one of the negative consequences of suburbanization, which is due to several factors. The most people works in such a position or workplaces which don't allow them to adapt to the public transport schedule, so they commute by car on a daily basis. A significant part of the services (e.g. shopping centers, post office, various customer service offices, clinics, etc.) are still located in the city, which would take much more time to reach by public transport, and in cases such as shopping, packing and transport would causes difficulty. And the children of those who moved out still go to school and kindergarten in the city, so in many cases before reaching the workplaces these institutions also have to be dropped, which also contribute to the formation of morning congestion. (Hardi – Nárai, 2005)

At the same time, the increased traffic causes problems not only in the city, but also in the settlements along the connecting road No. 1401, in which the fact that the agglomeration of Győr practically covers the entire Szigetköz plays a significant role, because there are some people who goes all the way from Rajka to work and learn in the city. (Hardi, 2008)

Therefore in my study on one hand I'm looking for the answer how has been the volume of the traffic changed in the Szigetköz between 2010 and 2019. On the other hand, what traffic problems exist and how traffic could be improved locally and how could be reduced the vehicle traffic into the direction of the city. In the current study, my investigations concern the following 32 Szigetköz settlements: Ásványráró, Bezenye, Darnózseli, Dunakiliti, Dunaremete, Dunaszeg, Dunaszentpál, Dunasziget, Feketeerdő, Győr, Győrladamér, Győrújfalu, Győrzámoly, Halászi, Hegyeshalom, Hédervár, Kimle, Kisbajcs, Kisbodak, Kunsziget, Lébény, Levél, Lipót, Máriakálnok, Mecsér, Mosonmagyaróvár, Nagybajcs, Öttevény, Püski, Rajka, Vámosszabadi, Vének.

3 THE CURRENT TRAFFIC SITUATION OF THE SZIGETKÖZ

3.1 The change of private transport

Looking at the traffic of the Szigetköz its busiest routes are its main traffic axis the 1401 road, the Mosonnmagyaróvár and the 1401 road connecting 1406 road, and the Mosonmagyaróvár and Rajka connecting 1408 road. (Fig. 1.)

Examining the traffic of the routes, it can be said each of them that the vehicle traffic exceeds 2,000 vehicles/day. The traffic of the road 1401 increased by 24% between 2011 and 2018, and the chart shows that further growth is expected in the future. (Fig. 2.)

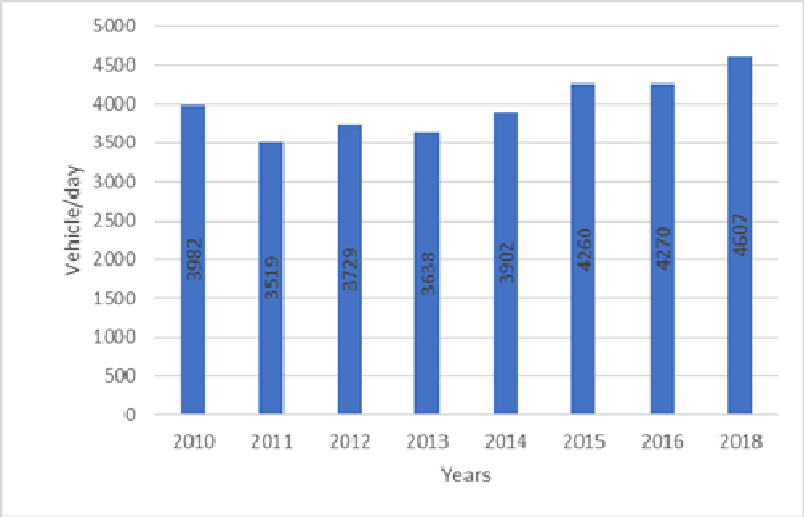


Fig. 2: Traffic increase on the 1401 road

The Mosonmagyaróvár and Máriakálnok connecting Road No. 1406 is almost 7 km long. The traffic of this road in 9 years has increased even more spectacularly than of the 1401 road. Because until 2012 it didn't even reach 2000 vehicles/day until than in 2013 it jumped over 3500 vehicles/day which represented a 45% increase. Between 2013 and 2018 with 19% has increased the vehicle traffic on road 1406. (Fig. 3.)

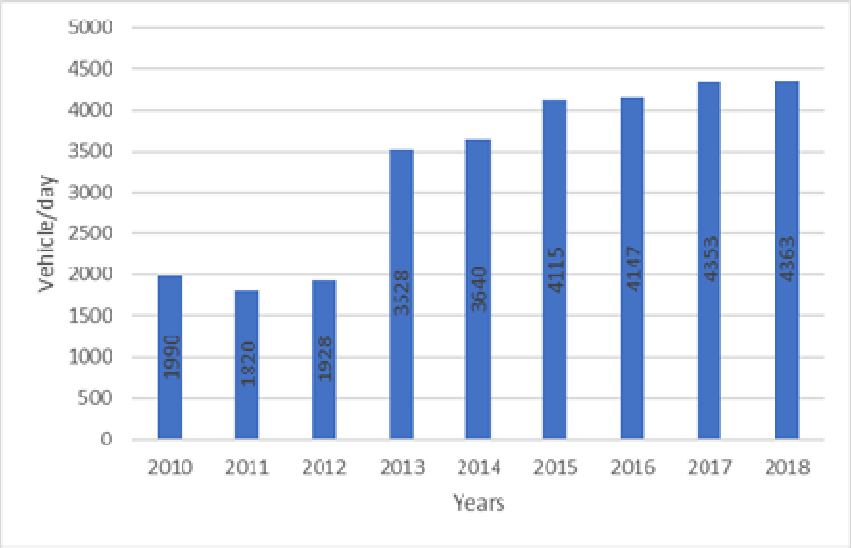


Fig. 3: Traffic increase on the 1406 road

The Mosonmagyaróvár-Dunakiliti-Rajka connecting Road No. 1408 is almost 18 km long. The highest increase in traffic was between 2013 and 2024 when the traffic of the route increased by 23%. Similar to the roads 1401 and 1406 the traffic of the 1408 road is also constantly increasing which between 2014 and 2018 has grown by 10%. (Fig. 4.)

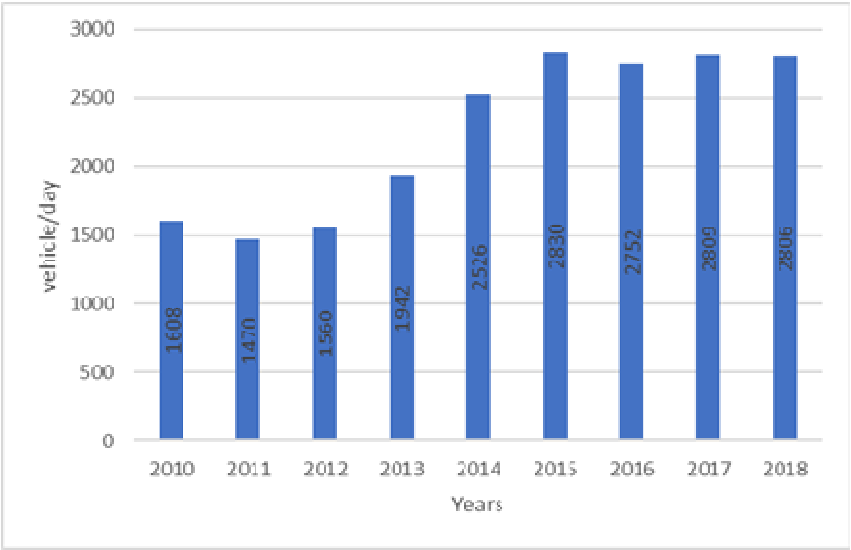


Fig. 4: Traffic increase on the 1408 road

Overall, it can be said that the traffic of the studied roads showed a significant increase in 9 years. All of this is true not only for the three busiest roads which were presented in the study, but also for all the routes located in the Szigetköz.

3.2 The change of public transport

Within the vehicle traffic of the Szigetköz it is important to study how the public transport has been changed between 2010 and 2018. As it can be clearly seen in Table 1. the number of buses increases every year on all in the paper studied roads which from the road 1406 is highlighted where the bus traffic has more than doubled. The traffic on the road 1401 increased by 59% and on the road 1408 by 42%. As it can be seen next to the private transport the role of public transport has also increased significantly in the Szigetköz in recent years, therefore its further development will definitely be necessary in the future.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Bus traffic			
	Road number		
Year	1401 (vehicle/day)	1406 (vehicle/day)	1408 (vehicle/day)
2010	41	7	33
2011	34	6	28
2012	35	6	28
2013	51	20	23
2014	60	25	46
2015	61	25	47
2016	52	20	38
2017	63	25	47
2018	65	25	47
Change 2010-2018 (%)	**58,54**	**257,14**	**42,42**

Table 1: The rate of change in bus traffic between 2010 and 2018 (%)

3.3 Bicycle traffic

During the study of the Szigetköz traffic it can't be leave out the bicycle traffic because the Szigetköz is a popular tourist destination that many people visit by bicycle. All of this is not coincidence, because the EuroVelo 6 international bicycle route, which connects the Atlantic Ocean with the Black Sea, passes through the region. The Hungarian section of the route starts at Rajka and leaves Szigetköz in the direction of Győr.

In the case of the three busiest roads in the Szigetköz from 2013 a clear increase can be observed in the annual average bicycle traffic. (Fig. 5.) Among them, the road 1406 is highlighted where most people cycle, and between 2013 and 2018, the rate of cyclists increased by nearly 60%. In the same period on road the 1401 with 65% and on the road 1408 with 61% .

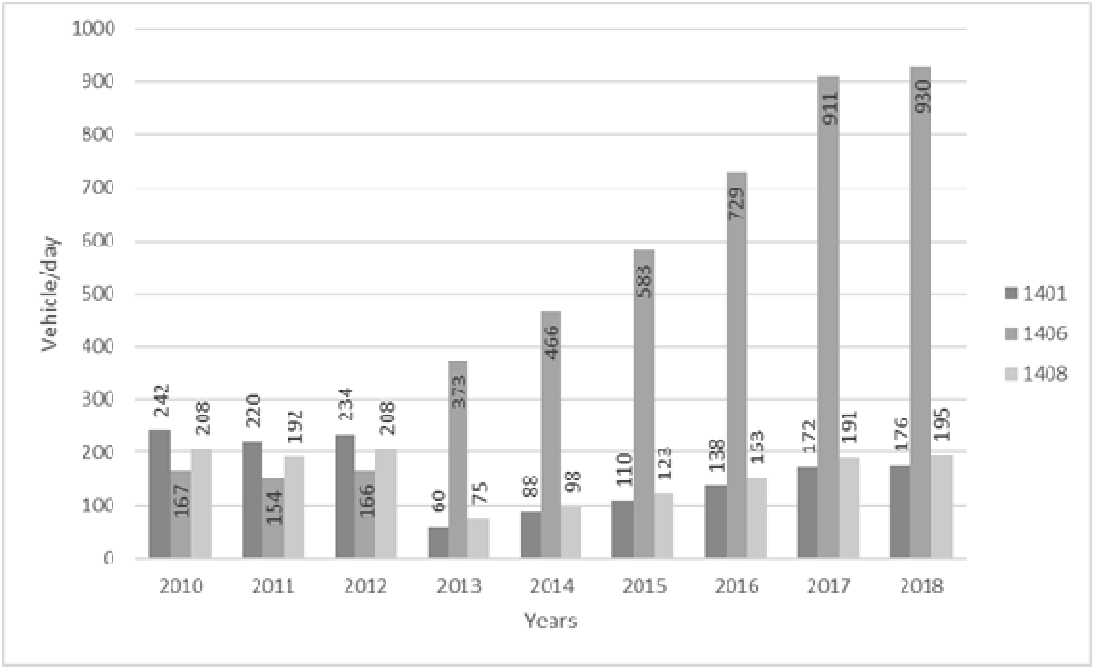


Fig. 5: The change of rate in bicycle traffic between 2010 and 2018 (%)

From the traffic data it clearly turns out, that cycling plays and important role in the area, and and its year-on-year growth also predicts that its development will be necessary. All of this will be important not only from a traffic point of view, but also from an environmental point of view. Therefore it is also necessary to study how the green areas of the Szigetköz settlements changed between 2010 and 2018. Because, as it can be seen vehicle traffic has increased significantly in 9 years, and it is expected that it will only increase in the future.

4 THE CHANGES IN THE GREEN AREAS OF THE SZIGETKÖZ

The size of the green areas of the Szigetköz settlements between 2010 and 2018 shows a rather varied picture. (Fig.6.) The reason for this is that form the studied 32 settlements Ásványráró, Dunaremete, Feketeerő and Mecsér have never provided statistical data on the size of their green areas. And form 2011 Győrújfalu and form 2013 Bezenye and Győrzámoly settlements did the same. In addition, the data provided by individual settlements show significant differences in certain years, of which the two big cities Győr and Mosonmagyaróvár are highlighted, where the most green areas are located. Therefore, the jumps and declines shown in the diagram are due to these two cities. However it is important to note that the size of green areas in the majority of the Szigetköz villages is mostly stagnant or slightly increasing, while the decrease is mainly characteristic of Győr and Mosonmagyaróvár. However due to the increase in traffic and the number of vehicles, it can be seen that the protection and increase of green areas is not enough for the Szigetköz area to remain sustainable without significant transport development. Therefore in the next chapter it will be presented that the settlements of the studied area what kind of transport developments planning in the future.

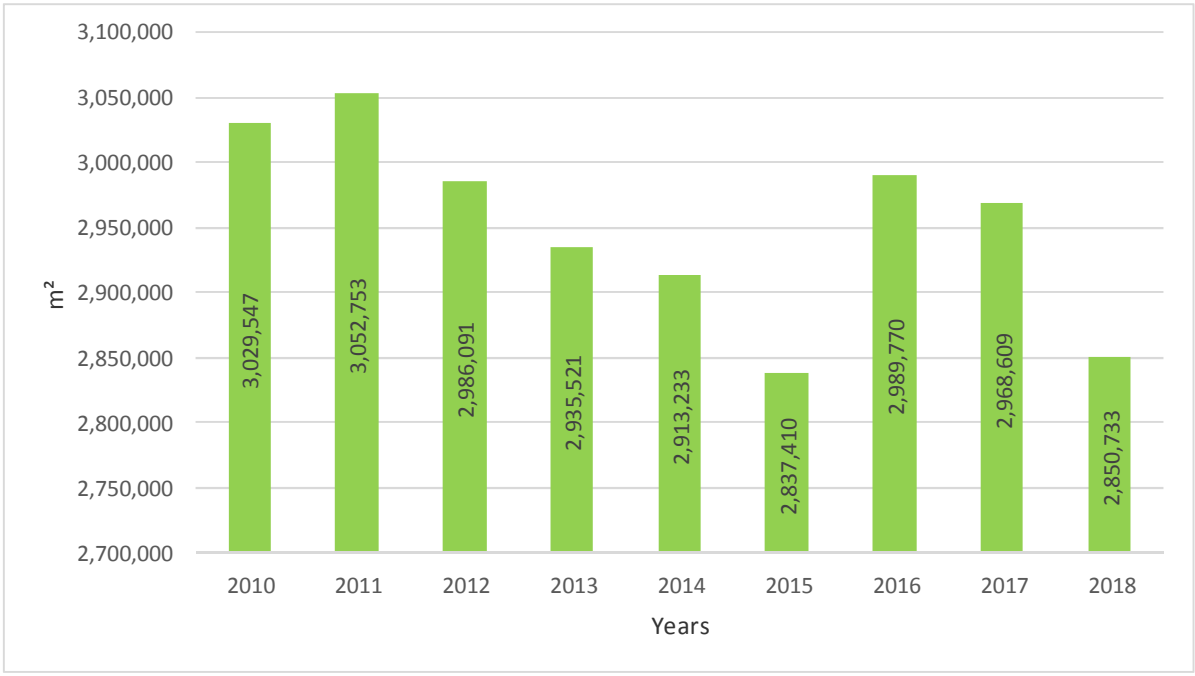


Fig. 6: The changing of the green areas in the settlements of the Szigetköz

5 THE TRANSPORT DEVELOPMENT PLANS OF THE SETTLEMENTS IN THE SZIGETKÖZ

To study what kind of transport related development are planning the individual settlements of the Szigetköz, 32 master plan of the Szigetköz settlements were reviewed where primarily I was looking for the answer what kind of transport development suggestions got each document. Therefore primarily within the master plan of each settlement I reviewed the structural plan, the transport supporting document and the technical description of the master plan where this was possible. From the studied settlements only in 15 cases were not reviewed the transport supporting document which is primarily due to the fact that it wasn't available either on the website of the settlement or at the office that prepared the master plan. I requested the missing data from Magyar Közút, and I asked all studied settlements to provide information about their planned future developments.

From the received data, the master plans, and after the detailed study of the technical descriptions it turned out that in the Szigetköz the following three planned developments affecting the most settlements:

- Construction of the 1401 bypass road
- Construction of a bicycle road along the embankment of the Danube
- Construction of connecting road/roads with the neighboring settlement/settlements

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Beside of the above mentioned developments the M14 motorway must be highlighted which doesn't directly affect the area of Szigetköz, but after its construction will have a significant impact on its future traffic. The planned transport developments of the studied settlements of the Szigetköz presents detailed the Table 2.

No.	Settlement	Planned development
1	Ásványráró	Settlement connecting road to Hédervár and Lipót Bicycle path along the Danube The 1401 bypass road
2	Bezenye	Bicycle road along the No. 1401 connecting road
3	Darnózseli	The section of the 1401 bypass road in two versions National side road in the direction of Dunaremete and Lipót Settlement road in the direction of Püski
4	Dunakiliti	Bicycle road along the connecting roads 1407 and 1408 connecting roads and the to Mosoni-Danube leading roads In the southern area of the settlement, inter-settlement roads have been designated
5	Dunaremete	Development of the junction between Fő utca and Arany János utca on connecting road no. 1405 Connecting road into the direction of Kisbodak and Darnózseli
6	Dunaszeg	The 1401 bypass road
7	Dunaszentpál	Bicycle road through the center of the settlement
8	Dunasziget	Bicycle road on road No. 1407, as well as along Szent István, Cikola, Dózsa György street, a bicycle path has been designated The extension of Nagysziget utca in the direction of Püski has been designated
9	Feketeerdő	The master plan of the settlement is not on the settlement's website, Magyar Közút hasn't give any information about future development in the settlement
10	Győr	M14 motorway Continuation of Ipar street Construction of a new entrance section of the main road No. 82. Construction of the western bypass road
11	Győrladamér	The 1401 bypass road
12	Győrújfalu	Western bypass road between the intersection of the 813 road and the main roads No. 1.-85.
13	Győrzámoly	The 1401 bypass road The renovation of road 1401
14	Halászi	The master plan of the settlement is not on the settlement's website, Magyar Közút hasn't give any information about future development in the settlement
15	Hédervár	Településközi összekötő út az 1401. útból kiindulva Ásványráró, és Mecsér irányába
16	Hegyeshalom	A település honlapja alapján a rendezési terv módosítása 2020.-ben kezdődött el. A Magyar Közút tájékoztatása alapján nincs tervezett fejlesztés a jövőben Hegyeshalomban.
17	Kimle	Settlement connecting road starting from road 1401 into the direction of Ásványráró and Mecsér
18	Kisbajcs	Bicycle road along the Danube
19	Kisbodak	There is no planned transport development in Kisbodak
20	Kunsziget	Kunsziget-Dunaszeg connecting road Börcs-Kunsziget connecting road
21	Lébény	Bicycle road along the main roads (from Ottómajor to Mosonszentmiklós) Settlement connecting road into the direction of Mosonszentmiklós Lébény-Károlyháza connecting road
22	Levél	Settlement connecting road has been designated in the continuation of Alsó Fő street into the direction of Mosonmagyaróvár
23	Lipót	Settlement connecting road has been designated through Ásványráró and the planned Lipót/Bősi harbor and Dunaremete into the direction of Darnózseli
24	Máriakálnok	The master plan of the settlement is not on the settlement's website, Magyar Közút hasn't give any information about future development in the settlement
25	Mecsér	Settlement connecting road into the direction of Dunaszentpál Bicycle road into the direction of Lébény The renovation of road 1402
26	Mosonmagyaróvár	A ring road has been designated touching the main roads No. 1 and 86. From Mátyás király street to the south, a bicycle path has been designated along the main road No. 86 and along Soproni street, as well as into the direction of Mosonudvar, touching Mosonszentjánosi street Móvár déli tehermentesítő út, valamint az M1 Moson-pihenő - 8505.j. út összekötése (csomópont kialakítás) Móvár southern relief road and the M1 Moson- resting place- 8505. road connection (junction formation)
27	Nagybajcs	Bicycle road along the Danube
28	Öttevény	There is no planned transport development in Öttevény
29	Püski	The master plan of the settlement is not on the settlement's website, Magyar Közút hasn't give any information about future development in the settlement
30	Rajka	The master plan of the settlement is not on the settlement's website, Magyar Közút hasn't give any information about future development in the settlement
31	Vámosszabadi	M14 motorway and the roads connected to it (Győrzámoly settlement connecting road), to the border Bicycle road between roads No. 14 and 1303 to the north of the inner area
32	Vének	Settlement connecting road into the direction of Gönyű (and Slovakia) New road into the direction of the Water feature

Table 2.: Planned transport developments in the master plan of the Szigetköz settlements

From the table it turns out clearly that the settlements connecting roads would primarily with the neighbouring settlements providing fast connection therefore cycling would be a good transport alternative on them. Therefore, with sustainability and environmental protection keeping in mind, it would be

recommended to limit passenger car traffic on these roads in such a way that, from spring to autumn, primarily cycling and public transport would be allowed on them. And by passenger cars could be used only in the autumn and winter seasons these roads which looking at their design would be single-lane.

6 SUMMARY

As it was presented in the study the traffic of each highlighted roads of the Szigetköz has significantly increased between 2010 and 2018. From these stands out the 1401 road which traffic exceeded 4,600 vehicles/day in 2018. Looking at the bus traffic also increase has been experienced on all roads of the Szigetköz. The highest increase in bus traffic was experienced on route 1406, which almost tripled in 9 years. Between 2010 and 2012 the bicycle traffic showed a rather varied picture, and then started to increase significantly from 2013. Since 2017 the road 1406 has exceeded 900 vehicles/day, until the roads 1401 and 1408 have over 150 vehicles/day.

A tanulmányban ahogy látható volt mindegyik kiemelt szigetközi út forgalma 2010 és 2018 között jelentős mértékben megnövekedett. Ezek közül kitűnik az 1401-es szigetközi út mely 2018-ban már meghaladta a 4600 jármű/nap forgalmat. Az autóbusz közlekedést tekintve szintén növekedés volt tapasztalható valamennyi szigetközi úton. A legnagyobb autóbusz forgalom növekedés az 1406-os úton volt tapasztalható, mely 9 év alatt majdnem megháromszorozódott. A kerékpáros forgalom 2010 és 2012 között meglehetősen változatos képet mutatott, majd 2013-tól jelentős növekedésnek indult. Az 1406-os úton 2017 óta meghaladja a 900 jármű/napot, míg az 1401-es, és 1408-as utakon 150 jármű/nap felett van.

After the review of the master plans of the settlements in the Szigetköz it was established that most of them want the construction of the 1401 bypass road, which is clearly due to the increasing proportion of people moving out to Szigetköz. Beside that as it was seen the development of bicycle transport is also a high priority in the plans, but primarily from a tourism point of view. Therefore, it is no coincidence that the settlements connecting roads roads were in the third place, which, primarily due to the increased traffic, can represent an alternative route for those living in the Szigetköz. However, the new road construction in the future will only generate additional vehicle traffic and reduce the green areas of the settlements. Therefore it would be recommended to create these settlement connecting roads in such a way that they are only single-lane, and from early spring to late autumn, only public transport or alternative means of transport would be allowed on them, such as the use of electric vehicles, cycling, etc. During the autumn and winter periods the passenger cars could only use to a limited extent these roads also, and in the morning and afternoon peak times due to the faster distribution of traffic, and in case of extreme weather (e.g. fog, intense rain, snow, etc.), taking traffic safety into account. In order to increase green areas, as far as the landscape and traffic safety conditions allow, vegetation must be planted along these roads, and where it is possible to protect the existing ones.

In the future, it is expected that even more people will move to Szigetköz, whose traffic will continue to increase. Therefore, it would definitely be recommended to implement the transport development presented in the study, as well as the increase of green space. With the help of this, Szigetköz can continue to be liveable and sustainable in the future.

7 REFERENCES

Alexay Zoltán: A Szigetköz múltja és jelene. In: Honismeret, Vol. 46. Issue 3, pp. 50-61. Budapest, 2018

Hardi Tamás, Nárai Márta: Szuburbanizációs és közlekedés a győri agglomerációban. In:Tér és Társadalom, Vol. 19. Issue 1, pp. 81-101. Győr, 2005

Hardi Tamás: A határtérség térszerkezeti jellemzői. In: Tér és Társadalom, Vol. 22. Issue 3, pp.3-25. Győr, 2008

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Transform Ternitz – Transformation der ehemaligen Arbeitersiedlung in Ternitz: Resiliente Quartiersentwicklung bottom-up gestalten

Katharina Kirsch-Soriano da Silva, Lukas Botzenhart

(Dipl. Ing. Dr. Katharina Kirsch-Soriano da Silva, Stadtteilarbeit, Caritas der Erzdiözese Wien, Absbergasse 27/Kulturhaus Brotfabrik/Stiege 3/2. Stock, 1100 Wien, katharina.kirsch@caritas-wien.at)
(Lukas Botzenharrt MA, Stadtteilarbeit, Caritas der Erzdiözese Wien,Absbergasse 27/Kulturhaus Brotfabrik/Stiege 3/2. Stock, 1100 Wien, lukas.botzenhart@caritas-wien.at)

1 ABSTRACT

Der Gedanke an Stadt ist aktuell meist mit der Vorstellung von Wachstum verbunden. Seit dem Beginn des 19. Jahrhunderts ist der Prozentsatz der globalen Bevölkerung in Städten von 2% auf 50% zu Beginn des 20. Jahrhunderts angestiegen. Prognosen rechnen mit 75% im Jahr 2050. Doch gleichzeitig existieren ehemalige von der Industrie geprägte Städte, die im Zuge eines strukturellen Wandels der globalen Produktionsverhältnisse seit Jahrzehnten einen Rückgang von Einwohnerinnen und Einwohnern verzeichnen. Auch abseits des wohl berühmtesten Beispiels, der ehemaligen „Motorcity“ Detroit, ist dieses Phänomen in Österreich und Deutschland in ehemals industriell geprägten Regionen zu beobachten. Die meisten Städte mit dieser Problemstellung befinden sich in den westlichen Industriestaaten. Die Ursachen reichen von Naturkatastrophen, über sich wandelnde Lebensformen und Lebensstile und damit einhergehenden demographischen Entwicklungen bis hin zu Abwanderung von Industrie. Wie wachsende Städte stehen auch diese Städte vor enormen Herausforderungen, jedoch werden diese weniger erforscht und auch das Interesse für Investitionen hält sich in Grenzen. Doch in schrumpfenden Städten liegt räumlich ein großes Potenzial für Umgestaltung, das die Möglichkeit bietet, Stadt neu zu denken.

Keywords: schrumpfende Städte, Arbeitersiedlung, Partizipation, Quartiersentwicklung, Resilienz

2 HANDLUNGSANSÄTZE FÜR EHEMALIGE ARBEITERSIEDLUNGEN

2.1 Von der Shrinking City zur Smart City – Arbeit an der Arbeitersiedlung

Im Fall des hier vorgestellten Smart-Cities-Projekts wurde das Potenzial in Form einer teilweise leerstehenden Arbeitersiedlung aus dem Jahr 1940, in der Stadt Ternitz im Industrieviertel entdeckt. Ähnlich wie in vielen Kleinstädten siedelten sich ab Mitte des 19. Jahrhunderts große Industriebetriebe in verschiedenen Städten Österreichs an. Der Bedarf an Wohnraum für die Arbeiterschaft wurde durch großmaßstäbliche Arbeitersiedlungen abgedeckt. Sie waren meist durch eine einfache Bauweise, kleine und serielle Wohnungsgrundrisse sowie Monofunktionalität gekennzeichnet. Es ging in erster Linie darum, rasch Wohnraum für Arbeiter (und deren Familien) zu schaffen, um die Wohnraumversorgung für die rasant wachsende Arbeiterschaft zu gewährleisten. Waren die kompakten Wohneinheiten mit eigenen Sanitäranlagen damals als modern einzustufen, so weisen sie heute häufig einen hohen Energieaufwand bei der Beheizung auf, sind baulich sanierungsbedürftig und entsprechen den Vorstellungen von zeitgemäßem Wohnen oft nicht mehr. Als die Industrie ab den 1970er Jahren abzuwandern begann, stürzten viele Städte und Gemeinden in eine immanente Krise. Die Arbeitersiedlungen verloren ihre Identität und haben – ebenso wie Betriebe und Arbeitsstätten – mit Herausforderungen und Veränderungen zu kämpfen.

2.2 Modernisierung der Arbeitersiedlung – Transformation gemeinsam gestalten

Erfahrungen aus Projekten der Sanierung und Modernisierung von Wohnanlagen zeigen, dass diese für die Bewohnerinnen und Bewohner immer eine große Herausforderung darstellen. Oftmals müssen die Bewohnerinnen und Bewohner für die Zeit der Sanierung temporär umgesiedelt werden. Hinzu kommt teilweise eine Erhöhung der Mieten und in weiterer Folge eine Verdrängung von sozioökonomisch benachteiligten Bewohnerinnen und Bewohnern. Wohnungen aus dem Bestand gemeinnütziger Wohnbauträger, bei denen die Wohnbaukredite bereits abbezahlt wurden, zählen zum günstigsten Wohnraum auf dem Markt und sprechen somit eine besonders vulnerable Gruppe an. Jede Veränderung in diesem Bereich muss daher sensibel geplant und durchgeführt werden. Gleichzeitig stellen die erforderlichen investiven Maßnahmen auch die gemeinnützigen Wohnbauträger vor die Herausforderung, wie sie tiefgreifende Modernisierungen unter Einhaltung der Mietzins-Obergrenzen und bei oft geringen vorhandenen Rücklagen finanzieren können.

Technisch ist die Umsetzung von Plus-Energie- und Passivhaus-Gebäuden und -Gebäudeverbänden heutzutage auch bei Sanierungen möglich. Die Finanzierung solcher Sanierungsvorhaben ist das primäre Hemmnis, für das es gilt, neue Modelle zu entwickeln. Veränderungen in der sozio-demographischen Zusammensetzung der Bewohnerinnen und Bewohnerund damit einhergehende veränderte Nachbarschaften und veränderte Bedürfnisse (etwa von Bewohnerinnen und Bewohnern verschiedenen Alters, verschiedenen Geschlechts und verschiedener Kulturen) sind ebenfalls zu berücksichtigen. Transformation muss – in diesem Sinn – gemeinsam und bedarfsgerecht gestaltet werden.

2.3 Modernisierung und Partizipation – „do it yourself" und „bottom-up"

Partizipation bei Sanierungs- und Modernisierungsprojekten ist nach wie vor kein Standard. Häufig fokussieren Sanierungsvorhaben auf ausgewählte technische und bauliche Aspekte (wie thermische Sanierung oder Verbesserung der Barrierefreiheit durch Liftanbau) und für eine ganzheitliche Transformation, die im Sinne der Smart City auf verschiedenen Ebenen gestaltet wird, ist meist wenig Spielraum. Im Kontext von ehemaligen Arbeitersiedlungen ist Partizipation ein besonders interessantes Thema. Denn gerade die ersten Wohnbaugenossenschaften Anfang des 20. Jahrhundertss entstanden auch aus bottom-up Bewegungen – wie bspw. der Siedlerbewegung in Wien, wo die Bewohnerinnen und Bewohner ihre Häuser selbst erbauten und auch das Gemeinschaftsleben und gemeinschaftliche Infrastrukturen in Selbstverwaltung organisiert wurden. Die Marienthalsiedlung aus den 1920ern, welche durch die Studie „Die Arbeitslosen von Marienthal" bekannt wurde, wurde teilweise ebenfalls von den Arbeiterinnen und Arbeitern selbst erbaut. Gerade in Hinblick auf bedarfsorientierte und leistbare Handlungsstrategien für Arbeitersiedlungen, könnten neue Konzepte der Selbstorganisation (wie DIY Sanierungen und bottom-up Prozesse) daher neue Perspektiven eröffnen. Internationale Beispiele wie „Wallisblok" in Roterdam oder „Grandby Four Street" in Liverpool können hier ebenfalls Inspiration und wertvolle Erfahrungen bieten.

3 AUSGANGSSITUATION IN TERNITZ

3.1 Ternitz – eine ehemalige „Stahlstadt" des Industrieviertels im Strukturwandel

Mit einem Gemeindegebiet von 65 km2 und rund 15.000 Einwohnerinnen und Einwohnern (Bevölkerungsdichte 223,90 Einwohnerinnen und Einwohner/km²) zählt Ternitz zu den größten Städten Niederösterreichs. Die Stadt liegt im südöstlichen Niederösterreich und gehört zum Industrieviertel. Mit den öffentlichen Verkehrsmitteln ist Ternitz über die Südbahnstrecke von Wien aus in einer knappen Stunde Fahrzeit erreichbar und verfügt über 2 Bahnhöfe (Ternitz und Pottschach). Darüber hinaus gibt es diverse Busverbindungen. Mit dem Individualverkehr ist die Stadt über die Südautobahn, Abfahrt Wiener Neustadt, die Bundesstraße 17 und über die S6-Semmeringschnellstraße zu erreichen.

Ternitz ist mit der seit Mitte des 19. Jahrhunderts dort angesiedelten Stahlindustrie gewachsen und war in den 1960er und 1970er Jahren, der Hochblüte der Stahlindustrie, auch durch die Zuwanderung von Gastarbeiterinnen und Gastarbeitern aus der Türkei geprägt. Seit den 1970er Jahren unterliegt die Stadt allerdings einem strukturellen Wandel. Die den Ort bestimmenden Industriebetriebe haben sich zahlenmäßig verringert und dementsprechend ist auch die Zahl der dort Beschäftigten schrittweise zurückgegangen. Ternitz ist dennoch noch immer die Stadt mit den meisten Arbeitsplätzen im Verwaltungsbezirk Neunkirchen. Heute gibt es in Ternitz - inklusive der Einzelunternehmen - 800 Betriebe der unterschiedlichsten Sparten, in denen rund 3.800 Mitarbeiterinnen und Mitarbeiter beschäftigt sind (Stand: 2016).

Demographisch lässt sich ein geringer, schleichender Bevölkerungsverlust in Ternitz erkennen. Die Geburtenbilanzen fallen leicht negativ aus, die Wanderungsbilanzen zeigen schwankende, in den letzten Jahren eher leicht negative Tendenzen, sodass insgesamt eine langsame Überalterung der Bevölkerung erkennbar ist. Seit dem Jahr 1981 hat sich die Bevölkerung in Ternitz von 16.104 auf 14.660 Einwohnerinnen und Einwohner (Stand 1. Jänner 2020) bzw. um rund 9 % reduziert. Bei einer durchschnittlichen Haushaltsgröße von 2,35 Personen pro Haushalt in NÖ bedeutet dies eine Reduktion um rund 614 Haushalte. Die Bevölkerungsprognose von 2015 bis 2050 signalisiert dem Bezirk Neunkirchen jedoch ein Wachstum von (derzeit veröffentlichten) rund 9%. Von derzeit 86.721 Einwohnerinnen und Einwohnern soll der Bezirk im Jahr 2030 auf 90.019 Einwohner anwachsen, bis 2050 auf 94.859 (ÖROK-

Kleinräumige Bevölkerungsprognose 2010). Laut statistischem Zentralamt wird ein Zuwachs in Ternitz bis 2050 in ähnlicher Größe prognostiziert; bis 2030 erwartet man einen Anstieg der Einwohnerinnen und Einwohner auf runde 15.400. Die Zusammensetzung der aktuell 14.660 (Stand: Jänner 2017) Einwohner* innen-Stadtgemeinde zeigt: der Seniorinnen- und Senioren-Anteil von 22,9% (ca. 3.400 Personen sind über 65 Jahre alt) ist im Vergleich zu anderen Städten Niederösterreichs hoch, wobei der Anteil an Ein-Personen-Haushalten mit 38% etwas geringer ist als in Wien (45% aller Haushalte, vgl. Österr. Städtebund 2018). Rund 2.100 in Ternitz lebende Personen sind nicht in Österreich geboren, wobei ca. 1.570 eine andere Staatsbürgerschaft haben (vgl. Statistik Austria 2018).

3.2 Großer Bestand an Arbeiterwohnsiedlungen

Der überwiegende Teil des Wohnungsbestandes in Ternitz sind Arbeiterwohnungen, die einst durch die Firma Schoeller Bleckmann Stahlwerke AG ausschließlich an Beschäftigte des Unternehmens vergeben wurden. Seit der Zwischenkriegszeit bis in die 1980er Jahre spielte die Wohnbautätigkeit der Wohnbaugesellschaft Schwarzatal Gemeinnützige Wohnungs- und Siedlungsanlagen GmbH in Siedlungen und Wohnhausanlagen unterschiedlichster Größe eine zentrale Rolle. Dementsprechend sind diese Siedlungen noch immer mit einem relativ hohen Anteil an Personen belegt, die entweder selbst oder deren Ehepartnerin oder Ehepartner früher im „Werk“ Ternitz beschäftigt waren. Diese Mieterinnen- und Mietergruppe ist heute in die Altersgruppe der über 70-Jährigen einzureihen. Die strukturellen und demographischen Veränderungen, die durch die Reduzierung der Industrie in Ternitz ausgelöst wurden, machen sich dabei auch im Wohnungsbestand der Schwarzatal bemerkbar, die in der Region der größte Wohnungseigentümer ist und in Ternitz ca. 1.420 Wohnungen besitzt.

Ein Großteil der ehemaligen Arbeitersiedlungen und des vor 1970 errichteten Wohnungsbestandes entspricht nicht mehr den heutigen Ansprüchen an Ausstattung, Wohnkomfort und Energieeffizienz. Dementsprechend wurden in den vergangenen Jahren bereits einige Sanierungsmaßnamen in ausgewählten Siedlungen gesetzt. In den Jahren 2017 und 2018 wurde zudem ein unternehmensinterner Prozess gestartet, um kreative, realisierbare Ideen und Entwicklungsoptionen zu identifizieren. Im Rahmen eines Werkstattverfahrens wurden Expertinnen und Experten eingeladen (u.a. ein Großteil der Projektpartnerinnen und Projektpartner des vorliegenden Projekts „Transform Ternitz“), die Inputs aus verschiedenen disziplinären Perspektiven einbrachten und, ausgehend von einer ersten Analyse des Status Quo, gemeinsam Visionen für zukünftige Handlungsstrategien entwickelten. In den Fokus gelangte dabei insbesondere die im Ortsteil Pottschach angesiedelte „Siedlung III“, eine der ältesten Siedlungen, die von Wohnungsleerstand gekennzeichnet ist, die aber auch eine Vielfalt räumlicher Potenziale aufweist.

3.3 Die „Dreiersiedlung“ im Ortsteil Pottschach

Die „Dreiersiedlung“ wurde 1940 errichtet und zählt 384 Wohneinheiten, mit einer Wohnnutzfläche von insgesamt ca. 18.800 m2 auf 96 Häuser verteilt. Die Siedlung hat von ihrer Anlage her einen Gartenstadt-Charakter – zwischen Zeilenbebauungen mit Durchgängen und unterschiedlichen Platzsituationen prägen großzügige, allerdings teilweise wenig genutzte halböffentliche Grünflächen sowie (ebenfalls halböffentliche) weite Vorgärten zur Straße hin das Erscheinungsbild der Wohnhausanlage. Die Wohnhäuser verfügen über zwei Wohngeschoße mit Kleinwohnungen jeweils im Erdgeschoß und 1.Obergeschoß sowie über Hauskeller und einen großzügigen (nicht ausgebauten) Dachboden. Das Erdgeschoß wird über einen Halbstock und somit nicht barrierefrei erschlossen. Daher gibt es auch keine direkt zugänglichen Erdgeschoßgärten und – aufgrund des Fehlens von Balkonen – generell keine wohnungsbezogenen Freiräume. Die Wohnungen, die seriell mit gleichen Wohnungsgrundrissen errichtet wurden, sind kompakt, mit kleinen Wohnräumen und niedriger Raumhöhe, und meist auch sanierungsbedürftig. Die Wohnräume werden zudem noch mit Einzelöfen (teilweise mit Öl) beheizt.

Die Siedlung nimmt in mehrerlei Hinsicht eine Sonderrolle im Wohnungsbestand der Schwarzatal ein. Sie ist nicht nur die größte zusammenhängende Wohnsiedlung der Wohnungsgenossenschaft in Ternitz, sondern in den vergangenen Jahren auch mit besonderen Herausforderungen konfrontiert. Etwas abgelegen vom Ternitzer Stadtzentrum stellt sie sich – aus Sicht der Hausverwaltung – über die letzten Jahre verstärkt als „sozialer Brennpunkt“ dar, charakterisiert durch einen höheren Anteil an Arbeitslosen oder Sozialhilfe Beziehenden. Die Mieten sind verhältnismäßig niedrig und die Zahl einkommensschwacher und sozial benachteiligter Mieterinnen und Mieter hat in den letzten Jahren zugenommen. Darüber hinaus leben viele

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

ältere Personen und Menschen mit Migrationsgeschichte in der Siedlung. Der Baubestand ist sanierungsbedürftig und der Anteil an (geplant und ungeplant) leerstehenden Wohnungen steigt. Viele Bewohnerinnen und Bewohner Pottschachs haben allerdings bis heute einen Bezug zur Siedlung, da sie selbst oder Familienangehörige oder Bekannte schon einmal in der Siedlung gelebt haben.

Abb. 1: Lage der Dreiersiedlung in Ternitz © einszueins Architektur

Die Caritas Stadtteilarbeit hat, gemeinsam mit dem Büro raum & kommunikation und gefördert durch den Fonds Gesundes Österreich, 2019 das Gesundheitsförderungsprojekt „Gesunde Nachbarschaft: Geschichten und Talente der Vielfalt“ gestartet und dafür u.a. die „Dreiersiedlung“ als Projektgebiet gewählt. Das bis 2021 umgesetzte Projekt begab sich auf die Suche nach bisher verborgenen Talenten, Fähigkeiten und Geschichten in der Nachbarschaft und entwickelte – ausgehend von diesen – gemeinsame gesundheitsfördernde Initiativen und Aktivitäten. Dabei wurde bewusst ein Handlungsansatz gewählt, der nicht die Defizite, sondern die Ressourcen und Potenziale in den Vordergrund rückte, und es konnten Kontakte zu Bewohnerinnen und Bewohnern aufgebaut und erste nachbarschaftliche Aktivitäten initiiert werden.

Mit dem Smart-Cities-Projekt „Transform Ternitz“, das zwischen 2021 und 2024 realisiert wird, soll die Arbeit mit Bewohnerinnen und Bewohnern fortgesetzt werden, nun aber auch die Transformation der räumlichen Struktur der „Dreiersiedlung“ – in Hinblick auf den Gebäudebestand, die funktionale Durchmischung, die Gestaltung und Nutzung der Freiräume und die Umstellung auf eine zukunftsweisende Energieversorgung – konkret in Angriff genommen werden. Auch lokale Akteurinnen und Akteure in der Siedlung wie ein Musikverein, ein Seniorinnen- und Seniorenverein und ein alevitischer Kulturverein werden involviert. „Transform Ternitz“ wird von einem Konsortium bestehend aus der Stadtteilarbeit der Caritas Wien, dem Wohnbauträger Schwarzatal, einszueins Architektur, Carla Lo Landschaftsplanung und Schöberl & Pöll Bauphysik umgesetzt.

4 DAS PROJEKT „TRANSFORM TERNITZ“

Ziel des Projektvorhabens „Transform Ternitz“ ist es, die „Dreiersiedlung“, welche aktuell einen hohen Sanierungsbedarf aufweist und von starkem Wohnungsleerstand betroffen ist, zu einem erneut lebendigen und resilienten Siedlungsorganismus zu transformieren. Herzstück des vom Klima- und Energiefonds geförderten Smart-Cities-Projekts ist ein partizipativer Prozess: Vor Ort wird ein interaktives Quartiersentwicklungslabor eingerichtet, in dem die Transformation mitgestaltet werden kann. Interessierte

Bewohnerinnen und Bewohner und lokale Akteurinnen und Akteure nehmen dabei eine aktive Rolle ein. Konzepte zur nachhaltigen Transformation der gesamten Siedlungsstruktur werden partizipativ erarbeitet und prototypische Maßnahmen durch Demonstrationshäuser und Impulsnutzungen gemeinsam umgesetzt und erprobt. Besonders innovative Aspekte sind Selbstbau-Konzepte, ein kreativer Umgang mit Leerstand sowie die Entwicklung von Maßnahmenbündeln, die ökologische, ökonomische und soziale Nachhaltigkeit miteinander verbinden.

4.1 Maßnahmenbündel im Rahmen des Smart-Cities-Projekts

Folgende Maßnahmenbündel werden im Rahmen von „Transform Ternitz“ konkret umgesetzt:

Maßnahmenbündel #1: Prozess – Recherche zu Best Practice Beispielen, Bedarfserhebung mit Bewohnerinnen und Bewohner , interaktive Formate vor Ort, DIY Holzbau mit Studierenden, Erprobung von Prototypen.

Maßnahmenbündel #2: Gebäude – Entwicklung von Konzepten für Modernisierung und Sanierung und Start der Implementierung von Prototypen, Ermöglichung zeitgemäßer und innovativer Wohnformen, Schaffung von gemeinschaftlichen Infrastrukturen und funktionaler Durchmischung.

Maßnahmenbündel #3: Freiraum – Aktivierung des Freiraums für soziale Treffpunkte und Gestaltung von Aufenthalts- und Verweilmöglichkeiten, Stärkung der Selbstversorgung in Form von Eigengärten ausgehend von bereits bestehenden Praktiken des Gärtnerns in der Sieldung.

Maßnahmenbündel #4: Energie – Analyse des bautechnischen und haustechnischen Bestands, Entwicklung von nachhaltigen Energielösungen und Umstellung des Heizsystems von Einzelöfen auf ein zentrales und ökologisch nachhaltigeres System.

Maßnahmenbündel #5: Ökonomie – Recherche von Förderungen, Erarbeitung entsprechender Rechts- und Finanzierungsmodelle, die einerseits die wirtschaftliche Realisierbarkeit der Maßnahmen durch den gemeinnützigen Wohnbauträger, andererseits die Leistbarkeit für die Bewohnerinnen und Bewohner im Blick haben.

Maßnahmenbündel #6: Erfahrungen transferieren – Stakeholder Workshops und Besichtigungen für interessierte weitere Stakeholder wie Bauträger und Gemeinden, Nutzung zielgruppenspezifisch relevanter Kommunikationskanäle, Gestaltung und Bespielung der Website: https://www.dreiersiedlung.at/.

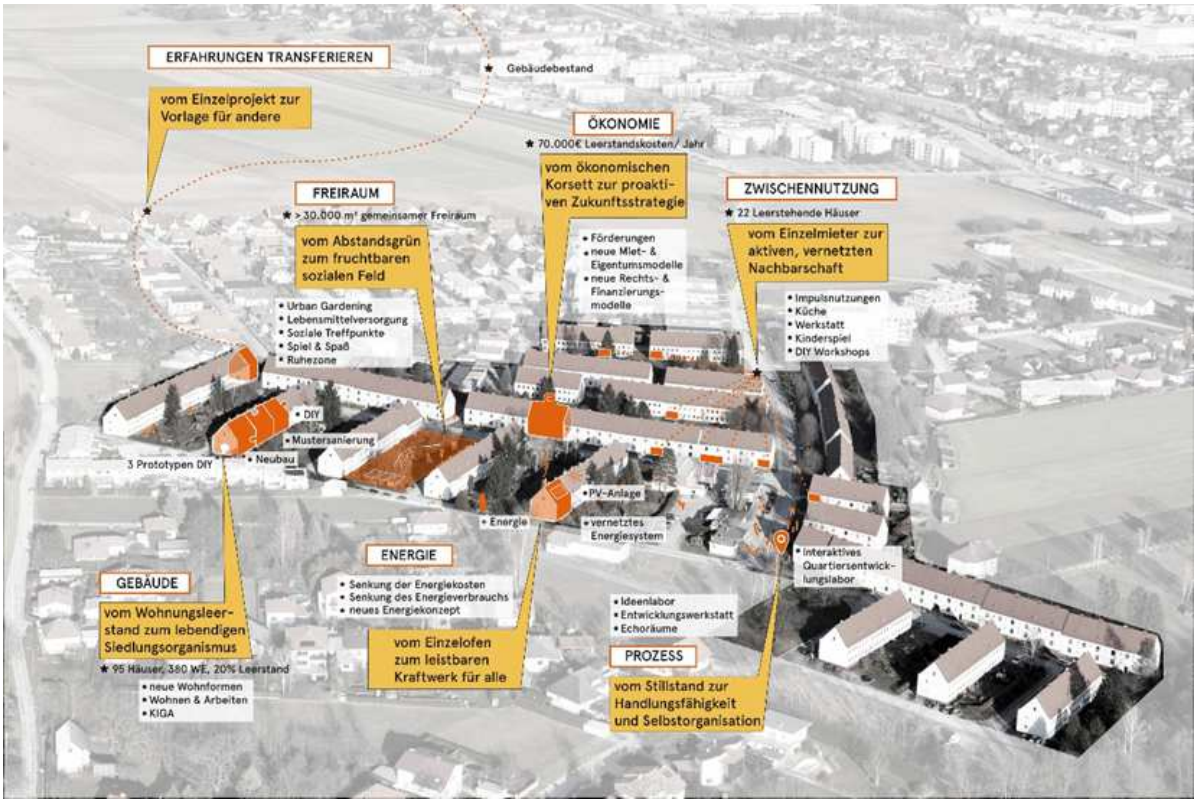


Abb. 2: Maßnahmenbündel zur Transformation der Dreiersiedlung, beispielhaft illustriert © einszueins Architektur

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

4.2 Beteiligung der Bewohnerinnen und Bewohner und Erhebung von Bedarfen

Ab Herbst 2021 wurden der partizipative Prozess vor Ort geplant und erste Bausteine des interaktiven Quartiersentwicklungslabors vorbereitet. Mit Jänner 2022 startete die Bedarfserhebung unter den bestehenden Bewohnerinnen und Bewohnern – diese erfolgte mittels eines schriftlichen Fragebogens sowie im Rahmen von persönlichen Gesprächen (die bei Bedarf auch in verschiedenen Sprachen geführt werden können).

Ziel ist es, von den Bewohnerinnen und Bewohnern selbst mehr über ihre Bedarfslagen und Perspektiven zum Wohnen in der Dreiersiedlung zu erfahren und auch ihre Ideen für die Zukunft der Siedlung einzuholen. Die Fragestellungen der Bedarfserhebung betreffen Wohnen und Wohnraum, Heizen und Energie, Nahversorgung und Mobilität, Freiräume und Gärten sowie Zusammenleben und Nachbarschaft. Bis Ende März 2022 wurden 18 ausgefüllte Fragebogen abgegeben, 7 leitfadengestützte Interviews durchgeführt und weitere 10 Gespräche geführt, um das Projekt vorzustellen und Kontakte zu knüpfen. Bei den bisherigen Gesprächen zeigte sich, dass vor allem die Themen Heizen und Energiekosten als belastend wahrgenommen werden, das Leben in der Siedlung – die Nachbarschaft und insbesondere die Grünräume und Gärten – allerdings sehr geschätzt werden.

Abb. 3: Ausschnitt Stiegenhaus-Aushang zur Ankündigung der persönlichen Gespräche © Projekt Transform Ternitz

Die Ergebnisse der Bedarfserhebung fließen laufend in die Planung der Prototypen und die Erarbeitung der Konzepte für die gesamte Siedlung ein. Zudem sind sie Basis für weitere themenspezifische Formate und Veranstaltungen, die ab dem Frühjahr 2022 – gemeinsam mit interessierten Bewohnerinnen und Bewohnern und lokalen Akteurinnen und Akteuren – vor Ort umgesetzt werden. Bei unseren Aktivitäten vor Ort gestalten wir unterschiedliche Formate und nutzen unterschiedliche Räumlichkeiten.

Abb. 4: Orte und Formate des interaktiven Quartiersentwicklungslabors © Projekt Transform Ternitz

4.3 Holzmöblierungen im Freiraum – erste sichtbare Interventionen vor Ort

In Kooperation mit der TU Wien und most likely wurde im Frühjahr und Sommer 2022 zudem eine Summer School realisiert. Rund 20 Architektur-Studierende errichteten im Rahmen eines Design-Build-Studios – auf Basis von Wünschen und Ideen aus der Bewohnerinnen- und Bewohnerschaft – vier Holzinstallationen in

den Freiräumen der Siedlung. Drei Wochen lang lebten die Studierenden, gemeinsam mit den Lehrbeauftragten des Städtebau Instituts, in der ehemaligen Arbeitersiedlung. Im zentral gelegenen Volkshaus fanden sie einen Raum zum Entwerfen, Kochen und Austauschen mit Bewohnerinnen und Bewohnern der Siedlung. Dadurch konnten sie in die Lebenswelt der Bewohnerinnen und Bewohner eintauchen, von denen sich manche sogar teilweise beim Bauen und Umsetzen der Installationen beteiligten. Das Ziel war es, Möbel im Freiraum zu gestalten, die das vorhandene Potenzial des Ortes stärken und neue Nutzungsmöglichkeiten, Verweilorte und Treffpunkte für die Bewohnerinnen und Bewohner der Siedlung eröffnen. Manche sind sogar dafür gedacht, sie entweder in den eigenen Garten mitzunehmen oder ganz einfach im Sinne von DIY nachbauen zu können.

Durch diese erste sichtbare Veränderung in der ehemaligen Arbeitersiedlung wird auf die in Gang gesetzte Transformation durch das Smart-Cities-Projekt aufmerksam gemacht und der Mehrwert kann bei der Nutzung der Möbel erlebt werden.

Abb. 5: Summer School in Kooperation mit dem Städtebau-Institut der TU Wien und most likely © einszueins Architektur

5 BISHERIGES FAZIT

Als bisheriges Fazit lässt sich festhalten: 1) Für die bestehende Substanz lassen sich energetisch, ökologisch, baulich und funktional spannende Lösungen entickeln – unter den derzeitigen Rahmenbedingungen für gemeinnützige Bauvereinigungen ist eine Sanierung des Bestands allerdings eine wirtschaftliche Herausforderung, für die es neue Lösungen und zusätzliche Fördermöglichkeiten bräuchte. 2) Die Bedarfe von Bestandsbewohnerinnen und Bestandsbewohnern müssen wichtige Eckpunkte für die Sanierung und Weiterentwicklung des Bestands sein – es sind daher sowohl deren Involvierung als auch die Leistbarkeit von potenziellen Maßnahmen zentral. 3) Sichtbare Interventionen können neue positive Dynamiken in eine scheinbar „vergessene“ Siedlung bringen – die Präsenz der Studierenden wurde sehr positiv wahrgenommen und auch die entstandenen Holzinstallationen im Freiraum werden gerne genutzt. Ein nächster möglicher Schritt könnte es auch sein, neben der Planung der Sanierung des Bestands bei leer stehenden Gebäudezeilen auch neue Konzepte zu entwickeln – bspw. mit einer gemeinschaftlichen Wohnformen wie einer Baugruppe, wo neue Menschen angesprochen und gemeinsam realisierbare Betriebs- und Finanzierungsmodelle entwickelt werden können.

6 LITERATUR

HANIKA, Alexander: ÖROK Kleinräumige Bevölkerungsprognose für Österreich 2010-2030 mit Ausblick bis 2050. Wien, 2009.
ÖSTERREICHISCHER STÄDTEBUND (2018): Tätigkeitsbericht des Österreichischen Städtebundes. Wien, 2018.
STADTGEMEINDE TERNITZ: Örtliches Entwicklungskonzept/Stadtentwicklungskonzept der Stadtgemeinde Ternitz. Erläuterungsbericht zur Planung. Ternitz, 2012.
STADTGEMEINDE TERNITZ: Zahlen und Fakten. Ternitz, 2020.
STATISTIK AUSTRIA: Statistisches Jahrbuch Integration. Wien. 2018.
UNIVERSITÄT GRAZ: Revitalisierung der Arbeitersiedlung Marienthal. Graz, 2010.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Virtual Intelligent Port "VIPort" – a Holistic Energy Approach

Clemens Bauer, Torsten Dunger, Nico Graf, Christina Warmann

(Dr. Clemens Bauer, ITK-Engineering GmbH, clemens.bauer@itk-engineering.de)
(Dr. Torsten Dunger, ITK-Engineering GmbH, torsten.dunger@itk-engineering.de)
(Nico Graf, ITK-Engineering GmbH, nico.graf@itk-engineering.de)
(Christina Warmann, ITK-Engineering GmbH, christina.warmann@itk-engineering.de)

1 ABSTRACT

The "Fit for 55 package" with the goal of reducing net greenhouse gas emissions by at least 55 percent by 2030 compared to 1990, requires a restructuring of the energy systems in the ports in order to supply ships with energy with as few emissions as possible. The virtual intelligent port takes a holistic approach to optimize the entire energy system of a port based on digitalization, data analysis, and artificial intelligence (AI). The optimization aims to maximize energy generation from renewable sources, minimize energy consumption, and keep investment and operating costs to a minimum through intelligent energy management. The digital twin of the port is created with the involvement of all participants relevant for the generation and consumption of energy. It is a very individual system for each port and can be further developed with future developments of the port. The digital twin is the basis for optimization and thus for intelligent investment decisions and efficient energy management.

Keywords: energy, greenhouse gas, digitisation, data analysis, holistic

2 THE CHALLENGES OF ENERGY SUPPLY IN PORTS

The optimal energy supply in the ports represents a very complex task due to the very individual requirements and boundary conditions. It has become considerably more complicated due to the requirements imposed by climate targets and the global political energy situation. The climate targets and the associated political requirements call for the minimization of emissions. This in turn requires a precise analysis of the energy demands as well as the potentials for renewable energies and the conversion and storage of these. The past few months have shown us all how important the topic of energy self-sufficiency is. The availability of renewable energies is subject to major fluctuations due to the influence of weather (wind, sun, waves, etc.), the annual and daily rhythm. This makes new concepts for energy storage and conversion necessary. What are the future energy sources? What storage requirements exist? How well equipped is the port for this? What is the connection to power plants and the public network like? Major changes are imminent, for which there is little or no experience to be resorted to. If there is a lack of experience, it is even more important to use new technologies such as digital twins, simulations and optimization algorithms to support investment decisions. This enables decisions to be made consciously and based on comprehensible data and facts.

3 THE METHODICAL APPROACH, DIGITALIZATION, DATA ANALYSIS AND ARTIFICIAL INTELLIGENCE

3.1 Generate added value from digitalization

Digitalization is much more than just a trend. Digitalization is the transformation from an analog environment to an environment in which physical objects and values are displayed in formats that are suitable for further processing or storage in digital systems. It will thus be possible in future to present, store and process real-time information of the systems. One approach to making this digitalization usable is the digital twin. The steps for an approach with a digital twin are explained below.

3.2 Analysis

The analysis phase deals with the collection and exploration of all information sources and data describing the system to be digitally represented. This refers to physical objects with their relevant data for the respective problem as well as the relationships between the objects, which are also described with data. The relevance of the data must be determined. Which objects and relationships, with which relevant properties are integrated into the digital system? Which data are available or must still be made available? Which interfaces are available to which data systems and/or must be created? What is the quality of the data in

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

terms of completeness? Analysis of the data also means the development of new information from data fusion and correlation.

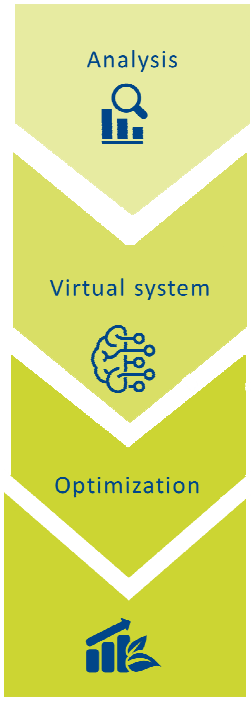


Figure 1: Procedure of the methodical optimisation approach

3.3 The digital twin

A digital twin is a digital representation of a real object using the data relevant to the respective objective, the so-called "data twin". Digital models expand this data twin into a digital twin. The term digital twin is not clearly defined and there are different expansion levels. For us, a digital twin is a system that is supplied with real-time data and is capable of simulation and learning, and that optimises itself. According to our definition, a digital twin can be used, among other things, to represent real-time states, to optimize operations, to reduce costs, but also for validation and verification in development or for investment decisions and predictive maintenance. A digital twin thus goes well beyond a simple virtual model or a simple visual representation! With the help of a digital twin, even complex relationships can be represented and understood. With the help of this fact-based procedure, it is possible to master complexity where even people with many years of experience reach their limits. The results can be documented transparently and comprehensibly.

3.4 Optimization

In most cases, optimization of very complex systems means larger solution spaces and, above all, the need for consideration of several (conflicting) targets that are often contradictory. This is often referred to as multi-criteria optimization. If there are several opposing goals, problem formulation becomes more complicated and increasingly complex with the increasing number of influencing factors and their interactions. Artificial intelligence methods provide us with the right tools for mastering such problems that are characterized by the fact that there is no global optimum. In this case, we speak of pareto optimization, or the search for a condition in which it is not possible to improve one of the criteria without having to worsen another. Here, the corresponding algorithms of the multicriterial systems provide the best solution for the specific situation to be selected. The following methods are available to select the best solution for the specific situation from this set of solutions:

(1) Expert interviews and decisions – Experts analyze the final solution quantity and make the selection based on situation-specific expert knowledge.

(2) Problem simplification through weighting – Individual target variables are given a higher weighting depending on the situation and are thus prioritized.

(3) Decision Support System - The decision making is achieved through machine learning or the solution quantity is further limited and connected with point 1, which combines expert decision.

3.5 Management

Intelligent energy management is made possible based on the digital twin and using a wide variety of AI algorithms. In addition to the topic of optimization, forecasts and anomaly detection also play an important role in the operation of the energy system.

4 THE CONCRETE IMPLEMENTATION FOR THE PORT

The theoretical approach described above is very well suited to efficiently master the current and future challenges of port energy supply.

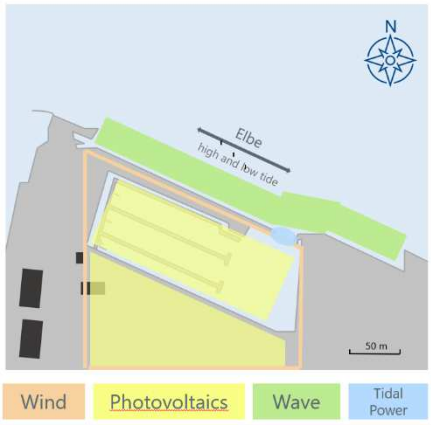


Figure 2: Result of the first area analysis

4.1 Energy potential analysis for ports

The aim of the energy potential analysis is to enable a maximum possible supply of renewable energy to the ports, starting from a purely physical consideration. This includes, on the one hand, the potentials of energy generation, but also the potentials of storage. In a first step, geo-information data are procured and the theoretically possible areas for energy generation are determined. In the case of ports, it is advisable to consider the following forms of energy: wind, sun, wave and possibly tidal energy. In this consideration step, no operational restrictions are considered. In the next step, the concrete usability of the individual areas regarding the possible forms of energy is analyzed. Now, restrictions such as shipping traffic, blocked areas, flood areas, possible shadowing in the case of PV installations, wind-reduced zones due to high buildings, compliance with distances to the security infrastructure (e.g., tank farm, radar stations, etc.). Once possible scenarios have been defined for the first time, the next step is data procurement. The following time-resolved (historical) weather data are of relevance:

- Wind speed and direction
- Temperature
- Solar radiation (global and diffuse)
- Information on tidal range and swell (depending on wind direction and thickness)

In addition, first technological decisions are made (e.g. performance and number of suitable wind turbines) and corresponding load curves are procured. After the data has been prepared, it is aggregated and the total energy yields are calculated for a calendar year. In this step, the individual regenerative yields can be considered independent, as there is practically no feedback to the overall energy system in the later real system. Through iterations and optimization algorithms, the regenerative energy yield is optimized in terms of energy demand. If the port's energy needs are known, initial estimates of the degree of self-sufficiency can be made on this basis. A similar procedure applies with regard to the energy storage. Here, too, the first step is to identify potential areas in the port area that can be used for energy storage, taking safety aspects into account. Storage types include battery electric storage, H_2, methane and ammonia storage, and heat/cold storage. A dimensioning of the storage requirement and the integration into the supply infrastructure takes place on a higher physical level and flows into the modeling of the digital twin.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

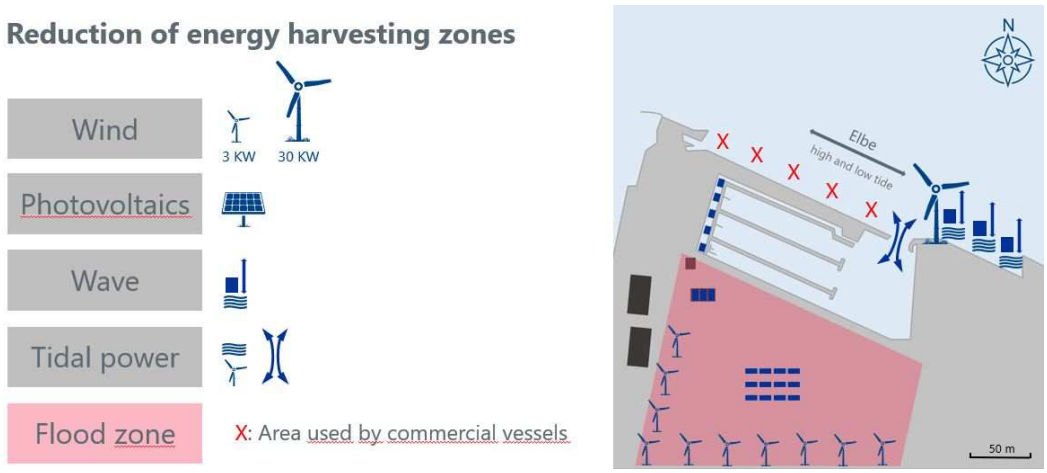


Figure 3: Result of area analysis including technological aspects

4.1.1 Energy sources

The energy transition will result in diesel fuel and heavy oil losing their role as an energy source in shipping. For this, H_2, ammonia, methanol, LNG and CNG will become more important. Since it is not yet clear whether one of these energy sources will play a dominant role in the future, both in shipping and in the processing industry, all these substances should be included in a new energy concept of ports.

	Unit	Diesel	Methanol	Ammoniak	LNG (liquid)	CNG (compr.)	H2
chemical formula		$C_{12}H_{23}$	CH_3OH	NH_3	CH_4	CH_4	H_2
Gravimetric energy density	kWh/kg	12,6	5,5	4,8	10,6-13,1		10,6-13,1 33,3
Volumetric energy density	kWh/l	10,5	4,3	0,003			0,003
General properties		toxic	toxic	highly toxic, explosive when heated	non-toxic, greenhouse gas, highly flammable, explosive in combination with air/O2		non-toxic, very reactive at high temperatures, highly explosive in combination with air/O2
Use		Internal combustion engines	chem. Intermediate, fuel cell	chem. Intermediate, storage and transport medium for H2	Internal combustion engines, heating		Internal combustion engines, fuel cell
Storage		Liquid tank	Liquid tank	Liquid tank	Freezer tank	High pressure tank	gaseous in high pressure tank

Table 1: Energy sources

Accordingly, appropriate storage facilities must be provided and simulated. In the case of H2 and LNG or CNG, storage must also be provided for the aggregate states gaseous, and liquid and the thermal behaviour must also be controlled. Electrical or electronic monitoring (functional safety) of the accumulators, since each material has specific critical properties (see table 1) and thus a corresponding safety must be guaranteed, which, as a rule, cannot be achieved solely through mechanical measures.

Ammonia as an energy source has a special dual role: on the one hand, it can be used directly as an energy source in marine engine combustion and on the other hand, it can be used as a liquid carrier material of H2. This transformation process must also be monitored and energetically optimized accordingly. There is no alternative to the use of a digital twin for the energy optimized orchestration and provision of all mentioned chemical energy sources.

4.2 Requirements Analysis

The collection and use of demand data is essential for optimum design and efficient operation of a port's energy system. The energy requirement has a direct influence on the required storage capacity, since the storage unit is intended to compensate for the time offset between energy generation and energy demand and to smooth out any peaks that occur. Since various forms of energy occur within a port, the first step is the collection of the relevant forms of energy. The following classification is recommended for systematic collection:

Propulsion energy of ships	**Auxiliary energy of ships (hotel)**	**Energy for port infrastructure**
Electric	Electric	Electric
Chemical	Chemical	Chemical
…	Thermal	Thermal
	…	…

Table 2:Classification of energy forms

In the next step, the energy demands are quantified and temporally resolved. As a rule, there are timetables for the ships from which the drive energy demand can be derived. For the planned waiting time, the ship-specific hotel demands will also be incurred. On the port side, the infrastructure requires energy. In addition to the base load, there are demands for the logistics applications that depend on the loading/unloading of the ships and thus correlate with the timetables.

Finally, the energy demands for each energy type are synthesized to form an overall demand profile.

The system design is based on the demand and generation profiles. Depending on the technology used, sectors or types of energy can be coupled. For example, the waste heat from electrolysis processes can be used to provide heating energy. Excess electrical energy can be stored in storage batteries or used to generate heat or cold. The storage of cold and heat is generally more favorable compared to electrical energy storage systems, assumed there is sufficient demand for cold and heat.

4.3 The digital twin of the port

The information and data collected during the analysis phases are now incorporated into the digital model of the port energy system. By modeling the physical behavior of the system as a digital twin, the interactions between the components are made transparent and the data collection effort is also reduced. Different system topologies are mapped, simulated, and evaluated using performance indicators such as total costs, energy efficiency or degree of self-sufficiency. The robustness and sensitivity of the system can also be evaluated by varying the input parameters.

After the design phase has been completed, the digital twin provides important information for the energy management of the real system. Decisions in storage management are simulated using the timetables and forecasts for energy generation and energy price development. The digital twin calculates the future energy storage levels. Charging and discharging as well as generation and conversion between different forms of energy are optimally regulated according to the requirements.

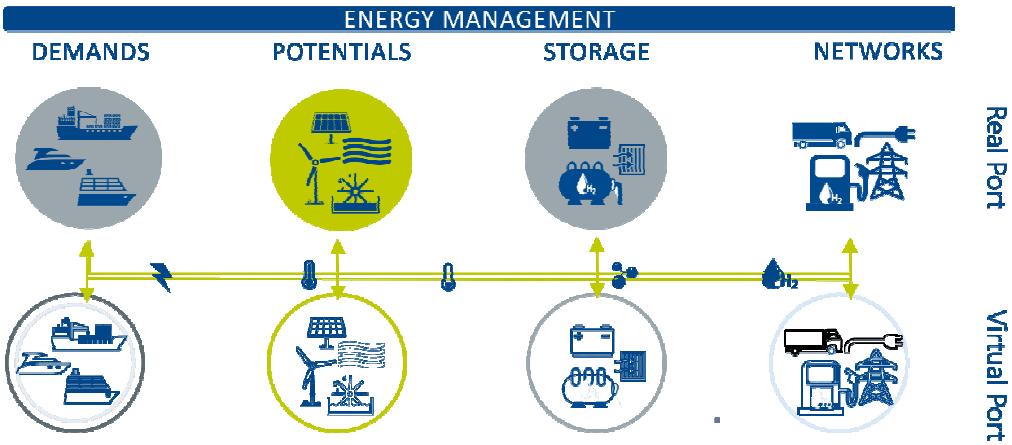


Figure 4: The digital port twin

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Figure 4 shows the typical real and virtual objects and their diverse relationships and interactions of a port twin. The respective characteristics for a specific port are very individual, even if individual objects such as a PV system or an energy storage unit can occur repeatedly as a module in the modeling. A port is a complex system consisting of energy, goods and mobility flows and systems and can be controlled by a virtual system.

4.4 Use of the digital twin for optimization in all phases of the port life cycle

Our approach is a first step to use the digital twin in all phases of the life cycle of a port for optimization. The life cycle of a port can be easily divided into three phases.

Phase1: Planning of investments and structural measures => the decisive added value of the digital twin lies in securing the investments through previous simulation.

Phase 2: Operation of the overall system => Real-time data is used in the digital twin to optimize the overall system regarding energy efficiency and costs.

Phase 3: Continuous optimization and automation => through continuous expansion and optimization of the digital twin, the path from decision-making to automated operation of the energy system becomes possible.

The digital twin offers clear benefits in each of these phases. The following examples explain how we can use the digital twin profitably in the three phases.

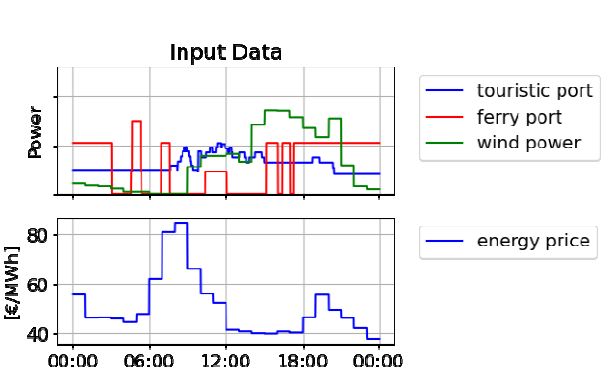
In planning, new technology and investment decisions can first be modelled with the digital twin and then their impact can be estimated thanks to AI prediction. “First modelling then investing” is quite easy with a digital twin, even with highly individual requirements. Different scenarios can be simulated, and the respective benefits shown. Not yet identified scenarios can be derived through such model-based data analysis and developed and prioritized in the form of use cases.

In the company, decisions must be made to ensure stable and economical operation. Experienced personnel usually make the decisions. The digital twin supports this by using real-time information. A digital twin can provide AI-based strategy and action recommendations for optimal operation and thus raise additional potential. The continuous further development of the digital twin with AI-supported algorithms offers the opportunity of automation and thus a far-reaching relief and Support.

In ports, for example, the smart use of stationary or mobile energy storage or land power units, the use of volatile energy sources as well as the flexible assignment of ship berths. By cleverly combining these areas, potential can be tapped to significantly reduce CO_2 emissions and air pollutants. Thanks to self-learning algorithms, the twin is constantly improving without neglecting stable operation.

4.5 Two modeling examples for the digital twin of the port

Using two concrete examples, we illustrate the added value of the digital twin in the planning and operation phase. By way of example, figure 5 shows the electricity demands for a small ferry port and a port with tourist excursion boats as well as the electricity yield of a wind turbine, supplemented by the electricity price profile of a day from the year 2020. It is already clear here that demand, income, and electricity prices differ considerably in size and timing depending on the scenario. In the current situation, electricity prices are once again more volatile and at a significantly higher level.



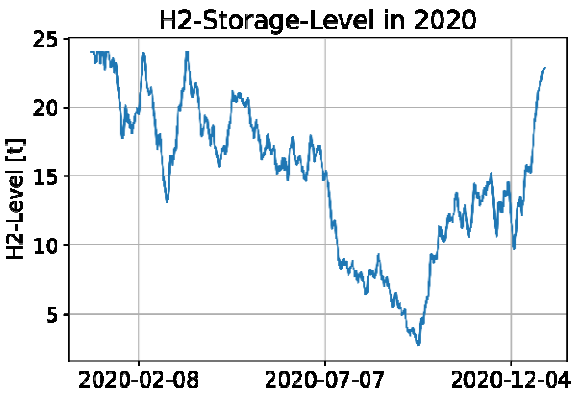


Figure 5 (left), Figure 6 (right).

In another scenario, a wind turbine feeds an electrolyser. The hydrogen produced is used to refuel ships. The demand for hydrogen is distributed quite evenly over the entire year, although there is a slightly higher demand in the summer. The average annual production of the electrolyser and the annual hydrogen demand are almost the same. Nevertheless, a large hydrogen tank is required, which is completely emptied during the calm months in the summer and filled up again in the autumn and winter months with lots of wind. The hydrogen tank level can be seen in figure 6. This illustrates the complex interaction between generation, storage and consumption.

4.6 Outlook

Ports will have to find further business models in the future to be able to compete, but also to identify new sources of income. A digital twin can be used to work out complex interrelationships and new correlations, if required also derive cross-domain business models. AI-based algorithms are used to detect even the most complex correlations, based on which new business models can then be developed.

5 CLASSIFICATION, OPPORTUNITIES AND MATURITY LEVEL OF THE APPROACH

The presented concept represents an important contribution in the context of digitalization with the aim of a CO_2-neutral port. Digitalization has already found its way into energy systems and their management in many areas. There are several projects that have overcome the first important hurdles and thus established a basis for use through the collection and monitoring of data. We see our approach as a holistic method that can build on these foundations, if available.

In addition to the holistic approach, our approach is characterized by the combination of AI and physical modeling. This combination is the important basis for stable energy management. Compared to purely AI-based approaches, our approach is less dependent on existing training data.

In principle, neural networks are very well able to map the relevant relationships. In practice, there is often a lack of quality and quantity of training data. In addition, in practice, edge cases for instability should be avoided as far as possible so that even fewer measurement data are available for these operating statuses. At this point, the combination of AI and physical modeling plays out its strengths. On the one hand, the training effort decreases because the neural network does not have to learn more things that are already implemented in the physical model. On the other hand, the physical model can also be specifically stimulated in order to generate virtual measurement data for the edge cases, with the help of which e.g., the neural network can be trained.

The presented approach is based on a series of methodical elements such as data analysis, physical modeling, optimization algorithms and other AI methods that have been tried and tested at ITK Engineering GmbH for many years. We can build on an ITK-own and proven modelling and optimization framework.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

Virtual Reality Simulators for Inclusion and Participation: Broadening Perspectives on Accessible Cities and Public Space

Leyla Kern, Fabian Dembski, Thomas Obst, Laura Bisinger, Benedikt Falk, Uwe Wössner

(Leyla Kern, High-Performance Computing Center Stuttgart, kern@hlrs.de)
(Fabian Dembski, High-Performance Computing Center Stuttgart, dembski@hlrs.de)
(Thomas Obst, High-Performance Computing Center Stuttgart, obst@hlrs.de)
(Laura Bisinger, High-Performance Computing Center Stuttgart, lauibisi@gmx.de)
(Benedikt Falk, High-Performance Computing Center Stuttgart, benedikt.falk2000@gmail.com)
(Uwe Wössner, High-Performance Computing Center Stuttgart, woessner@hlrs.de)

1 ABSTRACT

The design of urban public space often involves a convergence of different actors with different priorities in the use of available space. This becomes evident when different modes of transport are combined in the very limited space available. At the same time, the growing and aging population strengthens demands for action in public space design towards better accessibility and involvement of the vulnerable. Innovations in digital design and simulation tools have shown a great demand to address these challenges as they have the potential to facilitate mediation and improve citizen science, participative and collaborative planning processes. Joint evaluation is supported and planners, decision makers and foremost citizens are brought together [(Yang et al. 2019), (Sanchez-Sepulveda et al. 2019), (Buffel et al. 2012)]. In our research, we have implemented human-computer interfaces for urban digital twins. These digital twins combine geometry and point cloud models, simulation results, and sensor data and enable analysis of existing situations, scenario testing, as well as prediction, on all urban scales, from buildings to cities and regions. By visualization in VR environments such as a CAVE (Cave Automatic Virtual Environment) they provide a powerful method for informed discussions between all stakeholders which is essential for joint decision-making. Our recent work extends these tools to include often neglected groups, such as people with disabilities, the elderly, or children, with the aim to empower them and to address their specific needs with respect to public spaces, while making these needs more traceable for others. Therefore, we have implemented different modes of traffic in simulators: Cars, bicycles, skateboards, and wheelchairs. Using one of these simulators, users can then interactively explore virtual replicas of public spaces using a real vehicle for steering. In combination with a tracking system, the user's perspective in the virtual world is adjusted accordingly, enabling an impression of riding through the replica similar as in a real environment. Users can explore the accessibility of public spaces and detect shortcomings like high curbs or slopes. Often, these are unnoticed by pedestrians while posing major obstacles for people in wheelchairs, with strollers or roller walkers. Hence, this simulator helps to better understand and include the mentioned group in public participation. Moreover, the simulator was combined with traffic simulations (Zeile et al. 2021). These, in particular when visualized along with the digital twin, improve the depiction of the actual processes and dynamic scenarios, and allow to simulate and compare scenarios of different design proposals. Bottlenecks such as narrow sidewalks incapable of handling the load of pedestrians, or unclear intersections with an insufficient view can be detected as well as the use of space in certain conditions as during rush hours or at construction sites. Experiments were carried out using the different simulators as human-computer interfaces. Observations and questionnaires were used to analyse the experiences of 23 test subjects. In summary, the developed simulators are intended to contribute to safer and better accessible urban spaces for all. In this initial work, the focus lies on groups with special needs in public spaces - for example, highly mobile young people and in contrast people with limited mobility or the elderly. By detecting current barriers, the developed simulators make them tangible and understandable for the wider public but also for planners, designers, and decision-makers.

Keywords: Inclusion, Digital Twins, Public Space, Virtual Reality, Mobility

2 MOTIVATION

Public urban space is claimed by various actors, often with very different interests on how the limited available space shall be used. Urbanization and aging population amplify this problem as they pose even bigger challenges for future public spaces (UN Habitat 2021a). Marginalized groups of actors are often neglected in the design of public space. However, especially when associated with special needs, as people with disabilities or the elderly, their demands are essential to be able to participate in public life at all. The COVID-19 pandemic has even aggravated their vulnerability (UN Habitat 2021b).

Thus, there is need for an approach to unify the different needs through solutions which support all actors. This, however, requires mutual understanding of the respective other interests. Therefore, a tool is required which allows to depict these demands and make them traceable for other actors. At the same time, this tool should add value not only for citizens but also planners and decision makers to ensure consistency of information. A uniform communication tool which allows for tangible experience of urban space in various perspectives and integrates visualization and interaction could solve these challenges.

Furthermore, it could help to generally include a broader range of citizen and provide low-barrier access to more diverse and complex data. Moreover, experiences taught that inclusion of citizen and visualization of the project helps to increase acceptance in planning processes (Münster et al. 2017).

3 STATE OF THE ART

The inclusion of often neglected groups has been investigated in several works during recent years. (Buffel et al. 2012) explored the situation of the elderly in urban environments by determining changes and restrictions in cities. The focus of their work lies on assessing the current level of age-friendliness of cities and how to involve older people in development processes. (Yung et al. 2016) identified the needs of the elderly regarding public space, whether they are addressed and how they differ from planned and realized considerations. (Shahraki 2021) research considers urban planning for (physically) disabled people. They combined theoretical studies, case studies and weighted sum methods to derive planning procedures to specifically include disabled people. Inclusion of all was the subject of research by (Rebernik et al. 2019) who developed a 4-dimensional theoretical model. Their combined methodological approach showed benefits in understanding the complexity of cities and addressing needs of people with different impairments. Research showed that many contributions in this field consider the assessment rather than approaches for solutions or propose theoretical methods. This braces the need for tools that go beyond assessment and support the development of practical solutions. Digital tools are on the rise for tackling the challenges associated with inclusion in urban spaces. (Hasler et al. 2017) researched the value of digital tools for citizen participation in urban planning by developing a conceptual framework to classify their potential. Their work concludes by stating that digital tools are a valuable extension of current methods. (Szarek-Iwaniuk et al. 2020) conducted a case study in smart cities where e-Participation is used for co-creation of urban space. Further, they discussed the value of ICT technologies for participation and presented a Public Participation GIS. (Zeile et al. 2021) compared methods of real and virtual spaces for detecting conflicts in traffic systems to design optimization strategies for road courses. Their work combines the assessment of existing situations with simulations of scenarios. Smart cities, as an application of digital tools, were explored by (de Oliveira Neto 2018) to leverage their potential in favor of disabled people. They initiated the concept of Inclusive Smart Cities by employing a multi-instrument approach to determine the needs of different stakeholders. Based on the latter, the authors suggested tools for practitioners and a conceptual model using inclusive smart objects to assist people with disabilities in the exploration of urban spaces. (Dembski et al. 2020) presented urban digital twins on a case study of a small town in Germany. They combined various models and data into an all-encompassing model, establishing links between the different disciplines and levels, and visualization of the digital twin in Virtual Reality (VR). Comprehensive visualization techniques such as 3D or VR were presented to improve participation processes and engagement and lower barriers as evidenced by (Dembski et al. 2019) or (van Leeuwen et al. 2018). (van Leeuwen et al. 2018) assessed the use of VR in public participation. 3D-rendered scenarios for redesign of a park were presented to citizen and experts for collective decision-making processes. The results showed a raise of engagement when using immersive technologies. VR is also employed in a study by (Sanchez-Sepulveda et al. 2019) in collaborative urban design through human-centric problem-solving. It demonstrates the use of digital tools in decision-making processes and social development as they raise satisfaction and improve public motivation. A concept involving Mixed Reality (MR) is used by (Wolf et al. 2020) who concluded that MR supports resolving the paradox of participation, which states that participation is typically higher the more advanced a planning process is, by providing clarity and reducing abstraction for participation. With respect to traffic, VR is used for scenario testing, training et cetera as described in works by (Ju et al. 2022) who used VR to investigate situational awareness in car accidents or (Lv et al. 2022) using VR-based simulations for intelligent vehicles.

4 IMPLEMENTATION

In this work, a simulator was developed which enables navigation in virtual worlds, in particular digital twins of urban spaces, through real vehicles. In the first approach, a skateboard was used and modified by two students by adding sensors and other hardware. The refactored skateboard was then embedded into a Virtual Environment to enable navigation within the digital twin using the real vehicle. In a similar approach, a bicycle and a wheelchair simulator were subsequently developed on the basis of real devices.

4.1 Visualization & Digital Twins

The Vistle visualization software (www.vistle.io) was used to create a 3D virtual world, or digital twin, in which users can navigate. Vistle is a visualization software for highly parallel distributed and interactive visualization in immersive environments. It integrates a VR renderer ('COVER') that provides further interfaces for various data formats to integrate simulation data, GIS, or BIM, among others. A new interface has been implemented to connect the vehicles to the visualization software. This allows new simulators to be recognized automatically as soon as they log on to the network. Besides, also traffic simulations were integrated into the digital twin, to establish close-to-reality traffic conditions. The simulations were created using SUMO (www.eclipse.org/sumo/).

The software was used on a dedicated cluster to power a CAVE (Cave Automatic Virtual Environment), a virtual reality environment with 5-sided back projection for multiple users. The vehicles were placed into the CAVE. Users were equipped with tracked 3D glasses for immersive 3D experience of the virtual world when riding the vehicles. The simulators can be used in different digital twins of cities.

4.2 Virtual Skateboard

The skateboard is based on an ESP32 microcontroller with an accumulator for power supply. The module sends its measured values via network or wireless LAN to the VR software (COVER). Weight forces are transmitted to the individual four wheels, which have been replaced by sensors for pressure and traction. Based on the data transmitted in this way, the software computes the driving dynamics: Lateral dynamics are computed from the current forces on the wheels to implement steering to the left or right. However, the implementation of realistic longitudinal dynamics (acceleration and deceleration) posed a greater challenge. Deceleration is only performed for topographical reasons such as driving uphill. This emulates the downward forces that act when riding a slope with positive incline. Acceleration is more complex: In an earlier stage of development, it was only possible to control the skateboard by leaning forward to accelerate or backward to brake. However, this process did not reflect the real movement well. After technical extension, acceleration is now also achieved via downhill propulsion. Once the user is rolling, the acceleration is dictated by the terrain. Acceleration can also be achieved by leaning forward when the speed falls below a certain limit. This corresponds to a bump or acceleration. If the user wants to slow down, the skateboard must be ridden uphill. When dismounting from the skateboard and no weight is applied, the skateboard automatically brakes.

4.3 Virtual Bike

The bicycle simulator is based on a real bicycle mounted to a Tacx© roller trainer. Connection to the VR software is established via USB. The software reports the current gradient to the trainer in order to increase the braking force and thus contribute to a more realistic riding experience. Unfortunately, positive feedback cannot yet be given when going downhill, as this is not supported by the hardware. As the speed is computed by the frequency of the bike's real wheel, deceleration is imposed by operating the brakes of the bike which natively slows down the rear wheel. The steering angle is read out via the existing USB interface of the trainer and transferred to the VR software. A disadvantage of this setup is that the inertia of the rider's body mass is not taken into account, as only the inertia of the rear wheel is measured while the bike is mounted to a framework on the wheel fork. Another disadvantage of the roller trainer is the large wear of the rear tire and consequently the "slippage" of the tire during acceleration. This can be perceived as very unpleasant and can be a trigger for cyber-sickness (Rebenitsch et al. 2016).

4.4 Virtual Wheelchair

As a third simulator, a commercially available modern wheelchair was converted. In a first phase, an undercarriage with four castors was developed. The main wheels were placed on the latter (two castors per wheel) while the smaller front wheels rested on a metal console and had no direct function in the simulator.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

In this way, it is possible to turn the two main wheels separately for navigation and locomotion. The castors, which are designed as encoders and recorded the movements, were controlled by an ESP32 which transmits the current position of the wheels to the VR environment.

In order to make the experience more realistic, the castors have since been equipped with servo drives. This allows forces to be actively transmitted to the hand wheels with smooth tires, enabling realistic deceleration and acceleration for the user. This design is also sufficient to allow the wheels to slip and corresponds to a real wheelchair on a smooth road. The new control operates via a Raspberry Pi 4 single-board computer running real-time Linux and a real-time Ethernet network for control tasks. In this way, the current actual values can be read out and torques can be specified. The actual values are transmitted back to the software via the network.

5 EXPERIMENTS

The virtual vehicles or simulators were used by subjects in various test scenarios. Initially, users were asked to freely move in the virtual world to familiarize with the simulators (‘training phase’). Subsequently, they were asked to solve different tasks as described below (‘performance phase’). Finally, their feedback was obtained by means of a questionnaire (‘evaluation phase’).

5.1 Setup

Each test person was assigned to one of the two vehicles (bicycle, skateboard). They could then use the vehicle to navigate through the visualization of the digital twin. The virtual setting chosen was Marienplatz in Stuttgart, a typically busy square where different modes of transport meet and also come into conflict with each other. The test persons were asked to navigate to a specific location.

The VR model included traffic simulation for cars, pedestrians, bikes, and other vehicles to improve the reference to the real urban space. This exposed the subjects to various situations that allowed to capture conflict situations between road users, accessibility of spaces and reaction to unexpected changes. The scenes were chosen depending on the vehicle used, as different conditions also prevail in real space.

For the subjects riding the bicycle three tasks were presented (Figure 2). Task 1 consists of a mostly straight stretch of different types of infrastructure. It starts on and follows the city's main cycling route for about 130m which can be considered quite challenging. It leaves a narrow alley and confronts the subject with crossing a light shared with pedestrians (a), entering a zone with pedestrians with very unorganized paths (b), through a small gap between a subway escalator and a bus stop (c) and merge with motorized traffic at the end (d).

Task 2 introduces more turns and speed variation to the subjects. They have to cross motorized traffic at a left turn (a), avoid an obstacle which is a set of stairs (b), encounter more pedestrians (c), moving through the outdoor catering of restaurants and cafes (d) and entering a long right turn which allows higher speeds.

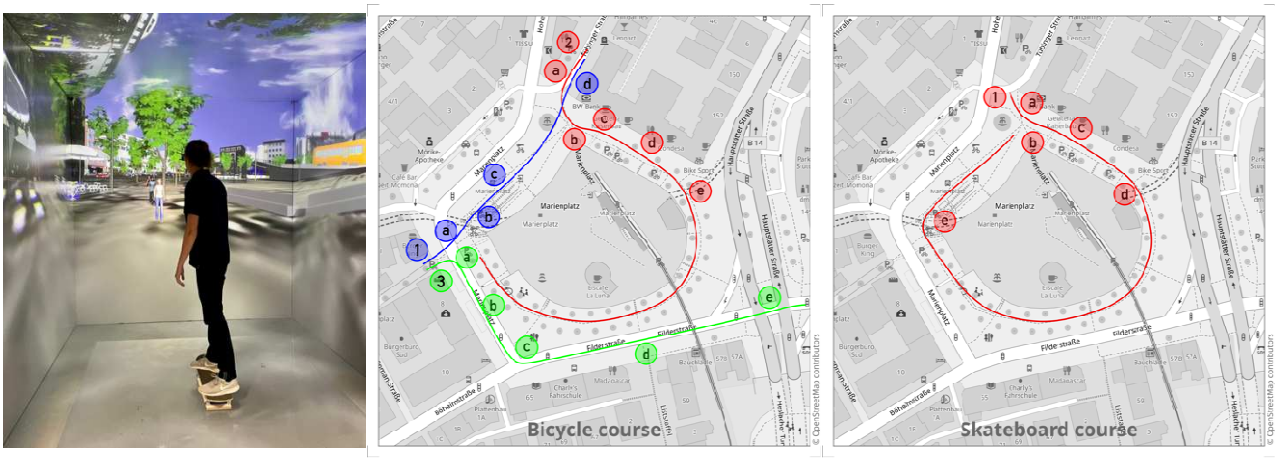


Figure 1 (left): Test person using the skateboard simulator in a CAVE. Figure 2 (center): Bicycle courses. Figure 3 (right): Skateboard courses

In task 3, more interaction with motorized traffic is presented to the subjects. They were asked to do a right turn and merge with traffic (a), approach a traffic light and choose wether to wait or to pass slow moving

traffic (b), perform a left turn at the light (c), enter multilane-traffic (d) and finally to cross another very busy multilane road (e).

Subjects riding the skateboard were presented a single task (Figure 3) and not asked to enter motorized traffic. It started entering the Marienplatz. At first, they were confronted with pedestrians (a) and an obstacle, a set of stairs (b). Then they had to move through the same outdoor catering of restaurants and cafes as the cyclist group and finally entered a long stretch all along the square.

5.2 Questionnaire

After completion of the experiments, all test persons were asked to fill out a questionnaire. The questionnaire consisted of 21 questions addressing usability, perception, suitability, and demographic background. Users could answer the Likert-scale questions on a scale from 1 (totally disagree) to 4 (totally agree). In addition, some questions were open-ended.

6 RESULTS

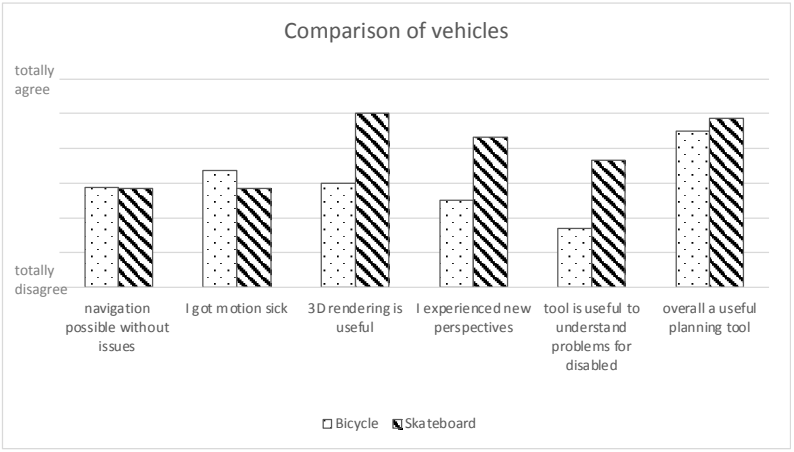
23 people participated in the experiments. 16 used the virtual bike, seven the virtual skateboard. In the questionnaire, people highlighted the well-mirrored details of buildings and the overall vast extend of the virtual world. Also, the concept of using the simulators to assess situations and improve public space was rated high (3.3). However, the capability of creating awareness for the needs of people with disabilities strongly depended on the employed vehicle (1.8 – 2.8). Also, the training phase was considered important (3.4) independent of previous experience with VR. Motion sickness was partially occurring (2.6).

In the open-ended section, a common negative remark referred to a problem with the steering of the bike. This only occurred on one of the test days and has been fixed. Another negative feedback, which was also expressed in other sections of the survey, was the lack of realism in the visualization. While buildings and objects were detailed enough to be recognizable, the lack of ground texture detail was seen as a particular shortcoming. Also the surfaces of the model were not smooth enough in some places. Curbs which can be passed under some circumstances and other obstacles (railings and buildings) which can never be passed are not treated differently which led to confusion and unrealistic behavior.

The comparison of the responses regarding the vehicles and their usability revealed that the skateboard simulator was rated as better overall than the bicycle. Especially the suitability of the simulator was graded as good (3.2) for the skateboard simulator and rather poor for the bicycle (2.4). However, the functionality of the navigation was ranked equally for both devices (2.4). Only few subjects regularly use a skateboard (1.1) while a lot use the bicycle regularly (3.4).

Loss of control over the skateboard was quite common, either in the way of hitting a wall and bouncing back or overcompensation in steering leading to an unwanted oscillation.

Although the tasks performed on the skateboard were shorter in time, motion sickness was also reported similarly (bicycle 2.6, skateboard 2.4).



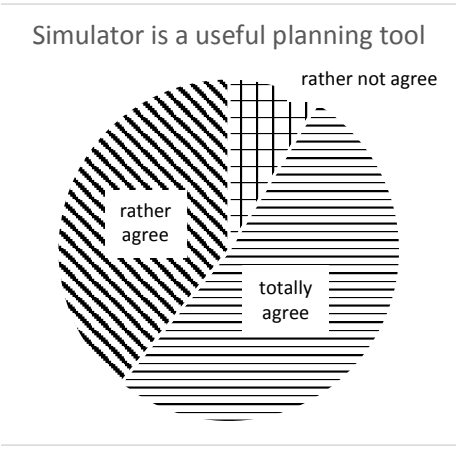


Figure 4 (left): Comparison of vehicles and agreement of users by category. Figure 5 (right): Overall suitability of the tool.

We decided to omit to wheelchair at this stage of the tests. The reason for this was that earlier testing proved that using the wheelchair is particularly peculiar for people unfamiliar with it, as the speed of movement is

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

relatively slow. Although it is equivalent to the speed of a real wheelchair, it appeared slower to the users. This may be explained by the fact that none of the subjects had comparable experience in using wheelchairs relative to the other vehicles.

7 CONCLUSION & OUTLOOK

The study has shown that simulators are considered a useful tool, although a lack of realism was criticized. We conclude that a higher level of detail in the visualization may therefore be an optional addition rather than a requirement to success in the applications described. The simulators allow testing of existing real-world environments and planning for future urban design in virtual realities. They also enable a playful approach to complex topics and raise awareness of limitations in public space.

As mentioned in the Implementation chapter, the bicycle simulator showed some shortcomings. Therefore, new solutions have already been developed to remedy the problems and provide a better immersive experience. A different framework is now used that is not based on direct contact between the rear wheel or tire and the roller. Experiments with the new hardware have yet to be repeated.

For the wheelchair, an option in this setting would be to use more profiled tires to improve grip. A promising force feedback was added, but the implementation of vehicle dynamics was not completed yet. As stated earlier, studies with the wheelchair simulator also still need to be conducted.

In general, the simulators are still under development and can be improved and stabilized. However, the current status allows the assessment of many key aspects. We will continue to address the identified challenges and perform further experiments. Work in the near future will include improved ground texture and surface, tuning and improving the simulators' hardware and implementing improved vehicle dynamics. The tasks in further studies (including their length and intermissions) will be based on the results from this study.

8 REFERENCES

Buffel, Tine, Chris Phillipson, and Thomas Scharf. 2012. ‘Ageing in Urban Environments: Developing “Age-Friendly” Cities’. Critical Social Policy 32(4): 597–617. https://doi.org/10.1177/0261018311430457.

UN Habitat. 2021. Cities and Pandemics: Towards a More Just, Green and Healthy Future. UN-Habitat.

Dembski, Fabian et al. 2020. ‘Urban Digital Twins for Smart Cities and Citizens: The Case Study of Herrenberg, Germany’. Sustainability 12(6): 2307.

Dembski, Fabian, Uwe Wössner, and Mike Letzgus. 2019. ‘The Digital Twin-Tackling Urban Challenges with Models, Spatial Analysis and Numerical Simulations in Immersive Virtual Environments.’

UN Habitat. 2021. ‘Cities for All: Ageing and Inclusion’. In Euskal Hiria Kongresua 2020, UN Habitat.

Hasler, Stéphanie, Jerome Chenal, and Marc Soutter. 2017. ‘Digital Tools as a Means to Foster Inclusive, Data-Informed Urban Planning’. Civil Engineering and Architecture 5(6): 230–39.

Ju, Uijong, Lewis L. Chang, and Christian Wallraven. 2022. ‘Acoustic Cues Increase Situational Awareness in Accident Situations: A VR Car-Driving Study’. IEEE Transactions on Intelligent Transportation Systems 23: 3281–91.

van Leeuwen, Jos P et al. 2018. ‘Effectiveness of Virtual Reality in Participatory Urban Planning: A Case Study’. In Proceedings of the 4th Media Architecture Biennale Conference, 128–36.

Lv, Zhihan, Jinkang Guo, Amit Kumar Singh, and Haibin Lv. 2022. ‘Digital Twins Based VR Simulation for Accident Prevention of Intelligent Vehicle’. IEEE Transactions on Vehicular Technology 71(4): 3414–28.

Münster, Sander et al. 2017. ‘How to Involve Inhabitants in Urban Design Planning by Using Digital Tools? An Overview on a State of the Art, Key Challenges and Promising Approaches’. Procedia Computer Science 112: 2391–2405. https://www.sciencedirect.com/science/article/pii/S1877050917314461.

de Oliveira Neto, João Soares. 2018. ‘Inclusive Smart Cities: Theory and Tools to Improve the Experience of People with Disabilities in Urban Spaces’. Université Paris Saclay (COmUE); Universidade de São Paulo (Brésil).

Rebenitsch, Lisa, and Charles Owen. 2016. ‘Review on Cybersickness in Applications and Visual Displays’. Virtual Reality 20.

Rebernik, Nataša, Barbara Goličnik Marušić, Alfonso Bahillo, and Eneko Osaba. 2019. ‘A 4-Dimensional Model and Combined Methodological Approach to Inclusive Urban Planning and Design for ALL’. Sustainable Cities and Society 44: 195–214.

Sanchez-Sepulveda, Mónica, David Fonseca, Jordi Franquesa, and Ernesto Redondo. 2019. ‘Virtual Interactive Innovations Applied for Digital Urban Transformations. Mixed Approach’. Future Generation Computer Systems 91: 371–81.

Shahraki, Abdol Aziz. 2021. ‘Urban Planning for Physically Disabled People’s Needs with Case Studies’. Spatial Information Research 29(2): 173–84.

Szarek-Iwaniuk, Patrycja, and Adam Senetra. 2020. ‘Access to ICT in Poland and the Co-Creation of Urban Space in the Process of Modern Social Participation in a Smart City—A Case Study’. Sustainability 12(5): 2136.

Wolf, Mario, Heinrich Söbke, and Florian Wehking. 2020. ‘Mixed Reality Media-Enabled Public Participation in Urban Planning’. In Augmented Reality and Virtual Reality, Springer, 125–38.

Yang, Liu et al. 2019. ‘Integrated Design of Transport Infrastructure and Public Spaces Considering Human Behavior: A Review of State-of-the-Art Methods and Tools’. Frontiers of Architectural Research 8(4): 429–53.

Yung, Esther H K, Sheila Conejos, and Edwin H W Chan. 2016. 'Social Needs of the Elderly and Active Aging in Public Open Spaces in Urban Renewal'. Cities 52: 114–22.

Zeile, Peter et al. 2021. 'Radfahren Auf Realen Und Virtuellen Flächen–Das NRVP-Projekt Cape Reviso'. In CITIES 20.50– Creating Habitats for the 3rd Millennium: Smart–Sustainable–Climate Neutral. Proceedings of REAL CORP 2021, 26th International Conference on Urban Development, Regional Planning and Information Society, 613–22.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

What Culture for European Cities? The Desperate Struggle of European Cultures against the American one

Olivier Lefebvre

(Dr Olivier Lefebvre, Olivier Lefebvre Consultant, 4 rue Rollin, 75005 Paris, France, o.lefebvreparis05@orange.fr)

1 ABSTRACT

For a long time, American culture is spreading and replaces the other European cultures. It is a real change. According to the French writer Régis Debray, image replaces writing, the theme of happiness replaces drama and space replaces time. Also, according to the German sociologist Max Weber, the Protestantism has made Americans "ascetic inside the world": an individual is the single responsible for his (her) own Salute. He wants success in the society. The idea of "collective grace" is suspected. In urban life there is a void which is fulfilled by tribalism: sport, music, events … In urban planning, places for people meeting, like public squares or parks, are neglected. Water and greening could be recourses. Also, there is a possible risk of placemaking taken over by private brands.

Keywords: sociology, cities, public spaces, urban planning, culture

2 INTRODUCTION

The predominance of American culture is an old story. Around 1900, the French sociologist Tarde warned that the English language was more practical than the French language: simpler grammar, words with an accurate meaning … (even if the French language was more capable of rendering some nuances). The Austrian author Stefan Zweig wrote "The uniformity of the world" in 1925 denouncing the source: American culture. He gave as examples radio, cinema, dance, fashion … He described a uniform and boring world. For those preferring the old European culture, like himself, he claimed a kind of retreat (Zweig, 1925).

At the opposite, the American sociologist Clooney was enthusiastic about the new civilization emerging in the USA. It relied on education, science and technology, communication… The youngsters were convinced (an argument resumed by Brzezinski). Was proposed to them, the "enlargement of the ego". No doubt, the American model should be imitated in the entire world, even if there were a few hurdles (the racism against black people, for instance). Later, Zbigniew Brzezinski wrote his book on the Techtronic society (1971). Again, the young generations are supposed to be enthusiastic about the new information technologies, bringing efficiency and dynamism. The model was poised to be diffused into the entire world, and it was checked. Interesting for our topic, the new information technologies have created new channels for culture (Internet, videogames, podcasts, blogs …). They have boosted the "cultural industry", a vehicle for American culture.

The French poet Paul Valery resented and described the end of French culture, but did not understand that the content itself of culture, and its channels, were changing (Debray, 2018). According to Régis Debray, a French writer and a specialist of Medias, when American culture becomes predominant, images replace writings, happiness is the main theme, not drama, and space replaces time.

The amateurs of strategic explanation could explain the predominance of American culture by the battle of Midway in 1942…And indeed, those who were won during the 2 nd World War were proponents of "collective grace" in so a condemnable way (race for Nazis and Nation for Japanese). The most interesting text on the topic remains the Max Weber's "The protestant ethics and the spirit of capitalism", written in 1905 (and 1920). According to Weber, the American individual is an "ascetic within the world". Indeed, the American culture is a mix of protestant ethics and materialist philosophy. The individuals are put to test and have to show their redemption thanks to social success. The player's qualities (flair, courage, perseverance …) are praised. The Salute is an individual stake. The role of the Star is admitted, since it is favorable to success. What matters for our topic is that "collective grace" is suspected.

In urban planning "collective grace" explains the nice public squares described by Camillo Sitte (Sitte, 1918). The French architect Viollet Le Duc has written a book "Histoire d'un hôtel de ville et d'une cathédrale" ("History of a city hall and a cathedral") showing the role of the central square of European cities, where there is the city hall and the cathedral (in catholic countries) (Viollet Le Duc, 2012). This square symbolizes the unity of the city (through political crises) and the "collective grace". It was a place for discussion, negotiation, ceremonies and feasts. The previous generation of French architects or urban

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

planning theorists (Poète, Hénard, Perret …) kept the role of public squares. But Le Corbusier forgets them. And the public squares (like green spaces) disappear from the plans made today for cities. One can make the hypothesis of an influence of American culture.

The plan of the article is the following:

- We develop on the causes of the predominance of American culture, and the features of this culture.
- The consequences (of the predominance of American culture) in urban planning are described
- In the conclusion we pose questions about the consequences of the disappearance of public squares: (1) what about the "greening" of cities, which could be an opportunity to relaunch public spaces? (2) urban life is more or less tribal, today, and its places are stadiums, sport palaces … The void of initiatives concerning public squares paves the way to a private role (brands) in placebranding.

3 THE PREDOMINANCE OF AMERICAN CULTURE, ITS CAUSES AND THE FEATURES OF THIS CULTURE.

Let us consider strategic explanation, the Régis Debray's theories and the Max Weber's one:

Strategic explanation.

The British general John Fuller, who commanded the British Tank Corps during the 1 st world War, was also a theorist. He thought that some battles have had an important role in the history of the Humanity (or the Western world), because the outcome favored a new civilization. That of the victorious side replaces that of the won side. He wrote the book "The decisive battles of the Western world and their influence", on the topic. But according to Régis Debray, the "soft grips" are more uneasy to explain than the "hard grips" (Debray, 2018). However, the outcome of an important battle is interesting: during the battle, luck has its role, but after the battle he won, the winner chooses a story to fix the meaning of this event. During the 2 nd World War, the Americans and their allies won foes believing in a "collective grace" (the German Nazis and the Japanese nationalists), while themselves supported the individual liberty. At the time of the battle of Midway (1942), it was needed to stop the advance of the Japanese army through the Pacific Ocean and the Indian Ocean, towards Australia, Africa and India. The Americans were outnumbered, in soldiers and material. The Japanese planes were technically good. Their soldiers were efficient. The Americans succeeded thanks to luck:

- They were able to intercept and understand the Japanese communications. So, they knew the plan of the Japanese navy concentrating at the island of Midway. On this island there was an American basis. In a message they knew the Japanese could intercept and understand it, they simulated a failure of desalinisator, in Midway. Then, when they intercepted a Japanese message warning to provide the Japanese fleet with boilers, they were sure that the goal of Japanese was to attack the island. Also, according to the Japanese plan, their ships were scattered in the Pacific Ocean.
- The Japanese carriers were defective. Sometimes, overcrowding on the deck prevented planes from landing. Supplying the planes was made not on the deck, but below, making a fire in case of a bomb breaking through the deck, more devastating.
- By chance an American reconnaissance plane saw a Japanese carrier, isolated, the Kuryu. It was attacked by American planes and sunk.

Finally, the Japanese lost four carriers and the Americans only one. It was an American victory. After, each side having to replace ships and planes which have been destroyed, the American arsenals were more efficient than the Japanese ones.

The Régis Debray's theories.

Image replaces writing, the theme of happiness replaces drama and space replaces time:

- Images replace writing in what is produced and provided by the cultural industry. Image influences, not text. The USA are the country of cinema. The image shows the playground. The players discover themselves (and cannot change anything, it is predestination). At the opposite, the European cultures describe the invisible, the psychological, the Egos. For instance, in the French novels written between the two World Wars, the main character indefinitely hesitates between evil and good, or faith or indifference to God… Since an American writer, Allan Edgar Poe, invented the detective

novel, an enigma is at the center of (almost) every story. The consequence is that any reflection on ethics is concealed (according to the German sociologist Siegfried Kracauer). But as far as the complexity of reality is respected, attention paid to the playground can be interesting and useful (for instance, awareness to the role of probabilities, is possible). But with television, this condition no more exists … The reduction of reality is phenomenal (doubling). Appears what the French sociologist Baudrillard called "hyper real". Take the example of westerns. Masterpieces like "The heaven's gate" (Michael Cimino) or Cimarron (Anthony Man) did not meet success. They were "acid" or "revisionist" westerns. They showed the role of "greediness" (the word used by the American Nobel Prize of economics Stiglitz) in the conquest of the West. But Bonanza, a TV series was an extraordinary success: 431 episodes, during 14 years … Bonanza says nothing interesting on Americans or history of America … It remains that when image replaces writing, an extraordinary dynamism appears, in particular because of "hybridizations" (Lipovetski, 2007). There are many: cinema / song, cinema / music, cinema / television, cinema / videogame, painting / fashion, cinema / urban scenography etc. The channels for cultural products have multiplied: Internet, podcasts, blogs, technologies producing an "immersion" etc.

- The theme of happiness replaces drama. American culture is obsessed with happiness. It is the stake in individual life. Americans are players. There are winners and losers and happiness is the reward for winners. The drama displays the fragility of happiness. It is concealed. The drama shows characters moved by passions. The passions determine the goals of characters. The playground shows the abilities of the players. Their player's qualities are put to test. Any civilization brings some answers to existential questions. An American knows what he (she) has to do in his (her) life: to play, to win and to be rewarded by happiness.
- Space replaces time. Americans have a short history. Also, there was a breakthrough at the end of the 19 th century, when the powerfulness of the USA (at the scale of the world) appeared, and the American society changed. So, the questions on American history are almost questions on the present. Some disdain for "collective grace" is displayed: the justification is more success in the present than some identity coming from History. Also, the space is the tool of economic success (too much, when the precautionary principle should be understood and chosen). Space is the means of success (to mobilize networks) and the sign (diffusion through networks). Space is at the start and at the end of any project. One has to find means taking into account the spatial division of labor (at the world scale). And the outcome has to be diffusion through networks, at the world scale.

The Max Weber's theories.

The American (the Protestant) is an "ascetic within the world". That is to say, he (she) looks for signs that he (she) is a God's chosen one. These signs are displayed when social success thanks to work occurs (Weber, 2003). The paradox is that a stark religion (that of Luther and Calvin) triggers pragmatism and … materialism. In the same vein, Americans appreciate democracy because only those who have proved their value deserve trust. Also, Americans appreciate meritocracy. Finally, there is a single source, the Protestant ethics, of pragmatism, acceptation of democracy and meritocracy.

4 THE EFFECTS OF AMERICAN CULTURE ON URBAN PLANNING

Culture does not explain all. We all know that political passions exist in America. So, the tableau (pragmatism, democracy, meritocracy) is less clear. But culture explains the "model" which is born in the USA and is imitated everywhere.

When "collective grace" as a great aspiration / inspiration disappears, what is the impact on urban planning? It remains a "focused space", while the urban life takes the form of tribalism:

- The "focused space" allows an idiosyncratic knowledge for inhabitants. Common mental atlases are possible. Anybody can be understood by another person, when he (she) speaks of location, travel from a place to another one etc. There are landmarks, visible and known by all the people (Lynch, 1998). The mobile phone has upgraded this ability (habit of describing where one is …). A landmark is "focal" (anybody thinks about the landmark, when it is needed to give explanations on a location). To travel in a city, it is necessary to be able to give or understand explanations on it.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

- Urban life takes the form of tribalism. Crowds are gathered to attend "events". Are concerned sport, music, ceremonies … Nice places (like the public squares of the past) are not needed. It is possible in fields (like the famous Woodstock Festival, in the USA, in 1969), in streets (Avenue des Champs Elysées, in Paris at Christmas), in stadiums, in nightclubs, dancing halls, sport palaces (or simply in a café). An event is a spectacle formatted by experts in urban scenography. The nice places inherited from the past can be used, but they are changed in a décor. Indeed, one can do without them.

Possible remedies could stem from water (in the city) and greening of the city. At the opposite, a risk is placemaking taken over by private brands:

Water.

For many years water in the city is considered an opportunity to have pleasant places where people can gather, walk, discuss or have a drink or dine. One can quote many examples: banks of the Seine and Canal de l'Ourcq in Paris, or the famous "river" (Cheonggyecheon) in Seoul. More, these places are fresh in Summer, in these times of global warming. Water in the city appears as a kind of "device", like arcades or fountains, which favors the meeting of people. It remains that there are not many places with water (rivers, lakes …) in the cities.

Greening.

Often "green corridors" are created thanks to old railway tracks which are no more used. Some are in cities, other in the countryside. Those in cities allow people to walk in a pleasant décor, or rest. So, the greening of cities, which is desirable because of the global warming, allows new places where people can meet. Otherwise, one can plant trees alongside avenues which embellish them. But trees can also be planted in gated communities. In the same vein, shared gardens are pleasant to look at but are not accessible. And there are not many old railway tracks in the cities. Like water, greening can help to "fill the void" when "collective grace" has disappeared from our culture and public squares are no more in the plans of new quarters. But it is not enough, if one recalls the massive use of public spaces in the past, in European cities.

Placebranding could be taken over by private brands.

Since "collective grace" has deserted the fabrics of the city, the void, when placemaking is concerned, could be fulfilled by private brands.

Let us quote two current examples in France.

Vendôme is a nice, mid-sized city, which owns the brand "Vendôme". There is a brand "Vendôme", which is a branch of a large firm, LVMH (Louis Vuitton) in the sector of luxury. The city has sold the brand "Vendôme", in the leather goods, to LVMH, for a small sum of money. There was a controversy… The episode does not matter very much, but it shows the fear that a firm which has influence, in a city, could take over the place branding (or the placemaking, to use a more blatant word). Indeed, LVMH has restored an old historical building in Vendôme to put in it a workshop, and will have a second workshop built in the city. About 400 jobs are concerned. This explains the influence of the firm in the city.

The village of La Gacilly, in Britain, is the birth place of Yves Rocher, the founder of a large, multinational firm in the sector of cosmetic. He was the mayor, and currently his son is the mayor. The brand is everywhere in the village: a museum (house of the brand), a photo festival in the streets, a botanic garden, a hotel, a restaurant … There are also industrial buildings, with jobs … Indeed, to visit La Gacilly is to be immersed in a Yves Rocher customer experience. Here there are explanations: a huge dissymmetry between the size of the firm (turnover of 2, 5 billion of euros) and the size of the village (4000 inhabitants), the personality of the founder Yves Rocher, who was a wise entrepreneur and a politician … But there is an excessive stranglehold on the city …The story is not new. In the past, firms have built cities for their workers, near the workplace. Often, they were in advance of social legislation, in fields like health, old age insurance, education of kids … There are many examples in various sectors: chocolate, shoes, heaters etc. The criticism was paternalism. Today, the stranglehold has another form. A firm can take over the placemaking because it is able to mobilize resources like experts, artists, architects … and financial means. Also, it has a project: to strengthen the image of the firm, to provide the customers with a new experience. The criticism is no more paternalism … It is an excessive stranglehold: the city is no more able to make choices when placemaking is concerned. The strategic priorities of the firms have changed: in the past it was

to manage the workforce, today it is marketing and to build the firm's image. So, the possible stranglehold on a city and its decisions, has changed.

5 CONCLUSION

The hypothesis of the paper is that "collective grace" is an aspiration which has vanished, when American culture has spread. But there is no void: it is replaced by a "collective trance", more tribal. The consequence on urban planning is that urban aesthetics is neglected. Let us quote an expert, Denis Baupin, who has been a city councilor in Paris: "If you speak of urban aesthetics, you make the people laugh" (Baupin, 2007).

There are remedies, water, greening, but they are insufficient.

The placemaking escapes from the hands of the populace. Let us quote an example in France. Etretat is a nice little city in the North of France. The city was shown in a TV series , which was a great success. The consequence was a flow of visitors, the city was overcrowded, the capacity of the car parks was not enough etc. The inhabitants were furious … It shows that the placemaking is not in the hands of the inhabitants since it was taken over by a TV chain .

However, the quality of the urban landscape, the preservation of some habitus of the inhabitants, remain stakes in some cities. Take the example of the "dark stores" (these American words are used in France). They are large premises, in big cities, in general at the ground floor, without windows. They are not shops. There are no customers entering and going out. There, are stored the goods that deliverymen take, then bring to the home of the customers of "quick commerce". They allow customers to order and have the ordered goods a quarter later. The criticisms of inhabitants are that they spoil the urban landscape, trigger disturbances (noise during the night) and make the little shops (grocery, butchery, drugstore …) disappear.

This recalls the criticisms raised by the platforms like Airbnb, accused of triggering a rise of the prices of flats, the closing of little shops, spoiling the urban landscape etc.

6 REFERENCES

BAUPIN Denis Tout voiture, no future ("All for cars, no future") Paris 2007.

DEBRAY Régis Civilisation. Comment nous sommes devenus Américains (« Civilization. How we have become American ») Paris 2018

LIPOVETSKI Serge L'écran global : culture, médias et cinéma à l'âge hypermoderne (« The global screen : culture, medias and cinema at the age of hypermodernity ») Paris 2007.

LYNCH Kevin L'image de la cité ("The image of the city") Paris 1998.

SITTE Camillo L'art de bâtir les villes. L'urbanisme selon ses fondements artistiques ("The art of building cities. Urban planning according to aesthetic criteria") Paris 1918.

VIOLLET LE DUC Eugène Histoire d'un hôtel de ville et d'une cathédrale ("History of a city hall and a cathedral") Paris 2012

WEBER Max L'éthique du protestantisme et l'esprit du capitalisme (« The protestant ethics and the spirit of capitalism ») Paris 2003

ZWEIG Stefan L'uniformisation du monde ("The uniformity of the world") Paris 1925.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

XR-Technologien in Partizipationsverfahren – Potenziale und Restriktionen einer smarten Stadtentwicklung mit den Bürgerinnen und Bürgern

Heidi Sinning

(Prof. Dr. Heidi Sinning, ISP – Institut für Stadtforschung, Planung und Kommunikation der FH Erfurt, Altonaer Straße 25, 99085 Erfurt, sinning@fh-erfurt.de)

1 ABSTRACT

Partizipative Stadtplanung und Stadtentwicklung stehen angesichts der zunehmenden Etablierung von Extended Reality (XR)-Technologien vor der Herausforderung, diese in die bestehenden Partizipationsformate zu integrieren. Dabei geht es darum, einerseits mögliche Vorteile von diesen immersiven Technologien (AR-, VR- und MR-/XR-Technologien) zu nutzen, und andererseits eventuelle Nachteile zu vermeiden und zugleich die ELSI-Kriterien zu erfüllen (ethische, rechtliche und soziale Anforderungen), um die Grundprinzipien demokratischer Planung und Qualitäten guter Partizipation sicher zu stellen.

Der folgende Beitrag befasst sich mit der Frage, welche Potentiale und Restriktionen immersive Technologien für eine crossmediale partizipative Stadtplanung bzw. -entwicklung bieten, und ordnet ein, welche Bedeutung XR-Technologien diesbezüglich zukommen kann. Darüber hinaus wird diskutiert, wie die Anschlussfähigkeit an die bestehende Beteiligungspraxis hergestellt und wie dabei insbesondere soziale Selektivitäten im Partizipationsprozess vermieden werden können. Hierzu werden im Fazit entsprechende Anforderungen formuliert.

Der Beitrag basiert auf dem inter- und transdiziplinären BMBF-Verbundforschungsprojekt „XR-Part: XR-Partizipationsräume zur erweiterten sozialen Teilhabe in urbanen Transformationsprozessen“ am Beispiel von partizipativen Planungsprozessen in den Modellstädten Mannheim und Rostock. Er präsentiert Ergebnisse einer Literatur- und Dokumentenanalyse.

Keywords: XR-Part-Forschungsprojekt, Potentiale und Restriktionen, urbane Transformationsprozesse, Partizipation, XR-Technologien

2 FORSCHUNGSKONTEXT

2.1 Metaverse und Extended Reality-Technologien – Perspektiven für partizipative Räume?

Metaverse wird in der Technologiedebatte als grundlegende Zukunftsinnovation verortet. Nutzerinnen und Nutzer bewegen sich nicht mehr nur auf der Oberfläche des World Wide Web, sondern sie begeben sich in den Cyberspace, kommunizieren dort mit Hilfe von XR-Technologien als Avatare bzw. digitale Zwillinge, und bewegen sich, interagieren, tauschen sich aus und debattieren wie in der „realen Welt“. Virtuelle werden mit physischen Elementen vereint. XR (Extended Reality)-Technologien erweitern die reale Welt. Sie umfassen Formen immersiver Technologien, etwa Augmented Reality (AR), Virtual Reality (VR) und Mixed Reality (MR), die bereits in verschiedenen Lebensbereichen, wie Wirtschaft, Medizin oder Immobilienwirtschaft, Einzug gehalten haben. Augmented Reality (AR) fügt virtuelle Objekte (u.a. Bilder, Text und Animationen) und Informationen in reale Umgebungen ein und ermöglicht dadurch, die eigene Wahrnehmung zu erweitern. Durch Virtual Reality (VR) entsteht eine vollständig computergenerierte 360°-Umgebung, die User in die Lage versetzen, in der virtuellen Welt zu interagieren. Die reale Welt ist dabei ausgeblendet. Mixed Reality (MR) als Funktionsprinzip verbindet Elemente von AR und VR und somit die reale Welt mit virtuellen Umgebungen, so dass eine neue Umwelt entstehen kann. Für die User bedeutet dies, dass sie zeitgleich in der realen und virtuellen Umgebung interagieren können. Noch ist zwar offen, welche Reichweite „Metaverse“ in seiner Entwicklung erzielen wird, aber die weltweite Entwicklung der dahinterstehenden Technologien erfolgt bereits mit hoher Dynamik. „Der Begriff Metaverse stammt aus den 90er-Jahren und meint digitale, dreidimensionale Räume, in der Menschen unterwegs sind, sich treffen, austauschen, spielen“ (Fromm 2022: 32). Die Idee wird von Kommerzialisierung und hohen Gewinnaussichten getrieben, in der Spieleindustrie, im Tourismus und auch in anderen Wirtschaftszweigen. Durch die Möglichkeiten von XR-Technologien, Partizipation in der Stadtentwicklung erweitert auszugestalten, können die Nutzerinnen und Nutzer beispielsweise zeitgleich in der realen und virtuellen Umgebung interagieren. Beteiligungsformate können sowohl zu Hause als auch unterwegs oder vor Ort zum Einsatz kommen und in verschiedenen Kombinationen und Ausformungen eingesetzt werden. Auch können

 ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

durch XR-Lösungen Emotionalität und Erlebbarkeit anwendbar gemacht werden, um bestehende Beteiligungskonzepte für verschiedene Nutzungsszenarien und Bevölkerungsgruppen weiterzuentwickeln, zugänglicher und attraktiver zu machen. Kritische Stimmen geben alerdings zu bedenken, dass enorme Risiken mit den neuen Technologien verbunden sind, von oligopolitischer Ökonomie, Privatsphäre und Datenschutz, Zugangsbarrieren zu Internet und technischer Infrastruktur für viele Menschen und damit der Gefahr der weiteren digitalen Spaltung, Abhängigkeit von Technologien bis hin zu kognitiven Beeinträchtigungen, psychischen Probleme wie sozialer Isolation oder negativer Selbstwahrnehmung. Es geht deshalb nicht nur um das „ob“ der Technologienutzung, sondern insbesondere auch um das „wie“, d.h. die Form des Technolgieeinsatzes.

Noch sind die neuen virtuellen Welten nur für einen kleinen Teil der Bevölkerung so attraktiv, dass sie dort „eintauchen“ und die virtuelle für einige Zeit zu ihrer realen Welt wird. Immersion stellt unsere Welt auf den Kopf, und es leitet sich die Frage ab, mit welchen zukünftigen Entwicklungen die Gesellschaft und damit auch die Stadtentwicklung und Stadtplanung rechnen kann. Wird Metaverse so attraktiv, dass tatsächlich die analoge in die virtuelle Welt übergeht? Welche Technologien werden sich zukünftig durchsetzen und menschliche Lebenswelten beeinflussen bzw. bestimmen? – Auch wenn die Zukunft unbestimmt ist und die erkannten und diskutierten Gefahren und Nachteile groß sind, ist die Bereitschaft in Teilen der Bevölkerung – insbesondere bei der Gruppe der Digital Natives – vorhanden, sich auf die technologischen Neuerungen einzulassen (Danker, Jones 2014).

Mit Bezug zu Stadtplanung und Stadtentwicklung lassen sich XR-Technologien beispielsweise in Partizipationverfahren ergänzend einsetzen, um Lösungen für Planungskonflikte zu finden, Alternativen aufzuzeigen und die Lebensqualität vor Ort zu verbessern. Doch was bedeutet der Technologieeinsatz konkret für eine nachhaltige Stadtentwicklung, für Prozesse der Partizipation und für die zivilgesellschaftlichen Mitgestaltung bzw. Koproduktion? Mit diesen Fragestellungen befasst sich der vorliegende Beitrag. Erkenntnisse aus umfangreichen Literatur- und Dokumentenanalysen konnten hierzu verwendet werden.

2.2 XR-Partizipationsräume zur erweiterten sozialen Teilhabe in urbanen Transformationsprozessen

Das Verbundforschungsprojekt „XR-Partizipationsräume zur erweiterten sozialen Teilhabe in urbanen Transformationsprozessen“, kurz: XR-Part (https://www.fh-erfurt.de/xr-part), setzt an dieser Debatte zum Einsatz von XR-Technologien in der partizipativen Stadtplanung bzw. -entwicklung an. XR-Part lotet aus, inwieweit XR-Partizipationsräume dazu beitragen können, eine erweiterte soziale Teilhabe in urbanen Transformationsprozessen zu erreichen. XR-Part integriert die Kritikpunkte zu Fragen demokratischer Planung beim Einsatz neuer Technologien und versucht, entsprechende Lösungsansätze zu generieren und diese in eine neu zu entwickelnde XR-Plattform für Partizipation einzubinden. XR-Part arbeitet an Lösungsansätzen, die für kommunikative Planungsprozesse in Kommunen nutzbar sind. Innovative Technologien werden im Kontext der räumlichen Planung entwickelt, erprobt, evaluiert und weiterentwickelt. Bezogen auf Governance- und Innovationsaspekte besteht dabei zudem die Herausforderung, nicht nur Bürgerinnen und Bürger, sondern auch Stakeholder, kommunale Verwaltungen und Politik, die oftmals langsamer auf neue technologische Entwicklungen reagieren als die Wirtschaft, für die entsprechenden Anwendungen zu gewinnen.

Innerhalb des Forschungsvorhabens werden sowohl Prozess- als auch technologische Innovationen angestrebt. So sollen auf der Grundlage von Fallstudien zu crossmedialen Bürgerbeteiligungsprozessen zu Planungsfragen in den Modellstädten Mannheim und Rostock Qualitätskriterien für XR-Partizipation und übertragbare Handlungsempfehlungen entwickelt werden, welche die organisationalen, prozessualen, planerischen und sozioökonomischen Kontexte zielgruppenadäquat berücksichtigen. Technisch geht es v.a. darum, eine XR-Plattform zu entwickeln, welche bisher oftmals getrennte Technologiebereiche (VR + AR + Web) in einem System verknüpft, integrierte Lösungen für demokratische Teilhabeprozesse ermöglicht, Erfahrungen der Nutzerinnen und Nutzer aufgreift und für sie alltagstauglich ist sowie kommunale Verfahren verbessert.

In einem transdisziplinären Forschungssetting setzt sich das XR-Konsortium aus Partnern aus Hochschulen, Wirtschaft und Kommunen zusammen. Die Wissenschaft vertritt die Fachhochschule Erfurt (ISP – Institut für Stadtforschung, Planung und Kommunikation; Fachgebiete „Digitale Medien und Gestaltung“ sowie „Gebäudeentwurf und Bauplanung“). Aus der Wirtschaft sind TriCAT GmbH mit ausgewiesener Kompetenz

im Bereich immersiven Welten und TriCAT spaces, Inpixon QH für AR-Technologien und Zebralog GmbH aus dem Bereich der crossmedialen Partizipation beteiligt. Neben den genannten Verbundpartnerinnen und Verbundpartnerngehören als assoziierte Partner die Modellstädte Mannheim und Rostock sowie die Tandemstädte Bonn und Köln zu dem XR-Part-Verbundteam.

TriCAT spaces bietet bereits heute Optionen für kommunikative Stadtentwicklung im virtuellen Raum (siehe https://tricat.net/en/tricat-spaces/). Teilnehmende können sich im virtuellen Raum beteiligen, wie in Realität bewegen, Platz nehmen, mit der Moderation und den anderen Teilnehmenden kommunizieren, Karten an ein Board pinnen, sich in Audio-Räume mit Teilnehmenden in einer Kleingruppe begeben, dort miteinander sprechen, ohne dass andere Teilnehmenden sie hören, und wieder zurück in das Plenum gehen, um über die Gesprächsergebnisse für alle hör- und sichtbar im virtuellem Raum zu berichten.

Bislang zeigt die crossmediale Partizipation, dass immer noch Bevölkerungsgruppen von der Teilhabe ausgeschlossen sind oder im Laufe der Beteiligung „verloren“ gehen. Die angebotenen Beteiligungsräume vor Ort oder im Netz sind entweder zu wenig attraktiv und zugänglich oder sie werden als brüchig wahrgenommen. Die Ausgangsthese des Forschungsvorhabens lautet deshalb, dass mit Hilfe von XR-Technologien wesentliche Ergänzungen und Qualitäten erreicht werden können. Konkret heißt dies, dass in den Modellstädten Mannheim und Rostock Verwaltungsmitarbeiterinnen, Verwaltungsmitarbeiter und beteiligte Akteurinnen und Akteure an städtischen Planungsprozessen mit Hilfe innovativer XR-Technologien räumlich und zeitlich (vor Ort, zu Hause, unterwegs) über verschiedene Kanäle bzw. Orte „erweitert“ kommunizieren können. Sie können bspw. virtuell an einem Workshop teilnehmen, von jedem Ort aus, also zu Hause, unterwegs oder auch vor Ort. Sie können sich virtuell begegnen und komplexe Planung verstehen und diskutieren. Dazu hilft, dass bspw. ein digitaler Twin als 3D-Modell im virtuellen Raum von TriCAT-Spaces steht. Die Teilnehmenden können virtuell als Avatare um das Modell gehen, verschiedene Perspektiven einnehmen und Kommentare posten. Das virtuelle Modell kann aber auch am Schreibtisch in Ruhe auf dem Padlet erkundet werden oder mit AR können zukünftige Planungen im Kontext der Vor-Ort-Situation betrachtet und kommentiert werden. Bürgerinnen und Bürger könnten so z.B. einen AR-Sparziergang zeit- und ortsunabhängig mit ihren Smartphones durchführen und ihre Meinungen dort mitteilen. Die Ergebnisse dieses AR-Spaziergangs würden dann im TriCAT spaces-Workshop wiederum eingeblendet werden können. Die gemeinsamen Planungen können aber auch vor Ort mit VR in Lebensgröße erlebt und erkundet werden. Hier besteht die Möglichkeit des gemeinsamen Erlebens und des Austausches im realen Raum.

Sowohl die technische Entwicklung dieser XR-Partizipationsplattform als auch die Nutzbarmachung für Städte und deren Prozesse stellen Herausforderungen dar. Eine wichtige Aufgabe besteht darin, die Anschlussfähigkeit der XR-Plattform an die städtische Beteiligungspraxis zu gewährleisten sowie ethische, rechtliche und soziale Prinzipien einzuhalten. Am Beispiel von zwei konkreten stadtplanerischen Partizipationsprozessen in Mannheim und Rostock wird die XR-Plattform in einem nutzerzentrierten, also an den Bürgerinnen und Bürgern und den Verwaltungsmitarbeiterinnen und Verwaltungsmitarbeitern ausgerichteten, interaktiven Entwicklungsprozess konzipiert, entwickelt, erprobt und evaluiert. Daran werden Potenziale und Grenzen überprüft und die Plattform iterativ weiterentwickelt.

3 POTENZIALE UND RESTRIKTIONEN VON XR-TECHNOLOGIEN

Durch die Nutzung von XR-Technologien in Partizipationsprozesse der Stadtplanung und Stadtentwicklung können sich verschiedene Potenziale und Restriktionen ergeben, die zugleich Chancen und Risiken des Einsatzes der Technologien darstellen. Im Folgenden werden ausgewählte Aspekte erörtert (s. Fig. 1).

3.1 Ausgewählte Potenziale

In Bezug auf Möglichkeiten oder Potenziale von XR-Technologien stehen inbesondere drei Aspekte im Vordergrund, zum einen technologische Neuerungen der Visualisierung, zum anderen die Überwindung von Zugangsbarrieren und darüber hinaus die räumliche Flexibilität des Einsatzes der Technologien.

Ein wesentliches Potenzial von XR-Technologien ist, dass XR-Partizipationsräume als Weiterentwicklung immersiver hybrider Lern-, Beteiligungs- und Kollaborationsräume Darstellungsmöglichkeiten im Raum mit den verorteten Planungsinhalten erweitern können. Neben diesen technologischen Neuerungen kann XR-Partizipation in Bezug auf die Zugänglichkeit der Partizipationsformate helfen, Zugangsbarrieren zu überwinden. Das betrifft z.B. ältere Menschen, Familien, Migrantinnen und Migranten oder auch

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

einkommensschwache Haushalte, aber auch Jugendliche und junge Menschen, die sich von herkömmlichen Beteiligungsformaten nicht ausreichend angesprochen fühlen.

Die erweiterten Möglichkeiten der Darstellung und Vermittlung bieten Vorteile für das Verstehen von stadtplanerischen und stadtentwicklungspolitischen Zusammenhängen. So können Laien bzw. Bürgerinnen und Bürger beispielsweise u.a. den Schattenwurf von Gebäuden und weiteren Objekten im Raum in ihrer Dreidimensionalität begreifen oder sich die zukünftige Möblierung eines Stadtplatzes plastisch vorstellen. Denn „der immersive Charakter der Technologie ermöglicht realistische Einblicke in die visuellen Auswirkungen möglicher Planungsvarianten“ (Schauppenlehner, Kugler, Muhar, Bautz 2018: 15; Spieker 2021: 74). Dieses Verständnis der Größenverhältnisse und Perspektiven eröffnet eine qualifiziertere Einschätzung vorgesehener Planungen und kann dazu beitragen, dass die geäußerten Wünsche und Bedarfe der Bürgerinnen und Bürgern in Bezug auf die spätere Umsetzung der Planung passfähiger ausgestaltet werden können.

Ein weiteres Potenzial von XR-Technologien für die partizipative Stadtentwicklung ist ihr räumlich flexibler Einsatz. XR-Technologien können vor Ort, zu Hause und unterwegs genutzt werden, so dass bisherige raumzeitliche und mediale Beteiligungsbarrieren abgebaut werden können. Wie oben dargestellt, stehen hierzu verschiedene Kanäle und Orte zur Verfügung, die genutzt werden können. Um diese Potenziale in Wert zu setzen, ist es erforderlich, die verschiedenen Beteiligungsformen und -techniken zu integrieren, und die immersiven hybriden Lern-, Beteiligungs- und Kollaborationsräume (XR-Partizipation) entsprechend weiterzuentwickeln. Die Interaktion kann auch die soziale Teilhabe an städtischen Planungsprozessen, z.B. für Eltern, die von zu Hause befähigt werden mitzuwirken, verbessern. Mobilitätseingeschränkte können partizipieren, ohne mühsame Wege auf sich zu nehmen. Aber nicht nur von zu Hause aus, auch vor Ort und unterwegs können mobile Geräte genutzt und erweiterte Möglichkeiten der XR-Technologien für die Partizipation an stadträumlichen Planungen zum Einsatz kommen und miteinander verknüpft werden.

3.2 Ausgewählte Restriktionen

Gegenüber den Potenzialen zeigen sich zugleich eine Reihe von Restriktionen, die den Einsatz von XR-Technologien in einem kritischeren Licht erscheinen lassen. Im Folgenden werden Aspekte der sozialen Selektivität, der Anschlussfähigkeit an die kommunale Beteiligungspraxis, von Unzulänglichkeiten der technologischen Weiterentwicklung in Bezug auf gesellschaftliche Diversität sowie der nicht vorhandenen personellen Kapazitäten und Zuständigkeiten in Verwaltungen, wenn es bspw. um Eindeutigkeit der Darstellung im XR-Raum geht, diskutiert.

Soziale Selektivitäten in digitalen Beteiligungsprozessen stellen eine maßgebliche Problematik dar. Sowohl technisch als auch in Bezug auf die Zugänglichkeit der Werkzeuge sind Barrieren zu überwinden. Dies betrifft z.B. ältere Menschen, Familien, Migrantinnen und Migranten oder auch einkommensschwache Haushalte. Beispielsweise ist das Onboarding für eine Beteiligungsveranstaltung in einem virtuellen Raum, etwa TriCAT spaces, für Bewohnerinnen und Bewohner (noch) keine Routine, so dass für nicht technikaffine Bevölkerungsgruppen erhebliche Zugangsschwellen bestehen. Nicht zu verkennen sind auch die mit dem erforderlichen Technikeinsatz verbundenen Kosten für die Nutzerinnen und Nutzer in Bezug auf Hard- und Software.

Eine weitere Restriktion für XR-Technologien stellt die Anschlussfähigkeit an städtische Strukturen und die Beteiligungspraxis dar. Dies zeigt sich beispielsweise bei der XR-Plattform, die im XR-Part-Verbundforschungsprojekt entwickelt wird. Diese Thematik betrifft u.a. die Datenverfügbarkeit bei den Kommunen. XR-Planung als Standardisierung des Datenaustausches wird dies zukünftig allerdings verbessern. Auch die bislang kaum vorhandenen Schnittstellen zwischen der Kommune und der XR-Technologie, um Technikinnovationen passfähig zuzuschneiden, sowie bestehende Routinen in Planungs- und Beteiligungsprozessen, die noch keine XR-Technologie enthalten, stellen Hürden für den Technikeinsatz dar. Bisher gibt es erst wenige Standardisierungen für diese neuartigen Prozesse. Damit kann der technische Aufwand, z.B. für die Modellierung, je nach Größe beträchtlich sein, was zu Finanzierungsengpässen führen kann (Schauppenlehner, Kugler, Muhar, Bautz 2018: 22).

Auch n Bezug auf die Weiterentwicklung der technologischen Möglichkeiten zeigen sich Grenzen. So stammen Prototypen von Avataren, die in virtuellen Räumen eingesetzt werden, beispielsweise häufig aus der Spielebranche und folgen klassischen Klischees. Diversität von Avataren, u.a. in Bezug auf verschiedene

Körpertypen im Hinblick auf Größe, Proportion und Form sowie Hautfarbe der Avatare, sind bislang kaum zu finden. Für die Partizipation sind aber breite Auswahlmöglichkeiten von Bedeutung, um Diskriminierungen zu vermeiden. Eine entsprechende Weiterentwicklung führt zu einem hohen Aufwand, der häufig nur mit entsprechenden Forschungs- und Entwicklungsförderung möglich ist. Auch fehlt es im Kontext partizipativer Stadtentwicklung noch an der Beforschung des Einsatzes und der Wirkungen von Avataren, z.B. von Selbst- und Fremdwahrnehmung je nach Auswahl eines Avatars. (u.a. Duschek, Schuster, Tu 2011; Bailenson, Groom, Nass 2009; Schauhuber 2019) Würden sich allerdings Avatare als digitale Zwillinge durchsetzen, könnte diese Debatte für partizipative Prozesse hinfällig werden.

Nicht zuletzt zeigen sich Restriktionen in Bezug auf die Darstellungsformen im Hinblick darauf, wer diese Aufgabe innerhalb der kommunalen Verwaltungen leisten kann. Wenn jedoch Zuständigkeiten und personelle Kapaziäten nicht gewährleistet sind, werden Qualitäten wie bspw. visuellen Eindeutigkeit, d.h. eine eindeutige Darstellung eines Objektes und der Umgebung, die zu einer verständlichen Darstellung führt, kaum in ausreichendem Maße realisierbar sein. Insbesondere über interaktive Visualisierungstechniken, wie beispielsweise das Ein- und Ausblenden unterschiedlichster Informationen oder Objekte, sowie eine freie Benutzerinnen- und Benutzerführung ist für die Erreichbarkeit und Motivation der potenziellen Nutzerinnen und Nutzer jedoch wesentlich.

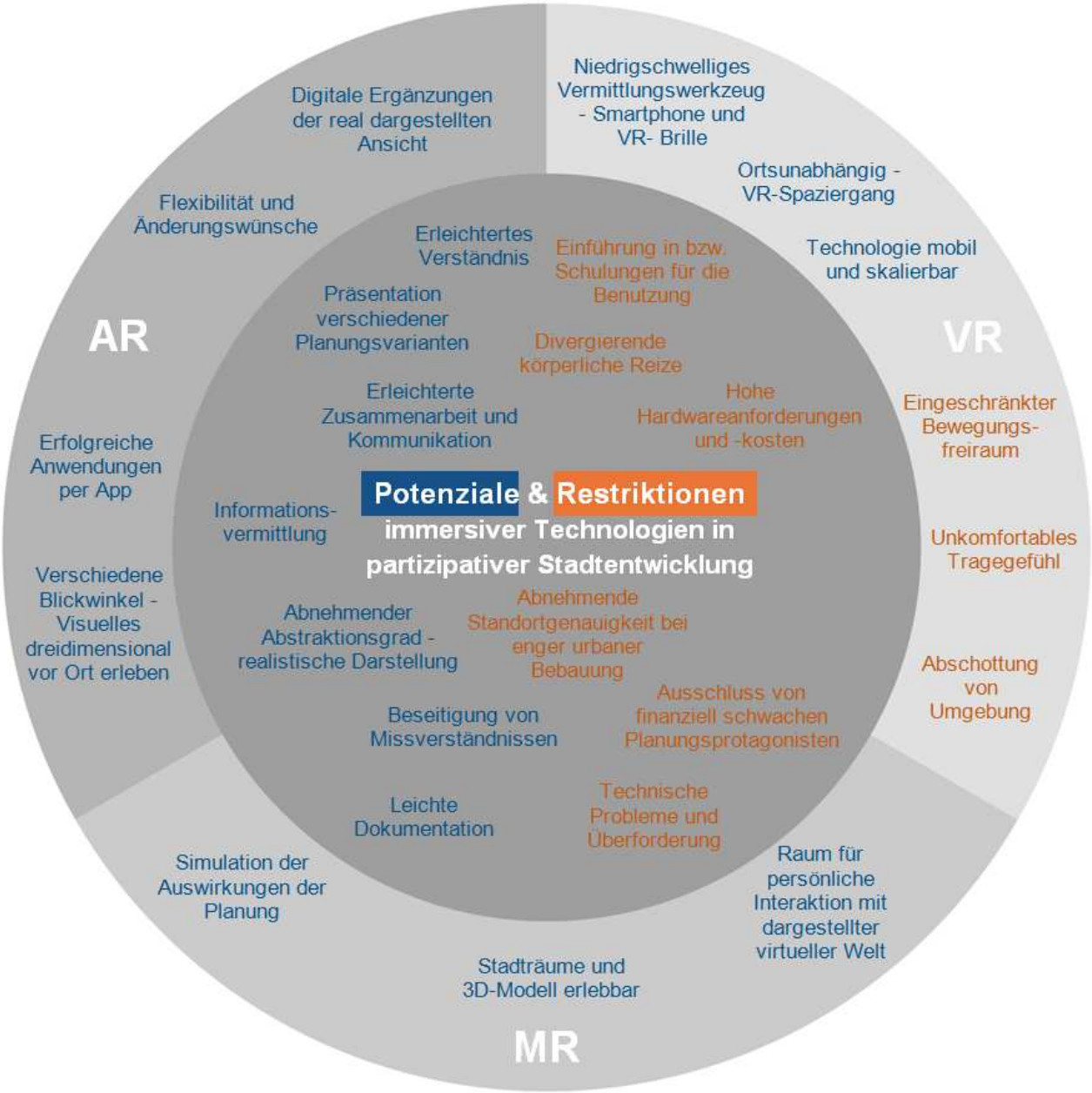


Fig. 1: Potenziale und Restriktionen immersiver Technologien in der partizipativen Stadtentwicklung

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

4 FAZIT

Für den Einsatz von XR-Technologien in stadträumlichen Planungsprozessen bestehen hohe Anforderungen in Bezug auf Qualitätskriterien demokratischer Teilhabe. Sie leiten sich aus den Potenzialen und Restriktionen von XR-Technologien in partizipativen Stadtentwicklungsprozessen ab, aber auch von bestehenden Qualitätsstandards zur Partizipation, die sich in den Kommunen etabliert haben. Zu den Anforderungen gehört die Berücksichtigung der spezifischen Nutzeransprüche und Qualitätsstandards für gute städtische Bürgerbeteiligung, wie sie in vielen Städten entwickelt und mit Hilfe von Leitlinien für Bürgerbeteiligung verankert worden sind. Daneben sind für den Einsatz von XR-Technologien die ELSI-Kriterien, die rechtliche, ethische, soziale Anforderungen umfassen, ein Qualitätsmaßstab. Diesbezüglich sind u.a. Implikationen in Bezug auf Gerechtigkeit, Würde, Privatheit, Schadensvermeidung und Autonomie der Nutzerinnen und Nutzer zu berücksichtigen. Hieraus leiten sich unter anderem Fragen eines „Userfriendly Designs“ oder auch einer freien Zugänglichkeit ab. Dieses breite und komplexe Anforderungsprofil deutet darauf hin, dass für den Einsatz von XR-Technologien in kommunalen Partizipationsprozessen sowohl inter- als auch transdisziplinäre Forschungsanstrengungen erforderlich sind, um disziplinäre Verkürzungen zu vermeiden.

In diesem Sinne verdeutlichen die aufgezeigten Potenziale und Restriktionen, dass es eine wesentliche Aufgabe der Stadtplanung und benachbarten raumbezogener Disziplinen sein muss, XR-Welten mit zu gestalten und Grundprinzipien qualitätsvoller demokratischer Planung und die ELSI-Kriterien zu erfüllen und die Qualitätsstandards guter Partizipation sicher zu stellen. Wenn es gelingt, die genannten Anforderungen zu berücksichtigen, können XR-Technologien einen Beitrag zur Weiterentwicklung demokratischer Prozesse leisten. Daneben ist dies nicht zuletzt auch zentral, um Gefahren einer digitalen Spaltung in der Gesellschaft im Allgemeinen und in der Stadtplanung und -entwicklung im Speziellen entgegenzuwirken sowie Menschen zur sozialen Teilhabe zu ermutigen und zu befähigen.

Maßnahmen zur digitalen Integration sollten zudem im Bereich der Rahmenbedingungen ansetzen, welche die Befähigung der Menschen in der Breite verfolgen, wie z.B. gezielte Beratungsangebote in bestehenden Bildungseinrichtungen oder die Einrichtung von Zentren der Digitalisierung, die auch besonders benachteiligten und wenig technikaffine Bevölkerungsgruppen einen einfachen Zugang ermöglichen. Andernfalls scheitert die digitale Partizipation bereits beim Onboarding für die AR-, VR- und MR-/XR-Technologien, wenn die entsprechenden Zugangsschwellen nicht überwunden werden können. Somit weist die Auseinandersetzung mit XR-Technologien im Bereich kommunaler Partizipationsprozesse zugleich auf die das Wechselspiel mit einer verantwortungsvollen Digitalisierung der Gesellschaft hin.

5 REFERENCES

BAILENSON, Jeremy N.; GROOM, Victoria; NASS, Clifford: The influence of racial embodiment on racial bias in immersive virtual environments. In: Social Influence, Jg. 4, H. 3, S. 231-248, 2009.

BBSR - Bundesinstitut für Bau-, Stadt-, und Raumforschung (Hg.): Die Weisheit der Vielen - Bürgerbeteiligung im digitalen Zeitalter, Bonn, 2017.

DANKER, Fabian; JONES, Oliver: Combining Augmented Reality and Building Information Modelling: An industry perspective on applications and future directions. In: BIM, Jg. 2, S. 525-536, 2014.

DUSCHEK, Alexander; Schuster, Philipp; Tu, Xi 2011: Avatar Framework. Fachstudie Nr. 130, Institut für Visualisierung und Interaktive Systeme (VIS), Abteilung Graphisch-Interaktive Systeme (GIS), Universität Stuttgart. Verfügbar: <https://www2.informatik.uni-stuttgart.de/bibliothek/ftp/medoc.ustuttgart_fi/FACH-0130/FACH-0130.pdf>

FROMM, Thomas: Jenseits der Realität. In: Süddeutsche Zeitung, Nr. 53, 5./6. März 2022, S. 32.

HÖFFKEN, Stefan: Mobile Partizipation - Wie Bürger mit dem Smartphone Stadtplanung mitgestalten, Detmold: Rohn Verlag, 2014.

SCHAUHUBER, Philipp 2019: Effekte der Verkörperung von Avataren auf die kognitive Leistung in kollaborativen virtuellen Umgebungen. Bachelorarbeit im Fach Medieninformatik, Institut für Information und Medien, Sprach und Kultur, Universität Regensburg.

SCHAUPPENLEHNER, Thomas; KUGLER, Klara; MUHAR, Andreas; BAUTZ, Georg: Anwendungserfahrungen von Virtual Reality als Kommunikationswerkzeug in partizipativen Planungsprozessen. In: Journal für Angewandte Geoinformatik, H. 4, S. 15-24, 2018.

SPIEKER, Arne: Chance statt Show – Bürgerbeteiligung mit Virtual Reality & Co. Akzeptanz und Wirkung der Visualisierung von Bauvorhaben, Wiesbaden, 2021.

WIETZEL, Ingo: Methodische Anforderungen zur Qualifizierung der Stadtplanung für innerstädtisches Wohnen durch Mixed Reality-Techniken und immersive Szenarien. Schriften zur Stadtplanung, Technische Universität Kaiserslautern, Lehrstuhl Stadtplanung, Kaiserslautern, 2007.

ISTER: Connecting Historical Danube Regions Roman Routes with a GIS-based Territorial Atlas and an Online Interactive Tool

Blaž Barborič, Clemens Beyer, Georg Neugebauer, Manfred Schrenk

(Blaž Barborič, MSc, Geodetic Institute of Slovenia, Jamova cesta 2, 1000, Ljubljana, Slovenia; blaz.barboric@gis.si)
(Dipl.-Ing. Manfred Schrenk, Department of Spatial, Landscape and Infrastructure Sciences, Institute of Spatial Planning, Environmental Planning and Land Rearrangement (IRUB), Peter-Jordan-Straße 82, 1190 Vienna, Austria, manfred.schrenk@boku.ac.at)
(Dipl.-Ing. Clemens Beyer, Department of Spatial, Landscape and Infrastructure Sciences, Institute of Spatial Planning, Environmental Planning and Land Rearrangement (IRUB), Peter-Jordan-Straße 82, 1190 Vienna, Austria, clemens.beyer@boku.ac.at)
(Dr. Georg Neugebauer, Department of Spatial, Landscape and Infrastructure Sciences, Institute of Spatial Planning, Environmental Planning and Land Rearrangement (IRUB), Peter-Jordan-Straße 82, 1190 Vienna, Austria, georg.neugebauer@boku.ac.at)

1 ABSTRACT

ISTER project addresses the challenge of Roman heritage discontinuity. Stepping further the isolated Roman settlements heritage, ISTER tackles the territorial dimension of the Roman Routes, as a contiguous transnational element that passes national borders acreoss the Danube region and provides a relevant scale for exchange and joint development. Therefore, ISTER's main objective focuses on rediscovering and revitalizing the ancient Roman Roads Network along the Danube river as a key driver in promoting territorial development based on sustainable use of cultural and natural heritage.

During the project, data from all local and regional partners were collected, sorted and harmonised. Based on a user requirements survey, a strategy for the deployment of the ISTER Interactive Tool was developed. The interactive tool uses the collected data and geodata for an open orientation and information platform which aims to foster knowledge about the Roman cultural heritage in the broad public.

The ISTER Interactive Tool is set up as a responsive website to be used with mobile devices like smartphones or tablets. The central element of the interactive tool is a map, all information is queried from a central database as location-based service. The tool does not only provide information about the cultural heritage elements (monuments, milestones), but also provides other information which can be useful when planning a trip, like places to eat or drink, accommodation facilities, public transport stops, or supermarkets. It is available not only in English, but also in the local languages of the ISTER project partners.

Keywords: Roman Routes, Interactive Tool, Cultural Heritage, Sustainable Tourism, Regional Development

2 ISTER GENERAL ISSUES

2.1 Project idea

ISTER project firstly addresses the challenge of Roman heritage discontinuity, which reflects both in a territorial dimension related to a low level of investment and connection between heritage resources and local/regional productive sectors, as well as in visualisation and attractiveness dimensions regarding the promotion and awareness raising on the importance of heritage resources as drivers for regional development. Stepping further the isolated/detached Roman settlements heritage, ISTER tackles the territorial dimension of the Roman Routes, as a contiguous transnational element that passes Danube Region state borders and provides a relevant scale for exchange and joint development. Therefore, ISTER's main objective focuses on rediscovering and revitalizing the ancient Roman Roads Network along the Danube Region as a key driver in promoting territorial development based on sustainable use of cultural and natural heritage (specifically, Roman routes). ISTER promotes this Roman roads and settlements network as a catalyst for touristic development, as well as an opportunity for territorial competitiveness and sustainable growth of Danube crossed-regions. To increase local attractiveness, ISTER is leveraging on three key assets:

(1) Adopting a multi-layered governance chain aimed at strengthening knowledge framework and institutional capacities of Danube Region actors through capacity building and collective knowledge mapping;

(2) Using advanced tools and technologies for enhancing non-physical accessibility, visibility and valorisation of Roman routes and settlements network, laying the foundation for a thematic cultural route based on Roman heritage with a narrative function, reviving ancient assets and promoting non-renewable and fragile, but yet unexplored and unexploited Roman legacy;

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

(3) Acquiring the shift from old policy approaches (protection through isolation) to new, integrative methods for improving the policy and regulatory framework in Danube crossed-regions.

2.2 ISTER GIS-based Atlas of Roman Routes in the Danube Region

ISTER GIS-based Atlas of Roman Routes in the Danube Region (https://ister.gis.si/) is an open-source, user-friendly online inventory and platform that provides a spatial representation of the Roman routes legacy in Danube Region.

The GIS-based Territorial Atlas is the central collection, administration and storage point for georeferenced information on Roman Heritage in the Danube region, including descriptions, photos and illustrations of Cultural Heritage Sites. Systematically collecting information about Roman Routes and sites in a co-ordinated, georeferenced way and build information systems on this basis is one of the central elements of ISTER. The status of the available data is very different throughout the whole Danube Region – whereas for example in Carnuntum (Austria) there are very extensive and systematic databases and information systems and also online tools availabe, there are some other – remote – regions, where data has to be collected by remote sensing (aerial photography, satellite imagery, ...), even some field surveys and excavation works will have to be done.

One of the core tasks of ISTER project is the Development of a GIS-based territorial Atlas of Roman routes legacy in the Danube Region.

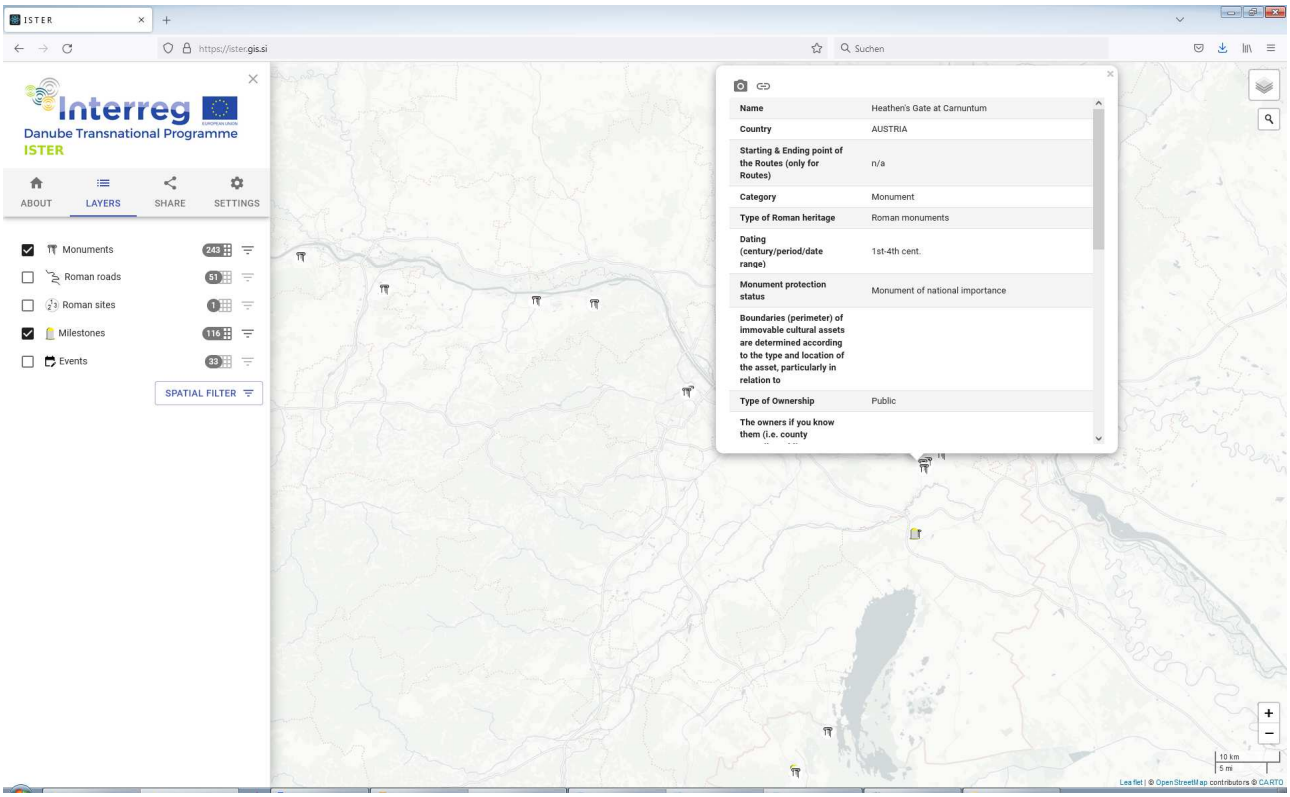


Fig. 1: The ISTER Atlas implemented by the Geodetic Institute of Slovenia. Source: Geodetic Institute of Slovenia.

The GIS Atlas provides the following functionalities:

- landing page,
- language selector,
- layer selector,
- table view:
    - layer attributes data table,
    - layer filter,
    - sharing filtered data.

2.3 The idea behind the Interactive Tool

Based on the extensive data collection and development of the territorial atlas the ISTER Interactive Tool will be a digital collaborative application, aimed at supporting the Roman eco-cultural route valorisation as well as effective communication and awareness raising on ISTER findings related to the Roman roads and settlements network.

The interactive tool provides a user-friendly interface, loading valuable content on the rich Roman routes' legacy, to be provided through an open-source knowledge portal. Since the interactive tool had to meet both transnational and locally-specific needs and challenges, a user requirements survey was conducted for ISTER territorial partners and external stakeholders to collect all input and expectations.

The survey comprised the following sections:

- Apps' key functions and processes;
- Available web content for the app;
- Target audience;
- Purpose of clients using the app.

The survey template has been prepared by University of Natural Resources and Life Sciences Vienna (BOKU) who is in charge of developing a responsive website which allows for the deployment of a useable mobile application. Therefore, input from different stakeholders is highly necessary to understand common and specific needs for the interactive tool. The interactive tool will continuously receive input from ISTER partners even beyond the official end of the ISTER project.

2.4 Survey results

From the collection of repondents' first thoughts the interactive tool should aim at promoting and fostering visibility of the Roman cultural heritage for mainly touristic and educational purposes. It should have some features which encourage people to use the tool and not Google. And it should support local languages. The most important target audience groups are tourism and travel, the public, and archaeology/museum/cultural heritage sites. Also education/research and recreation/leisure were rated as some kind of relevant. The main purposes, as seen by the survey respondents, should be promotion of tourism, education, and on site information/trip planning – from a content provider's point of view as well as from a client's point of view.

It was noticeable that the evaluation of the relevance of the potential purposes from the client's point of view was generally worse than from the provider's point of view. This may be due to the fact that the respondents found it difficult to put themselves in the role of a client without being able to assess the interactive tool in detail, as the theoretical description of the interactive tool in the project proposal allows for a wide scope of interpretation. Table 1 shows the importance of data and content for the interactive tool as seen by the project partners:

	photos	videos	audio guides	maps, geodata	web links	virtual reality	augmented reality
Roman cultural heritage	16	15	13	15	14	14	13
other cultural sites (museums, monuments, ...)	14	9	6	14	13	6	6
accommodation facilities (hotels, B&B, ...)	12	3	3	13	15	1	1
gastronomy (restaurants, pubs, ...)	10	4	4	12	14	2	1
current and upcoming events	11	8	4	11	15	3	2
public transport	4	3	2	9	13	1	1
leisure facilities	10	5	5	8	10	2	2
arts and crafts	11	7	5	8	12	2	2
other local information (like church services, markets, ... please specify below)	3	3	2	4	10	1	1

Table 1: Data and content considered important for the interactive tool. Source: own representation. Colour interpretation: the more to the red side, the more important; the more to the blue side, the less important.

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

The actual situation is depicted in table 2 showing all data and content which can be provided by the project partners according to the status quo:

	photos	videos	audio guides	maps, geodata	web links	virtual reality	augmented reality
Roman cultural heritage	11	6	2	9	9	3	4
other cultural sites (museums, monuments, ...)	6	4	0	6	8	0	1
accommodation facilities (hotels, B&B, ...)	4	0	0	4	7	0	0
gastronomy (restaurants, pubs, ...)	5	1	0	3	7	0	0
current and upcoming events	4	1	0	1	7	0	0
public transport	2	1	0	1	7	0	0
leisure facilities	3	2	0	2	4	0	0
other local information (like church services, markets, ... please specify below)	0	0	0	0	2	0	0

Table 2: Data and content available from the project partners for the interactive tool. Source: own representation. Colour interpretation: the more to the red side, the more important; the more to the blue side, the less important.

Comparing tables 1 and 2, it is obvious that the project partners had very high expectations for the interactive tool on the one hand, but were not able to deliver the material and data which would have been necessary to meet these high expectations on the other hand. Therefore, we concentrated on the collection of information regarding the Roman monuments and decided to retrieve all other necessary and useful data from Open Street Map.

3 IMPLEMENTATION OF THE ISTER INTERACTIVE TOOL

3.1 Framework for the ISTER Interactive Tool

The ISTER Interactive Tool combines information from the project's GIS atlas database (ISTER Atlas) with open source data from Open Street Map (OSM), a collaborative project to create a free editable geographic database of the world. The geodata underlying the maps is considered the primary output of the project.[1]

The ISTER Atlas is a project-internal tool aiming at collection, input and maintenance of project-related data concerning the ISTER monuments and milestones. Routes were also collected in the ISTER Atlas, but these route data are not used in the Interactive tool due to a lacking accuracy.

3.2 Technical setup

The goal of the Interactive Tool is to make the GIS atlas content accessible to the broad public in a user-friendly way. The initial idea was to create an app. After weighing up all the advantages and disadvantages, the decision was made in favour of a website:

- works on both Android and IOS (Apple) platforms;
- no double development and implementation efforts (for Android and IOS);
- nio exclusion of half of the mobile devices (if it were developed as an app, we would had to have a decision for either Android or IOS);
- no installation needed;
- no restrictions through limited user's permissions;
- always up to date, no updates necessary;
- works on any standard internet browser;
- does not use proprietary elements, looks exactly the same on any device;
- designed to behave like an app;
- internet connection necessary, no storage of offline data.

[1] https://en.wikipedia.org/wiki/OpenStreetMap

The Interactive Tool frontend consists of these components:

- user interface: classic HTML website generated with PHP;
- map: OpenLayers 6.14 using Open Street Map and own geodata layers;
- stylesheet: responsive CSS for adaptation to any mobile device screen size;
- interactive elements (like a QR code scanner): Javascript code with XHTTP (AJAX) requests.

In the background, there are a few more elements:

- UMN mapserver to create the project's own geodata layers and excerpts from Open Street Map data;
- PostgreSQL database with PostGIS extension for geodata operations and UMN mapserver data provision;
- PHP scripts for database interaction and the GIS Atlas interface;
- server cronjobs[2] for automatic database synchronisation between GIS Atlas and Interactive Tool.

3.2.1 Frontend

The Interactive Tool can be reached from any internet browser by opening the URL https://www.via-ister.eu/ and it is loaded as a website. From the startpage, the user can access a language switcher, some options and the map, which serves as the main interaction point of the tool.

The map shows Open Street Map as background layer and all ISTER monuments (Roman cultural heritage sites collected by all project partners). Additional layers can be added via the options page:

- ISTER milestones,
- places to eat and drink,
- supermarkets,
- accommodation facilities,
- public transport stops.

Additional information can be retrieved at any time by clicking (or tapping) on the map and is displayed in pop-ups directly over the map.

The language of the Interactive Tool can either be automatically detected by checking the internet browser's language, or may be manually set to any of the project consortium's languages. The functions (buttons, headers, warnings, …) of the Interactive Tool are available in all of the project consortium's languages. The information on monuments and milestones is always available in two languages: English as well as the local language of the monument or milestone location. If the selected language is not available for a milestone or monument, the English information is returned.

One of results of the ISTER project are so-called milestones which are place near Roman cultural heritage places. They have a QR code on them, which directly leads to the interactive tool with information on the respective site.

3.2.2 Background activities

The main background activities in the Interactive Tool are XHTTP requests which are triggered by the frontend user, e. g. by tapping on the map or entering a search term. User inputs are sent to PHP scripts which initiate PostgreSQL database queries with prepared statements. The query results are returned in JSON, an open standard file format and data interchange format that uses human-readable text to store and transmit data objects consisting of attribute-value pairs and/or array. It is a common and widely used data format in electronic data interchange, including that of web applications with servers.[3] When tapping on the map, the amount of database queries is directly dependent on the number of layers shown in the map, so the user can decide which information to retrieve simply by switching layers on or off.

[2] A cronjob is a task which runs automatically on a server. The system regularly issues commands for the execution of these jobs.
[3] see also https://en.wikipedia.org/wiki/JSON

ISBN 978-3-9504945-1-8. Editors: M. SCHRENK, V. V: POPOVICH, P. ZEILE, P. ELISEI, C.BEYER, J. RYSER

The Interactive Tool database is automatically synchronised with the GIS Atlas once a day to take over data updates which were made in the GIS Atlas.

3.3 User guide

Even though the Interactive digital tool adopts a user-friendly interface, a user guide is highly necessary, in order to provide a comprehensive explanation of the app's technicalities. Therefore, the user guide will comprise the following sections:

- Presentation of the app's purpose and functionality;
- Navigating the Web app;
- Browsing accommodation, places to eat, etc.;
- Customizable settings (language, notifications, etc).

The user guide will be available in English as a deliverable of the project.

3.4 Web address of the ISTER Interactive Tool

The interactive tool is available at https://www.via-ister.eu/.

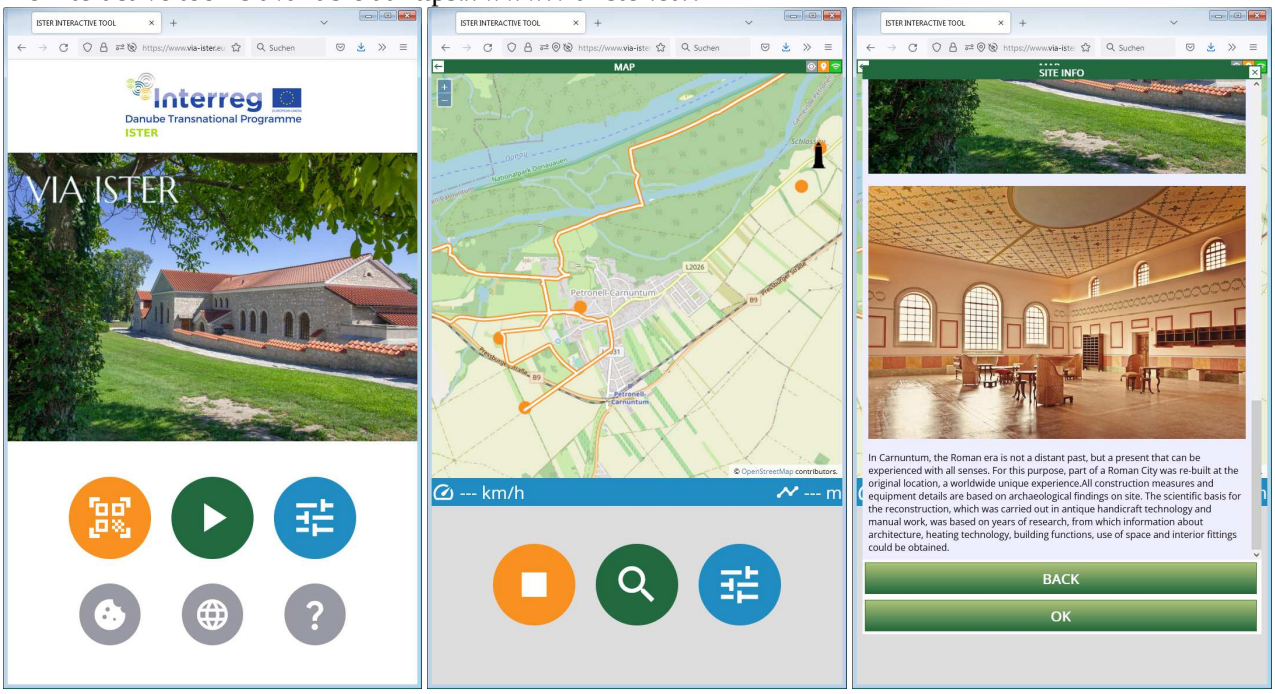


Fig. 2: Some impressions from the ISTER Interactive Tool. Source: https://www.via-ister.eu