

Mapping the Spatial Integration of Motorised and Non-Motorised Transport Infrastructures: a Case Study of the City of Johannesburg

Brightnes Risimati, Trynos Gumbo

(Brightnes Risimati, University of Johannesburg, Department of Operations Management, P.O Box 17011, Doornfontein, 2028, brightnesrisimati@gmail.com)

(Prof Trynos Gumbo, University of Johannesburg, Department of Town and Regional Planning, P.O Box 17011, Doornfontein, 2028, tgumbo@uj.ac.za)

1 ABSTRACT

Several developments that are tailored towards the improvement of transport integration, particularly public transport systems have been taking place in most cities of the developing world such as City of Johannesburg. Improvement of public transport integration begins with involving the all-inclusive transportation chain instead of only focusing on one part of the journey, by facilitating spatial integration between diverse transport modalities (for instance the bus, walking and cycling) to allow for a multiplicity in travel opportunities. Using an exploratory research design that involves an empirical enquiry to gather and analysed spatial and quantitative information, this paper presents the extent of spatial integration of non-motorised and motorised public transport infrastructures within the City of Johannesburg. The crowd-sourced datasets derived from the geolocation based mobile application Strava were used in this study. The datasets illustrate the spatial and temporal coverage of motorised and non-motorised patterns and trends in Johannesburg. Geographic Information Application (ArcGIS) was used to analyse and visualise the geographical location of the motorised and non-motorised public transport in the City of Johannesburg. Results demonstrate that the public transport interchange hub of the City of Johannesburg, the Park Station is the most integrated hub that serviced by both motorised and non-motorised; and public transport commuters at the station switch from one mode to another mode of public transport smoothly at a short walking distance. Although, the results further reveal that the most of motorised and non-motorised networks are not integrated; thus affects the effectiveness and conveniently switch from either motorised to non-motorised public transport or non-motorised to motorised public transport. There is therefore limited to no sharing of infrastructure between commuting, cycling and walking in the city. The paper recommends holistic approaches in planning and development of both commuting, cycling and walking infrastructures that are connected to promote convenience and efficiency of public transport systems.

Keywords: Integration, commuting, cycling, walking, infrastructure.

2 INTRODUCTION

Transport is vibrant to development as it provides accessibility to goods, services, employments, educational opportunities, family, social settings and economic activities. Without viable transportation, the quality of life does not improve and poverty is prolonged. The effects of inefficient transport systems in rural parts of Africa, which rely on non-motorised transport in its most basic form, are manifested in a lack of market integration, poor provision of education and health services, low productivity and low rates of regional and local economic activity. Transport systems developed in developed countries may not fit well with the safety needs of low income and middle-income countries for a variety of reasons, including the differences in traffic mix. In developing countries, walking, cycling, motorcycling and the use of public transport are the predominant transport modes. In developed countries, car ownership is high, and most road users are vehicle occupants. Despite the growth in motorised transport in developing countries such as South Africa, a large portion of the population depends on non-motorised forms of transport, and this will continue for some time. Walking is the cheapest, least space consuming and the most economical means of transport for short distances.

Non-Motorised Transport (NMT) includes Walking, Animal-Power and Bicycling, and variants such as SmallWheeled Transport (skates, skateboards, push scooters and hand carts) and Wheelchair travel. As a mode of transport, non-motorised is available to almost everyone. The majority of non-motorised class of transport modes are healthy, non-polluting, versatile and reliable. They encourage local movement and hence support local community facilities. A shift away from private car use to non-motorised transport, including improving accessibility for the mobility impaired, has a key role to play in using the existing road network more efficiently and delivering significant potential economic and environmental benefits to society,

alongside tangible health and lifestyle benefits for individuals. Most transport in South Africa takes place by road, ranging from walking on unpaved paths to moto transport on well-paved roads. For the majority of people in rural areas, walking is the only available option, even for transporting goods. Furthermore, most transport travel in South Africa is for essential trips rather than for leisure. For very short trips, walking is the main mode of transport in most societies, rich or poor. Indeed, most trips in all countries involve some walking as access and exit to the main mode.

Walking is the most important means of transport in developing countries, followed by public transport. Cycling has a smaller share of the total number of trips, except for a few (big) exceptions. Generally, bicycles serve as a means of transport of goods and people in peri-urban and rural areas, while in urban areas the recreational purpose of cycling is important. Cycling is another type of nonmotorised transport that incorporates bicycle, roller skates, in-line skates, skateboard, skates, tricycle, cycle trailer, cycle rickshaws, wheelchair and baby carriage. Non-Motorised Transport provides many indirect benefits. A community designed for walking and cycling must be compact (so many destinations are within convenient distance of each other), connected (with streets that allow direct travel), designed at a human scale, have functional and attractive sidewalks and paths, have effective strategies to control traffic speeds, and feel safe to vulnerable users. Increased non-motorised travel tends to improve community cohesion (the quality of neighbourly interactions), security and aesthetics. These features provide many benefits besides just mobility. Simple transportation improves people's lives in different ways among others, a child can get to school, access to economic activity, and health care services.

The 1996 White Paper on Transport Policy aimed to reduce dependence on the private car and promote other, more sustainable modes of transport such as public transport, animal-drawn transport, walking and cycling. Local authorities are expected to reflect this approach in their annual Integrated Transport Plan. Non-motorised transport such as walking, is the second most significant mode (after car travel), and has been identified as making an important contribution to these aims. Encouraging an increase in levels of non-motorised activity is consistent with the development of integration, social inclusion and sustainability in transport and other areas of social activity. Using an exploratory research design that involves an empirical enquiry to gather and analyse spatial and quantitative information, this paper presents the extent of spatial integration of non-motorised and motorised public transport infrastructures within the City of Johannesburg.

3 METHODOLOGY

This study adopted an exploratory research design to explore the extent of spatial integration of non-motorised and public transport infrastructure within the City of Johannesburg. Thus, the Exploratory Spatial Data Analysis (ESDA) was utilised. ESDA is a gathering of techniques to visualise and describe spatial distributions, identify spatial outliers or atypical outliers, discover patterns of spatial association, clusters of hot spots, and suggest spatial regimes or other forms of spatial heterogeneity (Anselin, 2012). The exploratory approach was used to formulate the research problem for precise investigation, and to gather complete and accurate information.

Accordingly crowd-sourced datasets derived from the geolocation based mobile application Strava Metro for the City of Johannesburg were collected to visualise the cycling patterns, trends and distribution in the city for the year 2017. Although the Strava datasets were chosen as they had been proven to be useful sources of data for cities such as Portland Oregon and Brisbane (Strava, 2015). The datasets illustrate the spatial and temporal coverage of motorised and non-motorised patterns and trends in Johannesburg. Strava Metro has three licences, namely: (1) Streets, (2) Nodes and (3) Origins and destination licenses.

The study was unable to acquire the street to acquire the streets and nodes license which gave better insights into cycling patterns. Although, the City of Johannesburg currently does not have any information on cycling patterns, thus the Strava Metro was a suitable source of data providing such information. Accordingly, origination and Destination license was obtained that records that start and end of cycling polygon activities. Datasets received from Strava were in the dbf and shapefile format. The dbf contained all the cycling attributes whilst the shapefile contained the (suburbs) of where the cycling activities took place in the city as well as motorised public transport systems networks (Gautrain and Rea Vaya BRT).

In this study, the data was spatially interpreted and visualised using Geographic Information Application (ArcGIS 10.3). Cycling patterns were analysed through kriging interpolation method on the basis of the

frequency, time as well as the origin and destination. The analysis was at city and neighbourhood level. At neighbourhood level spatial analysis, spatial statistics and map algebra functions of ArcGIS 10.3 were used to calculate the cycling trips, the originating and destination polygons.

4 RESULTS AND DISCUSSION

The total number of cycling trips recorded by Strava Metro in Johannesburg was 84297 for the year 2017 (from January to December). Only about 20% of the cycling trips recorded are for commuting, whilst recreational trips accounts for approximately 80% of the cycling trips in the City of Johannesburg. Table 1 below illustrate the total cycling activities for the year 2017 in the City of Johannesburg.

Activity	Trips	Percentage
Commuting	16844	20%
Recreational	84297	80%
Total	84297	100%

Table 1: Cycling activities for the year 2017 in Johannesburg.

It is observed during the study that the highest number of cycling trips are in the summer months of (9880), September (7786), October (8928), November (10997), December (6578). In the middle of winter (June and July months) the patterns is common for both recreational and commuting cycling patterns. During the day, the cycling trips follow a discernible pattern, where most cycling activities peak in the early morning hours between 06:00 am and 09:00 am and peak again between 15:00 pm and 17:00 for both recreational and commuting.

The drawback of conventional and traditional methods of data collection techniques on cycling patterns such as traffic counts, is that they cover a limited spatial extent and are often cumbersome to conduct. With strava Metro data this is circumvented, as it covers a broad spatial extent (national, provincial and local) and it is regularly updated. Figure 1 illustrate the spatial coverage of cycling activities within the City of Johannesburg in 2017.

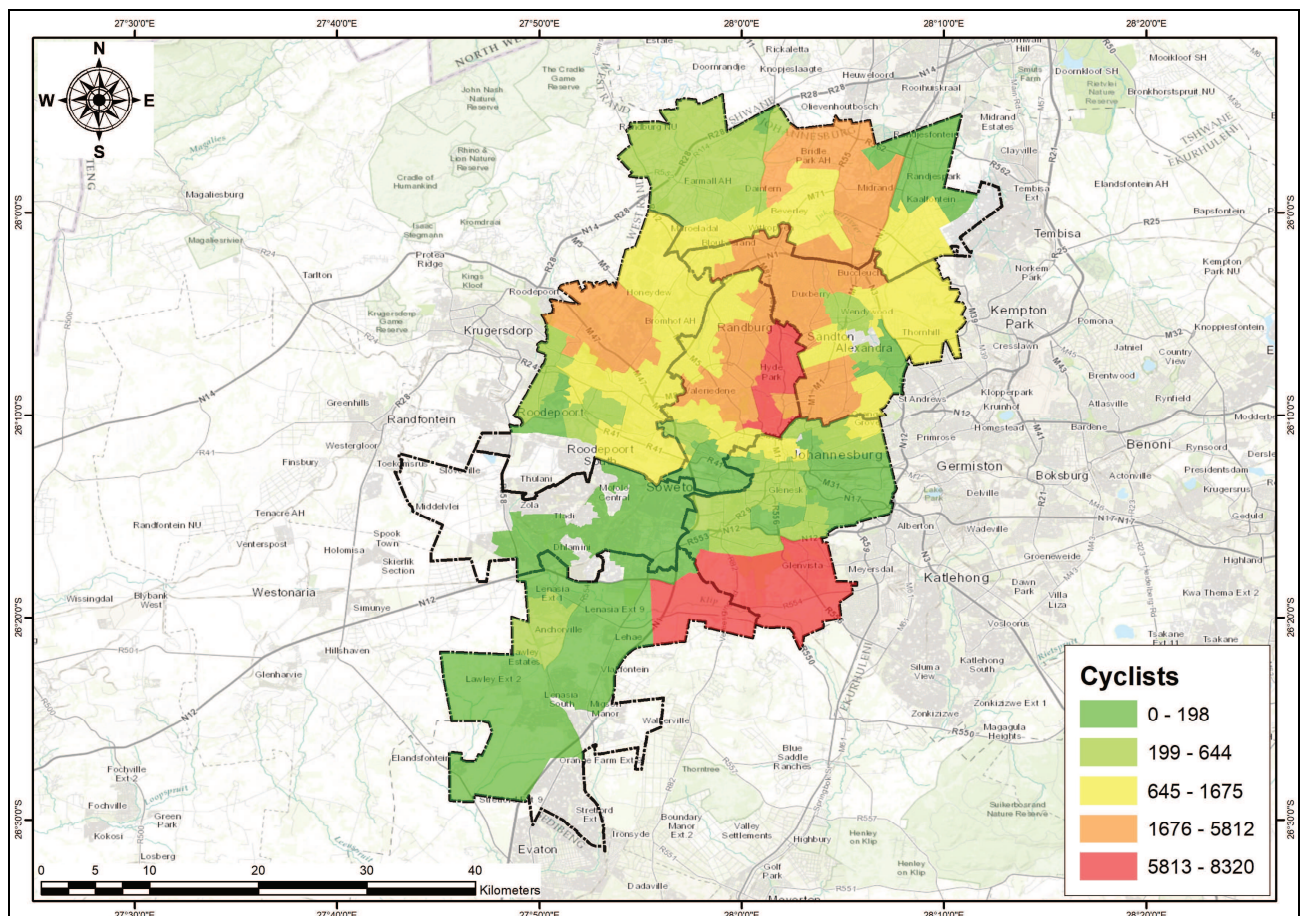


Fig. 1: The spatial coverage of cycling activities within the City of Johannesburg in 2017.

Mapping the Spatial Integration of Motorised and Non-Motorised Transport Infrastructures: a Case Study of the City of Johannesburg

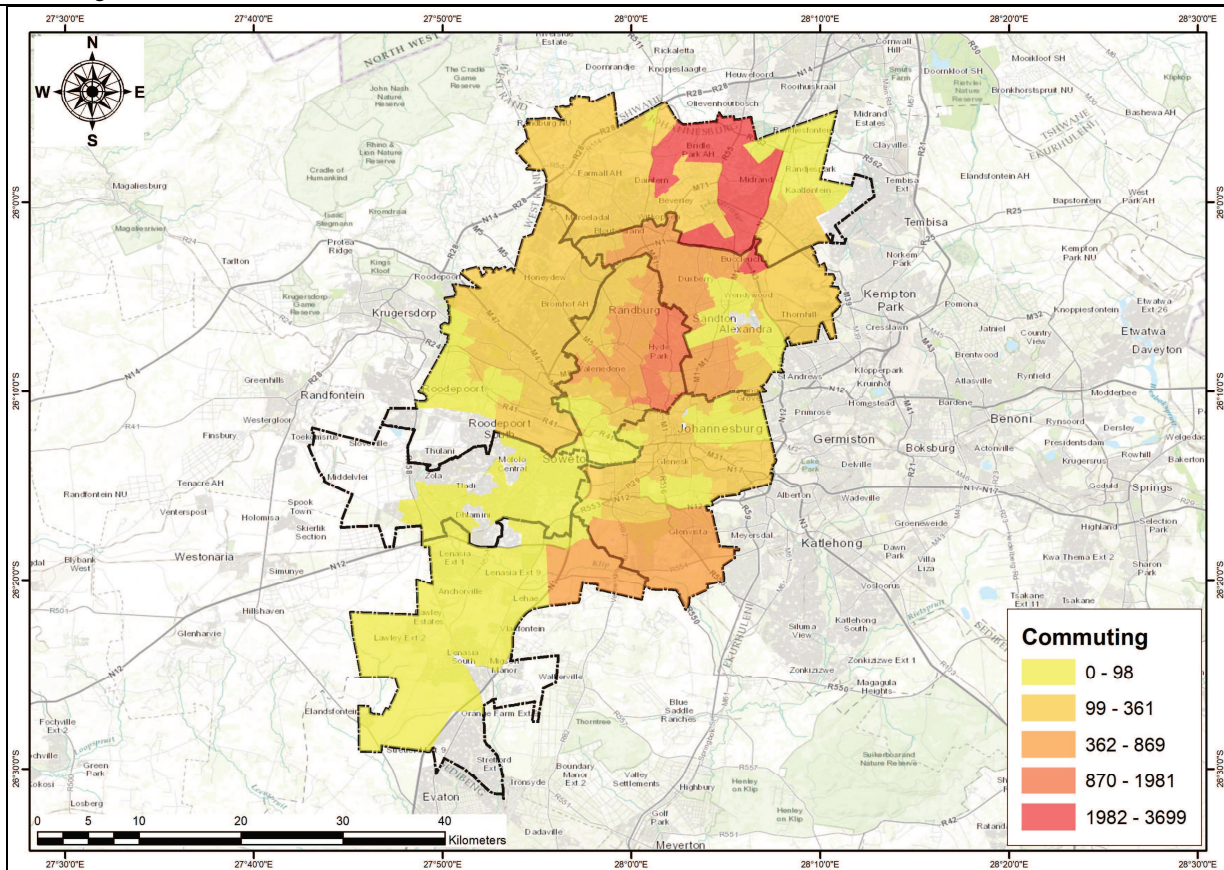


Fig. 2: Commuting cycling trips in Johannesburg for the year 2017.

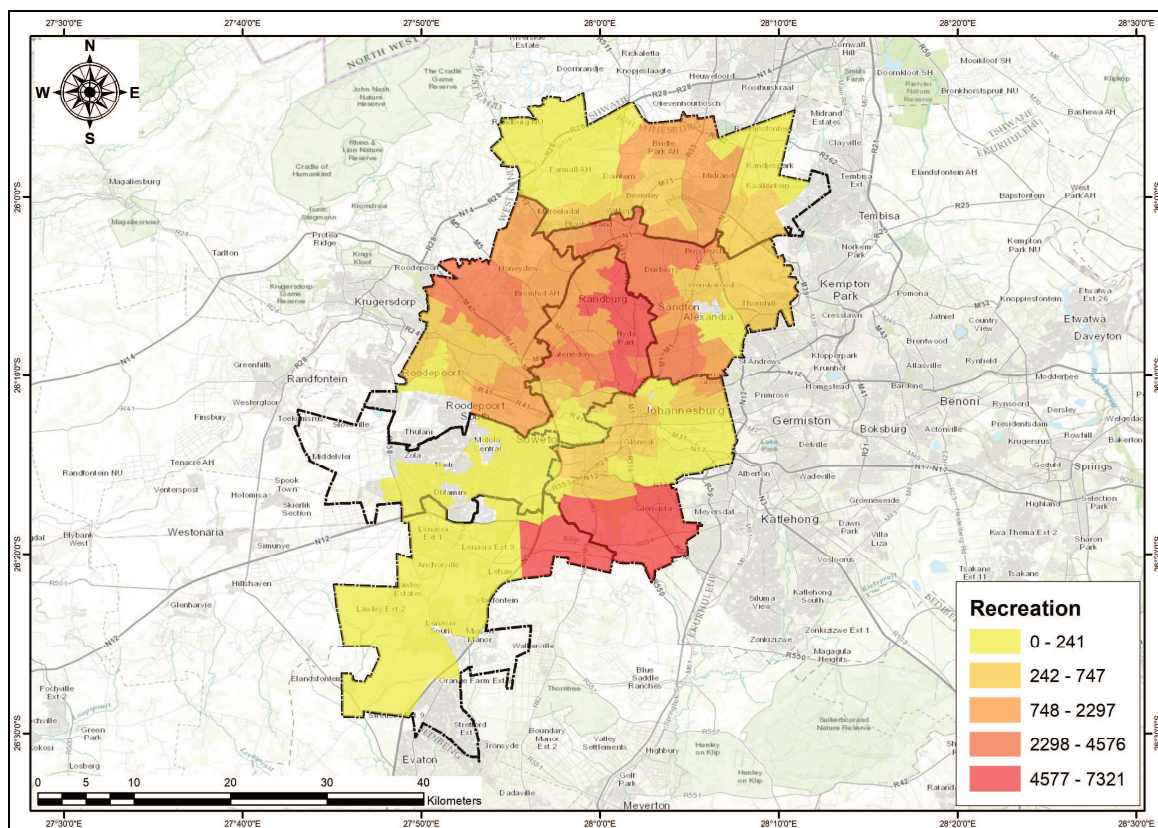


Fig. 3: Recreational cycling trips in Johannesburg for the year 2017.

It was observed during the study that the northern and northwest suburbs such as Parkview, Carlswald, Hyde Park, Sandton, Randburg and Midrand comprise the highest number of cycling activities; with between 1675 8320 cycling trips in a year 2017. Hyd Park and adjacent suburbs in Sandton are the hot spots of

cycling activities in the city. This pattern is also large in both recreational and commuting cycling (see figure 2 and 3). Notably, the Kibler Park, southeast of the city is the hot spot for both recreational and commuting cycling activities. The townships such as Lenasia and some part of Soweto located in the south of the city are cold spots of cycling activities with limited to no cycling activities. Figure 2 below illustrates commuting cycling trips in Johannesburg for the year 2017, whilst figure 3 illustrates recreational cycling trips in Johannesburg for the year 2017

4.1 Analysis of motorised and non-motorised spatial integration

During the study revealed that most of most of motorised and non-motorised operations are spatially disintegrated. There is limited to no sharing of infrastructure between commuting, cycling and walking in the city. Gautrain and Rea Vaya public transport modes are spatially disintegrated with the cycling activities (see figure 4). In most of public transit stops there is no adequate cycling and walking infrastructure, and public transit stops are not well accessible for non-motorised transport. Thus this affects the effectiveness and conveniently switch from either motorised to non-motorised public transport or non-motorised to motorised public transport. The results further demonstrate that the public transport interchange hub of the City of Johannesburg, the Park Station is the most integrated hub that serviced by both motorised and non-motorised; and public transport commuters at the station switch from one mode to another mode of public transport smoothly at a short walking distance. Figure 4 below illustrates the spatial coverage of Gautrain and Rea Vaya public transport modes as well as Johannesburg cycling activities.

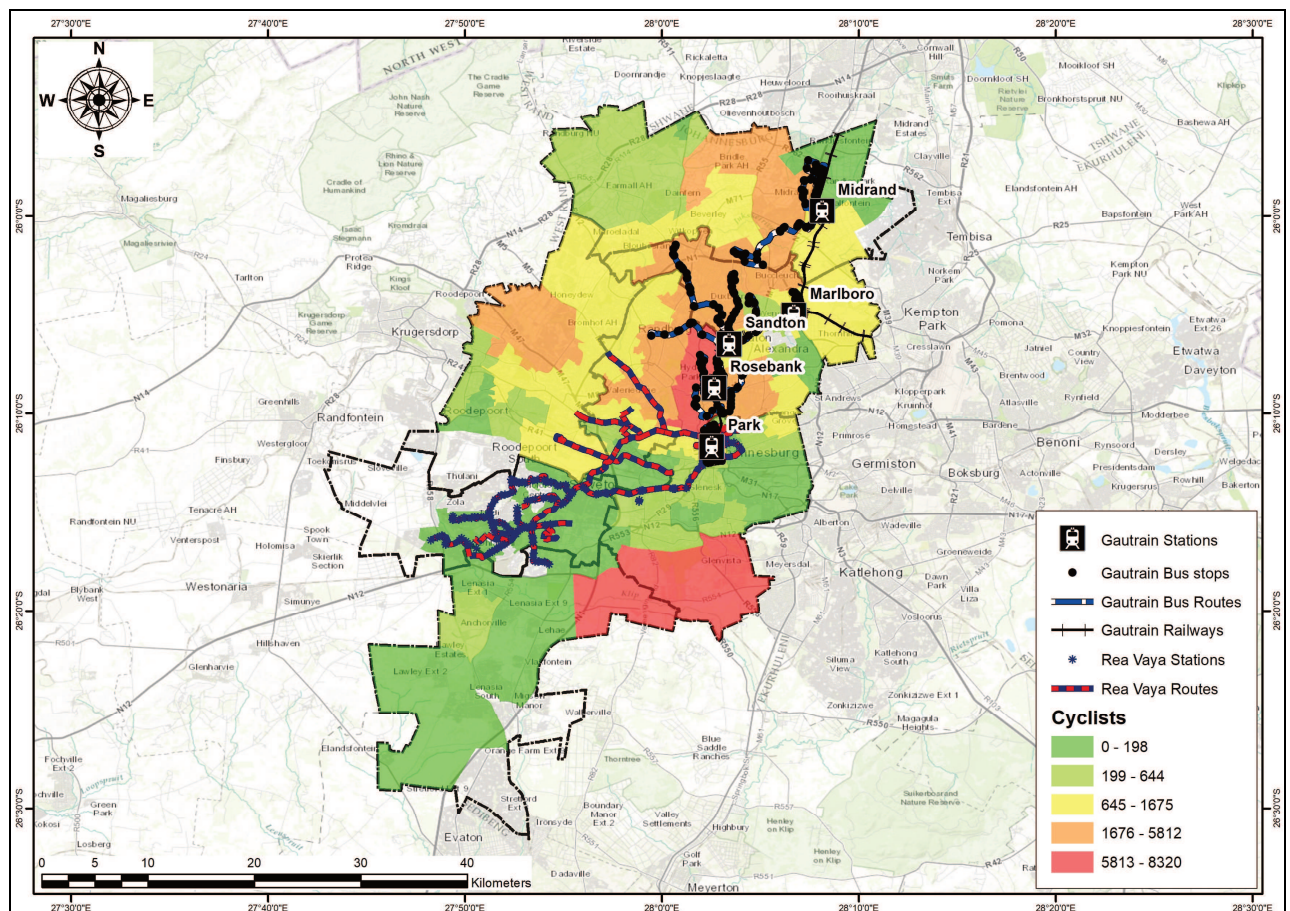


Fig. 4: The spatial coverage of Gautrain, Rea Vaya and cycling activities within City of Johannesburg.

From the spatial coverage illustrated above in figure 4, facilitating the integration of cycling and public transport modes is found to be capable to enlarge the catchment area for transit (Risimati and Gumbo, 2018). The predominant approach for integrating cycling and transit modes is to bring cycling on board transit vehicles. Although, Rea Vaya with the City of Joburg is committed to building cycle lanes, safe bike storage at bus stations and even cycle maintenance centres. Currently the City is busy with constructing 5 km of dedicated cycle lanes in Orlando, Soweto; implementing cycle lanes from Melville to Park Station as part of a University Corridor which will, in the following financial year, extend from Park Station to Doornfontein; design dedicated cycle lanes as part of complete streets in Orange Farm and Ivory Park with a focus on

schools; and develop an Integrated Transport Network which will include long-term city wide public transport, cycling and freight network. Joburg's liveability is highlighted in the Growth and Development Strategy (GDS2040), which serves as a guideline to creating a city that will be inclusive and sustainable in the future. During the consultative sessions for Joburg's Growth and Development Strategy (GDS2040), cycling was among the potential solutions to congestion on the city's roads.

The City of Johannesburg is committed to encourage cycling among commuters. Teaming up with the City, Rea Vaya, will ensure each station has safe bike storage facilities and also plans bike service stations for bike repair. According to the City, "Investing in the public realm in the immediate vicinity of such facilities such as upgraded lighting, CCTV, public conveniences can also support cyclists. The broader movement patterns to and from the Rea Vaya, Metrorail and Gautrain stations and major taxi ranks are being identified and the relevant paths and streets upgraded with pavements, signage, lighting. This is already underway in respect of Rea Vaya in Soweto." Creating a network of pedestrian and cycle routes is meant to protect people from cars and other traffic, which is essential to grow the popularity of cycling in the city. "So in addition to aiming for streets to be 'complete' there will be a focus on creating continuous routes and networks through the cycling and pedestrian infrastructure that is created in the complete streets programme. The aim is to create a dedicated network of high quality-pedestrian and cycling routes," said the City. The City's Framework for Non-Motorised Transport (2009) has mapped ten priority networks, using multiple criteria for designing the routes. The priority areas for this network indicated a potential, more extensive network based on modelling short trips (under 8 km) that are made in the peak periods for the present and also looking forward to 2040.

5 DISCUSSION

5.1 Improving bicycle and pedestrian environments

Improving the cycling and pedestrian environment is a desirable method for enhancing the non-motorised transit access and promoting transit ridership. The introduction of bikeways and sidewalks to the auto – dependent or auto-dominant streetscapes, complete with street furniture, landscaping, pedestrian-scaled lighting, and other features, makes roadways more inviting for people to travel by bicycle or on foot. The areas around the stations and stops covered by public transport systems should be expanded by 42% after the implementation bike lanes. Further places from the public transport stations or stops can reach the service if a safer and more comfortable bicycling environment is available. In addition, the cycling and walking infrastructure is much less expensive to build and maintain than highways and parking garages.

5.2 Integration cycling and public transport modes

Effort facilitate integrating cycling and public transport modes are found to be able to enlarge the catchment area for transit (Risimati and Gumbo, 2018). The predominant approach for integrating cycling and transit modes in the United State is to bring cycling on board transit vehicles. "In the year 2015, about 77% of new United State buses were equipped with exterior cycling racks, up from 32% in 2001 (Neff and Dickens, 2017). Thus, compared with the costs of increasing rail cars, buses and automobil facilities, it is much cheaper to install cycling racks at public transit stops and stations. Cycling racks have been popular with commuters, but they frequently run up against capacity constraints, typically two or three cycles on bus's front rack. An alternative to bringing cycling on board transit vehicles is bike-sharing programmes. Bike sharing programmes have been observed as ways to address the first and last mile problem and to connect commuters to public transport networks.

5.3 Promoting cycling-based transit oriented development

Studies have demonstrated that land use significantly impacts traffic mobility and an effective approach to reduce vehicle travel is through land use planning (Risimati and Gumbo, 2018; Moyo and Musakwa, 2016; Wei et al., 2017). Transit-oriented development (TOD) is a strategy that attracts more people and employment situated within walking or cycling distance to transit to promote public transport ridership and mobility. TOD involves very well the number of population and employment opportunities within public transport catchment areas. A common consideration is that the larger the catchment area is and the denser the population and employment opportunities are; the higher the transit travel potential is (Andersen and Landex, 2008). The more people residing and employed around public transport stations, the greater the probability that the service will be used. Using cycling-transit catchment areas in City of Johannesburg as TOD zoning

units allows more population, especially families with no cars, to access a wider variety of services and opportunities by transit.

In the land use and transportation planning, connecting employments, institutes, and services with communities through public transportation, accompanied with safe, direct, and comfortable cycling access to public transit at communities and other activity ends, would increase the safety and number of cycling-transit trips in the city. In the cycling-based TOD development, the availability of secure and convenient parking is critical for better integration of bicycle and public transport systems. Improving the availability of parking near public transport systems stops is beneficial to promoting cycling-transit trips (Pucher and Buehler, 2009), and good-quality cycling parking facilities are most useful to regular commuters (Bachand-Marleau et al., 2011). Priority siting of parking amenities near the public transport loading zone allows cycling transit operators to be free from carrying cycles up or down stairs or through large crowds of public transit commuters, and this is especially helpful to children, female, and elders. Facilities, including lockers, cycle cages, and storage rooms, for long-term parking (usually four or more hours), and bicycle racks for short-term parking should be provided associated with travel demand. Bicycling could be off-limits to some people who need to tote kids around, providing a kid's seat on bikes may be a possible solution to expand the use of bicycle and enhance cycling-transit integration. A kid-friendly bike sharing providing tiny bikes and helmets for toddlers allows kids to ride with families and encourage more kids to bicycle. By introducing the very young generation to the green transportation, it's beneficial to preparing for the future of a more sustainable society.

6 CONCLUSION

To conclude, this study explored the extent of spatial integration of non-motorised and motorised public transport infrastructures within the City of Johannesburg. The crowd-sourced datasets derived from the geolocation based mobile application Strava were useful in this study. Although, the study results demonstrated that the public transport interchange hub of the City of Johannesburg, the Park Station is the most integrated hub that serviced by both motorised and non-motorised; and public transport commuters at the station switch from one mode to another mode of public transport smoothly at a short walking distance. Although, the results further reveal that the most of motorised and non-motorised networks are not integrated; thus affects the effectiveness and conveniently switch from either motorised to non-motorised public transport or non-motorised to motorised public transport. As such, improving the cycling and pedestrian environment is a desirable method for enhancing the non-motorised transit access and promoting transit ridership. The introduction of bikeways and sidewalks to the auto-dependent or auto-dominant streetscapes, complete with street furniture, landscaping, pedestrian-scaled lighting, and other features, makes roadways more inviting for people to travel by bicycle or on foot. The areas around the stations and stops covered by public transport systems should be expanded by 42% after the implementation bike lanes. Furthermore, Bike sharing programmes have been observed as ways to address the first and last mile problem and to connect commuters to public transport networks. In addition, Transit-oriented development (TOD) has been chosen as a strategy that attracts more people and employment situated within walking or cycling distance to transit to promote public transport ridership and mobility.

7 REFERENCES

- Andersen JL, Landex A. Catchment areas for public transport. *WIT Transactions on the Built Environment*, 2008.
- Bachand-Marleau, Julie, Jacob Larsen, and Ahmed El-Geneidy. "Much-anticipated marriage of cycling and transit: how will it work?" *Transportation Research Record: Journal of the Transportation Research Board* 2247: 109-117, 2011.
- Cao Z, Simon T, Wei SE, Sheikh Y. Realtime multi-person 2d pose estimation using part affinity fields. In *Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition 2017* (pp. 7291-7299).
- Moyo, Thembanani, and Walter Musakwa. "Using crowdsourced data (Twitter & Facebook) to delineate the origin and destination of commuters of the Gautrain public transit system in South Africa." (2016).
- Musakwa, Walter. "The use of social media in public transit systems: the case of the Gautrain, Gauteng province, South Africa: analysis and lessons learnt." (2014).
- Pucher J, Buehler R, Merom D, Bauman A. *Walking and cycling in the United States, 2001–2009: evidence from the National Household Travel Surveys*. American journal of public health, 2011.
- Risimati, Brightnes, and Trynos Gumbo. "Examining the Role of Public Transport Interchange Hubs in Supportive Public Transport Integration in City of Johannesburg." In *REAL CORP 2018—EXPANDING CITIES—DIMINISHING SPACE*. Are "Smart Cities" the solution or part of the problem of continuous urbanisation around the globe? *Proceedings of 23rd International Conference on Urban Planning, Regional Development and Information*, pp. 207-214. CORP—Competence Center of Urban and Regional Planning, 2018.

- Risimati, Brightnes, and Trynos Gumbo. "Exploring the Applicability of Location Based Services to Determine the State Routes Transport Networks Integratedness in the City of Johannesburg." In REAL CORP 2018–EXPANDING CITIES–DIMINISHING SPACE. Are “Smart Cities” the solution or part of the problem of continuous urbanisation around the globe? Proceedings of 23rd International Conference on Urban Planning, Regional Development and Information, pp. 225-234. CORP–Competence Center of Urban and Regional Planning, 2018.
- Risimati, Brightnes, and Trynos Gumbo. "Exploring the Applicability of Location-Based Services to Delineate the State Public Transport Routes Integratedness within the City of Johannesburg." *Infrastructures* 3, no. 3 (2018): 28.
- Risimati, Brightnes, and Trynos Gumbo. "Exploring the Applicability of Location-Based Services to Delineate the State Public Transport Routes Integratedness within the City of Johannesburg." *Infrastructures* 3, no. 3 (2018): 28.
- Selala, M. K., and W. Musakwa. "The potential of strava data to contribute in non-motorised transport (Nmt) planning in Johannesburg." (2016).