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The riddled city – where demographic change adds to the woes of urban sprawl

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1 ABSTRACT

International research on sustainable urban development largely focuses on negative growth-related aspects, known as urban sprawl. However, the realities of demographic change in the Western world are increasingly working against the forces of growth, and many urban areas are going to be or already exposed to the forces of decline. If current population projections hold true, the maintenance of urbanity, quality of urban life and infrastructure efficiency will be a major challenge for generations to come. The purpose of this paper is to introduce methods and procedures to monitor the impact of demographic change on urban systems in Germany. We especially focus on cost implications of demographically driven changes of urban land use and urban form. The paper presents indicator implementations for land use, population, and housing data to identify where cities are already affected. In addition, it looks at disaggregated projections on population, housing, and infrastructure to identify future problem areas. Put into the context of urban sprawl dynamics that we presented in earlier contributions, the results provide valuable information on long-term sustainable planning directions.

2 INTRODUCTION

There is widespread agreement that urban land use patterns and the cost for providing neighbourhood and community services such as roads, public transport, water supply, sewer disposal and schools are closely interlinked. Urban sprawl characterized by low density development, large outward expansion and a leapfrog growth pattern raised suspicion of producing much higher infrastructure expenditures compared to a compact urban form. The way our cities and metropolitan areas grow obviously influences the efficiency of public infrastructure.

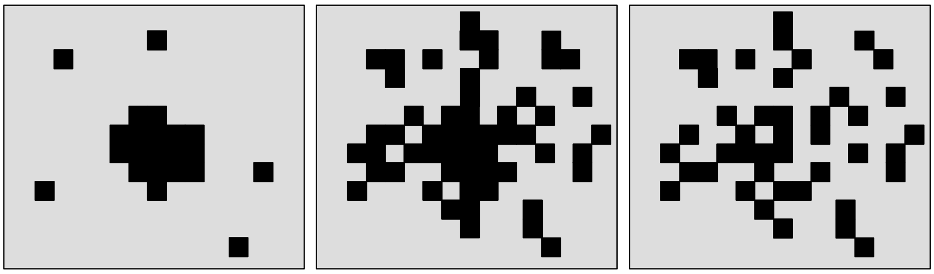
Given the fact that most developed countries and nearly all developing countries are still experiencing population growth and expanding land and infrastructure needs, it is not surprising that previous research on the cost of urban sprawl has always been conducted from the perspective of growth. The majority of available cost-of-sprawl studies intend to show that substantial infrastructure cost savings can be achieved by increasing urban densities and locating new development near to existing built-up areas. However, more and more European regions are already facing population decline accompanied by housing and infrastructure overcapacities. Does the problem of sprawl come to rest with the end of urban growth?

Based on recent empirical work in this field, we believe that urban sprawl, its main physical features, and its negative outcomes on the efficiency of urban infrastructure systems are not merely a by-product of urban growth. Quite the contrary, in the absence of an effective land use management, future demographic decline could lead to a costly "shrinkage sprawl" (see Table 1, see also Siedentop/Fina 2009 and Nuissl/Rink 2005). Recent experience in Germany demonstrates that the decrease of population densities and the incremental perforation of urbanized areas (as brownfield land or underutilized urban areas) are strongly linked with additional costs due to inefficient infrastructure operation grades: fewer residents have to pay more for oversized facilities.

The purpose of this paper is to introduce methods and procedures to monitor the impact of demographic change on urban development in Germany. It presents indicator implementations for land use, population, and housing data to identify where cities are already affected. In addition, it looks at disaggregated projections on population, housing, and infrastructure to identify future problem areas. Put into the context of urban sprawl dynamics that we presented in earlier contributions, the results provide valuable information on long-term sustainable planning directions.

3 EMPIRICAL EVIDENCE ON THE COST OF SPRAWL

Following the general concern over urban sprawl and its alleged environmental and social implications, the literature on the relationship between infrastructure cost and urban form has grown rapidly during the past decade. Most of these studies suggest that low density development is costly and inefficient in terms of constructing, operating and maintaining network-related technical infrastructures. Based on empirical case studies as well as modelling studies researchers found that per-capita infrastructure costs are significantly affected by the type, form and location of residential and commercial development. Three key attributes of urban form on different spatial scales can be addressed with a view to per-capita or per-unit costs of providing infrastructure services.



Key issues	"(historical) Compact City"	„Growth Sprawl“	„Shrinkage Sprawl“
Development stage	until 1960	1960 – 2000	from 2000
Population growth	moderate/high	high	negative
Dominating growth pattern	concentric	leap-frogging	-
Urban form	compact	dispersed	highly dispersed
Urban density	high	moderate/low	low
Centrality	monocentric	polycentric/dispersed	none
Infrastructure efficiency	high	moderate/low	low

Table 1: Shrinkage sprawl as a stage in urban form evolution

First, at the neighbourhood level the residential density is directly linked with the expenditure on neighbourhood infrastructure: the higher the density the lower the per capita length of residential roads, water distribution lines or sewer collection lines (Ecoplan 2000; Doubek/Zanetti 1999). Secondly, at the subregional level the spatial arrangement of development, especially the degree of centralization and contiguousness of built-up areas is of particular importance. In compact, contiguous patterns, infrastructure costs are significantly lower than in spread-out patterns (Carruthers/Ulfarsson 2003; Speir/Stephenson 2002). Thirdly, the spatial distribution of service areas affects per-capita costs on the regional level. Urban systems with a higher concentration of built-up areas in central cities offer better opportunities for the use of economies of scale (e.g. the use of larger treatment plants): in large cities, fixed costs spread over a larger number of people, so that the per capita costs are lower than in small towns or spread-out subdivisions.

The question now is: what are the effects of decreasing urban densities on infrastructure costs? The few studies in this domain that exist have reported that per-capita costs for providing and maintaining technical infrastructure increase in line with the decrease in urban density (Koziol 2004; Siedentop et al. 2006). Compared to social infrastructure such as schools or public health services, the technical supply economy is less capable of adapting its cost structures to shrinking population figures. As a result, per-capita costs rise due to efficiency losses. For example, increasing (overhead) costs are incurred by the necessity to keep up an ubiquitous provision with decreasing population figures ("duty to supply"), by the immobility and indivisibility of facilities (for example the necessary minimum size of water treatment plants), as well as the share of fixed costs (70-80 percent with technical infrastructure networks). Consequently, areas with population decline will have to accept higher costs if the existing infrastructure provisions are to be kept and maintained. Alternatively, a development path where infrastructure services adapt with a time lag to the decreasing demands is described as "cost remanence" (see Figure 1).

In addition to the problem of income losses because of lost fees, which in the beginning is the most critical problem for the providers, additional mid-term and long-term costs emerge due to necessary operation-related improvement measures. For example, costs arise if the amount of time in which the water remains in the drinking water networks increases because additional flushing of the pipes is necessary in order to prevent the water from being contaminated by germs. The case is similar for sewage pipes where additional flushing is necessary to prevent offensive odours and deposits in the pipes.

The tolerance and affordability for operational and building underutilization differs depending on the type of infrastructure. With respect to sewage treatment and district heating, it is estimated that an underutilization of 20 to 30 percent% compared to the original rated network capacity will already require operational measures. The drinking water and electricity supply are much more robust; measures like the ones just mentioned are only necessary when the operation grade is below 60 to 70 percent of capacity. Moreover, if underutilization figures fall below 50 to 60 percent for sewage, district heating and gas capacity, and 70 to 80 percent for drinking water and electricity capacity, additional building measures might be necessary (Freudenberg, Koziol 2003).

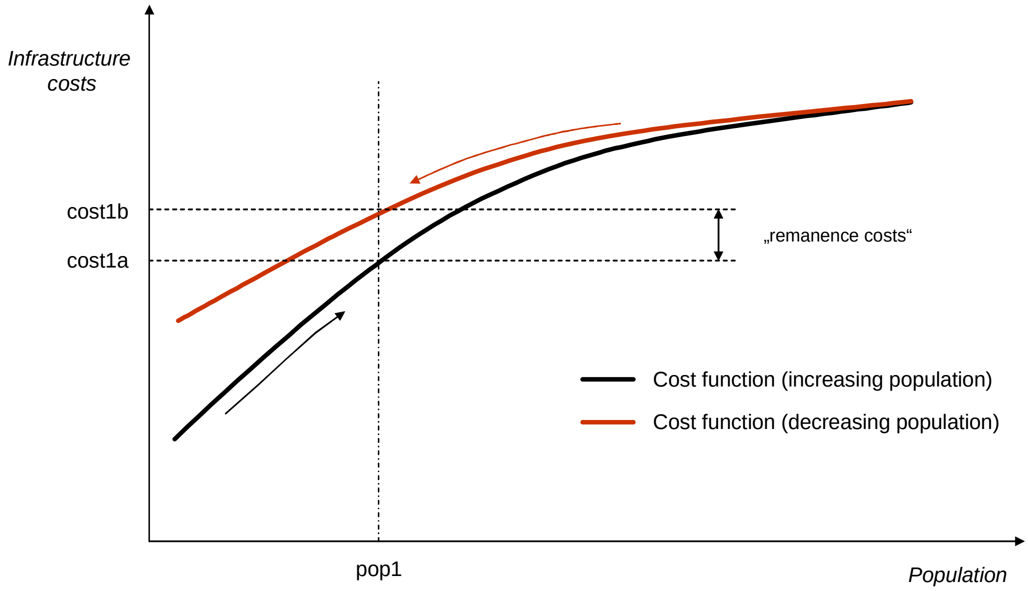


Fig. 1: “Cost remanence” in the case of decreasing demand on infrastructure services (adapted from Junkernheinrich, Micosatt 2005)

4 FROM “GROWTH-SPRAWL” TO “SHRINKAGE SPRAWL”

In many parts of Europe a new “post-growth” urban era is emerging. The German Federal Office for Building and Regional Planning estimates that in 2005, 25 percent of all Europeans lived in cities or metropolitan areas with shrinking populations (Gatzweiler et al. 2006). In Germany, the population has declined since 2003, due to a decreasing migration surplus and a negative natural population development. The latest forecast issued by the Federal Statistics Office predicts a population decrease of between 8 and 13 million people by 2050 (Statistisches Bundesamt 2006).

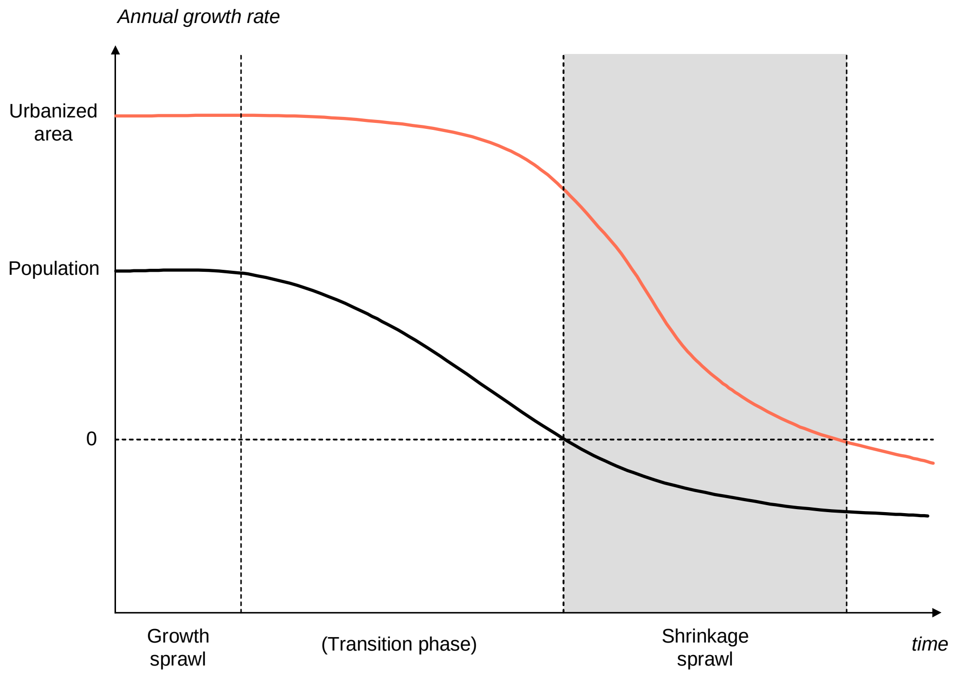


Fig. 2: From “growth sprawl” to “shrinkage sprawl

One could assume that urban shrinkage should discourage urban sprawl because fewer residents require fewer housing units, less urbanised land, and less infrastructure. However, major factors work against this logic in Germany. Firstly, it is the ongoing demographic trend towards smaller households which counterbalances the negative effect of population decline on housing demand. Secondly, the fiscal competition between communities to attract new inhabitants and companies leads to the provision of newly urbanised land for housing as well as for industrial and commercial land uses, supported by tax regulations and public subsidies for economic development. Thirdly, the “planning routines” of local land use planners still tend to favour greenfield development, because brownfield development is perceived as more complicated and risky. Based on recent data on German population and land use, a characteristical three-stage sequence for urban land use can be observed (see Figure 2). In stage 1, called “growth sprawl”, annual growth rates of population and urbanised areas are positive with urban growth outpacing population growth. Stage 2, a period of transition, is characterized by a growing imbalance of urban and population growth. While the annual population growth drops, the growth of urbanised areas remains high. Stage 3, called “shrinkage sprawl”, shows a negative population development accompanied by a fall in urban growth rates. In addition to these three characteristical stages, a fourth stage with a negative growth of urbanised areas can be expected in regions that are faced with a severe decline in population figures.

5 MEASURING SHRINKAGE SPRAWL

From an empirical point of view, there is currently no agreement how urban sprawl can be measured in quantitative terms. Although much research has been devoted to discuss suitable indicators and related frameworks, the multi-faceted causalities and unique urban development paths of city environments have so far been an insurmountable barrier for the formulation of an agreed upon methodology. Although most research suggests that there are different forms of urban sprawl – one of them is the “shrinkage sprawl” type described in the previous section – the limited understanding of urban sprawl as a process of market-led urban development is still wide-spread. One could argue that shrinkage sprawl as an urban development process warrants its own definition, separate from urban sprawl. At the same time it is our intention to clearly show the similarities in the effect on urban forms, which is declining urban densities and related efficiency problems as described above. For this reason, we define shrinkage sprawl as a mature type of urban sprawl that is characterised by demographic change and low-density urban area developments. The result is a cumulative effect of declining urban densities. Demographic change, in this context, is made up of two components:

(1) An aging population, caused by low fertility rates and low death rates

(2) The migration balance of an area

The following analysis will therefore focus on the detailed description of shrinkage sprawl in terms of its demographic driving forces, and propose suitable indicators, data, and methodological considerations for analysis. On top of well-known indicators that focus on visible trends for recent statistics, we include measures that reflect upon expectable development paths in terms of demographic change and urban sprawl, and long-term forecasts on population, housing, and land consumption. The conceptual background has been explained in section 2 (see figure 2) – the challenge is now to benchmark empirical data against these development paths.

5.1 Indicators

Indicators that aim at measuring shrinkage sprawl need to incorporate aspects of population change, land consumption and configuration, and related density effects. There are a range of limitations we adhere to with this contribution with respect to available datasets. One problem is the aggregation level for which this data is available. On an area-wide basis, the variations can currently only be shown for the administrative hierarchies of municipalities, forecasts are limited to counties or spatial planning units. The reason is that more detailed area statistics are not available below these levels. A more disaggregated research approach would require data collection and harmonisation work that is not feasible for an area-wide coverage. The items in table 2a & b therefore focus on indicators that are suitable to reflect upon shrinkage sprawl for available datasets. The corresponding maps illustrate sample implementations of the said indicator based on area statistics, where a uniform 10km-grid was used for data harmonisation and visualisation. From a technical point of view, this process uses polygon-in-polygon arithmetic in a GIS for data transformation. From a conceptual point of view, the indicators are characterised by two defining attributes: (1) static vs. dynamic indicators, and (2) simple vs. composite indicators. The first differentiation relates to the base year for which a measure is calculated, i.e. if it demonstrates a certain situation for one snapshot in time (like 2.7: aging index), or if it tracks changes over time (like 2.3: urban density decline). In the second differentiation, simple indicators focus on the visualisation of one statistics element (for example 2.8: migration losses for people aged 25-50), whereas composite forms are based on two or more elements, mostly in the form of a weighting mechanism for area or housing (for example 2.4: new houses per hectare of new urban area). Area (in the form of total, urban or residential area) is used more often to characterise urban sprawl processes, housing (buildings, dwellings, households) is more prominent when it comes to the description of demographic change. The reason for this difference is mainly owed to methodology and data availability: where urban sprawl is often related to low density developments at the urban fringe, demographic change causes densities to decrease within the existing urban compound. From a methodological point of view, the former is therefore open to analysis of spatial datasets on the amount and structure of new urban land, the latter can only be characterised by studying statistics on occupancy rates and housing structures.

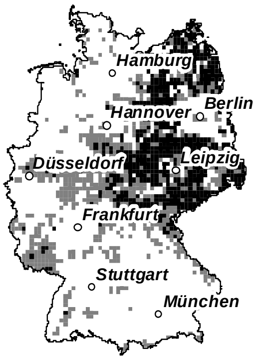
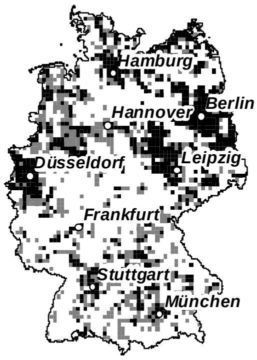
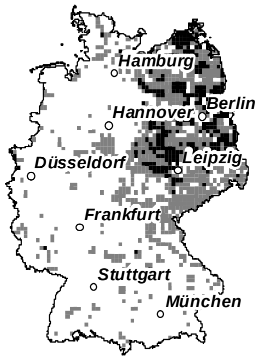
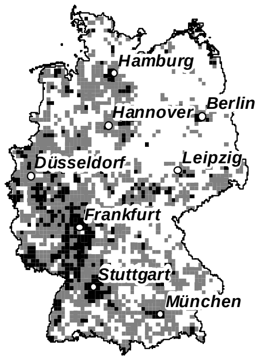
2.1 Population decline, 1996-2004	**2.2 New urban area in hectares per 100 km2, 1996-2004**	**2.3 Urban density decline, 1996-2004**	**2.4 New houses per hectare of new urban area, 1996-2004**
SP has traditionally been seen as a growth-related phenomenon. However, there is strong evidence that similar patterns emerge when population is in decline. In contrast, DC is usually characterised by aging or population decline, depending on the cohort structure of the population.	SP dynamics are characterised by extensive amounts of new urban area. Under DC conditions, demand for new urban area is likely to decrease on the long run - otherwise significant amounts of oversupply are being generated. This is a typical characteristc of shrinkage sprawl, reinforcing the decline of urban density.	Indicator for changing urban forms, initially used to measure the effects of sprawling, low density, ribbon or leapfrog developments under growth conditions over time. Under conditions of demographic decline, a strong effect from population decline can be expected.	Efficiency indicator, measures how many new buildings have been constructed compared to the land provided (new residential area in hectares). In the SP context, low values reflect typical extensive use of land. Under DC conditions, low values indicate oversupply of new residential area and low density development.
			
> 5% 0 - 5%	< 100 101 - 150 > 150	> 25% 10 - 25% < 10%	< 5 5 - 10 > 10

Table 2a: Selected indicators for shrinkage sprawl

5.2 The current situation

The maps in table 2a & b illustrate implementations for each indicator, giving an initial overview for the state and risks of shrinkage sprawl in Germany: the first map (2.1) shows where population decline occurred in the years 1996-2004. This has foremost been the case in the former East German areas, with the exception of the suburban belt around Berlin. In the same time period, these areas have also been characterised by high amounts of new urban area (see 2.2), despite declining population. The map on urban density decline (2.3) shows the resulting drop in densities which are significantly higher than population decline would have caused by itself. Accordingly, living space in the form of residential buildings per 1000 people (indicator 2.5) increased significantly, in some areas by over 10%. The implementation for 2.4 (new houses per hectare of new urban area) shows where new urban area is used inefficiently, which is evidently the case in much of Eastern, to a lesser degree also in north-western Germany and some parts of Bavaria. The results presented so far portray some well-known facts. The overarching drivers are related to the consequences of Germany's reunification: the subsequent population dynamics, in combination with land-extensive economic initiatives and laissez-faire policies provided much of the substance for what we now label the prototypical shrinkage sprawl. The next three items in the table, however, show more subtle trends that aim to reflect upon demographic preconditions for shrinkage sprawl. They give an idea that much of Western Germany will also have to deal with shrinkage sprawl in the near future. The aging index (2.7) is relatively high in the southern parts of the Eastern German states, also in some areas of Rhineland-Palatinate and Hesse. The balance of people aged 25-50 leaving an area (per thousand residents, indicator 2.8) is highly negative in remote areas of Mecklenburg and Brandenburg, and negative for large parts of the exurban areas in other states. The northwest areas of Schleswig-Holstein and Lower Saxony, are not affected by high values for the aging index or the migration balance. However, they have the highest shares of single-family homes (2.6), together with exurban parts of Rhineland-Palatinate, Bavaria, and the Northeast.

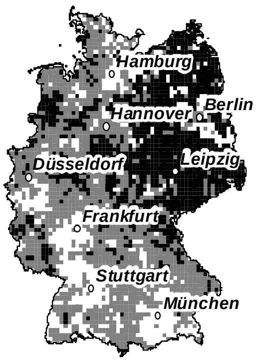
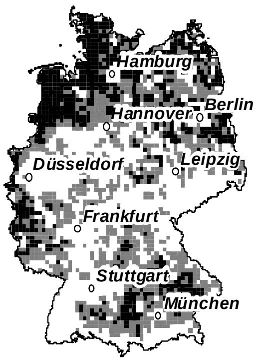
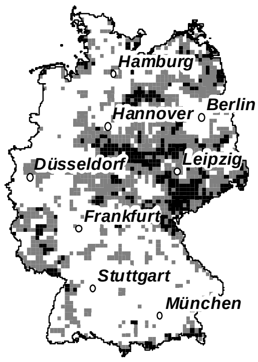
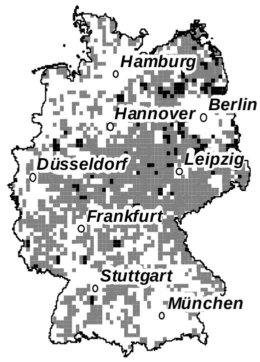
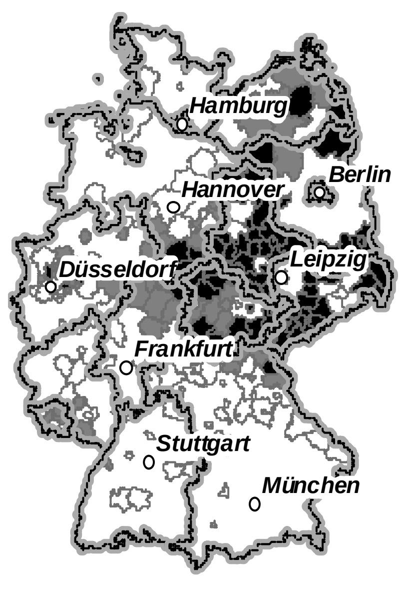
2.5 Change in buildings per 1000 people	**2.6 Share of single family homes 2005**	**2.7 Aging index**	**2.8 Balance of people aged 25-50 leaving an area (per thousand residents)**
Indicator for the consumption of living space per person. Under urban sprawl conditions, assumed to increase significantly due to extensive forms of living. Under DC conditions same effect caused by the remanence effect or population decline (vacancies).	The preferred housing form of SP-like developments is single-family homes - sprawling areas typically have a comparatively high share. Demographic change includes the argument that – at least in the German context – an aging population and the diversification of lifestyles will reduce the attractiveness of single-family homes for large parts of the society. It is also here where the remanence effect leads to the highest over-consumption of living space.	Aging is a defining element of the expected demographic change in Germany. The future population will have a higher share of old (65+) and very old people (80+). Areas with a high share of people aged 65 and above are therefore more likely to be affected.	Knowledge on the migration of young people is essential for the future demographic configuration of an area’s population. However, people under the age of 25 can not be assumed to settle permanently after migrating. It is more the age groups between 25 and 50 who settle permanently, become property owners, and become part of the future population. This indicator shows where – in balance – more people in this age group have left an area than moved into it.
			
< 5% 6 - 10 > 10%	< 65% 65 - 75% > 75%	< 20% 20 - 22,5% > 22,5%	> 5 0 - 5 < 0

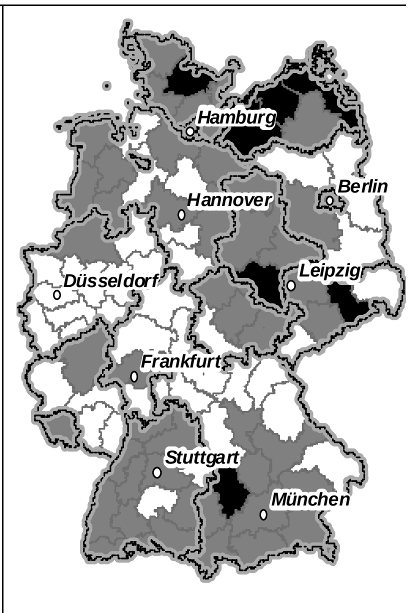
Table 2b: Selected indicators for shrinkage sprawl

Overall, the results of this part of the analysis are suitable to show where shrinkage sprawl occurs in a national perspective. In addition, the risk indicators (2.6 - 2.8) illustrate that other areas have certain conditions that can act as factors for future shrinkage sprawl. The underlying trends are inputs for future population forecasts that we analyse in the next section.

5.3 Projections

In order to substantiate our general assessment postulated in section 2 – the state of shrinkage sprawl in Germany – we analysed the results in the context of the forecasts shown in figure 3. Data has been sourced from the Federal Ministry of Building and Spatial Planning in the case of population and housing, based on the spatial planning outlook (in German “Raumordnungsprognose 2020”) published in 2005 (BBR, 2005). Initial results for an updated version for 2025 have recently been published (BBR, 2009), but for consistency reasons we have opted to use the previous version here. In terms of infrastructure, forecasts on land consumption for urban area are used as a generic measure for infrastructure requirements. The assumption is that infrastructure provision in terms of water, electricity, and transportation networks, as well as social services, will follow – in some variations – the provision of new urban land. The results of the settlement forecasting model “Panta Rei Regio” on future land consumption have been adopted for a preliminary analysis, using average daily land take rates from a paper map (Gesellschaft für Wirtschaftliche Strukturforschung, 2008): the method uses the average hectare value from each land consumption class and applies it to the timeframe 2004-2020. In the future, we intend to replace this approach with the actual model figures. Figure 3 gives an overview over the three prognosis elements: each of them provides disaggregated forecasts for the year 2020 on the county level in the case of population and housing, and the spatial planning units (in German "Raumordnungsregionen") for data on land consumption.





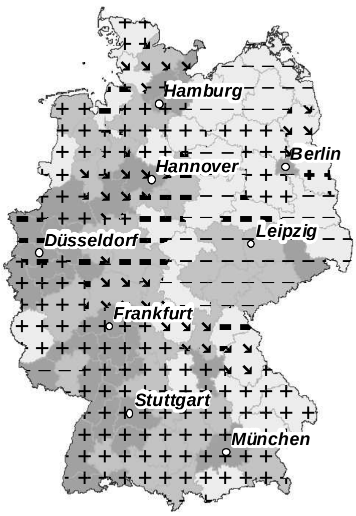
> 10%	< 15%	< 5%
5 - 10%	16% - 20%	6% - 10%
< 5%	> 20%	> 10%
Population decline, 2004-2020 (BBR, 2005)	Growth in building stock, 2004-2020 (BBR, 2005)	Urban land consumption (percent of existing), 2004-2020

Figure 3: Selected indicators for shrinkage sprawl

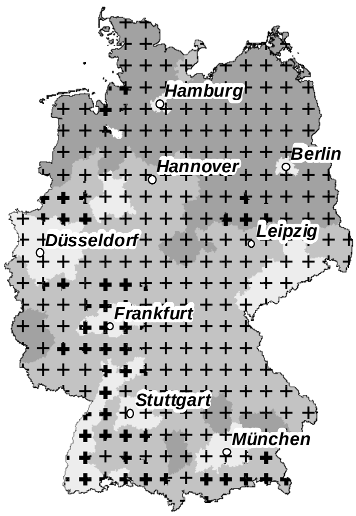
The map in the left-most column of figure 3 shows that population will decline further in much of the areas in Eastern Germany that are already affected by decreasing population numbers. There are also parts of Hesse (north of Frankfurt), Northrhine-Westphalia (around Düsseldorf) and in Saarland and Rhineland-Palatinate in the southwest where population decreases by 5 to 10 percent. To a lesser degree this is also the case in remote areas of Baden-Württemberg, Bavaria (northeast), Lower Saxony (around Hannover) and in the far northwest. In terms of the growth in building stock (see map in the centre of figure 3), all areas will add additional capacity, with much higher building activities in the south, in the central western states between Frankfurt and Düsseldorf, and in a band running from northern Northrhine-Westphalia to the west of Mecklenburg-Vorpommern. Following these forcasts, large amounts of new housing stock will also be made available for the surrounds of Berlin. The third map illustrates that there is a discrepancy between population development, housing provision and new urban land. Urban land consumption rates (= residential, industrial and transport-related land) are increasing by over 10 percent (black) in parts of Schleswig-Holstein, Mecklenburg-Vorpommern (black areas in the very north), in Saxony (east and west of Leipzig), and in remote areas of Bavaria. Increases of 6 to 10 percent (grey) are wide-spread in the south where population increases, but also in many areas that will experience population decline, mainly in former Eastern states.

In order to assess the recent developments described in part 5.2 in the light of these forecasts, we calculated average yearly rates of change, and compared the resulting values for the observation period 1996-2004 against the expected rates of change for the years 2004-2020. For this purpose, all data was aggregated to the most detailed common denominator in terms of spatial resolution: the 97 spatial planning units of the Federal Office for Building and Spatial Planning. Figure 4 shows the results of this assessment on composite maps. The maps are designed to illustrate the predicted situation in 2020 on hand (in three shades of grey for low –

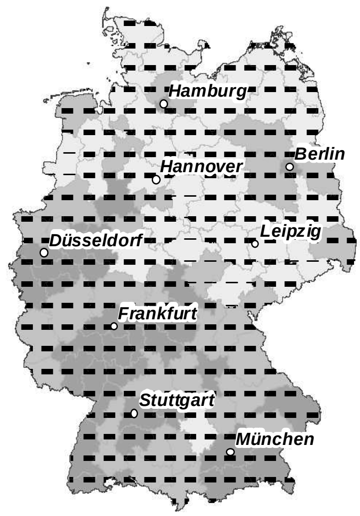
medium – and high values), and a comparison of recent versus predicted rates of change on the other (symbolised by plus and minus signs, and arrows for trend changes).



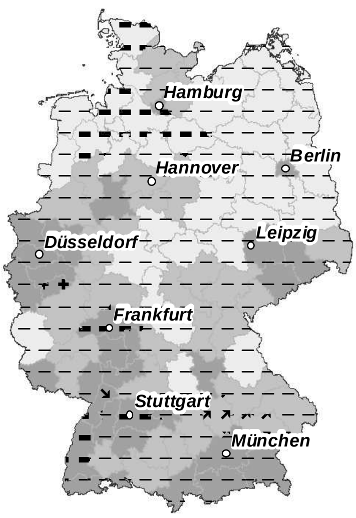
Map 4.1: Population change – Population density 2020



Map 4.2: Single-family homes per 1000 people – Share of single-family homes 2020 (of all buildings)



Map 4.3: New houses per hectare of new urban area



Map 4.4: Change in urban density – Urban density 2020

Key for maps 4.1-4.5:

Annual rates of change 1996-2004 compared to predicted rates of change for 2004-2020

Decline	Growth
▬ Accelerated	+ Decelerated
− Decelerated	✚ Accelerated

Trend change

↘ Growth --> Decline

↗ Decline --> Growth

Value in 2020

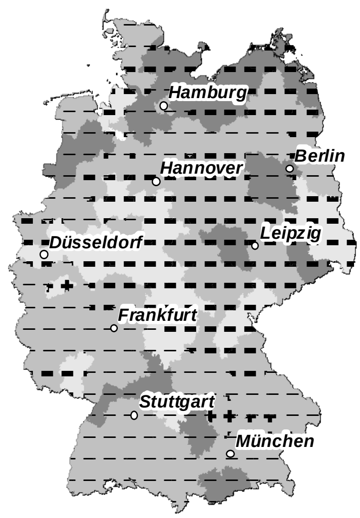
Low Medium High

see text for detailed description

Key for map 4.6:

Density decline due to:	Role of new urban area
▬ Demography	< 5%
− Demography & Sprawl	6 - 10%
(✚ Increase)	> 10%

see text for detailed description



Map 4.6: Urban density 2004-2020: population decline vs. new urban area

Figure 4: Selected indicators for shrinkage sprawl

For example, the map on population (map 4.1) shows where population density will be high (dark grey), medium (medium grey) or low (light grey) in 2020. The symbols indicate that much of the South, the West and Northwest, and areas around Berlin will continue to experience population growth, albeit with a decelerating rate of change compared to the years 1996-2004 (standard plus symbols). Bold plus symbols (east of Berlin) indicate that the rate of change is going to accelerate, i.e. population is increasing more in the future than in the recent past. Accordingly, standard minus signs show where population decline is going to continue with decelerating rates, bold minus signs depict areas with accelerated population decline. There are also instances where previously growing areas are predicted to decline in the future, symbolised through arrows pointing in a five o'clock direction (west of Hannover, north of Hamburg, north of Berlin, around Frankfurt). Corresponding instances where areas go from decline to growth (the symbol would show an arrow pointing to two o'clock) are not present on this scale and aggregation level.

Maps 4.2 to 4.4 are designed in the same fashion. The share of single-family homes (4.2) is highest in the northern and northeastern parts of the country, also in some patches in the central West and the South. Low shares can be found around the main agglomerations, the Black Forest in the Southwest, and southern Saxony. In terms of the dynamics, accelerated growth in the building stock can be expected for the southwest, around Frankfurt, south of Munich, and north of Düsseldorf, also north of Leipzig. In all other areas, the housing stock will continue to grow, but with lower rates of change than in the recent past. Map 4.3 shows housing densities for new urban area, which are generally higher in the southern and western parts of Germany, and within these areas highest in and around the agglomerations. What is critical in this context is the wide-spread acceleration of housing density decline, i.e. there will be no areas with increased housing density on the aggregation level of spatial planning units, and very few with a decelerated decline (namely in Thuringia and the very West of Lower Saxony. Map 4.4 confirms the decline in densities, in this case for urban density. In most areas the forecasts predict decelerated decline. Accelerated decline can be expected for northeastern parts of Lower Saxony (west of Hamburg), around Frankfurt, Stuttgart, and in the Southwest. However, the shades of grey show that the highest densities remain in and around the main agglomerations for 2020.

The design for the last map in this figure (4.5) differs from the previous ones. It shows where urban densities will decline in any case, even if no new urban area would be added from 2004-2020 (bold minus symbol: "density decline due to demography"). In other words, a hypothetical urban density based on population 2020 urban area 2004 was still lower than the actual urban density in 2004. This is the case in large parts of central Germany, also in the very North. The map also shows where densities would not decline because of population decline alone: here, it is the summarized effect of population decline and new urban area in the forecasting horizon that moves urban density development into the negative (standard minus symbol: "density decline due to demography & sprawl"). Such areas are widely distributed in the South and Southwest, also north of Düsseldorf and between Hamburg and Berlin. Some areas (central Bavaria, south of Düsseldorf) will exhibit increasing urban densities. In terms of the grey pattern in the background of this map, we implemented an assessment of the role that new urban area will play in the decline of urban densities. This was done by calculating a hypothetical urban density for 2020 with the amount of urban area that was there in 2004. We then compared these values to the predicted urban density for 2020, including the expected amount of new urban area from the forecasts. The results show that in some areas over 15 percent of urban density decline will be caused by new urban area additons, namely in the North on the border to the Netherlands, around Hamburg, southwest of Berlin, west and east of Leipzig, in a band north of Stuttgart, and also in the very South. In most other areas, the role of new urban area will be between 6 to 10 percent, in a band between Düsseldorf and Frankfurt less than 5 percent.

In summary, the maps presented here give a detailed overview over the factors that cause shrinkage sprawl and that will markedly continue to do so in most areas of Germany. On the one hand, they provide evidence that population decline is a fundamtal driver for declining urban densities (map 4.1, 4.4). On the other, it is obvious that future land use and housing developments (map 4.2, 4.3, 4.5) will significantly add to the problem. If forecasts are anything to go by, the current figures therefore demonstate the importance of more land-saving planning strategies and the support of more efficient housing forms.

6 CONCLUSION

Cost-of-sprawl studies claim that significant cost savings regarding infrastructure supply could occur if a better planned and more compact urban development is achieved. In contrast, in countries such as Germany, the infrastructure debate with regards to urban development is fundamentally different due to the effects of population decline. Some scholars point out that lower densities in urban areas are associated with an enhanced quality of life. Planned reduction of built density in the dense urban fabric of metropolitan cores creates opportunities for enhancing the quality of neighbourhoods and the establishment of lower density living in cities. Under the slogan "more green, less density", urban development in shrinking cities says "Good by" to a traditional policy of compact urban growth and densification. However, recent development patterns in Germany have to be addressed in terms of their infrastructure effects. Large amounts of vacant urban land, vacant housing, and underutilized supply networks and facilities raise the question whether cost-effective urban infrastructures can be sustained under conditions of demographic change.

This paper aims to identify areas where a new type of urban sprawl called "shrinkage sprawl" is evident. A number of widely accepted and new indicators show the current and expected future distribution of shrinkage sprawl in Germany. As an effect, an ongoing perforation process of urbanised areas can be expected, that leads to a dispersed and fragmented urban form. The potential outcomes of these processes with respect to infrastructure costs are problematic. Keeping all other factors constant, reduced urban density can be assumed to cause higher per-capita infrastructure costs. The point is that "growth sprawl" and "shrinkage sprawl" – although totally different in their causative factors – are quite similar in their negative effects on infrastructure efficiency. A dispersed and fragmented pattern of urban land use can be found in areas with intensive growth pressure as well as in areas with a severe decline of population and employment. Urban land use policies need to incorporate effective strategies to cope with this "post-growth" type of urban land development.

Future national and regional policies on spatial planning, infrastructure and real estate need to utilise strategies and instruments that focus more specifically on the root causes of land consumption. This means that the driving forces of greenfield development have to be taken into account when formulating strategies and choosing instruments. Demand-driven land consumption, which is still characteristic for flourishing western German urban centres, can predominantly be controlled with instruments that aim at land-saving settlement and urban forms and ensure environmentally compatible site selection. This can be achieved with regional planning instruments, for example with maximum development capacities in town and district plans, through strict controlling of local development, the definition of minimum densities for new developments, or price controls (tax, duties) for settlement and building forms that use land extensively. These policies are generally targeted towards private households, enterprises, and their land consumption, and communicated through zoning designations. In contrast, the recognisably increasing practice of fiscally motivated, (land) supply-oriented local development strategies requires more effective controls on town and regional planning policies. These controls are explicitly designed for municipalities and their development strategies. The objective is to engage local actors in an active reflection of their development and building policies, and to link the consents for further greenfield designations with plausible arguments for their actual need. In addition, further emphasis on the debate on development policies on the state level can help to increase awareness for more efficient land-savings in urbanisation and transport development.

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