# Super-diversity and urban development – challenges and possibilities of simulating future scenarios for the case of Berlin, Germany

H. Haacke*[1] and T. Lakes[1]

[1]Department of Geography, Humboldt-Universität zu Berlin, Unter den Linden 6, 10099 Berlin, Germany

*Email: hannah.haacke@geo.hu-berlin.de

## Abstract

The population is growing older and becoming more diverse. However, there is a lack of research on modelling the combination of an ageing population and the impact of super-diversity on it. Progress on this subject might have a huge impact on urban development, since those factors influence the spatial distribution of the (ageing) population. We therefore study data sets on the example of Berlin, and analyse them with statistical methods towards those factors. The aim of the analysis is the division of the population into groups, which will be the foundation for agents, states and transition rules in the modelling process which will be done with ABM and/or CA. Some examples and division possibilities will be given as well as a discussion of challenges for future research directions.

**Keywords:** spatial simulation, demographic changes, urban development, agent-based modelling, cellular automata.

## 1 Introduction

Super-diversity is a concept based on a higher diversity of migration. Vertovec (2007) introduced the term to describe the more diverse background of immigrants in England. In recent years, there was extensive research focusing on either, super-diversity or the ageing of the population. However, there is a lack of research on both aspects and their impacts on each other (see: Angel and Angel (2006); McMullin (2000)). Depending on the country of origin, the ageing process can be different. People have different needs that can be reflected in urban developments. Furthermore, there is little knowledge about the spatial distribution of an ageing population with a diverse background.

In this paper, an approach how to analyse and model super-diversity in an ageing city by the example of Berlin will be presented and discussed. We begin by describing the study area of Berlin. Afterwards we discuss which data is needed to find connections between ageing, migration and spatial location. After the analysis of the data and the classification of the ageing population into different groups, a modelling approach needs to be chosen to reflect the spatial distribution and to develop and test scenarios of future development. Such scenarios will support the city of Berlin and city planners to identify and spatially allocate the needs of different ageing groups and act accordingly. Finally, we conclude the paper with challenges for the next steps.

### 1.1 Super-diversity in Berlin

Berlin is divided into 12 districts which are structured into several "Lebensweltlich Orientierte Räume" (LOR). Those are the spatial basis in Berlin for planning, prognosis and observation (Senatsverwaltung für Stadtentwicklung und Wohnen, nd).

In December 2016 Berlin had approx. 3,700,000 inhabitants. Among those were 1,100,000 inhabitants that were 55 years old or older. This group is divided into approximately 970,000 Germans without migration background, 70,000 Germans with migration background and 110,000 foreigners (Statistisches Landesamt Berlin-Brandenburg, nd). The spatial distribution of the population with and without migration background can be seen in figure 1.

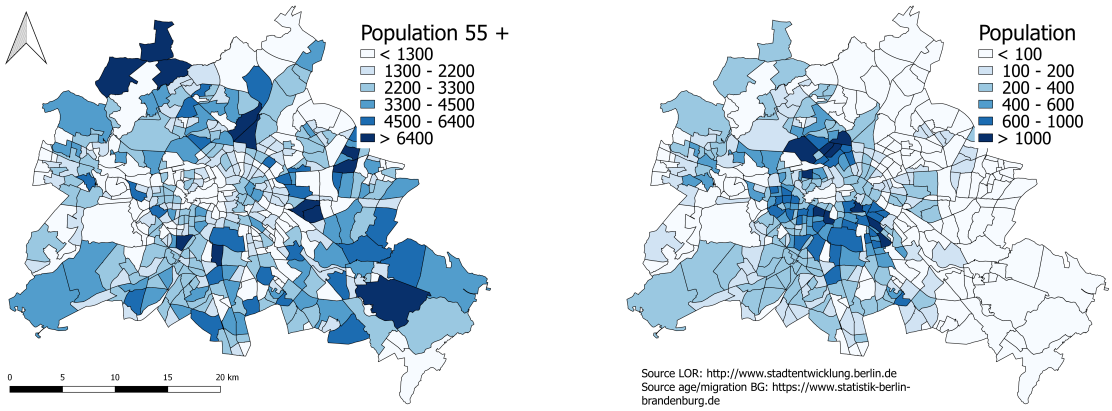


Figure 1: Distribution of Germans (left) and foreigners (right) over 55 years of age in Berlin (note the different classifications).

## 2 How to capture super-diversity in data?

To assess super-diversity in a given population, data is required that includes age and migration status in combination with further information for example income and family status in the different districts, or ideally on LOR level.

Dependent on the available data, the temporal and spatial resolution of the model will be chosen. This will be the foundation for the statistical analysis and the modelling process. The analysis will be done to establish the motives for the choice of residence or the resettlement in other districts as was also done in Fontaine et al. (2014). Here, the population was divided into households as, usually, decisions are made by households and not by individuals (Fontaine et al. (2014); Lauf et al. (2012); Huang et al. (2014)).

With the help of statistics (for example PCA - principal component analysis, correlation of predefined characteristics), the ageing population will be separated into different groups/households. One possibility might be to separate the groups according to the migration background. In figure 1 it can be seen that in some areas there is an accumulation of older residents independent of the nationality while in other areas the spatial distribution of people with and without migration background varies. But it is also possible that aspects like age or income provide a good basis for a classification

of the population. However other approaches will be considered as well. Rounsevell et al. (2012) for example propose to classify the groups according to their behavioural mechanisms.

Possible bases for the divisions into different groups are:

- Age (55 as starting age)
- Country/region of origin
- Income
- Residence status
- Family status/children
- Education
- Gender

Aspects that can be important in the choice of residence:

- Household size
- Infrastructure
- Spatial distance to shopping opportunities/health care
- Rent index

Furthermore, it is necessary to show the relationship between groups and the impact of the aspects on the decisions of them. For example, it is likely that an older person with a higher income has a higher tolerance to a rising rent index while a person with a low income has a lower tolerance and is therefore more likely to move to another area. Hunt (2010) shows the different impacts of aspects on residence choice of groups dependent on income and number of children. The established relationships between groups and aspects will be used in the model. Therefore, it is necessary to rank the impact of the aspects on the decisions.

A challenge in modelling is data availability (Liu, 2009). Most of the above mentioned data is provided by different departments in Berlin, but in different spatial and temporal resolutions. Available data that can be combined with age and nationality of the inhabitants and has in some cases a time range from 2007 – 2016 are:

- Gender
- Family status
- Germans with/without migration background
- Country of origin
- Religion (evangelic, catholic, others)
- Residential area (good, middle, bad)
- District/LOR

The above mentioned data is provided by the Statistisches Landesamt Berlin-Brandenburg (department for statistics Berlin-Brandenburg). Other departments only provide data with lower spatial resolution and without the age/migration information. Another possibility is to use approaches by

social scientists who make assumptions about the connections between age/migration and other parameters and their influence on the spatial distribution.

The collected data can be used to divide the population with statistical analysis into groups, according to overlapping motives. The resulting groups provide the basis for the establishment of transition rules, spatial behaviour and neighbours.

## 3 How to model super-diversity in an urban environment?

The model will be developed following the steps described by Liu (2009) (see figure 2). The first step was already specified: "how is the spatial distribution of inhabitants older than 55 years and what reasons do they have to stay in their area or move to another?" Now, we need to develop a static model (step 2 and 3 in figure 2), which will act as the foundation for a dynamic model with the aim to show a prognosis of the population development.

To answer the question, thresholds might be useful to describe critical values for moving. The relationships between residents might also be a key influence and show the behaviour of agents (Macal and North, 2010). Furthermore human decision-making for choosing a certain location needs to be included. Therefore housing preferences for household types will be used, as already done in another approach for Berlin by Lauf et al. (2012).

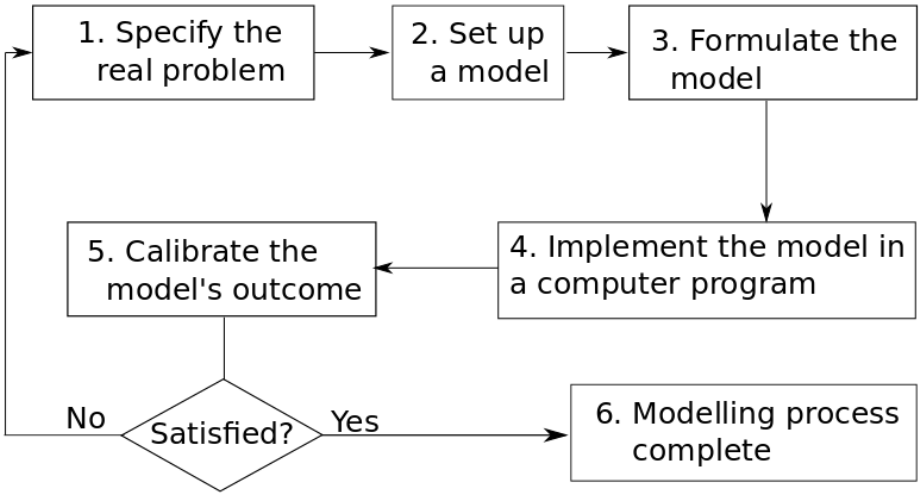


Figure 2: Flow chart for the various stages of the modelling process (Liu 2009 p. 6).

It is possible that older residents have a strong connection to the district and therefore have a lower probability to move. Besides, aspects like the rent index or being in a certain distance to (health) infrastructure can be essential and might have to be weighted differently. Also, it has to be considered if the spatial aspect (where the people are) is more important than their movement within space to decide on the model, or a combination of models.

We propose to combine two types of models: cellular automata (CA) and agent based models (ABM). Both have automata states and transition rules. The difference is the treatment of space. In CA the cell remains fixed in space while in ABM, space is not represented in detail. The focus

of ABM is on the visualization of movement in space (Benenson and Torrens, 2004). The results of the statistical analysis can help to develop the transition rules and the different states of a CA, or the relationships and agents in an ABM and their behaviour. The question will be: who interacts/influences whom and what are the impacts of the factors.

The agents (in an ABM) will be the groups while the number of households within a group could show the state of an area/cell. One group could be, for instance, persons with low income which are 70 – 75 years old, while another group contains persons that have a high income with the same age. The neighbourhood consists of different groups and the transition rules can explain, why and when certain groups move to another area/cell.

Afterwards the model will be implemented and calibrated. Therefore data from the past (10 years if available) will be used as starting values. Then the model will be applied and the results will be compared with the present state. If the matching of the model and reality is sufficient, then can be used for a prognosis. Otherwise the hypothesises need to be improved. Furthermore, the plausibility of the model needs to be evaluated. Here it needs to be checked if the outcome is feasible. At the end, the model can be used to answer different questions, like the development of the spatial distribution or the clustering of population.

# 4 Challenges and outlook

Because of the increasing heterogeneity it is probable that a clear distinction between the population groups will be a challenge. Therefore, it might be necessary to work with fuzzy groups. It might be feasible to do sensitivity analyses with different groups as well because the households can not be differentiated clearly. Furthermore, there is a temporal and spatial variability of the groups.

Another challenge is the research gap. Former research had a focus either on ageing population (of the same country), on inhabitants with migration background or on the population in general, it is therefore not possible to use parameters of already established groups. Furthermore, it is necessary to find feasible statistical approaches for splitting the population into several groups if possible.

Moreover, there will be a restriction for the temporal resolution, because the departments of Berlin started to collect consistent data for the local resident registration office only from the year 2006 onwards. Therefore, earlier data is not available. For other data catalogues, data from former years is provided. However, it is not collected for every year. Therefore, an extrapolation might be necessary to have consistency for all years. The general problems with the data will be the consistency and the availability. Sometimes the data is only available for districts because the data was not collected on smaller spatial resolution or because of privacy.

Another challenge is the fact that with the Zensus survey in the year 2011, the population of Berlin lost about 200,000 inhabitants because of inconsistencies in the population count in the years before (Statistisches Bundesamt, 2013). It has to be considered how to work with this difference. Maybe an average value will be used, or the population development will be smoothed.

The next steps will be to collect and format the data. Afterwards, statistical analysis will be done and the population will be grouped. Then, a first modelling approach will be performed.

## 5 Acknowledgements

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