EVALUATING SPATIAL AND SOCIAL INEQUALITY BY USING GIS TO ANALYZE THE CATCHMENT AREA AND CAPACITY OF PRESCHOOLS IN GHENT, BELGIUM

Koos Fransen[1], Niels Verrecas[2], Michael Ryckewaert[3,4], Philippe De Maeyer[5], Greta Deruyter[1,5]

[1]*Ghent University, Department of Industrial Engineering (BELGIUM)*
[2]*Teccon BVBA (BELGIUM)*
[3]*Vrije Universiteit Brussel, Department of Geography (BELGIUM)*
[4]*KU Leuven, Department of Architecture (BELGIUM)*
[5]*Ghent University, Department of Geography (BELGIUM)*

Abstract

The growing popularity of the city as a qualitative living environment has an explicit and distinct impact on all regional cities in Flanders (Belgium). As a result of the pressure exerted by the increase in population, different kinds of spatial and social inequality can be perceived for multiple urban functions, for example for the educational system. Pupils of primary schools (in Flanders children between the age of 2.5 and 12 years) living in densely populated areas characterised by a capacity shortage in education are forced to attend schools at greater distances, because the capacity of nearby schools is exceeded. As a consequence, parents setting up camp in front of the school gates during enrolment periods are an annually recurring phenomenon. Methods pinpointing areas where problems concerning capacity are to be expected are missing.

The research at hand used two different methods (short-term and long-term) to analyse the pressure exerted on preschools as a result of the growing urban population. The first analysis researched the change in capacity needs of preschools taking into account the rise of the number of children between the ages of 2 and 5 years to be expected over the next two years. The second analysis predicted the impact of urban growth on the accessibility to preschools. Instead of prognoses in overall population growth, the supply of new housing units from 2013 till 2025 was used to predict the rise in the number of children between the ages of 2.5 and 5.5 years for the next decade.

Both analyses were validated for pre-schools in the city of Ghent, Flemish Region, Belgium and proved to be valuable tools to support local policy in education. The results indicated areas with considerable capacity and accessibility problems, on the short term as well as on the long term.

Keywords: Geographic Information System (GIS), education, accessibility, catchment area, location-allocation, network analysis, prediction models, spatial inequality.

1   INTRODUCTION

Since the beginning of the 21th century, the vast migration from the city to the surrounding suburban landscape has halted. The urban fabric of urban centres and outer city rims of Flemish regional cities is again becoming a more attractive living environment [1]. Especially the latter, characterized by small but affordable housing, is popular amongst young families (for example the neighbourhood Brugse Poort in Ghent). However, this rise in urban population, amplified by a global growth of the population, inevitably leads to a growing pressure on urban facilities. As a result, cities struggle with the effects of spatial and social inequalities. These are amongst others manifested in the educational system. In different regional cities in Flanders, pupils of primary schools (aged between 2.5 and 12 years) are forced to attend school at greater distances, because the capacity in nearby schools is exceeded. The phenomenon of parents camping in front of the school gates during enrolment periods was countered by the Central Application Register (CAR), which is being applied in Ghent since 2008. The CAR assigns children to preschools mainly based on the distance from the home location to the school. Still, new kinds of spatial and social inequality issues based on the capacity of and the distance to preschools have risen.

2   BACKGROUND

2.1   Accessibility

2.1.1   Definition

Accessibility is characterized by two main elements: on the one hand, the relationship between origin and destination (spatial component) and on the other hand, the characteristics of the network where travel takes place (transport component) [2]. In addition, social barriers should also be taken into consideration [3]. Recent research on space-time accessibility and personal restrictions considers two additional components [4,5]: a temporal and an individual component. Mainly, most of the analysis methods only take into account the spatial and the transport component.

2.1.2   Analysis methods

Various methods can be used to calculate accessibility in general. The most basic methods include distance or time to the nearest facility and average distance or time to a certain number of facilities. However, these methods give merely an estimation of the accessibility [6]. Although most analyses make use of indicators to determine the accessibility to a certain facility, three more complex methods are commonly applied [7]. The method of isochrones or cumulative opportunities, the gravity based method or the relationship between accessibility and travel time and the utility based method or individual accessibility. However, these indicators are calculated with zonal data based on administrative borders, leading to important intra- and interrelational limitations [6]. A method that partly overcomes these limitations is the two-step floating catchment area (2SFCA) method developed by Luo and Wang [8]. In this method, a catchment area centred on the centroid of the administrative area or the facility is used instead of using a predefined administrative area, thus eliminating limitations because of boundary effects. Geographic Information Systems (GIS) are applied to increase the effectiveness and precision of accessibility measurements [3].

2.1.3   The link to inequality

Accessibility plays an important role in defining different kinds of inequalities and thus in creating social sustainable and just urban neighbourhoods. Social sustainability is characterized by two main dimensions: the accessibility of services, facilities and opportunities and the community sustainability [9]. Not only will local governments strive to maximize the accessibility of the services and facilities; they must also distribute these services and facilities as equally as possible. Especially in primary facilities (for example healthcare, education), an equal distribution of and accessibility to these services and facilities is important in planning a sustainable neighbourhood.

3   METHODOLOGY

Two methods were applied to analyse the current and future capacity and accessibility for preschools in Ghent, Belgium. The first method is used to determine short-term changes in preschool capacities, while the second method is used to analyse and predict mid- and long-term changes in the accessibility to preschools.

3.1   Short-term analysis

3.1.1   Data

As input data, four important datasets were needed: a population dataset containing addresses and age of the inhabitants of Ghent, a geographical dataset containing the administrative borders of the census tracts in Ghent, a facility dataset containing address and capacity (per age group) of all preschools in Ghent and a network dataset containing the road network on which travel takes place.

3.1.2   Analysis of the current capacity

In a preliminary phase of the capacity analysis, the overall under- and overcapacity for every preschool in Ghent, based on the current demographic situation (the home location of children aged between 2.5 and 5.5 years) was determined. First, a theoretical catchment area was calculated for every preschool. This is the catchment area for which the maximal capacity of each preschool is reached, allocating inhabitants of a certain age category to the school based upon the minimal

network distance [10]. Next, the amount of children per census tract situated outside or inside these theoretical catchment areas was calculated. This resulted in a theoretical under- and overcapacity for each census tract. This method was modelled in ESRI ArcGIS Modelbuilder, thus making the process automated.

3.1.3   Analysis of the short-term future capacity

The automated model used for the analysis of the current under- and overcapacity per census tract was applied to determine the future under- and overcapacity per census tract. Instead of the children aged between 2.5 and 5.5 years, children aged between 1.5 and 4.5 years and 0.5 and 3.5 years were used as input to determine the preschool under- and overcapacity for respectively 2013-2014 and 2014-2015 predictions. These predictions were compared to the current under- and overcapacity to determine changes in the short term. The same automated model was used to determine changes in under- and overcapacity when a fictive school location with a certain capacity was added to the facility dataset containing address and capacity of each preschool, in the census tract Brugse Poort in the northern part of the city's outer rim.

3.2   Long-term analysis

3.2.1   Data

As input data, the same four datasets as for the short-term analysis were used: a population dataset containing addresses and age of the inhabitants of Ghent, a geographical dataset containing the administrative borders of the census tracts in Ghent, a facility dataset containing the address and capacity of all preschools in Ghent and a network dataset containing the road network on which travel takes place. In addition, a dataset containing the centroid per census tract is required.

3.2.2   Analysis of the current accessibility

For analysing the accessibility to preschools per census tract, the 2SFCA method was applied. This method was slightly adapted to take into account the respective age group (children aged between 2.5 and 5.5 years) and the capacity of each preschool. First, an overall accessibility index R was calculated per preschool, by summarizing the amount of children aged between 2.5 and 5.5 years old related to the census tract centroids that fall inside the 1500 meters catchment area for each preschool and then dividing the preschool capacity by the calculated sum. Next an overall capacity index A was calculated per census tract, by summarizing the R-values of preschools that fall inside the 1500 meters catchment area for each census tract centroid. This A-value is a relative measure for the accessibility to preschools per census tract. The method was modelled in Python, thus leading to an automated programming script.

3.2.3   Analysis of the long-term future accessibility

The automated programming script applied for the analysis of the current accessibility per census tract was used to determine the future accessibility per census tract. For determining the future location of children aged between 2.5 and 5.5 years, a dataset containing all planned housing projects in Ghent till 2025 was used. By multiplying the current percentage of children aged between 2.5 and 5.5 years old with the expected additional inhabitants as a result of these housing projects, a prediction of the future locations of children aged between 2.5 and 5.5 years was made. This new population dataset was used as input for the automated programming script, thus leading to an analysis of the future preschool accessibility per census tract. These predictions were then compared to the current accessibility to determine changes in the long term.

4   RESULTS

The methods applied for the analysis of the capacity and accessibility to preschools for the current constellation and future constellations led to two different prediction models. The first model is an automated Modelbuilder tool that allows the determination of capacity changes in the short term. The second model is an automated programming script that predicts changes in accessibility in the long term.

4.1 Case study Ghent

The city of Ghent was used to validate the analysis methods used in the research at hand. Ghent is the capital of East-Flanders and is known as an educational city, attracting the largest numbers of pupils and students in Belgium. The city counts 98 preschools with an overall capacity of 12.545 pupils. Geographically, Ghent consists of an historical city centre, encircled by a 19th century outer rim. This outer rim is surrounded by a peripheral area with a village-like structuring [10].

4.2 Changes in the short term

Because this method used the actual home location of children aged between 1.5 and 4.5 years and 0.5 and 3.5 years, it is accurate in pinpointing areas where capacity and accessibility issues will occur in the short term. The predictions of the theoretical shortage or overcapacity for the next two years indicate that the spread of the theoretical catchment area of the preschools will diminish for most areas (Oostakker in the north of Ghent, Railway Station just south of the city centre and Vogelhoek in the eastern part of the outer rim, Fig. 1). As a result, the overall overcapacity in the city centre shall gradually reduce or disappear. Also, the outer rim is characterised by a general lowered capacity, especially in the northern parts. In the suburban areas, little change is to be expected (Fig. 2). In addition, adding a preschool with a certain capacity to the facility dataset resulted in local switch in overall capacity. Surrounding census tracts were not influenced by adding more capacity on one specific location (Fig. 3).
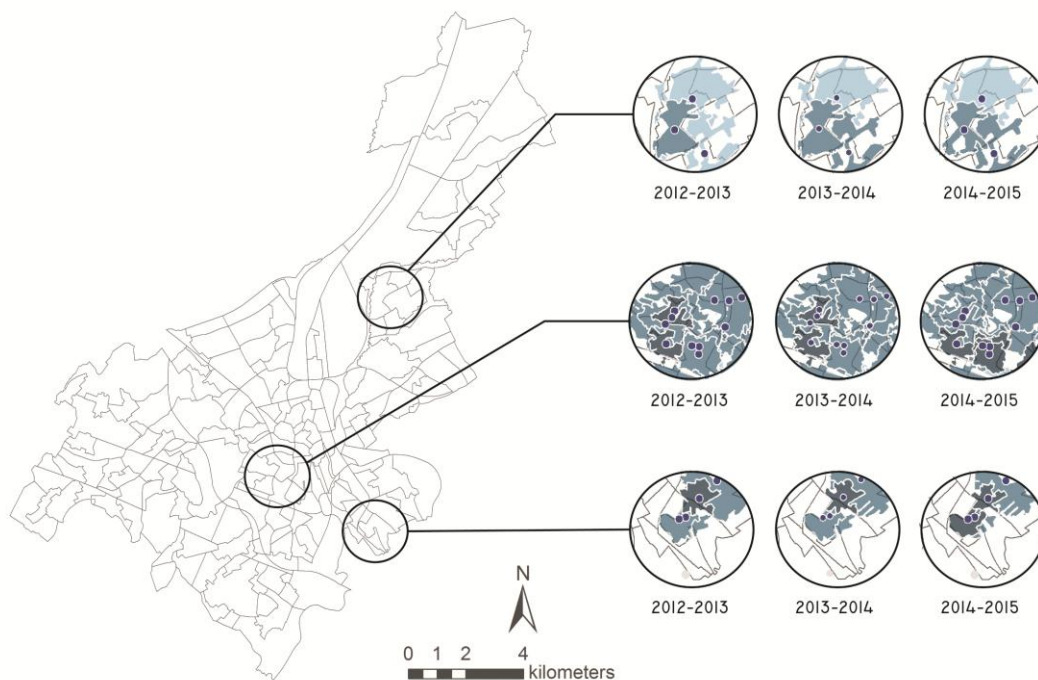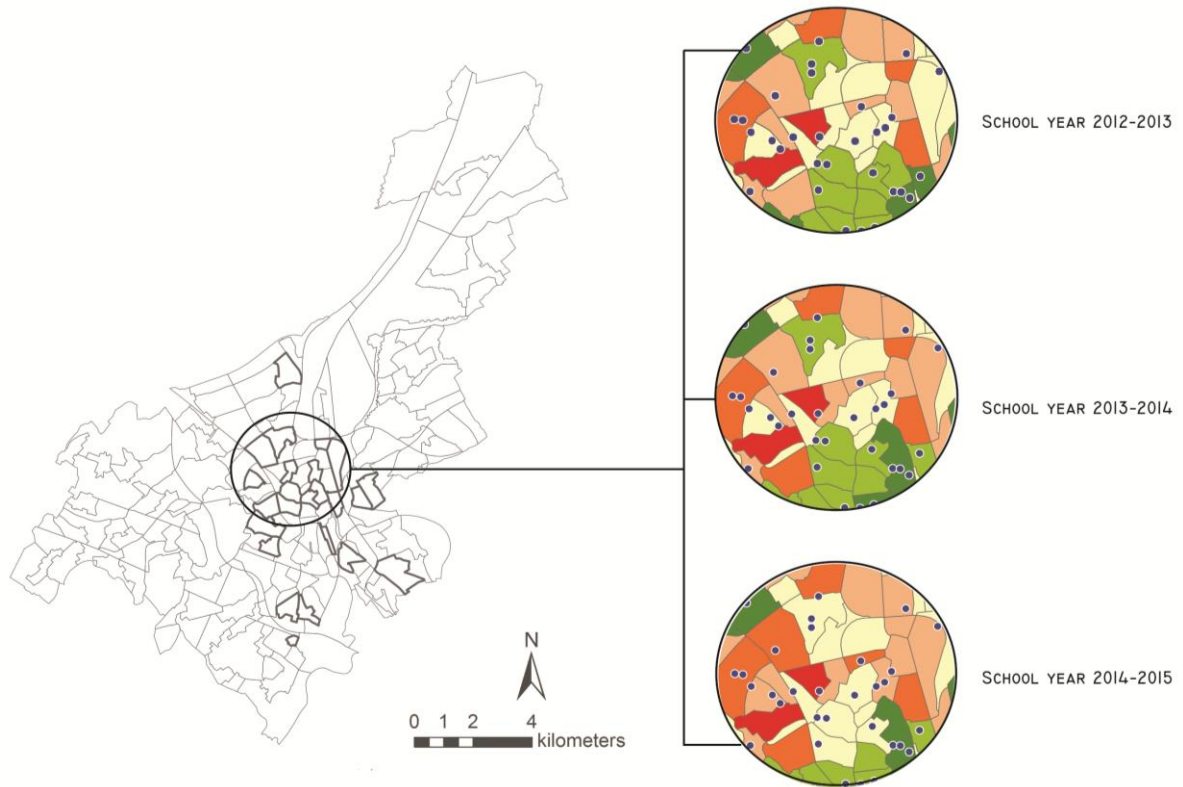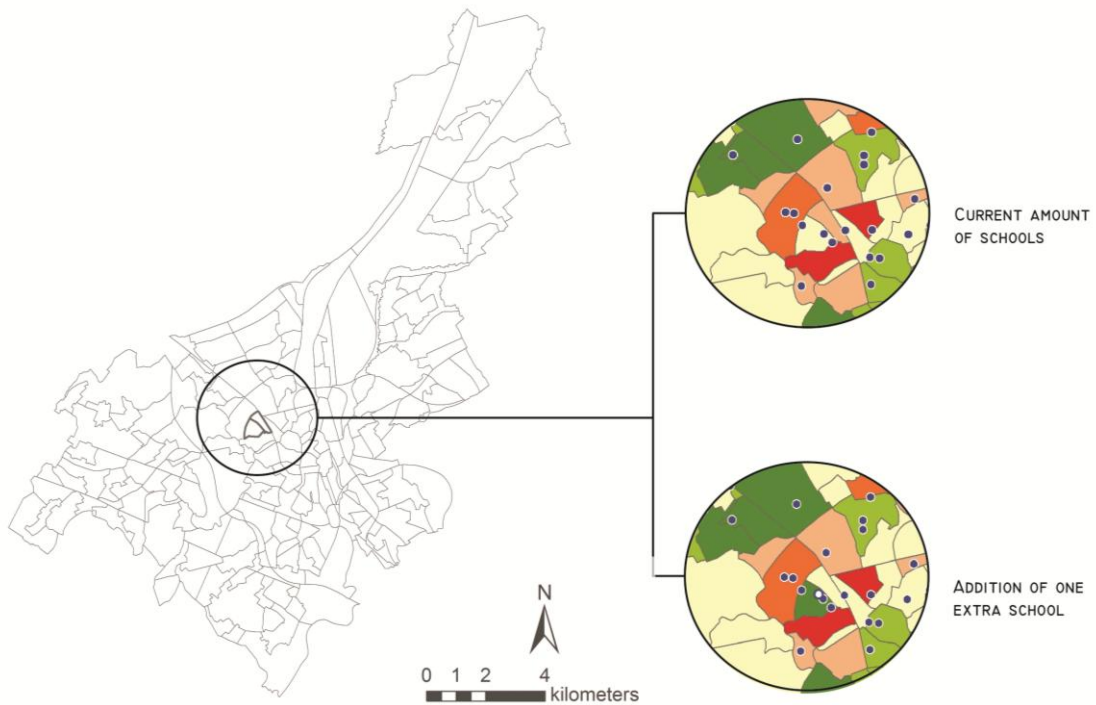

Figure 1: Changes in the school catchment areas for the school years 2013-2014 and 2014-2015 (Ghent)

Figure 2: Changes in the theoretical shortage or overcapacity for the school years 2013-2014 and 2014-2015 (Ghent)

Figure 3: Changes in the theoretical shortage or overcapacity by implantation of an extra school (simulation for Ghent 2012-2013)

4.3   Changes in the long term

Because this method used a prediction of additional home locations of children aged between 2.5 and 5.5 years, it is more applicable to pinpoint areas where capacity and accessibility issues could occur in the long term. The predictions of the preschool accessibility for 2025 also point out the city centre and the northern and eastern areas of Ghent's outer rim as important areas for long-term policy. In these areas, the accessibility will degrade. The southern and western areas of the city's outer rim are not influenced by the planned housing projects (Fig. 4). As a result, not only areas that are currently characterised by a diminished accessibility to preschools were indicated, but also areas where the accessibility to preschools will degrade in the future.
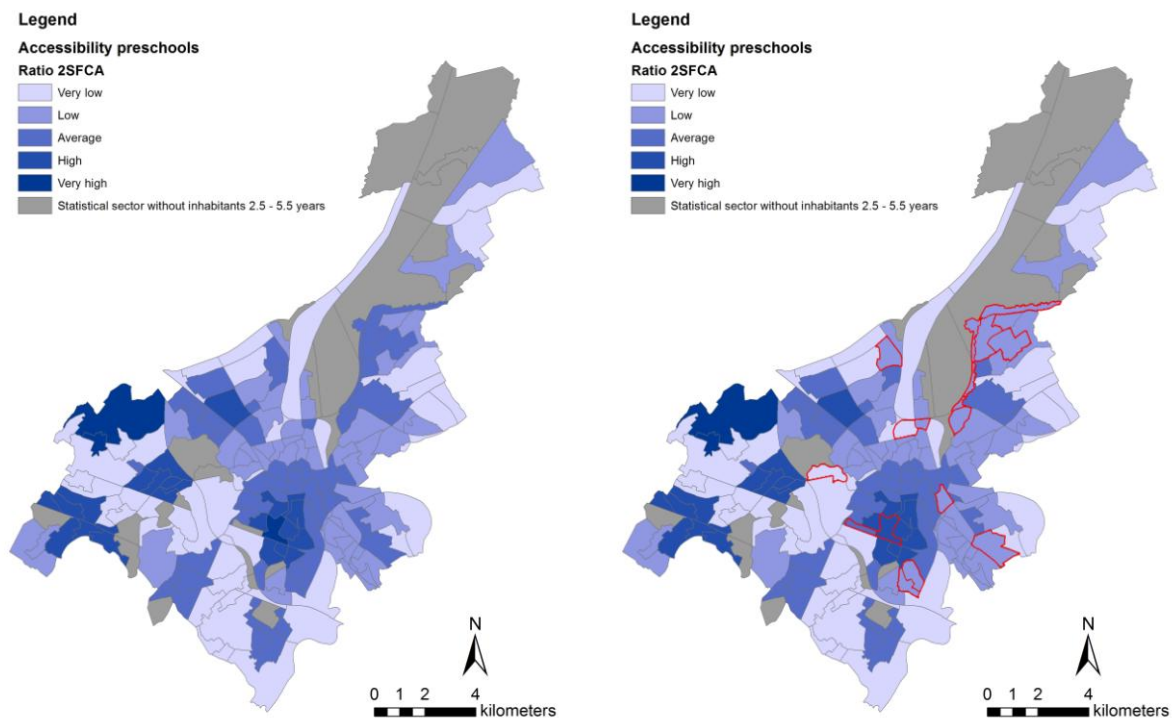

Figure 4: Comparison of the current (2013) accessibility of preschools per census tract in Ghent (left image) and the future (2025) accessibility of preschools per census tract in Ghent (image right)

5   CONCLUSION

As indicated, the capacity of, as well as the accessibility to primary facilities play an important role in the overall neighbourhood sustainability. Both analysis methods used in the research at hand provide a framework for policy decision making in light of the distribution of preschools in Ghent. Whereas the first method used the actual home location of children aged between 0.5 and 2.5 to predict shifts in preschool capacity, it is more accurate in determining important areas for educational policy on the short term. However, because the second method used the supply in housing (extrapolated to the increase of children aged between 2.5 and 5.5) it is less accurate and therefore better for predictions on the long term. Both methods do not take internal (between census tracts in Ghent) and external (to and from the city of Ghent) migrations into account.

The pressure exerted by population growth is highest for the city centre and northern and eastern parts of the city rim, on the short term as well as on the long term. In the suburban southern and western parts of Ghent, no apparent issues are to be expected. A more conclusive analysis which combines the techniques in the research at hand with general urban prognoses would provide a detailed conclusion as to which areas are most important in the educational agenda of the city of Ghent.

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