Spatial Analysis of Peri-Urban Areas of Bucharest in the Context of Big Data

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Abstract. *The territorial expansion of the Bucharest-Ilfov region is a continuous process. This expansionist process is not always followed by an increase in the quality of life of the citizens, because in order to produce this effect, it is important that the territorial expansion is carried out in all branches (road infrastructure, residential buildings, access to medical services, access to education, access to shared public transport). As the specialized literature observes a chaotic development of this region, the research aims to analyze the peri-urban areas of the Municipality of Bucharest and the 6 sectors of the Municipality of Bucharest from the perspective of citizens' access from residential buildings to 3 basic services of society (transport, education and medicine), but also the identification of the spatial association relationship between the 6 sectors and peri-urban areas. In order to achieve these objectives, geospatial data of the big-data type were extracted, more precisely by extracting them with the help of artificial intelligence from satellites, and then processing these data. Also, the selected sample includes the 6 sectors of the Municipality of Bucharest, as well as the peri-urban areas. The main results indicate real development discrepancies both at the level of the 6 sectors of the Municipality of Bucharest, and at the level of the peri-urban areas, on all 3 dimensions analyzed. In addition, with the exception of two semi-significant local spatial autocorrelations, it cannot be stated that there is a spatial association relationship between the units in the sample, the development gaps being the result of the decision-making process at the local public administration level. Through the research results, development directions of the peri-urban areas and the 6 sectors can be identified to increase the quality of life of their citizens.*

Keywords: spatial analysis, peri-urban, urban development, geospatial data, big data

Introduction

The expansion of the City of Bucharest is closely related to the expansion of peri-urban areas. The increase in population density in the Bucharest-Ilfov region was not necessarily accompanied by the increase in public services to serve the high level of the population. Starting from the hypothesis that the development of the 6 sectors and peri-urban areas of the Municipality of Bucharest does not represent a uniform process, the research aims to analyze the peri-urban areas, but also the 6 sectors of the Municipality of Bucharest, from the perspective of population access from residential buildings to 3 basic services of society: transport, education and medicine. Also, this research aims to identify the spatial separation relationship between the peri-urban areas and the 6 sectors of the Municipality of Bucharest.

To achieve the first objective of the research, using geospatial data, the average, median and maximum distances from residential buildings to kindergartens, general schools, high schools (education), medical offices, hospitals (medicine) and public transport stations (transport) were

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calculated. Subsequently, to address the second objective, both global and local Moran spatial autocorrelation indices were used. By achieving the second objective, possible partnerships can be identified between the peri-urban areas and the 6 sectors of the Bucharest Municipality, in order to increase the resilience of services in the 3 areas: education, medicine and transport.

The work begins with the Literature Review part in which the territorial expansion of the Bucharest-Ilfov region is presented, but also possible measures to increase the resilience of the peri-urban areas and the Bucharest Municipality from the perspective of the population's access to the 3 dimensions. In the Methodology section, the methodology used to achieve the objectives of the paper is explained in detail. In addition, this section also details the data collection process in the context of Big Data by extracting geospatial coordinates directly from satellites, using Open Street Map. Later, in the Results and Discussions section, the main results of the research are presented and discussed in relation to other studies from the specialized literature. Finally, in the conclusions part, the main conclusions of the study, the limits of the research, but also the further development directions of the study are presented.

Literature review

Bucharest - Ilfov development region had an impressive expansion during the investigated time interval in comparison with the other Romanian regions. In 30 years, the built-up area corresponding to Bucharest and the Ilfov County doubled, 2007 being the most prolific for the development of new built-up areas (Lazar et al., 2022). Post-socialist changes in Bucharest are clearly reflected in the dynamics of built-up space. Land cover dynamics were evaluated using spectral mixture analysis of Landsat 5 TM (Thematic Mapper) data to map percent impervious surface area in 1988 and 2010. Change analysis reveals a decrease of built space in central and peri-central areas of Bucharest, an expansion of new residential areas to the south, land fragmentation to the east and southeast, a mixture of densities to the north (Ianos et al., 2016). Lincaru et al. (2016) conclude that the land use change towards land coverage with buildings indicates a major structural change from rural to urban, where the main change of land use is from agricultural toward land covered with buildings, where those buildings could be both for industrial use and for residential use.

Subsequently, Bacau et al. (2020) have studied the consistency among Bucharest`s planning instruments. Thei main results have indicated that consistency among Bucharest's plans is high on a temporal scale regarding issues and general measures, but low for spatialized planning intentions on both vertical and horizontal scales. In order to deal with spatial resilience, Lu et al. (2021) sustain the idea that resilience provides an adaptive approach for dealing with environmental change, natural risks and public health emergencies. Rosu et al. (2018) state that urban expansion, often seen as an indicator of economic growth and a possible response to housing crisis in big cities, is the main driver for carbon emissions in the metropolitan area due to higher values of household income, vehicle ownership and home size. In addition, the expansion of the urban areas in Romania has faced similar patterns in all major cities in Eastern Europe. Traffic congestion and increasing pollution became common aspects of urban life, as most big cities were not prepared for this fast change in urban land use (Rosu et al., 2018).

Wen et al. (2023) concluded that applying polycentric city concept it could be improved the air quality index by its positive effect on smart urban mobility concept. Thus, the EU's Sustainable Urban Mobility Planning (SUMP) has a little focus on inclusive and safe mobility planning that caters to attractive cities and high quality of urban life (Muller and Kosmidis, 2023).

Moreover, Muller and Kosmidis (2023) sustain the idea that smart mobility measures are relatively conventional, and their goals and ambitions are often stated on an abstract level and rarely measurable with specific indicators. In order to measure the smart mobility concept, Sharif and Rahman (2022) have proposed six smart mobility indicators, namely, location efficiency, reliable mobility, health and safety, environmental stewardship, social equity, and robust economy.

Methodology

Proceeding from the hypothesis that residential development has developed at a much faster rate than the social development of urban and peri-urban areas. In order to achieve all the objectives of the research, the work was developed in several stages, with the capital of Romania, the Municipality of Bucharest, as the spatial unit. Therefore, the sample consists of the 6 sectors of the Municipality of Bucharest: Sector 1, Sector 2, Sector 3, Sector 4, Sector 5 and Sector 6, but also the peri-urban areas of the Municipality of Bucharest: Otopeni, Voluntari, Chitila, Mogoșoaia, Chiajna, Domnești, Bragadiru, Jilava, Berceni, Popești-Leordeni, Glina, Pantelimon and Dobroești, totaling a total of 19 statistical units.

The first stage consisted of extracting the data from the satellites in order to be able to calculate the statistical indicators at the level of the 19 units in the sample. This process was done in RStudio, using the osmdata package, the source being Open Street Map. In this research, the access of the population from residential buildings to 3 basic services of society (education, medicine and public transport) was analyzed. Therefore, the first step consisted in extracting the geospatial coordinates of the residential buildings in each statistical unit. In order to achieve this process, from the building module of the osmdata package, the coordinates for the following assignments were extracted: residential, house, apartment. Later, for each individual dimension, the coordinates for the characteristic areas were extracted. Thus, for the Education dimension, from the amenity module of the osmdata package, the coordinates for college, school and kindergarten were selected. The shared public transport dimension was defined by extracting the coordinates from the public_transport module of the shared public transport stations. The medicine dimension was defined by the coordinates extracted from the amenity module, having the following attributes hospital, medical center. Later, in order to be able to calculate the distance from the residential buildings to each of the 3 dimensions, the coordinates related to all road categories were extracted. Finally, the variables were calculated in Rstudio, using the dodgr package, as distances from residential buildings to the 3 dimensions (education, medicine and transport), using the coordinates of the road network that makes possible the connection between the two points of interest). However, there were cases where the resulting distance was of the "Inf" type, due to the fact that some roads did not reach directly to one of the points of interest (kindergarten, school, high school, doctor's office, hospital, public transport station). In such cases, this value was corrected by calculating the areal distance from the residential buildings to the points of interest (kindergarten, school, high school, doctor's office, hospital, public transport station).

Table 1. The description of variables

Acronym	Definition	Type of distance
Average_education	The average distance from residential buildings to education units (kindergarten, school, college) .	By foot
Median_education	The median value of distances from buildings to education units (kindergarten, school, college).	By foot

Acronym	Definition	Type of distance
Max_education	The maximal distance from residential buildings to education units (kindergarten, school, college).	By foot
Average_medicine	The average distance from residential buildings to medical units (medical centre, hospital).	By motorcar
Median_medicine	The median value of distances from residential buildings to medical units (medical centre, hospital).	By motorcar
Max_medicine	The maximal distance from residential buildings to medical units (medical centre, hospital).	By motorcar
Average_transport	The average distance from residential buildings to public transport station.	By foot
Median_transport	The median value of distances from residential buildings to public transport station.	By foot
Max_transport	The maximal distance from residential buildings to public transport station.	By foot

Source: Authors' own research.

For the transport and education dimensions, the distance was calculated as being traveled without means of locomotion (by foot), and the medicine dimension was calculated by using the means of locomotion (by motorcar). These two approaches were chosen because for the citizens of an area, it is important to get to school, kindergarten, even high school, as well as to the bus station without using another means of locomotion, in this way a traffic decongestion can also be achieved. However, because the frequency of travel to medical facilities is very low, and in case of emergencies, the ambulance is the means of locomotion from residential buildings to medical facilities, it is more relevant to analyze the distance traveled by a motorized vehicle (Table 1).

The second stage consisted in the analysis of the performances of the units in the sample on each individual variable, but also the testing, as well as the identification of the possible spatial autocorrelation between the 6 sectors of the Municipality of Bucharest and the peri-urban areas. This step was performed using Moran's spatial, global and local autocorrelation indicators.

Spatial autocorrelation is a statistical measure used to assess the similarity or differences between attribute values that are close to each other in geographic space. Positive spatial autocorrelation indicates that high or low attribute values tend to cluster in space, while negative spatial autocorrelation suggests that neighboring locations exhibit opposite attribute values.

The spatial autocorrelation function is described by the following relation:

$$R(k) = \frac{\sum_{i=k+1}^{n}[(c_i-\bar{c})(c_{i-k}-\bar{c})]}{\sum_{i=1}^{n}(c_i-\bar{c})^2} \quad (1), \text{ where}$$

k represents the spatial gap;
ci is a sample for a space series of volume n;

$$\bar{c} = \frac{\sum_{i=1}^{n} c_i}{n} \quad (2) \text{ represents the average of the values } c_i \text{ (Baumont et al., 2002).}$$

Global spatial autocorrelation provides a single summary of the relationships between each territorial unit and its neighbors, while local spatial autocorrelation magnifies the relationships between each territorial unit and its neighbors (Baumont et al., 2022).

The Moran statistic measures the strength of the linear association between an attribute (y) at a given location and the weighted average of the same attribute at neighboring locations (Wy) and can be interpreted as the slope of the regression of (y) on (Wy). The Moran index measures the degree of similarity between the geographical structures analyzed, taking values in the range [-1; 1].

Moran's I statistic is described by the following calculation formula:

$$I = \frac{n}{S_O} \frac{\sum_{i=1}^{n} \sum_{j=1}^{n} w_{i,j} z_i z_j}{\sum_{i=1}^{n} z_i^2} \quad (3),\ \text{where}$$

z_i represents the deviation of an attribute from its mean, $(x_i - \bar{x})$;
$w_{i,j}$ is the spatial gap between territorial units *i* and *j*;
n represents the number of territorial statistical units;

$S_O = \sum_i^n \sum_j^n w_{ij}$ indicates the aggregate measure of all spatial weights (Anselin, 1995).

The statistical hypotheses tested for Moran's I statistic are as follows:

Null hypothesis H0: There is no spatial autocorrelation (random spatial variation)
Alternative hypothesis H1: There is spatial autocorrelation (spatial dependence)

$$z_I = \frac{I - E(I)}{S_{error\ I}} \ (4), \qquad \text{where } E(I) = \frac{-1}{n-1} (5)$$

If $z_I > Z_{\alpha/2}$, then there is spatial autocorrelation.

Anselin (1995) argues that the local Moran Index assesses the statistical significance of each location-specific indicator. Local statistics can be defined as follows:

$I_i = z_i \sum_j w_{ij} z_j$, where
z_i, z_i represents the deviations from the mean;
w_{ij} is the weighting factor;
sum for j values indicates that only neighboring values are included

It establishes a proportional relationship between the sum of the local statistics and the corresponding global statistic, the global Moran Index being obtained as the average of the local indices:

$$I = \frac{\sum_{i=1}^{n} I_i}{n} \ (6)$$

The local index establishes clusters in the form of four types of spatial association, corresponding to the quadrants of the Moran diagram.

Quadrant I includes regions with an above-average level of the variable of interest, having neighbors with values also above average (High-High).

Quadrant II includes the regions with a below average level of values, having as neighbors regions located above the average (Low-High).

Quadrant III contains the spatial structures with a level below average for the variable of interest, having neighbors that follow the same trend (Low-Low).

Quadrant IV includes those regions that have values above the average and neighbors located below the average (High-Low).

Results and discussions

The first step in achieving all the research objectives is represented by the analysis of the per-urban areas of Bucharest from the perspective of access to 3 basic services (transportation, education, medicine).

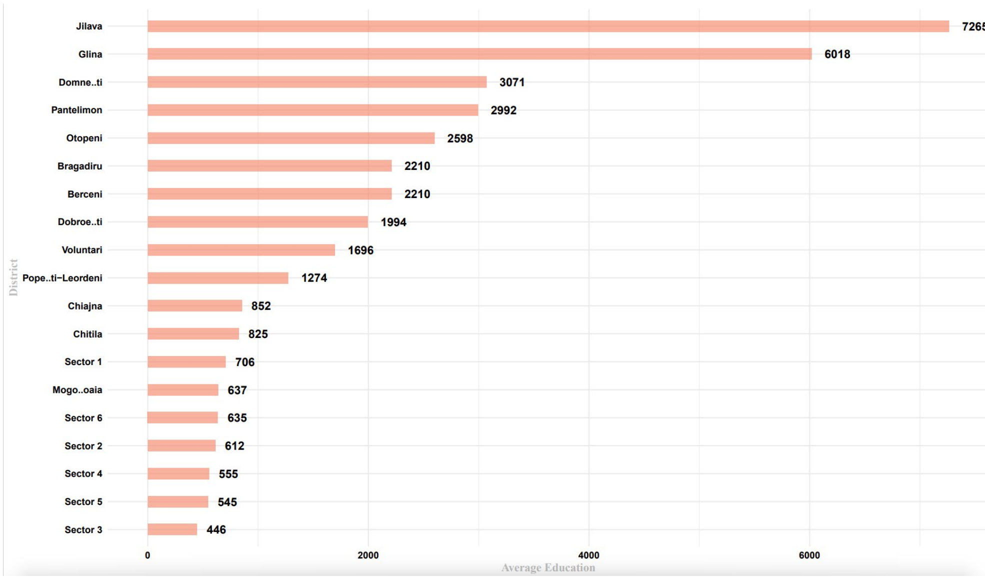

Figure 1. Average education distance

Source: Authors' own research.

Access to education services is easier in the 6 sectors of Bucharest, the only peri-urban area that enters this top is Mogosoaia (637 m). At the opposite pole, average distances from residential buildings to school units are recorded in Jilava and Glina, registering values more than double compared to the next peri-urban area in this ranking (Domnesti). Distances below 1 km, are registered in the 6 sectors of the Bucharest municipality and in 3 peri-urban areas (Chitila, Mogosoaia and Chiajna). It is interesting that the 3 peri-urban areas that register values similar to the 6 sectors in Bucharest come from the northwest area of the capital (Figure 1).

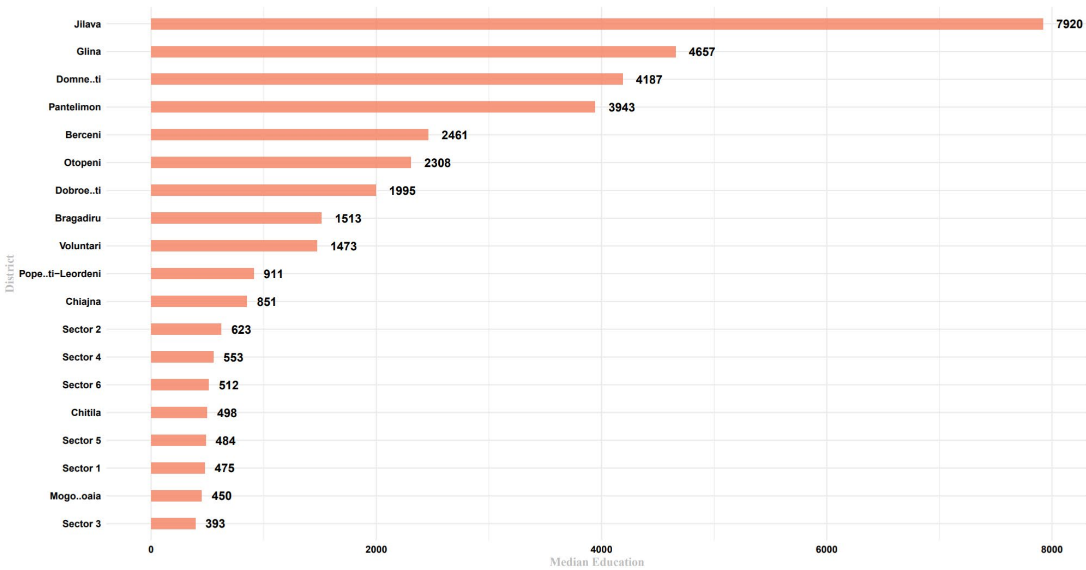

Figure 2. Median Education distance

Source: Authors' own research.

Half of the residential buildings in Jilava are located at a distance of more than 7.9 km from the school units, which leads to poor access of the school-age population to education services. The easiest access is in sector 3, where 50% of residential buildings are located at a maximum distance of 393 m from a school unit. It is interesting that between the 6 sectors of the capital, which present the smallest distances from residential buildings to school units, there are two peri-urban areas in the northwest of the capital (Mogosoaia and Chitila). In these two peri-urban areas, with values close to the 6 sectors of the Municipality of Bucharest, the density of residential buildings is higher around the school units, while in areas such as Jilava, Glina, Domnești or Pantelimon, the density of buildings is relatively reduced around school units (Figure 2). Another factor that leads to a high level of distances from residential buildings to school units is represented by urban infrastructure (alleys, roads, etc.).

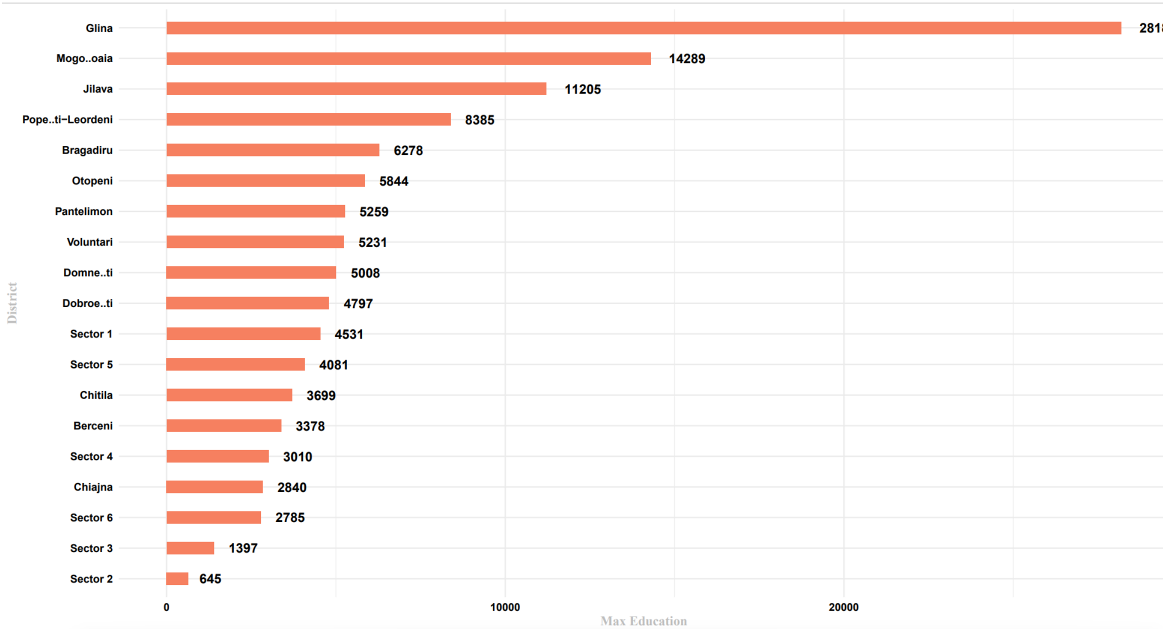

Figure 3. The maximal distance of Education

Source: Authors' own research.

Although Mogoșoaia has an increased density of residential buildings around school units, it has one of the highest maximum distances from residential buildings to school units (approx. 14 km). The localities of Glina and Jilava, which are in the top negative regarding access to school facilities, also present some of the highest values in this case, confirming the idea of poor access to school facilities for the school-age population. Although the density of residential buildings is high around the school units in the 6 sectors of the Municipality of Bucharest, high relative distances are observed for Sector 1 and Sector 5, the main cause being the residential urban expansion in these sectors, which is not followed by the expansion of the educational system. On the other hand, localities such as Chiajna and Berceni show low values, determined by a concentric development of these localities (Figure 3).

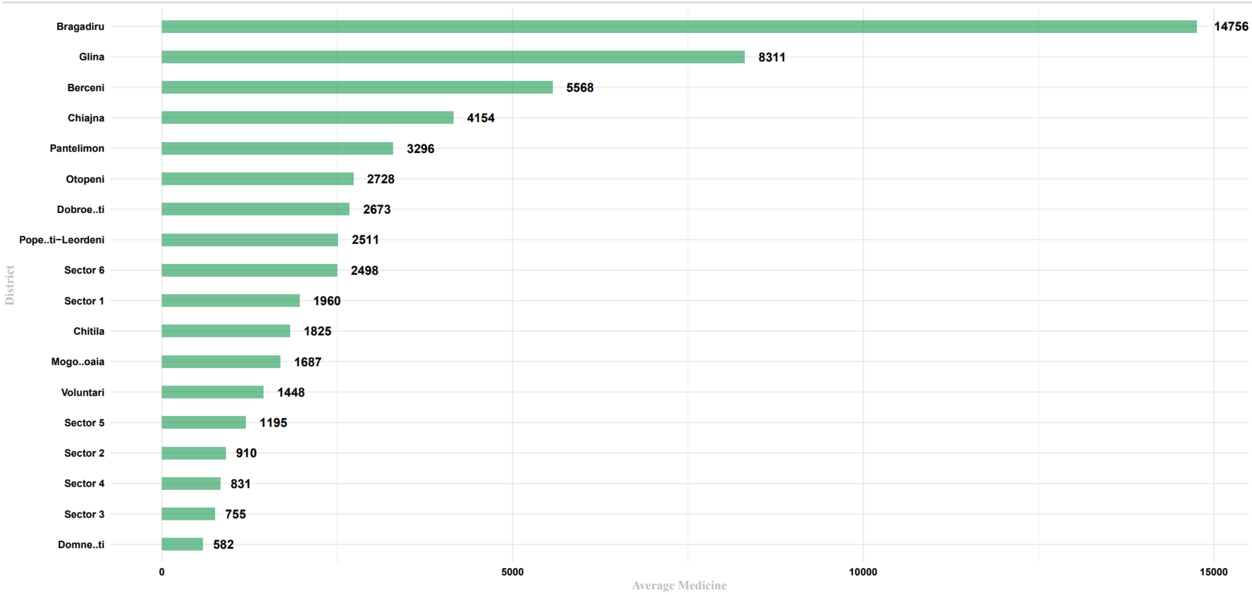

Figure 4. The Average distance of Medicine

Source: Authors' own research.

Regarding, the average distance from residential buildings to medical facilities Bragadiru and Glina register the highest values, mainly due to the high territorial surface of the two peri-urban areas. At the opposite pole, Domnești, but also the 6 sectors of Bucharest register relatively low values for this indicator. Interesting to discuss is the case of the peri-urban areas of Chitila, Mogoșoaia and Voluntari, which show low values. Interesting to discuss is the case of the peri-urban areas of Chitila, Mogoșoaia and Voluntari, which show low values (Figure 4). These areas experienced a strong residential expansion, but also an increase in entrepreneurs in the medical field, the number of medical offices opened by private operators being on an upward slope. However, Sectors 1 and 6 show higher values compared to the rest of the sectors in the Municipality of Bucharest, the main reason being the expansion of these sectors towards the peri-urban areas, in the context where the medical units in these sectors are concentrated around the center of the capital.

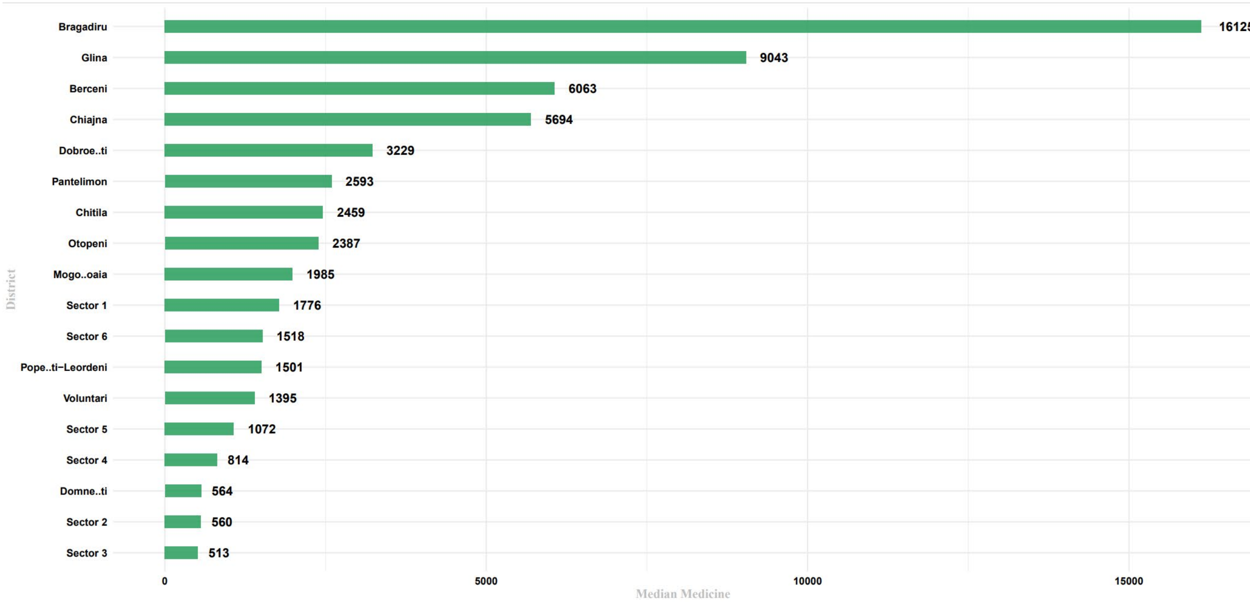

Figure 5. The median distance of Medicine

Source: Authors' own research.

As in the case of the average value for access to medical facilities, Bragadiru and Glina also present the highest values in the case of the median value, which opens the premise of a development model from the outside to the inside, a different model compared to other peri-urban areas, such as: Voluntari, Mogoşoaia, Domnești or Popești-Leordeni. The lowest values are recorded in Sector 2 and 3, where half of the residential buildings are at a maximum distance of 560 m from the medical facilities. Again, sectors 1 and 6 show higher values compared to the rest of the sectors, the explanation being similar to the case of the average distance (Figure 5).

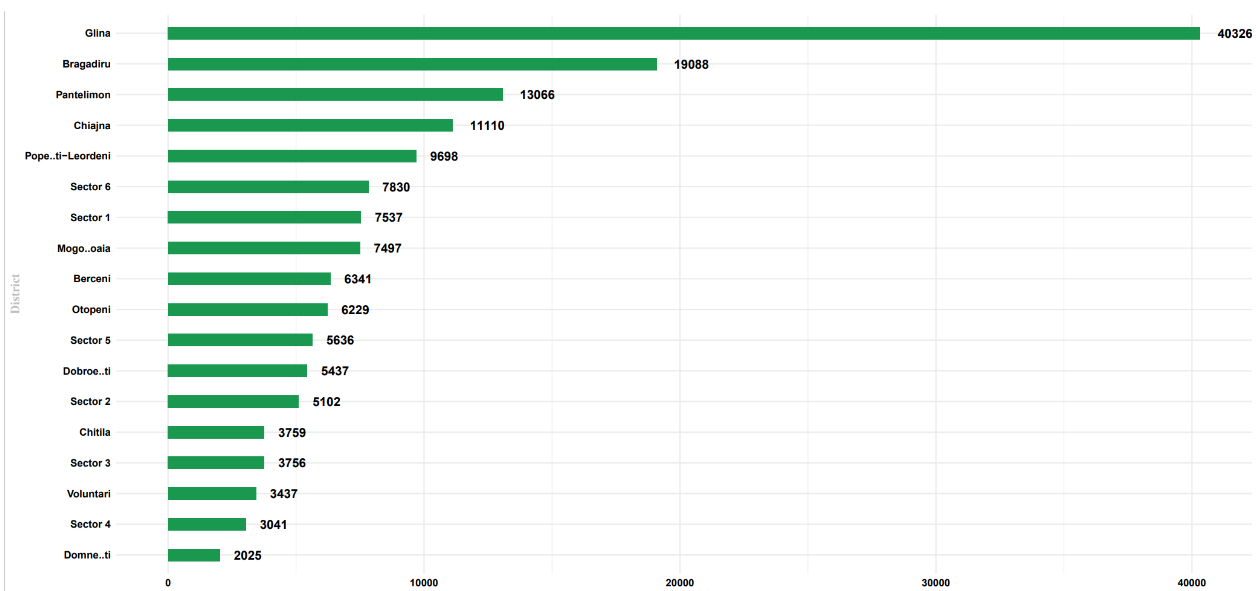

Figure 6. The maximal distance of Medicine

Source: Authors' own research.

The highest value in the case of the maximum distance from residential buildings to medical units is recorded in the locality of Glina, being followed at a considerable distance by Bragadiru, confirming the hypothesis of development from the outside to the inside. In the peri-urban areas, the lowest values are recorded in Domnești, Voluntari and Chitila, these areas having a more unitary development model, arbitrarily taking over the basic concept of polycentric cities. Important to discuss is the fact that Sectors 6 and 1 present high values, a fact that confers the trend of residential buildings moving from the center to the extremity of these sectors. However, the cause of this situation is the lack of investments by entrepreneurs from the medical system in the areas at the edge of the cities, a different development model than that of the Voluntari area. A particular case is represented by Dobroești, presenting a relatively low value, but as a result of the situation in which the area finds itself at the moment, not being a very developed area from a residential point of view (Figure 6).

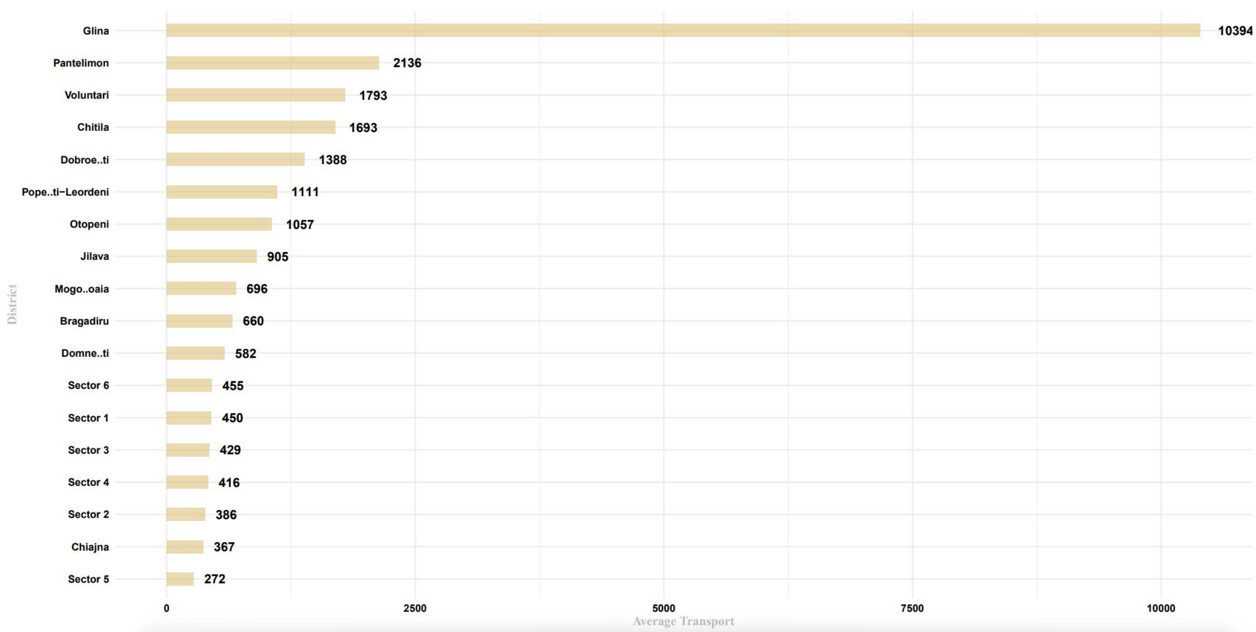

Figure 7. The average distance of Transport

Source: Authors' own research.

The Glina area is the area that performs the worst in terms of access from residential buildings to public transport, being considered an outlier, the distance from the next area in this ranking (Pantelimon) being approximately 8 km. As expected, the smallest distance is recorded at the level of the 6 sectors of the Municipality of Bucharest, with values below 1 km. Short distances are also found in the peri-urban areas of Chiajna, Domnești, Bragadiru or Mogoșoaia, which indicates a development of public transport in these areas, being positively impacted by the collaboration between the local administration of the Municipality of Bucharest and the local administration of these areas for the introduction of shared transport lines to carry out integrated transport in the extra and intra-urban area. On the other hand, the case of the city of Voluntari presents a lack of development of public transport, the majority of citizens using their personal vehicle as a means of travel (Figure 7).

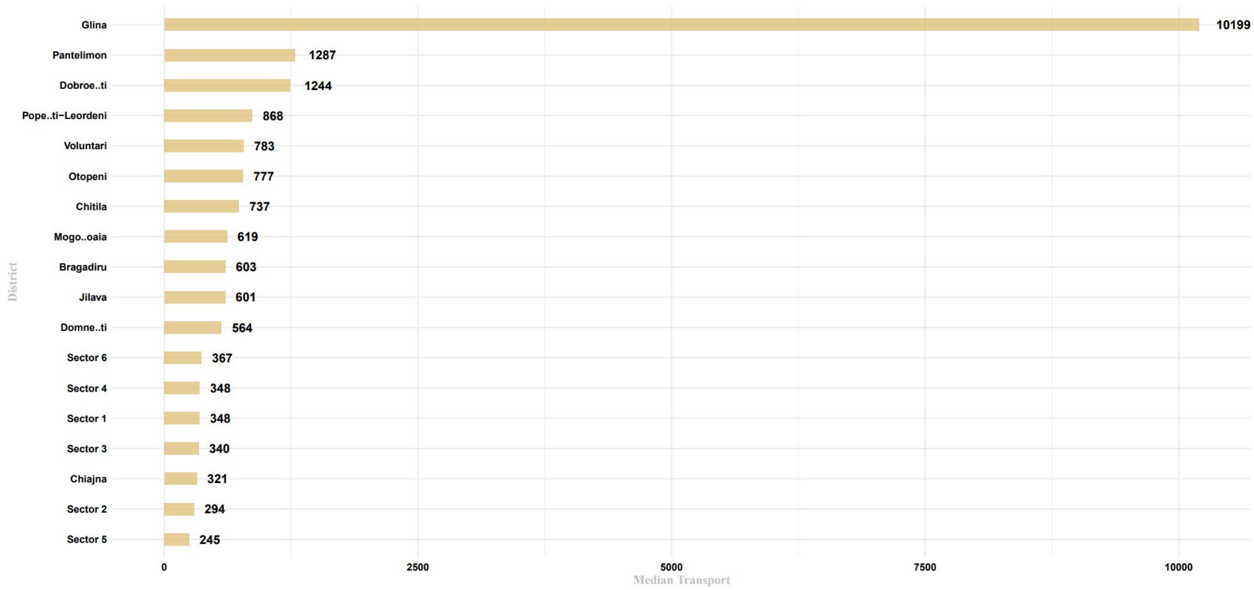

Figure 8. The median distance of transport

Source: Authors' own research.

Regarding the transport dimension, the particularities for the median value follow the situation described in the case of the median value. The Glina area has a 50% share of residential buildings located at a distance of at least 10 km from a common public transport station, being at a great distance from the rest of the peri-urban areas. Except for the case of the Glina area, the amplitude of the series is reduced, which confirms a relatively uniform development at the level of the analyzed statistical units. A particular case, which deserves to be discussed, is represented by Jilava, which presents a relatively low value (approx. 600 m). Therefore, it can be stated that half of the residential buildings in Jilava are located at a maximum distance of 600 m, the main residential areas being served by public transport, a similar case is also represented by Bragadiru (Figure 8).

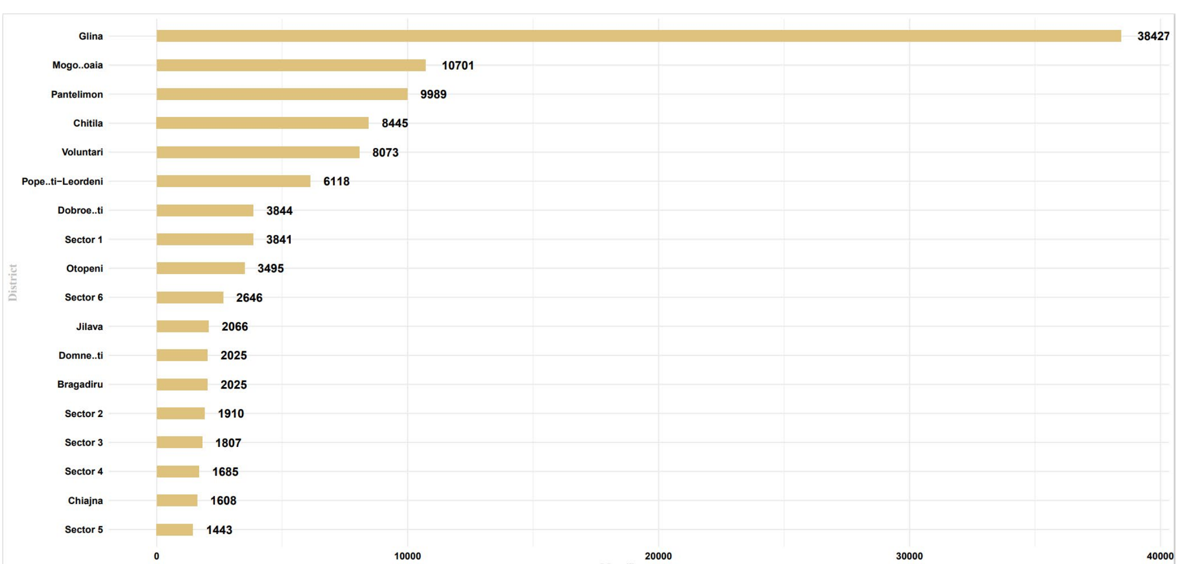

Figure 9. The maximal distance of Transport

Source: Authors' own research.

Again, Glina confirms the status of outlier value, presenting a dispersion of residential buildings over the entire surface of this peri-urban area and at the same time the lack of an administrative policy to increase the inclusion of citizens in the local community. Sectors 1 and 6 show high maximum values, which indicate the need to reconfigure public transport routes to serve the new residential districts, developed at the edge of these cities, following the example of Sector 4 which is the third best performing statistical unit on this variable, where new public transport routes were introduced to serve the new residential buildings. Sector 5 is the best-performing area on this variable, mainly due to the reduced pace of residential development towards the unexploited areas of bad neighborhoods such as Rahova or Ferentari (Figure 9).

As can be seen, several patterns of development have been identified up to this point. Furthermore, the possible relationship of association between the peri-urban areas and the 6 sectors of Bucharest is analyzed.

Table 2. P-value of Global Moran Index

Variables	P-value
Average_Education	0.75
Median_education	0.77
Max_educaion	0.37
Average_transport	0.25
Median_transport	0.11
Max_transport	0.25
Average_medicine	0.76
Median_medicine	0.85
Max_medicine	0.58

Source: Authors' own research.

At 95% probability, there is insufficient evidence to state that there is global spatial autocorrelation at the level of statistical units in the sample. Therefore, there is no association relationship between the statistical units in the sample on the 3 dimensions of socio-economic development. However, even if the global spatial autocorrelation is not significant, the local autocorrelation will be tested, through the Local Index of Spatial Autocorrelation developed by Moran (Table 2).

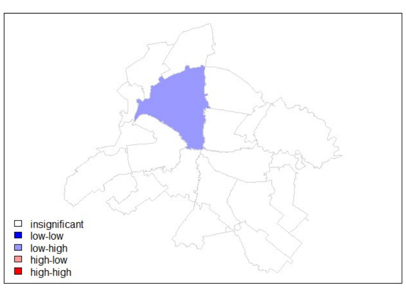

Figure 10 a. LISA of Average_education

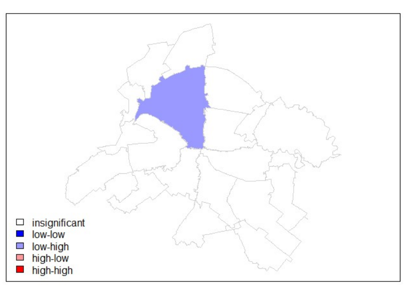

Figure 10b. LISA of Median_education

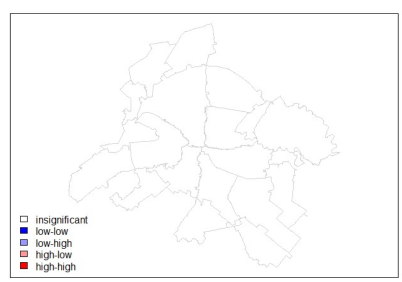

Figure 10c. LISA of Max_education

Source: Authors' own research.

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For the mean distance and the median distance, with a probability of 95% we can state that there is significant local spatial autocorrelation between Sector 1 and its neighbors. The present spatial autocorrelation is of the low-high type, Sector 1 having a low value of this indicator, but its neighbors, especially Otopeni and Voluntari, show a lower level of this indicator (Figure 10a, Figure 10 b). Therefore, Sector 1 offers a higher degree of inclusion in the educational system, compared to neighboring areas. However, this situation will lead to the migration of the school-age population from neighboring areas to Sector 1 in order to have access to adequate education services. This phenomenon will have negative effects on traffic, the time wasted in ensuring access to the educational system, but also negative effects from a neuro-psychological point of view, effects felt by both parents and children as a result of the long time spent in traffic and the long distances from the residence to the educational institution

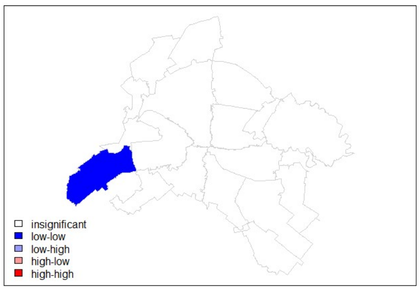

Figure 11a. LISA of Average_medicine

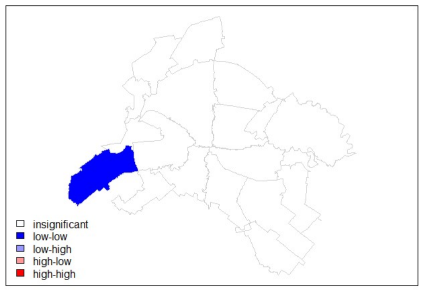

Figure 11b. LISA of Median_medicine

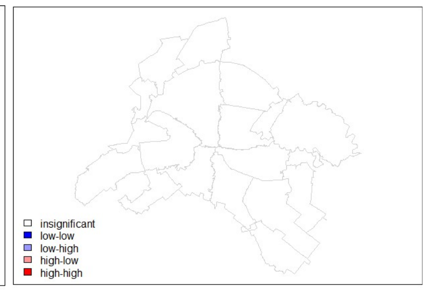

Figure 11c. LISA of Max_medicine

Source: Authors' own research.

With a probability of 95%, on the medicine dimension, it can be stated that there is local spatial autocorrelation between the peri-urban area Domnești and the peri-urban area Chiajna. This spatial autocorrelation is the low-low type, both localities, both Chiajna and Domnești registering low values on the two variables, access to medical services, in terms of the distance traveled (Figure 11a, Figure 11b).

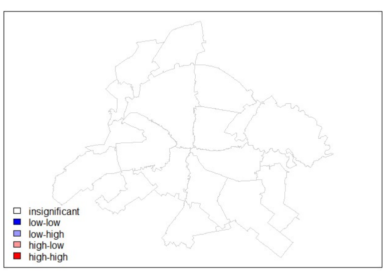

Figure 12a. LISA of Average_transport

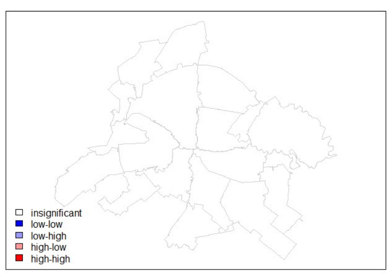

Figure 12b. LISA of Median_transport

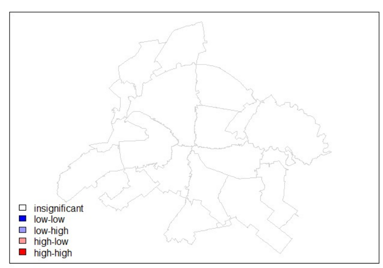

Figure 12c. LISA of Max_transport

Source: Authors' own research.

On the transport dimension, regardless of the indicator we are referring to, average, median or maximum distance, we can see that there is no significant autocorrelation at the level of the units in the sample. Therefore, it can be stated that there is a relatively even distribution at the level of

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these 3 indicators, each of the local administrations developing their public transport network, mainly at the local level (Figure 12a, Figure 12b, Figure 12c).

Interestingly, for the maximum distance, on all 3 dimensions, with a probability of 95% there is no spatial autocorrelation. This situation arises as a result of the fact that the maximum distance is rather a characteristic of the size of the spatial surface of a territorial administrative unit, in any of the units in the sample there are residents who therefore live at their extremity. These citizens mainly use personal vehicles and can contribute to traffic congestion and, implicitly, the decrease in air quality, as stated by Rosu et al. (2018). In addition, the results of the study, on all 3 dimensions, confirm the idea of Bacau et al. (2020), according to which the consistency of the spatial planning of the Municipality of Bucharest and peri-urban areas reaches a low level of consistency from the perspective of spatial planning, there being no coherent and well-articulated strategy at the local public administration level to increase the resilience of these settlements. Therefore, in order to face these challenges, the local administrations of the statistical units could develop and implement strategies on the polycentric development area, so that citizens are facilitated access to basic services and implicitly, guaranteeing a higher standard of living (Wen et al., 2023).

Conclusion

The main results of the study confirm the working hypothesis, of the development of the Bucharest-Ilfov region in an uneven manner. If from the perspective of public transport, at the level of the 6 sectors of the Municipality of Bucharest and the peri-urban areas, things are somewhat standardized, there is a development of the transport network in the newly built residential areas, for the other two dimensions, education and medicine, things are otherwise. For the education dimension, in the newly built residential areas, with the exception of the development of some private kindergartens and high schools, especially in the Voluntari area, in the other areas no new investments were made for the construction of educational units to serve the new residential neighborhoods. Similarly, for the medical dimension, most citizens have to travel long distances, most of the time with their personal vehicle, to have access to health services. This makes traffic difficult, generating negative effects on the environment, such as decreasing air quality.

The median and average values show, with few exceptions, the same situation of results, confirming the expansion of most peri-urban areas from the center to the outside. On the other hand, the results provided by the maximum indicators offer a different perspective, the areas that register high values also have large areas. Therefore, the high values on these indicators appear exclusively as a result of the surface of the territorial-administrative units, in each of these units there is a part of the population that prefers to live at the extremes.

The main scientific limits of this research are represented by the quality of geospatial data extracted through Open Street Map. This open-data platform has several data providers from central and local administration. Thus, there may be gaps in terms of the punctuality of the existing data in the Open Street Map database, but also problems in the area of data accuracy in the case of certain indicators.

This research will be expanded by adding several variables, relevant for the evaluation of the quality of life of the inhabitants, but also by expanding the sample, in a first phase, at the level of the large urban settlements of Romania, in order to identify certain patterns of relationship between the urban center and the areas its peri-urban areas, in order to develop a set of recommendations that can be applied at the level of central and local administrations.

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