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Assessment of Residential Areas of City on the Example of Olsztyn

Iwona Cieslak ¹, Szymon Czyza ¹, Karol Szuniewicz ¹, Michał Ogrodniczak ¹

¹ Prawochenskiego Str. 15, 10-720 Olsztyn, Institute of Geoinformation and Cartography, UWM Olsztyn, Poland

michal.ogrodniczak@uwm.edu.pl

Abstract. The contemporary city is undergoing dynamic transformations, as well as public urban space, which is an elementary part of it. Rapid urban development causes an increase in the number of inhabitants, who are looking optimal living conditions. Creating them is the main aim for urban-planners, which can prevent urban sprawl and depopulation of its central parts. Nonetheless it's possible only when we can constantly monitor the quality of the city's residential areas. That purpose requires new tools for assessment of residential areas. One of the main aspect of those ratings should be to determine the usefulness of housing estate. The term usefulness of city space should be understood as basic needs of inhabitant accessibility. Their availability in the area of neighbourhood guarantees a high standard of living for its residents. Sometimes this access is limited as a result of which the functionality of the area is falling and this part of city become unattractive for living. Over time, this may result in a decrease in the value of the space and even its depopulation and eventually degradation of the city space even in its central districts. The main aim of the article is to develop a method for assessing the useful value of residential areas based on criterion of distance to forms of basics services for residents. The article analyzes this problem in residential areas located within the city, which are also determined as city's separate administrative divisions. Real-time maps of availability for selected basic services prepared during the studies were the basis for the further studies. Mainly with their help we can indicate the directions of shaping space by planning development specific services in the specific areas. The article presents the results of assessment of residential areas of city on the example of Olsztyn. This example show that presented in article approach and methodology could be very useful tool for urban-planners and private investors. Moreover, the biggest advantage of developed methodology is that it indicates specific location of investment deficiencies.

1. Introduction

The quality of life in urbanized space is made up of multiple factors ensuring the satisfaction of basic and higher needs of city dwellers [1]. Usually, space that is safe and aesthetic and offers convenient communication solutions and guarantees good access to basic public facilities is regarded as resident-friendly [2, 3]. The best access is access which does not require reliance on municipal transport, when such a facility is situated within a walking distance which can be covered without physical or mental strain. As Chmielewski [4] notes, the quality of residential environment can be measured with the use of various indicators, e.g. a share of built-up and recreation areas (e.g. in the general area covered by the study or per inhabitant) or climatic conditions (e.g. air quality, sun exposure of flats, noise level). In the study presented in this paper, the useful quality of this space was measured based on an index describing service infrastructure availability in residential units. The **usability of residential space**



should be understood as the provision of basic services capable of satisfying residents' needs. Their accessibility within the residential estate significantly improves the comfort of life of its inhabitants. The access to services such as school or kindergarten is very frequently a criterion determining the choice of a place to live.

In the process of space assessment, the primary issue is to specify the aim of this evaluation. It permits to diagnose the conditions for a given phenomenon [5, 6, 7]. It is also important to establish norms and assume proper measures [8]. There are several space evaluation methods, and most of them are of a utilitarian type. Their task is to interpret specific (social and economic) needs of residents. Assessments help to describe the scale of the phenomenon and illustrate the existing conditions. A correct interpretation and analysis of evaluation results leads to understanding the nature of the given problem. This provides the possibility to take appropriate measures towards possible improvement of the existing state of space [9].

Following the above line of reasoning, **the main aim** of the presented study is defined as development of a procedure for evaluating the usability of space in residential districts. Its implementation requires developing an assessment procedure pursuant to the established criteria and testing this procedure on a selected space.

2. Assumptions and research methods

Numerous indicators presenting utilitarian evaluation of urban space apply the measure of the distance between the objects. Despite the lack of applicable and clear standards referring to location and relative situation of objects, there are certain rules of urban design, the preservation of which can prove the useful quality of urbanized space [10]. Residential estates should be designed with the impact of their surroundings on the user in mind. According to Chmielewski [4], the near access distance to selected services should not exceed 80 m. A walking distance covered without major problems is 500 m. On the other hand, a distance within a 1,000 m radius is considered an acceptable distance. When the distance to day nursery, kindergarten, school or other primary services or public transport stops exceeds 500 m, and in extreme cases 1,000 m, it is regarded as an inconvenient distance. As the most important service utilities in residential estates, the author [4] lists the following facilities:

1. Primary school;
2. Kindergarten;
3. Day nursery;
4. Shopping infrastructure (groceries and general stores, with the basic offer);
5. Health centre;
6. Cultural and recreation facilities (including cultural centres, fitness clubs, cinemas).

The above-mentioned facilities and distances were used as model values for determining utility zones in the residential estate. However, since an urbanized space is complex, the best solution as regards evaluation of a distance to public facilities from the place of living is to use time distances [11]. The time required to reach a specific service takes into account the need to cover field obstacles resulting from the arrangement of urbanized space. These are obstacles such as pedestrian crossings, landform features or the need to extend the route caused by density of buildings [12]. The average speed of a pedestrian moving in a built-up area was assumed as 6 km/h. In view of the considerations presented above, it was assumed that the optimum time for reaching the above-mentioned services is 5 min (500 m). The maximum time for accessing the service was assumed as 10 min (1,000 m). When the values exceed this time limit, the service becomes not fully useful for residents, which results in a more frequent use of car transportation, or the need to search for substitutes of the given service. In the evaluation conducted, while applying the procedure selected, several phases must be distinguished. Those phases will allow better understanding of the nature of the examined issue and facilitate correct interpretation of the obtained results. The evaluation was carried out in six stages:

Stage I. Six objects responsible for provision of primary services were chosen in each district. Their selection was specifically related to the subject of the evaluation. These are the facilities of significant impact on the useful structure of residential estates.

Stage II. Data necessary for evaluation were obtained from orthophotomaps available in urban spatial information system of the city of Olsztyn, websites and web services (Open Street Maps, Google Maps) and the study of conditions and directions for land development for the city of Olsztyn.

Stage III. The subsequent stage consisted in compilation of isochrone maps of equal travel time required to access selected services. Those maps were created using data on the existing traffic routes of residential estates in the Open Route Service. Areas of equal time accessibility, i.e. isochrones, were determined for the boundary of 5 and 10 min of the access time to a service facility.

Stage IV. The next stage concerns assigning weights and establishing the criteria for the time of access to the facility. Selected facilities were assigned respective weights, corresponding to their importance value, in other words – rendering the significance of the facility for catering for the needs of the city inhabitants [13]. Weights were determined on the basis of opinions provided by one hundred inhabitants of Olsztyn. In the survey, residents expressed their view on the significance of specified facilities for the feeling of comfort of their residential space in their estates.

Weights were described using the Simos method, based on facilities ranking using a constant rank order scale and analysis of these positions in relation to each other and intervals between them [14]. Such ranking of facilities results in the creation of subsets, which can be assigned rank numbers in the form of subsequent natural numbers. The procedure for establishing weights is carried out in two stages.

- determination of non-normalized weights (w_n) – sum of items assigned to the rank number by the number of positions;
- determination of normalized weights (w) – the weight that has not been normalized by the sum of weights of all facilities.

The surveyed residents described the importance of facilities using the 1 to 10 scale. The opinion of the survey participants was averaged and presented in Table 1.

Table 1. Weight determination for useful facilities in residential estates using the Simos procedure,[14].

<i>position</i>	<i>object</i>	<i>order number</i>	<i>position</i>	w_n	w
10, 9	shopping infrastructure,				
8	primary school	8	2	$(10+9)/2 = 9.5$	0.27
7	-	7	-	-	-
6	-	6	-	-	-
5	kindergarten	5	1	$6/1 = 6$	0.17
4	health centre	4	1	$5/1 = 5$	0.15
	-	3	-	-	-
3, 2	day nursery, cultural				
1	and recreation facilities	2	2	$(3+2)/2 = 2.5$	0.07
	-	1	-	-	-

The space of residential estates was evaluated according to the criterion of access time to the facility. In the evaluation of urban space usability, pedestrian communication routes are of great importance. Easy access to an object depends, to a large extent, on the course and quality of pedestrian routes and the level of space urbanization. Pedestrian accessibility is important for evaluating an urban space area such as residential estates [9].

If the space of the residential estate was within the boundaries determined by the isochrones for 5 min access to a selected service, it was assigned 3 points. The area between a 5 min isochrone and a 10 min isochrone of service accessibility was assigned 2 points. The area between the isochrone for 10 min access to the service and boundaries of the estate was given 1 point. The services which were not situated within the boundaries of the estate were considered as non-affecting its useful value.

Stage V. For the need of the evaluation, for each basic service selected, a percentage share of areas within the isochrones in the total area of individual residential estates i was calculated. In order to obtain a reliable result of residential estate evaluation for the utility of each service, the service accessibility index, A_s , was applied, which was calculated on the basis of the following formula (1).

$$A_{Uti} = \sum_{i=1}^3 ar_i \times R \quad (1)$$

where:

A_{Uti} – evaluation of service t availability within the space of residential estate i ,
 ar – percentage share of the areas within the isochrones of service t , of assessment R in the total area of estate i ,
 R – points granted for time distance to service t .

The value of the index makes it possible to compare usability of individual residential estates taking into account specific services.

The final evaluation of estate usability was calculated as a sum of weighted indices A_{Uti} for each of the estates (formula 2).

$$A_{Ui} = (\sum_{t=1}^6 v_{ut} \times A_{Uti}) / 6 \quad (2)$$

where:

A_{Ui} – evaluation of residential space usability for estate i ,
 v_{ut} – weight of service t ,

The results of conducted evaluation of space usability for individual estates were determined on the basis of a percentage share of the area within the isochrones in the total area of the residential estate, weights assigned to selected basic service facilities and points assigned for individual isochrone ranges.

Stage VI. The final stage involved classification of the residential estates evaluated. Three quality classes describing residential space usability in estates were determined. Classes of space usability evaluation for individual estates were established preserving a geometrical interval.

3. Description of the research space

The proposed procedure for space usability assessment was decided to be tested in the areas of Olsztyn. This is the largest city in north-eastern Poland, the capital of the Warmia and Mazury Province [15]. For about a dozen years, the city has been facing demographic problems, undergoing the phenomenon of de-urbanization in favour of neighbouring communes. The city's population growth within the last five years with reference to neighbouring communes is presented in Table 2.

Table 2. Population growth for Olsztyn and neighbouring communes in 2012-2016.

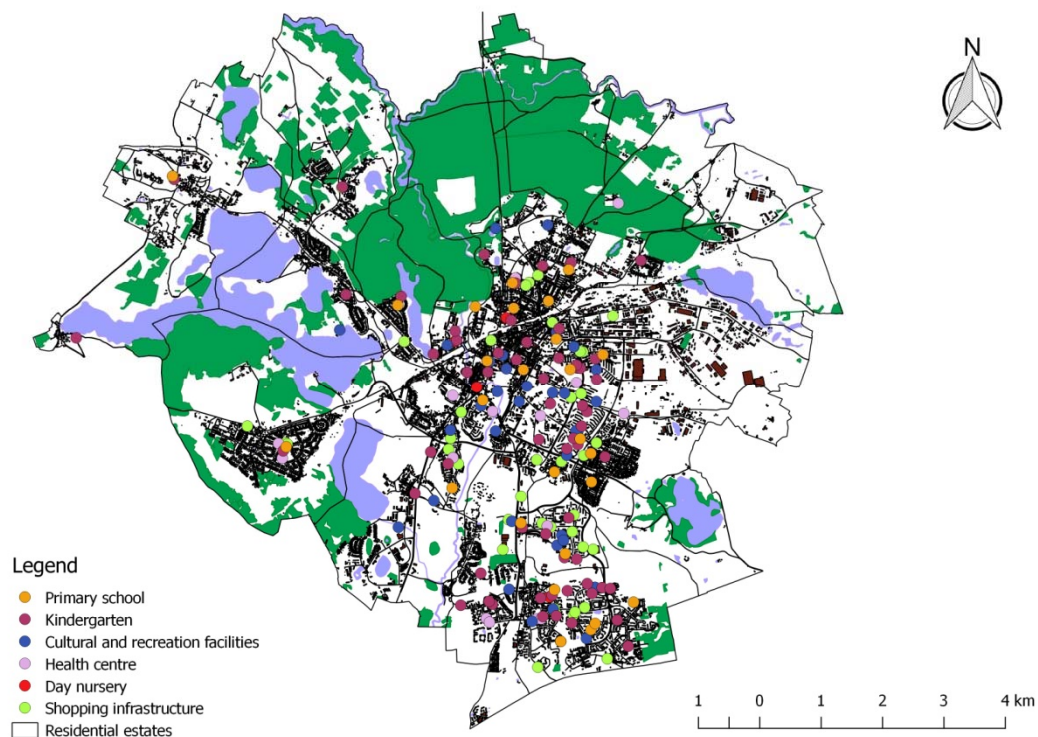
<i>Communes</i>	<i>Population growth (%)</i>				
	<i>2012</i>	<i>2013</i>	<i>2014</i>	<i>2015</i>	<i>2016</i>
Barczewo	1.49	0.74	0.91	0.74	0.25
Dywity	1.40	2.04	0.78	1.41	1.08
Gietrzwałd	2.06	2.54	2.16	0.57	0.21
Jonkowo	1.15	1.99	1.08	0.25	1.70
Purda	1.18	1.54	0.52	0.66	0.57
Stawiguda	4.87	4.12	3.49	4.17	5.94
Olsztyn	-0.44	0.02	-0.48	-0.22	-0.26

To prevent the phenomenon of de-urbanization, the quality of space should be increased to become resident-friendly. The city of Olsztyn offers numerous environmental values (greenery, large forest complexes or 15 lakes). The basic task of city space administrators is to increase the usability value of this space [16].

The city features 23 estates of highly diversified areas and development density. Those estates were described as subjects of the analysis, diversifying their quality with reference to their capacity to satisfy service-related needs within their boundaries. The classification performed will determine the directions of activities targeted towards increasing the quality of residential space in the city.

4. Result

For all 23 residential estates of Olsztyn, the service facilities identified in Chapter 2 were identified. Result of this stage is shown in Figure 1.

**Figure 1.** Service facilities identified in Olsztyn estates.

Their centroid was assumed as a basis for determining isochrones for 5 and 10-minute access to the facility. Sample results of this operation are shown in Figure 2.

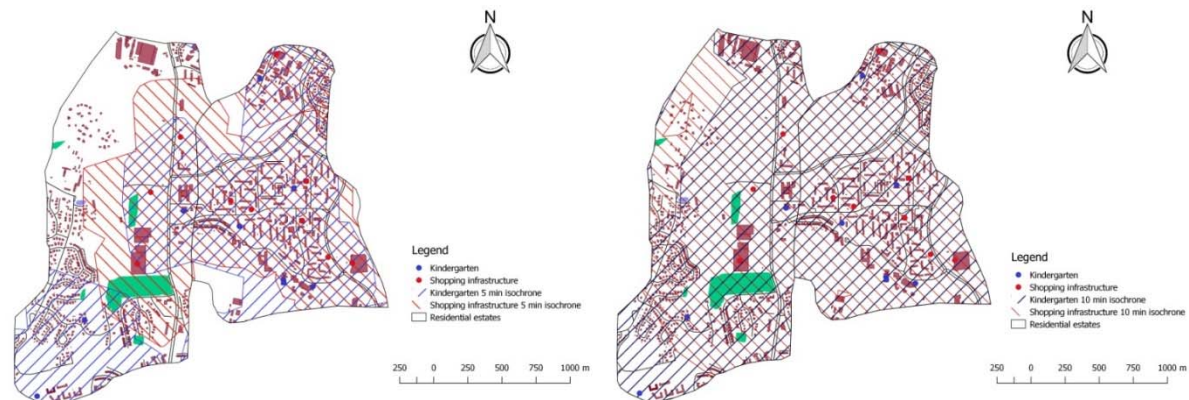


Figure 2. Sample of 5 min and 10 min isochrones for access to selected service facilities in examples residential estates.

On the basis of the isochrones established, shares of estate areas with boundaries described by access to services up to 5 min, between 5 and 10 min and above 10 min were determined [17]. Thus calculated area shares provided the basic parameter for determining A_{Uti} index, specifying service t accessibility in the space of estate i . The results of those calculations are presented in Table 3.

Table 3. Evaluation of service t availability within the space of residential estate i .

Communes	A_{Uti}					
	shopping infrastructure	primary school	kindergarten	health centre	day nursery	cultural and recreation facilities
Brzeziny	0.39	0.21	0.38	0.27	0.22	0.34
Dajtki	0.25	0.22	0.22	0.22	0.17	0.17
Generałów	0.23	0.18	0.32	0.34	0.32	0.26
Grunwaldzkie	0.30	0.24	0.32	0.28	0.31	0.29
Gutkowo	0.17	0.20	0.22	0.17	0.17	0.17
Jaroty	0.46	0.44	0.45	0.30	0.33	0.44
Kętrzyńskiego	0.24	0.23	0.23	0.17	0.18	0.22
Kormoran	0.47	0.40	0.49	0.41	0.42	0.47
Kortowo	0.18	0.18	0.26	0.18	0.20	0.27
Kościuszki	0.34	0.37	0.44	0.38	0.23	0.43
Likusy	0.18	0.19	0.24	0.17	0.17	0.22
Mazurskie	0.21	0.21	0.22	0.20	0.17	0.18
Nad Jez. Długim	0.24	0.25	0.31	0.17	0.22	0.23
Nagórki	0.47	0.43	0.48	0.34	0.29	0.41
Pieczewo	0.25	0.33	0.35	0.17	0.17	0.22
Podgrodzie	0.43	0.41	0.39	0.45	0.34	0.41
Podleśna	0.19	0.20	0.22	0.21	0.17	0.19
Pojezierze	0.29	0.31	0.31	0.29	0.19	0.32
Redykajny	0.22	0.17	0.22	0.17	0.17	0.17
Śródmieście	0.41	0.50	0.50	0.28	0.39	0.50
Wojska Polskiego	0.22	0.23	0.25	0.21	0.20	0.26
Zatorze	0.49	0.50	0.48	0.41	0.33	0.31
Zielona Górka	0.17	0.17	0.18	0.17	0.17	0.17

The index provides the possibility of evaluating residential estates in terms of the overall access to services. Based on the values provided in Table 3 and weights specified in Table 1 for individual

services, the final A_{Ui} index for useful residential space of estate i was determined. The results of the assessment performed are presented in Table 4.

Table 4. Evaluation of residential space usability for estate i .

<i>Oommunes</i>	<i>object and weight w</i>						A_{Ui}
	<i>shopping infrastructure</i>	<i>primary school</i>	<i>kindergarten</i>	<i>health centre</i>	<i>day nursery</i>	<i>cultural and recreation facilities</i>	
	0.27	0.27	0.17	0.15	0.07	0.07	
Brzeziny	0.10	0.06	0.07	0.04	0.02	0.02	0.31
Dajtki	0.07	0.06	0.04	0.03	0.01	0.01	0.22
Generalów	0.06	0.05	0.05	0.05	0.02	0.02	0.26
Grunwaldzkie	0.08	0.07	0.05	0.04	0.02	0.02	0.28
Gutkowo	0.04	0.06	0.04	0.02	0.01	0.01	0.19
Jaroty	0.12	0.12	0.08	0.04	0.02	0.03	0.42
Kętrzyńskiego	0.07	0.06	0.04	0.03	0.01	0.02	0.22
Kormoran	0.13	0.11	0.08	0.06	0.03	0.03	0.44
Kortowo	0.05	0.05	0.04	0.03	0.01	0.02	0.20
Kościuszki	0.09	0.10	0.07	0.06	0.02	0.03	0.37
Likusy	0.05	0.05	0.04	0.03	0.01	0.02	0.19
Mazurskie	0.06	0.06	0.04	0.03	0.01	0.01	0.20
Nad Jez. Długim	0.06	0.07	0.05	0.03	0.02	0.02	0.24
Nagórki	0.13	0.12	0.08	0.05	0.02	0.03	0.42
Pieczewo	0.07	0.09	0.06	0.03	0.01	0.02	0.27
Podgrodzie	0.12	0.11	0.07	0.07	0.02	0.03	0.41
Podleśna	0.05	0.05	0.04	0.03	0.01	0.01	0.20
Pojezierze	0.08	0.08	0.05	0.04	0.01	0.02	0.29
Redykajny	0.06	0.05	0.04	0.03	0.01	0.01	0.19
Śródmieście	0.11	0.13	0.08	0.04	0.03	0.03	0.43
Wojska Polskiego	0.06	0.06	0.04	0.03	0.01	0.02	0.23
Zatorze	0.13	0.13	0.08	0.06	0.02	0.02	0.46
Zielona Górka	0.04	0.05	0.03	0.03	0.01	0.01	0.17

For the clarity of results and with a view to establishing priorities in shaping the space, the obtained results were classified according to the geometrical interval principle. The results of classification are presented in a cartogram – Figure 3.

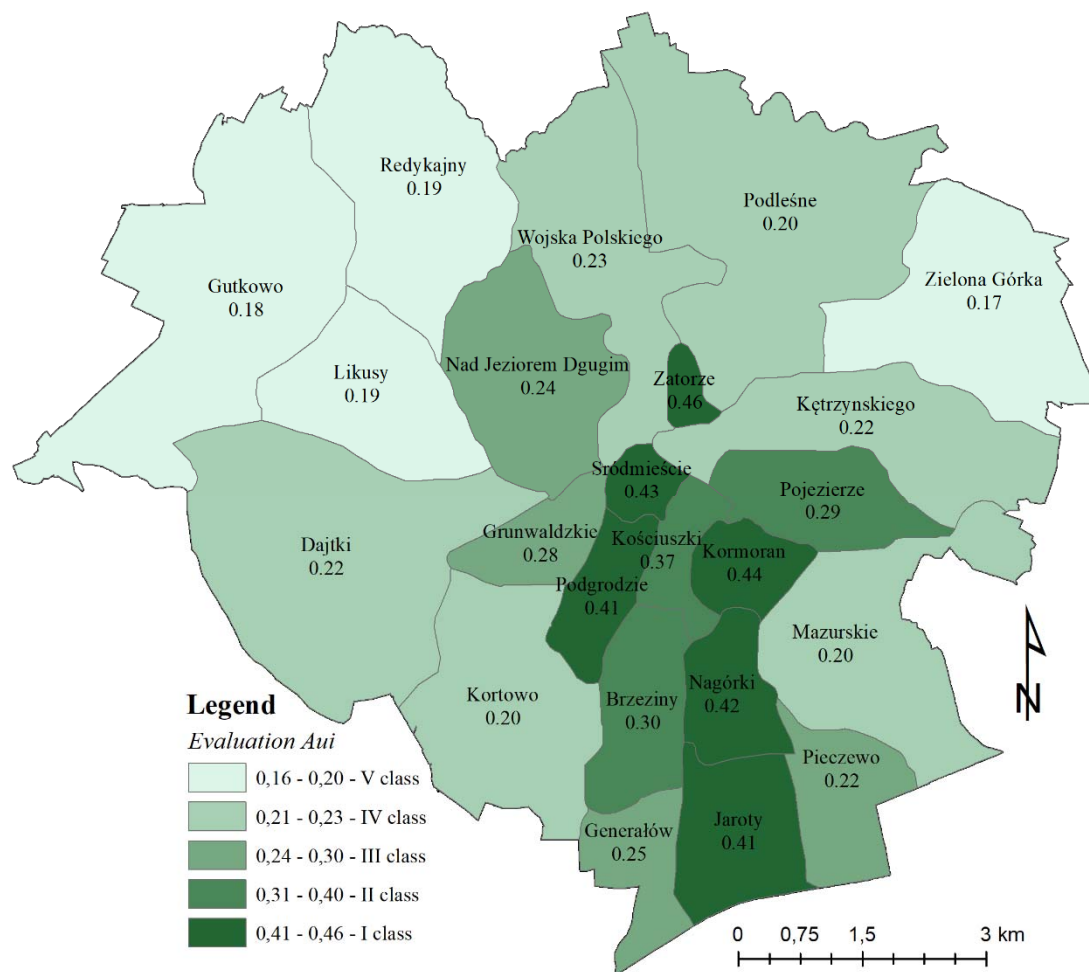


Figure 3. Cartogram of residential space usability assessment in Olsztyn estates.

5. Discussions

The A_{ui} index for residential space usability can take values from 0 to 1. In the area under analysis, its value reached the maximum of 0.46. This means that usability of residential estates of Olsztyn is low and does not satisfy general objectives. In none of them can we talk about comfortable access to common public services.

Analysing the obtained results in terms of the classification performed, it can be observed that residential estates with the best service offer are situated in the central and southern part of the city, of higher development density and higher population. Table 5 provides classification results with reference to the area and number of inhabitants in individual estates [18].

Classes with the lowest assessment results (IV and V) include estates located in the north of the city and estates of relatively large areas. However, it should be emphasized that this result was significantly affected by green areas and lakes situated within those residential estates. This does not change the fact that services existing in this area are situated away from inhabitants, which reduces their comfort of life within the space of those estates.

As it can be seen in Table 4, such assessment results are caused mainly by low access to health centres, day nurseries or schools. Estates are quite well-equipped with supermarkets, kindergartens and cultural or recreational services. This corresponds to a clear division of services into commercial and non-commercial and applies also to kindergartens and day nurseries, the majority of which are private facilities.

Table 5. Area and number of inhabitants of Olsztyn residential estates

<i>communes</i>	<i>number of inhabitants</i>	<i>area km²</i>	<i>density of population</i>	<i>A_{vi}</i>
Brzeziny	2088.00	2.24	932.10	0.31
Dajtki	5682.00	7.50	757.60	0.22
Generałów	9032.00	1.95	4631.70	0.26
Grunwaldzkie	5630.00	1.46	3856.10	0.28
Gutkowo	3553.00	7.19	494.10	0.19
Jaroty	24573.00	2.87	8562.00	0.42
Kętrzyńskiego	7273.00	4.83	1505.70	0.22
Kormoran	14698.00	1.10	13361.80	0.44
Kortowo	1057.00	4.22	250.40	0.20
Kościuszki	6272.00	1.18	5315.20	0.37
Likusy	2233.00	2.10	1063.30	0.19
Mazurskie	4909.00	5.95	825.00	0.20
Nad Jeziorem Długim	2798.00	4.23	661.40	0.24
Nagórki	11615.00	1.69	6872.70	0.42
Pieczewo	10225.00	2.24	4564.70	0.27
Podgrodzie	10250.00	1.35	7592.50	0.41
Podleśna	10133.00	9.93	1002.40	0.20
Pojezierze	11897.00	2.39	4977.80	0.29
Redykajny	1336.00	6.10	219.00	0.19
Śródmieście	3038.00	0.58	5237.90	0.43
Wojska Polskiego	6309.00	5.03	1254.20	0.23
Zatorze	6503.00	0.46	14136.90	0.46
Zielona Górka	603.00	6.44	93.60	0.17

This proves that commercial services respond faster to the demand of residents than the public sector. What is particularly alarming in this aspect is the poor access to schools and health centers.

6. Conclusion

Location of services within the residential estate, the existing land development status and the level of transport development affect time accessibility of service facilities. A negative impact of one of those factors on the estate area results in creating barriers reducing time accessibility of selected facilities.

The study presented in this paper fulfils the main objective of the research, which consists in the development of a procedure for assessing residential space usability. The method developed for space usability assessment is universal and can be used to evaluate medium and large city districts. Of course, the assumptions adopted for evaluation of specific residential estates can be adjusted depending on the purpose and scope of conducted analyses.

Achievement of the main aim of the research confirms the need to develop similar tools for evaluating the useful aspect of residential space. It revealed unsatisfactory access to basic services and indicated the need to develop networks of those services and communication routes to increase access to those services.

The conducted analyses can be used for compiling development plans for the city and evaluated residential estates and by investors looking for a market for their services.

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