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THE ISSUE OF GREEN AREA ACCESSIBILITY – THE EXAMPLE OF THE CITY OF ŁÓDŹ

PROBLEM DOSTĘPNOŚCI TERENÓW ZIELENI W MIEŚCIE NA PRZYKŁADZIE ŁODZI

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ABSTRACT: The article is devoted to the subject of urban greenery. The paper attempts to present real green areas and not only those that have such a purpose featuring in lists and registers. The authors also refer to the topic of availability of urban greenery for the residents of the city, taking into account an uneven density of places of residence. The aim of the article is to present the method for assessing the availability of green areas around places of residence, using spatial data showing residential buildings and official data on greenery. The relevant analyses are based on a regular network of squares of 90 m × 90 m. It was found that Łódź is a city with rich greenery resources. However, this judgment needs revising because a significant part of the residents both in their places of residence (R = 50 m) and further surroundings (R = 500 m) do not have access to green areas intended for recreation.

KEY WORDS: greenery, urban greening, NDVI, quality of life

ABSTRAKT: Artykuł poświęcony jest tematyce zieleni miejskiej. W pracy podjęto próbę przedstawienia rzeczywistych terenów zieleni, a nie tylko tych, które posiadają takie przeznaczenie w wykazach i rejestrach. Autorzy odnoszą się również do wątku dostępności zieleni miejskiej dla mieszkańców miasta, biorąc pod uwagę nierównomierne zagęszczenie miejsc zamieszkania. Celem artykułu jest przedstawienie propozycji metody oceny dostępności terenów zieleni dla mieszkańców miast. Wykorzystano dane dotyczące rozmieszczenia budynków mieszkalnych oraz obiektów, które są oficjalnie uznawane za tereny zieleni. Analizy prowadzono w regularnej siatce kwadratów o wielkości 90 m × 90 m. Analizowano dostępność zieleni w miejscu zamieszkania oraz w promieniu do ok. 500 m. Stwierdzono, że Łódź jest bogata w zasoby zieleni, jednakże ta ocena powinna być zweryfikowana ponownie, gdyż wciąż wielu mieszkańców zarówno w miejscu zamieszkania (R = 50 m) jak również w najbliższym otoczeniu nie ma dostępu do zieleni rekreacyjnej.

SŁOWA KLUCZOWE: tereny zieleni, zieleń miejska, NDVI, jakość życia

Introduction

In the common knowledge, there are two conflicting opinions about the size of green areas in Łódź. Łódź is perceived as a post-industrial city full of tenement buildings,

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abandoned industrial plants and with a small share of green areas, or just opposite – as a city with a record amount of greens planned in the form of parks and green areas, as well as with a lot of greenery.

Official data collected by the Łódź Department of Geodesy, the City of Łódź Office and the Main Center for Geodetic and Cartographic Documentation, include areas for which the greenery function is officially assigned. However, statistical data, averaged in official statistics, do not reflect the actual availability of green areas, which should also take into account the uneven distribution of population (concentration in the center) and green areas (located mainly on the outskirts). What is more: official repositories show different data with reference to the size of green areas in specific places. There are also different nomenclature and definitions between the sources.

The aim of the study was to assess the availability of green areas in the place of residence (R = 50 m) and a further surroundings zone of a radius of about 0.5 km (R = 500 m) around the place of residence, using data on the distribution of population and urban greenery.

The problem of the availability of greenery in the context of literature

Access to something is understood as the possibility of getting to it (to some place), we can also have access to someone or to some things or matters, that is, to have contact with them or "use these things or matters for ourselves" (Bańko 2007, 380-381). From this perspective, we approach the issue of accessibility in this study.

Assessment of accessibility in the city space is an issue undertaken in science very often and relates to a very wide range of issues, e.g. to medical services (Wang 2011, 237-251; Jankowski and Brown 2014, 39-53; Wiśniewski 2016, 157-166), public transport (Gadziński 2012, 177-186; Soczówka 2012, 197-203), sports and recreation facilities, workplaces, schools (Guzik 2003, 47-134), offices, banks, telecommunications networks (Kozubek and Werner 2007, 53-62) and many others. It is also worth noting that, as is the case with forests (Paschalis-Jakubowicz 2020, 1062), the use of urban greenery also occurs when there is no direct contact with it. The problem of accessibility is often also considered from the perspective of specific social groups, especially people with disabilities, in the broad sense of the term (Stauskis 2017, 199-216). The level of accessibility is also compared with other social or economic phenomena, such as property prices, health status, quality of life (Burdziej 2018, 219-234). According to the philosophy of universal design developed in modern urban planning, solutions adapted to the possibilities of the weakest user are preferred, as they will also be suitable for other users. Solutions that meet this principle ensure that physical exertion is minimized, that each user can use the same range of use, and that the user is flexible, depending on their individual predispositions (Błaszak and Fojud 2017, 58-83.).

In this article, we focused on the availability of taking advantage of green areas, irrespective of their type, in the nearest neighbourhood of the inhabitants of Łódź. This means that those people, who live in such areas, have also a direct access to the benefit

of all kinds of plants located nearby (e.g. fresher air, less noise, etc.). The issue of availability of greenery in the city was also considered with the application of the Lorenz's concentration curve (Będkowski and Bielecki 2017, 5-14). In other research, we can find information about the vegetation filling of urban quarters in city centre using only remote sensing data (Worm et a. 2019, 5-20).

When we attempt to assess the availability of greenery at the outset, we encounter difficulties in determining which of the coverage (use) classes of the terrain presented in individual data sources can or should be considered as representing urban green areas. In literature, we find many definitions of green areas. One of them, quite general, defines green areas as "urban areas covered with vegetation" and urban green areas as "spaces covered with vegetation in urban areas" (Łukasiewicz and Łukasiewicz 2016, 11-13). Böhm (1999 in Walkowicz 2002, 347-358) wrote: "Mostly urban greenery is defined as all biologically active areas within cities, regardless of how they are used and who owns them." Green areas are officially defined as areas furnished with technical infrastructure and buildings functionally connected with them, covered with vegetation, performing public functions, in particular parks, green spaces, promenades, boulevards, botanical gardens, zoological, Jordanian and historic gardens, cemeteries, greenery accompanying roads in buildings, squares, historic fortifications, buildings, landfills, airports, railway stations and industrial facilities.

Studies in landscape architecture, urban planning, environmental protection and sociology highlight many social, aesthetic, educational and economic aspects of greening in urban space (Chrobak and Kryczka 2018, 12). Greenery has a number of functions important for residents of cities (Białobok 1976, 223-245, Gill et al. 2007, 115–133):

- protecting against dust, soot, poisonous volatile substances,
- increasing air humidity,
- mitigating temperature differences,
- providing a wind shield,
- improving water balance,
- suppressing noise and air vibrations,
- aesthetic impressions,
- didactic and educational (collections of specimens in botanical gardens).

Greenery provokes positive emotions and impressions. Introduction of vegetation in human's environment usually meets general acceptance (Sobczyńska 2014, 56). Greenery, especially trees, is a very desirable element of the living environment, which has been confirmed in many countries (Szczepanowska 2012, 25-49). Accessibility to green spaces is now considered to be as important as for basic service areas (Chrobak and Kryczka 2018, 132).

The presence and quality of green areas is an important factor influencing the choice of place of residence (Wu et al. 2019, 133-144). Respondents repeatedly indicate the presence of greenery as a condition for a happy life and demand it as much as possible (Durecka 2017, 39). According to studies by Bułhak (2004, 209-214), the proximity of green areas is the most frequently indicated factor determining the attractiveness of

a given housing estate. Iwańczak (2017, 69-85) stated that in places where residents spend most of their time (home and work) greenery is most desirable. Nevertheless, in recreational areas, it may be indispensable, but it is of no importance in the places of trade. What is also important, according to the recent studies, parks in urban area can be an effective policy instrument to encourage people to live in a specific part of city (Wu et al. 2019, 133-144; Schipperijn et al. 2017, 253–263). That advantage of urban parks can help the local government to implement its local spatial policy.

Due to the importance of green areas for the functioning of urban centres, they have become an element defined in the recommendations and regulations and norms obligatory for decision-makers planning the development of cities. Some of the first greening recommendations were related to the garden city concept by Ebenezer Howard. He showed, using the example of Krakow, that the most suitable ratio of the area of built-up areas to undeveloped is 1:10; however, for Letchworth, the flagship and implemented city-garden, this index was only 1:2 (Czyżewski 2001, 96). According to Wodziczko (1937) (Łukasiewicz and Łukasiewicz 2016, 34) 1/3 of the city's area should be covered by natural vegetation, without agricultural crops.

Accessibility is expressed in the form of "cost" of reaching a given place, which can be understood as access or travel time, physical distance, energy or financial inputs, and more and more methods are used to model it, especially in the area of spatial analysis (Burdziej 2018, 219-234; Śleszyński 2014, 171–215). Urban planning norms also apply to green areas, specifying their total size, average size per one inhabitant, or the average travel time for residents per feature. We are talking about central parks (minimum 15-20 ha in area, average 2 m^2 per capita, and access within 15-30 minutes), district (5-10 ha, access in 10-15 minutes) and culture and leisure (from 20 to several hundred ha). The greenery and squares should be located within the housing estates and occupy the area within 1-2 ha. Every resident should have such an object no more than 0.5 km distant from his place of residence.

Suburban forests are treated separately, for which the main criterion is the area, which should amount to about 25-30% of the suburban area (Łukasiewicz and Łukasiewicz 2016, 43). The following norms regarding the area of greenery per one inhabitant are found in the legal act of 1964, although not obligatory, in which it was stated that one inhabitant should have 8-15 m^2 of greenery, and 10.6 m^2 of publicly available, including 1.5-2.5 m^2 of estate parks with a minimum area of 2 ha, and 1.5-2.5 m^2 of green areas (Order 1964). According to Ptaszycka (1950, 99), the correct systems are only those that provide a minimum of 15 m^2 of green areas per one inhabitant. Myczkowski (1976, 170), on the other hand, speaks about the need for 50 m^2 of green areas to provide adequate health conditions for human beings. Orzeszek-Gajewska (1984, 96) states that there should be 8-15 m^2 of greenery per one inhabitant.

There are also many studies focusing on parks as the green areas most recommended for cities. Most often, it is recommended to locate a park not more than 500 meters from residential buildings (or the location of buildings at such a distance to parks), which would take a 10-15 minute walk (Czarnecki 1968, 279). The minimum size of a park

should be, depending on the researcher, 2 ha (Łukasiewicz and Łukasiewicz 2016, 35) or 5 ha; however, not less than 8 m^2 per one inhabitant (Czarnecki 1968, 279).

When analysing the availability of green areas, the so-called service radius should be taken into account. It should be remembered that a distance of 500 meters in a straight line in urban conditions means the importance of a longer distance to the passage for a resident (Figure 1).

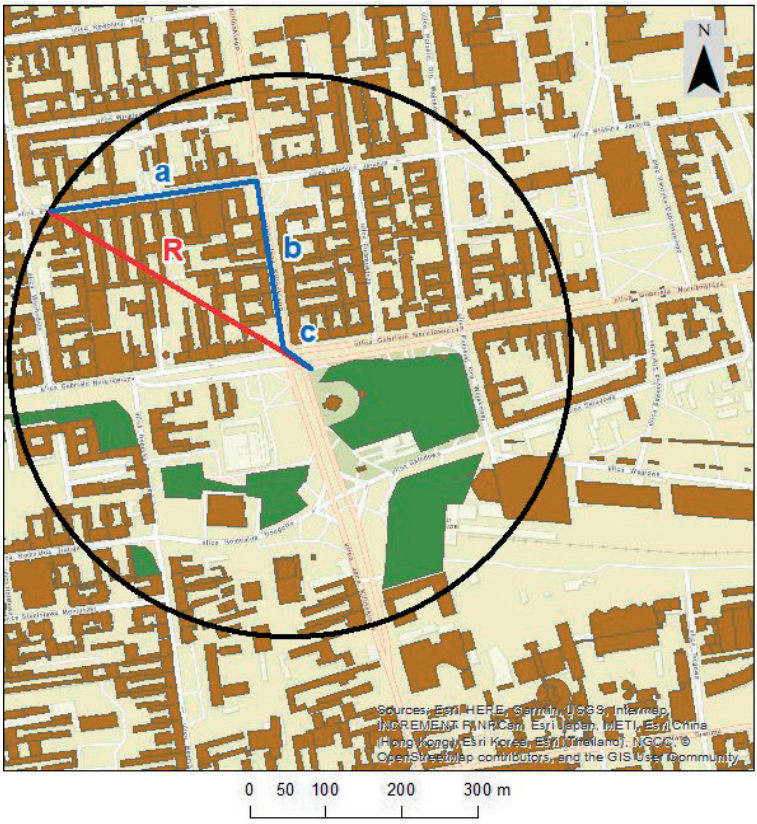

Fig. 1. Service radius and range of S. Moniuszko Park in Łódź, designated from one of the entrances. For the radius of service *R* the distance to cover is the sum of the values of a, b and c. For a place in a straight line of about 400 meters, the distance to the crossing is about 540 meters

Source: Prepared by the author on the basis of OpenStreetMap map.

Availability of greenery in Łódź

Łódź, the capital city of a province located in central Poland, occupies respectively the 3rd and the 4th place in terms of the number of inhabitants and the size of the area within the administrative borders (CSO 2016, Local Data Bank). The city is full of

contrasts, also with regard to green areas. Known for its industrial character, Łódź is associated with production plants, smoking chimneys and tight rental buildings, but it is also rich in historic parks offering high-quality greenery.

The basic source of information is the geodesic state, according to which two types of land can be classified as green. As can be seen from Table 1, half of the city's area is covered with permanent or temporary vegetation, which gives approx. 190 m^2 for one inhabitant of Łódź.

Table 1

Geodetic status of green areas in Łódź in 2017

Type of land	Area [ha]	Area of the city [%]	Per capita[a] [m^2]
Agricultural land (including arable land, orchards, permanent meadows and pastures)	11,670	39.8	154.0
Forest land, woody and bushy land	2,489	8.5	36.0

[a] 700,000 residents were accepted according to the same source.

Source: Statistical Office (SO) Łódź. Provincial Statistical Office, Łódź.

According to the same source, urban green areas (without areas with agricultural functions which have an ecological impact) constitute 13% of the city's area (Table 2). Therefore, there is less than 59 m^2 of green urban areas per one inhabitant.

Table 2

Municipal green areas in Łódź in 2017

Type of land	Area [ha]	Area of the city [%]	Per capita[a] [m^2]
Parks	627.4	2.14	9.0
Lawns	80.0	0.27	1.1
Estate green belts	999.7	3.41	14.3
Zoological gardens	17.0	0.06	0.2
Botanical gardens	66.7	0.23	0.9
Nature reserves	79.7	0.27	1.1
Landscape parks	1,605.9	5.48	22.9
Street green belts	650.4	2.22	9.3
			Total: 58.8

[a] 700.000 residents were accepted according to the same source.

Source: Statistical Office (SO) Łódź. Provincial Statistical Office, Łódź.

For every inhabitant of a Polish city, there falls an average of 21.6 m^2 of public and estate green areas (Table 3). Note that in 1971 this index was only 10.6 m^2 and it was

assumed then that the target should be just 20.5 m^2 (Białobok 1976, 223-245). Comparing this data with the values related to Łódź, we will find that the greenery indicator per citizen of Łódź is relatively high.

Table 3

Urban green areas in Poland

Year	Public and community green areas [m^2 per capita]
2005	19.9
2010	20.6
2013	20.4
2014	20.5
2017	21.6

Source: Statistical Yearbook of the Republic of Poland 2018, Central Statistical Office, Warsaw.

Materials and research methodology

For the spatial analysis of greenery distribution, data from public databases and data repositories were collected, such as:

– DataBase of Topographic Objects (*Baza Danych Obiektów Topograficznych 10k – BDOT*)

– Register of Land and Buildings (*Ewidencja Gruntów i Budynków – EGiB*)

– Atlas of the City of Łódź (*Atlas Miasta Łodzi – AMŁ*)

In each of these databases, a different division of areas is used; there are also, sometimes significant, differences in the boundaries of many objects.

DataBase of Topographic Objects

– 24 different terrain functions,

– Areas are in the overlap relation with each other (the total area is about 136% of the city area),

– More detailed than EGiB,

– Classes that can be qualified as green areas:

- PKLA – forest, copse, other trees,
- BBSP – playing fields,
- OIMO – marshland, wetlands,
- OISI – reed, bulrush,
- OIPR – clump of bushes, trees,
- PKKR – thicket,
- PKTR – crops, grassy vegetation,
- PKUT – orchard, plantation, garden plots,

- TPCY – landscape park,
- TCRE – nature reserve.

Register of Land and Buildings

– 38 different terrain functions,
– Areas are not in the overlap relation with each other,
– 5 types of useable lands, which can be qualified as green areas:
  - forests,
  - wooded and bushy land,
  - recreation areas,
  - pastures,
  - arable land.

After thoroughly reviewing the data in the above-mentioned sources, it was decided to take into account only the data from the Land and Building Register, because they were characterized by the highest consistency and had fewer topological errors. When designating green areas of the park type, only those that had such a function were directly assigned, i.e. forests, wooded and bushy land, as well as recreation areas (so the area without estate and street green belts from Table 2 or agriculture areas from the Table 1).

The structure of the population in Łódź was based on a layer of buildings from the Register of Lands and Buildings, containing such attributes as the number of stories, the surface area of the ground floor, and the function (single- and multi-family buildings). The data from the City of Łódź Office regarding the number of people living in individual housing estates (auxiliary units) were also used. Based on these data, the number of people assigned to a given auxiliary unit per unit of living space was determined first, followed by the number of people living in each residential building. At the final stage, two raster layers were created in which the meshes were 90 m × 90 m: population distribution (Figure 2) and green areas (Figure 3). The premise for choosing the mesh size was the assumption that the place of residence is determined by the closest surroundings within a radius of around 50 m around the reference point. In this way 36,894 meshes were designated, of which 14,569 (40.25%) were inhabited.

The conversion of the vector layer of green areas from EGiB into the raster layer was made automatically in compliance with to the rule, according to which a given raster mesh was included in green areas if the share of green areas, according to EGiB, exceeded 50% of its area. The transition from the vector format to the raster format inevitably leads to a change in the shape and surface of individual objects, as well as the disappearance of objects that are too small (Figure 4). The balance of the city scale is also changing. In our case, the total area of green areas in Łódź in terms of vector was 30.76 km^2, while in the 90 m × 90 m grid – 30.55 km^2 (3772 meshes).

The second, enlarged zone of proximity for each mesh 90 m × 90 m was determined in such a way that all the meshes of which at least 50% of the area were contained in a buffer with radius R = 500 m from the central point were included (5). This distance resulted from the multiples of the number of raster meshes and their size (R = (11 × 90 m) / 2).

Fig. 2. Population density in Łódź, 2016 in 90 m × 90 m pixels

Source: Prepared by the author on the basis of data from Łódź City Hall.

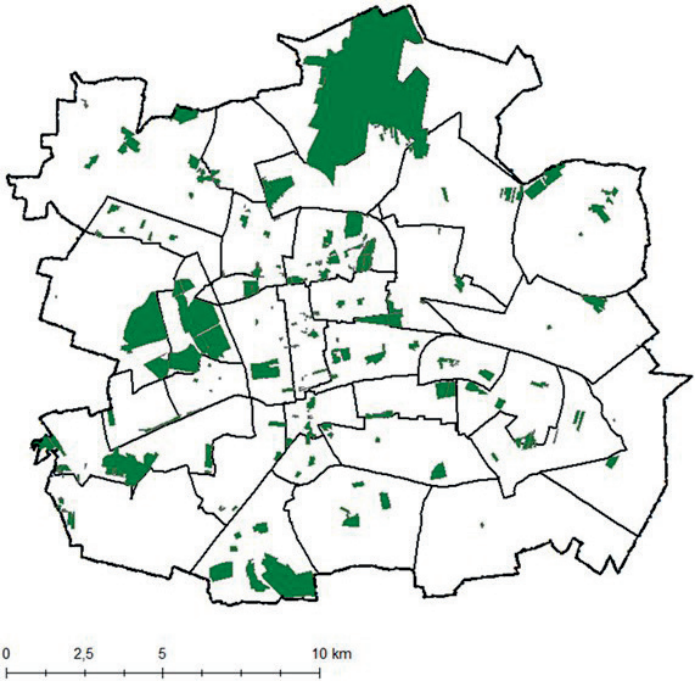

Fig. 3. Arrangement of green areas in Łódź according to EGiB

Source: Prepared by the author on the basis of data from Łódź Office of Land Surveing.

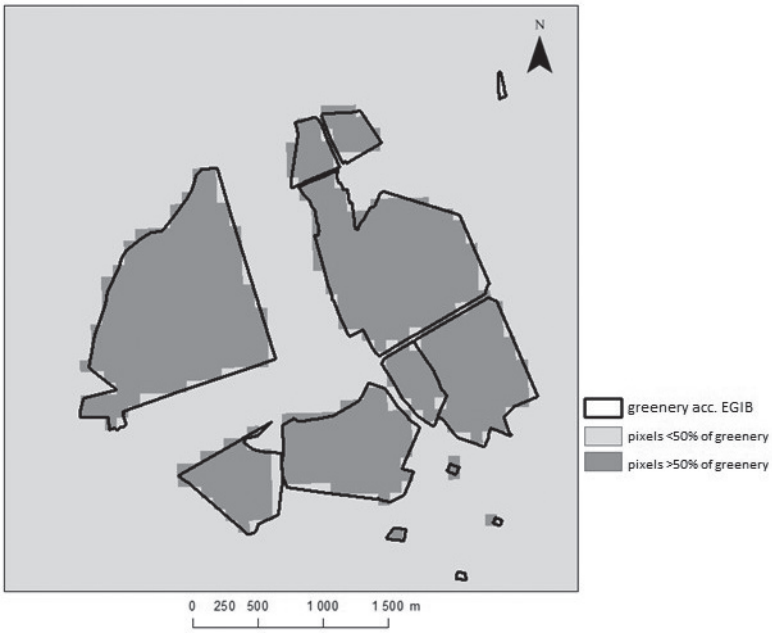

Fig. 4. Changing the shape and size of green areas when switching from a vector format (black line) to 90 m × 90 m raster

Source: Prepared by the author on the basis of data from EGiB.

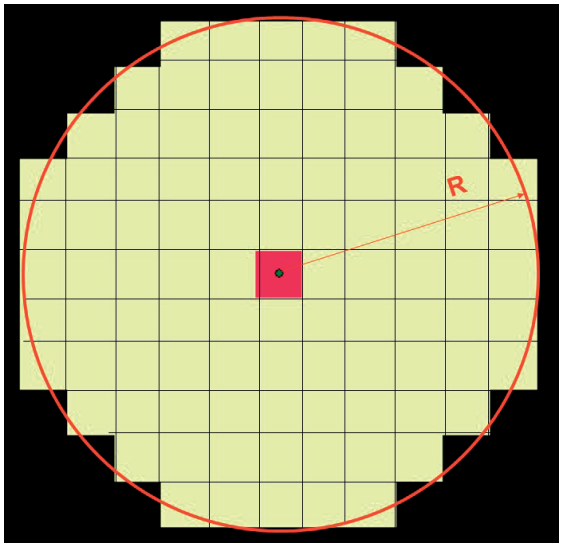

Fig. 5. Determination of the neighborhood zone: within a radius of R = 500 m there are 97 cells 90 m × 90 m considered

Source: Prepared by the author.

So the designated zones contained 97 square meshes with a total area of 0.786 km^2, which is approximately equal to the area of a circle with a radius of 500 m (0.785 km^2).

The prepared data made it possible to analyze the availability of greenery in the place of residence and within 500 m.

Results

Greenery in the place of residence, i.e. in the pond of 90 m × 90 m

200 meshes of 90 m × 90 m raster were found that meet two conditions, i.e. at least 50% are green areas, according to EGiB, and are a residential area (out of 14,569 inhabited pixels). There are 2,537 people living in them (for 624,372 inhabitants of Łódź designated by the housing method), which constitutes only 0.41% of all the inhabitants of Łódź. The defined area is 0.54% of the area of Łódź.

Greenery around the place of residence, i.e. in a zone with a radius of 500 m

For each mesh of 90 m × 90 m raster it was checked whether in the radius up to 500 m from their central point there are raster holes, which were included in the green

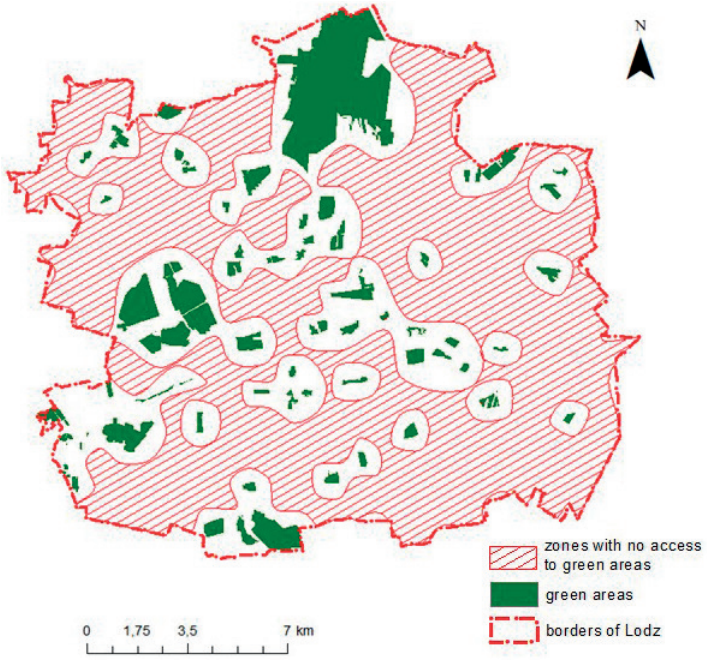

Fig. 6. Zones in which the distance to the green area (included in the EGiB) with an area of at least 0.81 ha (corresponding to the area of 1 mesh of the screen) exceeds 500 m

Source: Prepared by the author on the basis of data from Łódź Office of Land Surveing.

areas. In addition, the analysis includes the size of the green area – two variants were considered: greenery, in one complex, at least 1 mesh (0.81 ha) or 6 meshes (4.86 ha).

The zone, whose inhabitants did not have access to even a small green area (0.81 ha), occupies 139.5 km^2, which is 47.6% of the total city area (6). Using the previously mentioned algorithm for calculating population density, it was calculated that about 20% of all the inhabitants of the city live in this zone. The largest distance to the green area was also determined, which is 1,498 m. Increasing the requirements, by changing the criterion of the minimum area available for a 6-mesh raster (4.86 ha), caused the zone without access to greenery to expand up to 172 km^2 (about 60% of the city's area). Almost half of the inhabitants of Łódź (293,000, 45%) live in such a marked area. The largest distance to a park is in this case 1,928 m.

Discussion of results

On the basis of very generalizing statistics, the reality, e.g. considering the overall size of green areas and the number of inhabitants, we get good values of indicators of green areas per one inhabitant of Łódź. Both indicators calculated on the basis of data from EGiB (57 m^2 per person) or GUS data (79 m^2 per person) in each case exceed the previously quoted norms of the green area per one person: 15 m^2 (Ptaszycka 1950, 99), 20.5 m^2 (Białobok 1976, 223-245), 50 m^2 (Myczkowski 1976, 170), 18-25 m^2 (Zarządzenie 1964).

When comparing with other cities in Poland, it should be based on the same data sources for each of them, assuming that they were collected according to the same methodology. The Local Data Bank of the Central Statistical Office was used, which contains information, including on the share of parks, green areas and estate green areas in the urban area (Figure 7). This is the default list of green area function made by CSO. In the above field, Łódź ranks high in the fourth place, reaching 5.8%. Cities with a better indicator are Bydgoszcz, Katowice and Warsaw.

In the same source we found information about the area of parks, green areas, street greenery, estate green, cemeteries and commune forests (Figure 8). That means that in this option also cemeteries and street greenery are taken into consideration. In the case of green areas defined in this way, their percentage in the area of Łódź grows more than three times (from 5.8% to 18.8%). The position of Łódź among provincial cities in this respect is slightly better, as Łódź occupies the third place, this time behind Olsztyn and Poznań.

The presented data show that Łódź is a city with rich greenery resources. However, this judgment has to be revised due to the uneven distribution of people and green areas, because a significant part of residents in their place of residence (R = 50 m) and further surroundings (R = 500 m) do not have access to greenery areas of adequate size (there were two variants considered: min. 0.81 ha and min. 4.84 ha in one complex), intended for recreation. It should also be mentioned that green areas of a regional, city-wide and regional character also have an impact on the assessment of the availability

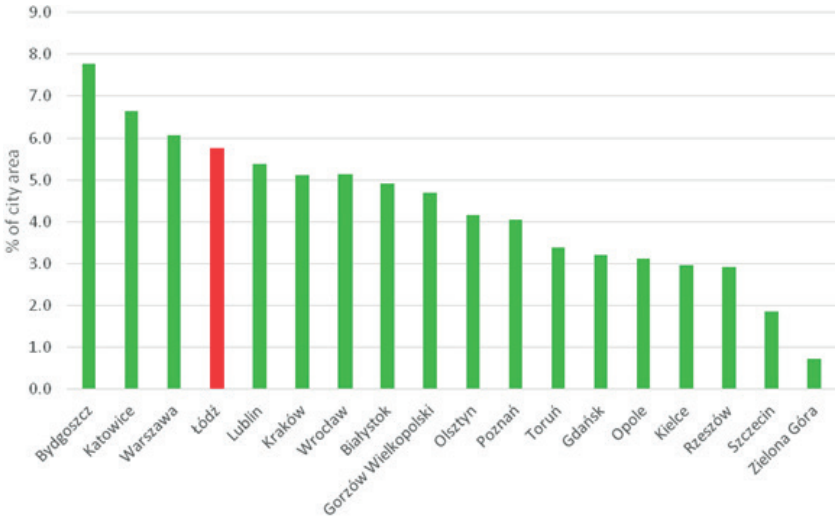

Fig. 7. Share of parks, green areas and estate green areas in the area of voivodship cities in 2016

Source: Prepared by the author on the basis of data from Local Data Bank, GUS, www.stat.gov.pl.

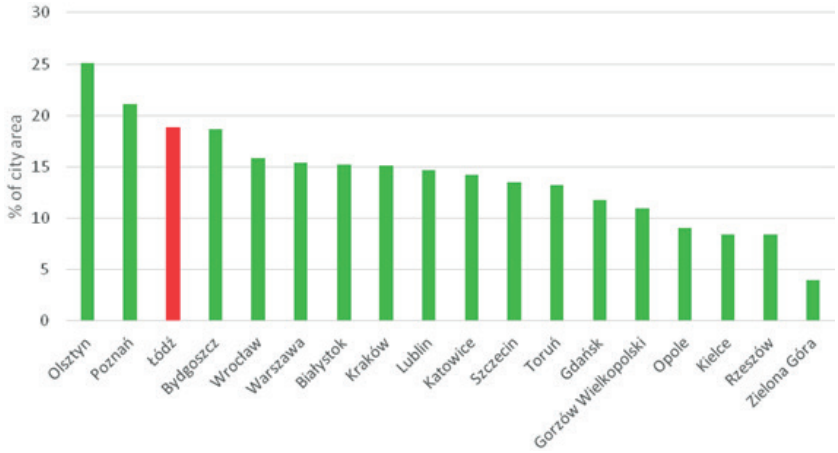

Fig. 8. Share of the total area of greenery (walking and recreation parks, green areas, street greenery, greenery areas, cemeteries, communal forests) in the area of provincial cities in 2016

Source: Prepared by the author on the basis of data from Local Data Bank, GUS, www.stat.gov.pl.

of greenery for residents. This is primarily important for residents of areas located near the city border. In many cases, in the neighboring commune, residents can use well-developed green areas. A great impact on the quality of a place of residence is the ability to quickly take a means of public transport or one's own car to places of leisure offering nature in the open green space. The work, however, focused on examining the quality of greenery in the immediate vicinity of a place of residence.

The results of the conducted analysis were influenced by the quality of available data and the manner of their processing. We did not have precise data on the distribution of population, and the number of inhabitants of individual buildings and raster spots was determined based on the number of residents assigned to auxiliary administrative units. The data source was the Decision No. XXXIX / 1029/16 of the City Council in Łódź, dated December 28, 2016. How uncertain these data are is shown at least by the fact that the total number of residents assigned to auxiliary units is lower by more than 44 thousand from the number of inhabitants according to GUS (Local Data Bank). The second source of significant distortion of the access to green areas is the quality of the EGiB database. There are green areas in the zone that the greenery has officially been assigned to. Therefore, it is not possible to include in the analyzes areas with a different function, even if there is vegetation on them, in the form of lawns and meadows or individual bushes and trees or even large groups of them. These include areas officially recognized and actually used for agriculture, but also many rows of roadside trees, vegetation on building plots or temporarily undeveloped post-industrial areas. Nobody can deny that they play an important environmental role and should be included in the balance of urban greenery. The problem, however, in the methodology, is that it has not been established what methods should be used to properly measure and valorize such areas. It seems that modern data and geomatics tools, such as aerial and satellite photos, and laser scanning, can be helpful. The potential of these new methods has been demonstrated, for example, in the analysis of ventilation in Kraków (Godłowska 2016, 44-54).

Conclusions

According to the methodology used in official statistics, only the areas, to which the greenery function is officially assigned, are taken into account when determining the size of green areas per one inhabitant of the city. It does not take into account the significant resources of greenery that occur in other areas, and often have great importance in shaping the positive living conditions in the city. According to the results, about 80% of the inhabitants in Łódź have in their neighborhood at least one small fragment of green area (0.81 ha), despite the fact that almost half of the city area is covered by grounds where there is no greenery within 500 meters. The second source of creating a false image of the condition of greenery is its unequal accessibility for residents, which results from the clustered distribution of people and green areas. Therefore, it is necessary to develop and implement a new methodology of inventory and valorization of all the city's greenery resources.

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