

THE ACCESSIBILITY OF PUBLIC URBAN GREEN SPACE. A CASE STUDY OF BIAŁYSTOK CITY

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ABSTRACT

Motives: Urban green spaces have many functions in cities. They are used for recreational purposes, and they contribute to improving social interactions and community cohesiveness. For this reason, the location and area of urban green spaces should correspond to the size of the city and its population.

Aim: The main aim of this study was to analyze the accessibility of managed and publicly available urban green spaces, referred to as public urban green spaces (PUGS), in four functional and spatial zones in the city of Białystok. The analysis included parks, green squares (pocket parks, ornamental green squares, boulevards) and public forests. The accessibility of PUGS was determined in view of their size and role in the urban spatial structure. Spatial data were processed in GIS and quantitative analyses.

Results: The study demonstrated that the area of PUGS per capita meets the requirements of the World Health Organization (WHO), but the area of parks and green squares should be increased. The accessibility buffers of public green spaces often overlapped, in particular in downtown Białystok (Central zone) which is most abundant in these green infrastructure components. The analysis also revealed locations that do not have access to urban green spaces. The results of the study were used to formulate guidelines for incorporating new green spaces in Białystok and improving the urban spatial structure.

Keywords: green areas, city, accessibility of urban green spaces, Białystok.

INTRODUCTION

Urban green space, in particular those that are available to the general public, deliver a host of benefits. Their location is often determined by historical factors and successive stages of urban spatial development. Rapidly developing urban areas exert a negative impact on the natural environment by

contributing to deforestation and the loss of biological diversity. Cities should feature large swathes of open areas, including urban green spaces that can be freely visited by the local inhabitants. Urban green spaces have positive implications not only for human health and social interactions, but also for business activities. Urban green spaces play an important role in the sustainable development of cities [Senetra et al., 2018,

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Fornal-Pieniek & Źarska, 2020, Szarek-Iwaniuk, 2021], and urban landscaping significantly improves the quality of life in the urban environment.

In the Act of 16 April 2004 on Nature Conservation, urban green spaces are defined as developed land that features technical infrastructure and buildings, is covered by vegetation and is open to the public, in particular parks, pocket parks, promenades, cemeteries, boulevards, zoos, botanical gardens, historical parks, playgrounds, roadside trees, green squares, green areas surrounding historical fortifications, buildings, airports, storage yards, railway stations and industrial sites. Numerous definitions of urban green spaces have been proposed in the literature. The term “urban green spaces” is often used interchangeably with “green areas”. In the dictionary of the Polish language, green areas are defined as all types of land that are covered with vegetation and are used for recreational purposes in cities [https://sjp.pwn.pl, date: 1.06.2020]. Similar definitions can be found in the literature, where green spaces have been described as various types of land that are covered with vegetation and used primarily for relaxation and recreation [Siewniak & Mitkowska, 1998, Szumański, 2005]. Giedych [2009] defined green spaces as vacant land that is covered with vegetation and serves various recreational purposes. According to Czarnecki [1961], urban green spaces include not only green squares, public parks and boulevards, but also sites that are accessible to specific groups of users, such as hospital parks, allotment gardens and school gardens. The above author argued that only vegetated areas that are managed and maintained in line with the local zoning plan can be defined as urban green spaces. In other studies, green spaces were described as areas where vegetation is functionally and spatially arranged and serves recreational purposes. Fan et al. [2017] defined urban green spaces as public parks and other green areas that are available to the public and managed by the local authorities. A review of the existing definitions indicates that urban green spaces are closely associated with public spaces. Therefore, urban green spaces are an important part of public space. The presented definitions indicate that green spaces play a very important role in cities

and constitute an integral part of urban public space [Chojecka, 2013].

The accessibility of urban green spaces significantly affects the quality of urban life by enhancing the residents’ physical and mental well-being [Giles-Corti et al., 2005, Shin et al., 2011, Andersson et al., 2019, Nastran, 2020], promoting social integration [Kemperman & Timmermans, 2014], minimizing the discomfort associated with traffic noise [Senetra et al., 2014] and promoting air exchange between the urban core and the surrounding areas [Szulczewska, 2015]. Local residents are more likely to visit urban green areas that are situated in the vicinity of their homes. The vital role of green spaces in cities has led to the development of targets and standards for urban green provision. According to the guidelines of the European Environment Agency (EEA), urban residents should have access to green spaces within a walking distance of 15 minutes, which is approximately 900–1000 m [Wüstemann et al., 2017]. A study of green space provision in large German cities with a population higher than 100,000 demonstrated that nearly 93% of the German population have access to green spaces within a radius of 500 m from their homes [Wüstemann et al., 2017]. According to Coles and Bussey [2000], the size of urban green spaces should be linked with distance, and they argued that residents should be able to access at least 2 ha of urban green space within 5–10 minutes walking distance (100–400 m). Van Herzele and Wiedemann [2003] also linked distance with the size of green spaces and observed that urban dwellers should live within 5 minutes walking distance (approx. 400 m) from 1–10 ha of urban green space. The distribution of green spaces in cities should be determined by population, population density and the serviceability of urban districts [Oh & Jeong, 2007, Fan et al., 2017].

According to the World Health Organization (WHO), at least 9 m² of green space should be available per individual, and the ideal value is 50 m² per capita [Łukasiewicz & Łukasiewicz, 2016]. However, from the perspective of urban residents, the mere existence of urban green spaces is not sufficient or important if these areas cannot be easily accessed by all potential users. Many cities feature extensive open spaces that

are located remotely and cannot be fully and equally used by local dwellers. The accessibility of urban green spaces can be impeded by various barriers, such as fencing, paid access, dangerous surroundings or a busy road that is difficult to cross [Biernacka et al., 2020]. In some cases, the accessibility of green infrastructure is determined in local zoning plans. The Local Land Use Plan adopted by the city of Łódź in 2018 defines the linear distance between the residents' homes and the nearest urban green space. For instance, the distance to urban green spaces in the center of the city should not exceed 800 m for green spaces larger than 3 ha, 400 m for green spaces with an area of 1–3 ha, and 200 m for green spaces smaller than 1 ha. As regards green spaces outside downtown Łódź, the corresponding distances are shorter at 500 m, 400 m and 200 m, respectively [Local Land Use Plan of the City of Łódź, 2018]. Senetra et al. [2018] analyzed the serviceability of public green spaces in the city of Tczew based on their area and functions in the urban fabric (municipal green spaces – distance of 1200 m, district green spaces – distance of 600 m, local green spaces – distance of 300 m). Areas with access to various categories of green infrastructure often overlapped. The cited study identified urban districts and locations without access to public green spaces. According to Gajda [2015], a distance of 500 m between the residents' homes and the nearest urban green space can be easily traveled, and it does not discourage potential users from visiting these sites. In most cases, the linear distance to the nearest urban green space is defined at 500–1500 m. In a study of the Warsaw Suburban Garden Tricity Area (Brwinów town and municipality, and the towns of Milanówek and Podkowa Leśna), green space provision was set within an accessibility buffer of 1250 m around households [Gajda, 2015].

Research indicates that the size of urban green spaces should be linked with their accessibility (distance) in local zoning plans. Green space provision is becoming an increasingly important consideration in urban planning. Green spaces are appreciated not only by the local residents, but also by architects and civil officers. Green spaces promote relaxation,

recreation and social integration. In many cities, green infrastructure is a part of public spaces that play a representative or symbolic role. In such sites, green spaces should occupy an extensive area, and they should be adequately maintained [Trzaskowska & Adamiec, 2017, Biernacka et al., 2020].

High-quality urban green spaces not only exert a positive impact on the quality of urban life [Branas et al., 2011, Demuzere et al., 2014], but they also significantly affect the value of residential real estate. Research indicates that home prices are higher in the proximity of attractive landscapes, including urban green spaces. In a study by Wachter and Wong [2008], home prices were 7–11% higher within 4,000 feet (more than 1200 m) of curbside plantings. According to Karanikolas et al. [2011], greening projects increase the prices of residential property by 2% to 35%. Green surroundings in residential areas significantly influence home-purchase decisions. A survey of real estate professionals in Olsztyn revealed that more 54% of home buyers were willing to pay a higher price for property situated in the proximity of green spaces, which are regarded as the most important environmental factor in the home-buying process [Szczepańska et al., 2016].

The aim of this study was to determine the quantity, distribution and accessibility of urban green spaces in the city of Białystok in north-eastern Poland. Various types of green spaces and the area of urban green spaces per capita were taken into consideration. The distribution and accessibility of the following types of public urban green spaces (PUGS) were analyzed: parks, green squares (pocket parks, ornamental green squares) and public forests. The study covered four functional and spatial zones defined by the Local Land Use Plan of the City of Białystok in 2019 [Local Land Use Plan of the City of Białystok, 2019]. The results were used to formulate guidelines for incorporating new managed green spaces in Białystok and improving the urban spatial structure. The proposed methodology can be applied in spatial planning and green space management to promote orderly and sustainable development of cities.

MATERIALS AND METHODS

The accessibility of urban green spaces was analyzed in Białystok, the capital city of Podlaskie Voivodeship in north-eastern Poland (Fig. 1). Białystok has a population of 297,554, area of 102.13 km² [Local Data Bank of Statistics Poland, date: 25.02.2021], and population density of 2,913/km².



Fig. 1. Location of Białystok and Podlaskie Voivodeship on a map of Poland

Source: own elaboration.

The accessibility of urban green spaces was analyzed in PUGS, including parks, green squares (pocket parks, ornamental green squares, boulevards) and public forests. The urban green spaces included in the analysis had a minimal area of: parks – 2 ha; green squares, pocket parks, ornamental green squares, boulevards – 0.10 ha. Forests were selected for the study if they promoted active recreation,

walking and relaxation. The accessibility of green infrastructure was analyzed in four functional and spatial zones that had been introduced by the Local Land Use Plan of the City of Białystok in 2019. These zones had been established to account for the presence of permanent barriers that divide the city – railway lines and the ring road around the urban core. Each zone serves different functions, including residential, services, production, recreation, traffic and utility networks, which are taken into account in local zoning plans. Population data were obtained from the Local Land Use Plan of the City of Białystok [2019], and they account only for the permanent residents of Białystok. Zones I, II, III and IV are marked in maps illustrating the distribution and accessibility of urban green areas. Each zone is characterized in Table 1.

Spatial analyses was performed using geoprocessing tools. A tool such as intersection (trimming), buffering or linking was used. The data useful for the study was downloaded from the website <http://download.geofabrik.de/> in the shape format for the Podlaskie Voivodeship. By using database filtering, only the objects necessary for the analyses were left. By using the raster base with an orthophotomap of Poland loaded from the geoportal (geoportal.gov.pl) new objects – polygons – were added. In addition, in the attribute table, information about its name and area was placed for each of the objects, which allowed to calculate:

- the area of selected PUGS (ha);
- percentage share of each PUGS category in the area of each zone and in total city area (%);
- the urban green space index expressed by the area of PUGS (in each zone and in the city) in m² per resident.

Table 1. Description of functional and spatial zones in the city of Białystok

Zone	Area (ha)	Population	Population density ('000/km ²)	Apartment buildings (%)	Single-family homes (%)	Services (%)	Green spaces and forests (%)	Traffic routes (%)	Farmland (%)
Central (I)	810	69.2	8.6	33.8	2.1	26.5	10.2	24.7	0.1
Southern (II)	3665	54.3	1.5	1.4	14.0	7.3	40.3	10.7	18.4
Western (III)	3215	116.3	3.6	10.4	9.2	6.8	17.7	17.0	28.1
Eastern (IV)	2513	39.6	1.6	4.9	13.2	7.2	30.2	14.0	23.6

Source: own elaboration based on Statistics Poland data and the Local Land Use Plan of the City of Białystok.

The accessibility of PUGS was determined by calculating the linear distance to the evaluated sites. This method was adopted because Białystok has a relatively simple street network. The calculated distance is a measure of the quality of the urban environment. The distance to urban green spaces was determined within a radius of 700 m around parks and public forests, and within a radius of 300 m around green squares. Radius values were adopted based on an analysis of the results of numerous studies discussed in the Introduction. Extreme values (200 m and 1500 m) were eliminated. The results are presented graphically on maps generated in the QGIS program.

RESULTS

Public Urban Green Spaces

All categories of urban green spaces have numerous functions and play important roles in cities. However, green spaces that are managed and available to the general public are characteristic of the urban fabric. The total area of the analyzed PUGS is presented in Table 2.

The area of PUGS per resident was very high (65.6 m²) because Białystok abounds in large public forests. In a study by Senetra et al. [2018], the area of PUGS per capita in Tczew was determined at 11.3 m², but forests were not included in the analysis due to their small area in the town. In large German cities with a population higher than 100,000, the average green space provision per capita was determined at 8.1 m² [Wüstemann et al., 2017]. In the above study, the distance to urban green spaces was examined within a 500 m buffer around the place of residence, and considerable variations were observed between cities – from 2.5 m² per capita in Schwerin to 36.3 m² per capita in Bergisch Gladbach.

In Białystok, the area of PUGS per resident was calculated based on the area and location of each PUGS category. Municipal parks are visited mainly for recreational purposes, and they are among the most popular leisure-time destinations for the residents. Białystok has 11 municipal parks, six of which have conservation status (Table 3). Historical parks are meticulously landscaped and feature design elements characteristic of the 19th century.

Table 3. Area of municipal parks in the city of Białystok

Park	Area (ha)	Total area (ha)	Area per resident (m ²)
Historical parks			
Prince Józef Poniatowski Old Park	5.40		
Planty Park	9.24		
Lubomirski Park	14.38		
Konstytucji 3 Maja Park	16.03		
Branicki Park	9.06		
Zygmunt Kościalkowski Boulevards	5.42	59.53	2.0
Municipal parks			
Municipal park on Fredry St.	3.36		
Jadwiga Dziekońska Park	2.32		
Central Park	4.46		
Antoniuk Park	12.65	27.36	0.9
Public green space on Marczukowska St.	4.57		
Total		86.89	2.9

Source: own elaboration based on the results of GIS analyses.

The location of parks with 700 m accessibility buffers is presented in Figure 2.

Most parks are situated in downtown Białystok (Central zone) and in the Western zone, and their buffers often overlap due to a small distance between the parks in the spatial structure of the city. Park buffers cover more than 70% of the Central zone, and the local residents can choose from a variety

Table 2. Area of public urban green spaces (PUGS) in the city of Białystok

Area (ha)	Population	Area of PUGS (ha)	Area of PUGS per resident (m ²)	Area of parks (ha)	Area of parks per resident (m ²)	Area of green squares (ha)	Area of green squares per resident (m ²)	Area of public forests (ha)	Area of public forests per resident (m ²)
10213	279.4	1832.49	65.6	86.89	3.1	17.08	0.6	1728.51	61.9

Source: own elaboration based on the results of GIS analyses.

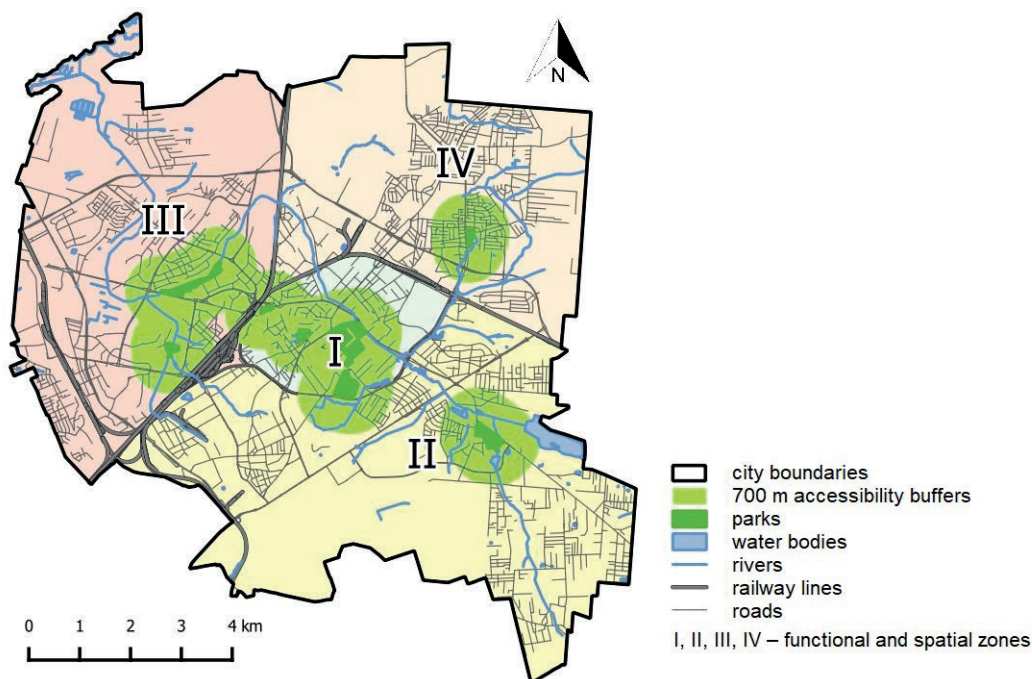


Fig. 2. Location of parks in functional and spatial zones with 700 m accessibility buffers in the city of Białystok
Source: own elaboration.

of recreational sites. The Eastern zone and the Southern zone feature one park each. Park area per resident was determined at 2.9 m^2 . In a study of municipal parks in Gdańsk, park area per capita ranged from 0 to 33.0 m^2 , and 24 out of 34 city districts did not have parks [Korwel-Lejkowska & Topa, 2017].

Białystok has 14 green squares (pocket parks, ornamental green squares, boulevards) with a combined area of 17.08 ha . The area of green squares per resident was determined at 0.6 m^2 (Table 4).

The combined area of green squares, pocket parks and ornamental green squares in Białystok is very small, accounting for only 0.17% of the city's area. The location of green squares with 300 m accessibility buffers is presented in Figure 3.

Green squares are used for casual leisure and short walks, and they often accompany representative buildings. Most green squares are located in downtown Białystok (Central zone), as well as in Western and Eastern zones. Their buffers often overlap, mainly in the Central zone. The close proximity of green squares and parks creates numerous recreational options for the local residents.

Table 4. Area of green squares in the city of Białystok

Green square	Square area (ha)	Total area (ha)	Area per resident (m^2)
Tamara Sołowiecz Square	2.65	17.08	0.6
Wygoda Square	0.95		
Włodzimierz Zankiewicz Square	1.38		
Armii Krajowej Square	1.23		
Anna Markowa Square	0.22		
Mordechaj Tenenbaum Square	1.03		
Ludwik Zamenhof Square	0.28		
Father Michał Sopoćko Square	1.68		
Small park at 11 Rzemieślnicza St.	0.10		
Father Stanisław Hałko Boulevards	0.80		
Father Aleksander Chodyka Boulevards	0.24		
Irena Sendlerowa Boulevards	0.82		
Father Henryk Szlegier Square	1.49		
Blessed Bolesława Lament Square	1.48		
Green square on Herberta St.	1.54		
Green square with a Monument to the Defenders of Białystok	1.19		

Source: own elaboration based on the results of GIS analyses.

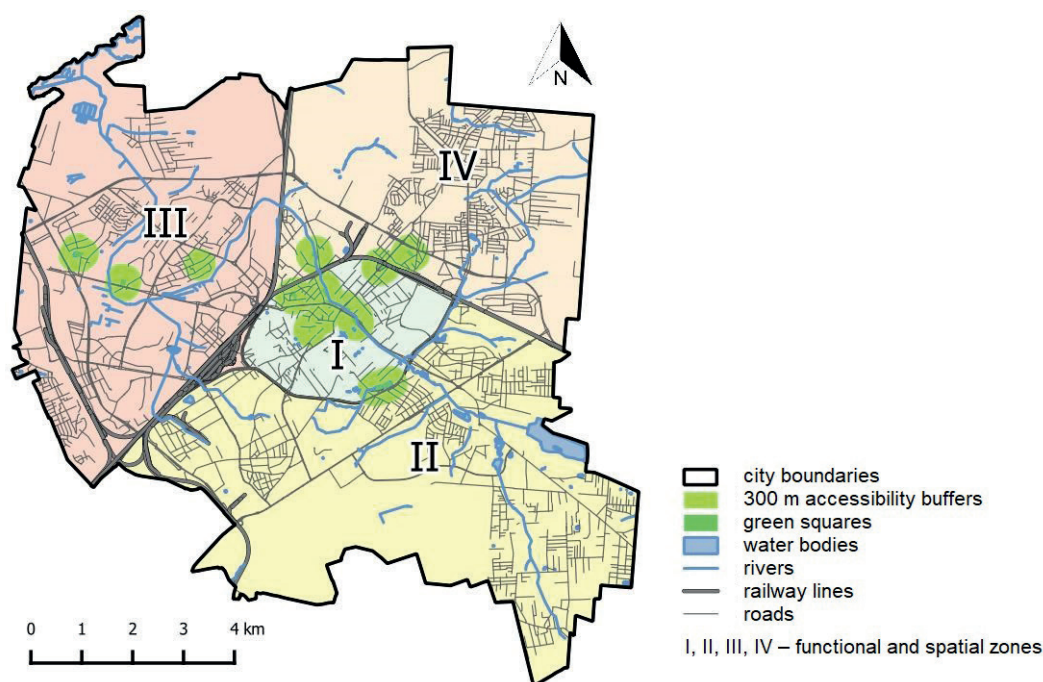


Fig. 3. Location of green squares with 300 m accessibility buffers in the city of Białystok
Source: own elaboration.

Forests are undoubtedly the most valuable component of the natural landscape. Forest cover is generally low in large cities with high population density and a high percentage of built-up land. In Białystok, forests are situated on the northern and southern outskirts of the city. State-owned forests occupy an area of 1500.22 ha, and municipal forests span an area of 228.29 ha (Table 5).

Table 5. Area of public forests in the city of Białystok

Forest	Area (ha)	Forest cover in the city (%)	Forest area per resident (m ²)
State-owned forests	1500.22		
Municipal forests	228.29	16.9	58.0
Total	1728.51		

Source: own elaboration based on the results of GIS analyses.

Public forests in Białystok have a combined area of 1728.51 ha and cover 16.9% of the city area. Forest area per capita was determined at 58.0 m². The location of public forests with 700 m accessibility buffers is presented in Figure 4.

Forests are located along the outer edge of the city, and they are accessible to the residents of peripheral districts. These areas are devoid of parks and green squares, and forests act as urban green spaces in peripheral zones. Forests well complement public green spaces on the outskirts of the city. Forest cover is highest in Southern and Eastern zones. The Central zone is devoid of forests.

The serviceability and population of functional and spatial zones should be considered in analyses of the location, area and accessibility of urban green spaces in each zone. The area occupied by different categories of PUGS in each zone was determined in a GIS analysis. The area of PUGS per resident was calculated in each zone. The results are presented in Table 6.

Public urban green spaces occupy the largest area in the Southern zone (26.2% of zone area), which can be attributed to the presence of extensive public forests (946.80 ha). In the Eastern zone, PUGS occupy 20.5% of the zone's area, and public forests span 511.84 ha. The Central zone is least abundant in PUGS which

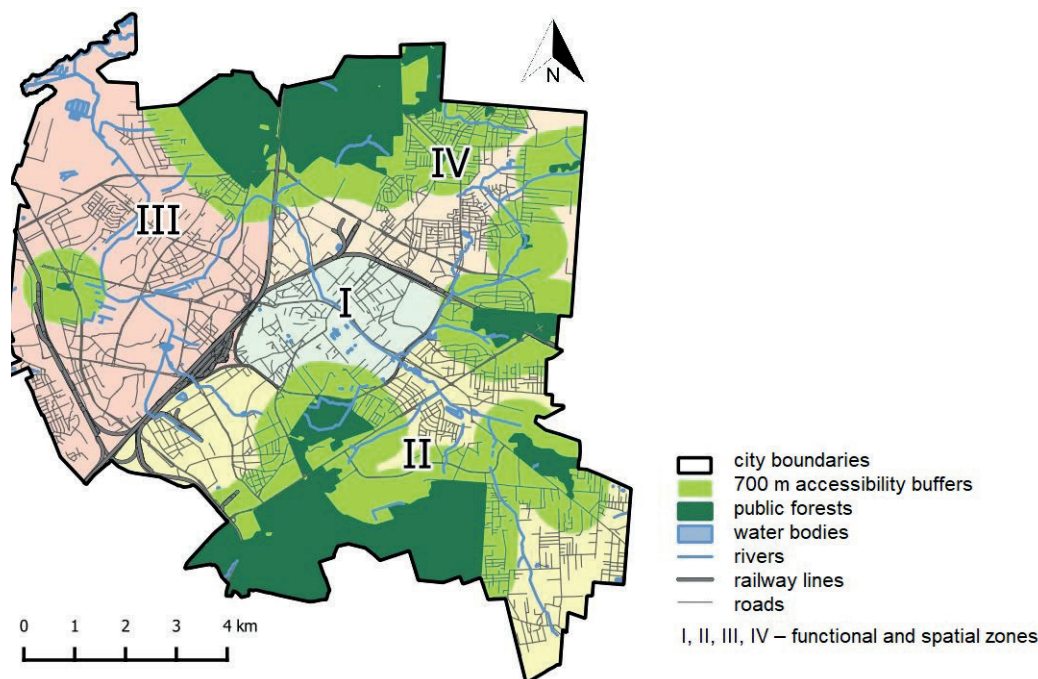


Fig. 4. Location of public forests with 700 m accessibility buffers in the city of Białystok
Source: own elaboration.

Table 6. Area of public urban green spaces (PUGS) in the functional and spatial zones of the city of Białystok

Zone	Area of PUGS (ha)	% PUGS in zone area	Area of PUGS per resident (m ²)	Area of parks (ha)	Area of parks per resident (m ²)	Area of green squares (ha)	Area of green squares per resident (m ²)	Area of public forests (ha)	Area of public forests per resident (m ²)
Central	63.63	7.9	9.2	51.94	7.5	11.69	1.7	0	0
Southern	961.18	26.2	180.0	14.38	2.7	0	0	946.80	174.4
Western	289.83	9.0	24.9	17.22	1.5	2.74	0.2	269.87	23.2
Eastern	517.85	20.5	130.8	3.36	0.8	2.65	0.7	511.84	129.3

Source: own elaboration based on the results of GIS analyses.

occupy only 7.9% of the zone's area. This zone features only parks and green squares.

A synthetic analysis of the accessibility of the analyzed categories of PUGS is presented in Figure 5.

The combined area of PUGS accessibility buffers in each zone is presented in Table 7.

The overlap between the accessibility buffers of each PUGS category was analyzed to identify areas in each zone that do not have access to the examined types of PUGS. The accessibility of PUGS was high

Table 7. Combined area of the accessibility buffers of public urban green spaces (PUGS) in the city of Białystok

Zone	Zone area (ha)	Area of PUGS accessibility buffers (ha)	% of zone area
Central	810	593	73
Southern	3665	2483	68
Western	3215	1202	37
Eastern	2523	1965	78

Source: own elaboration.

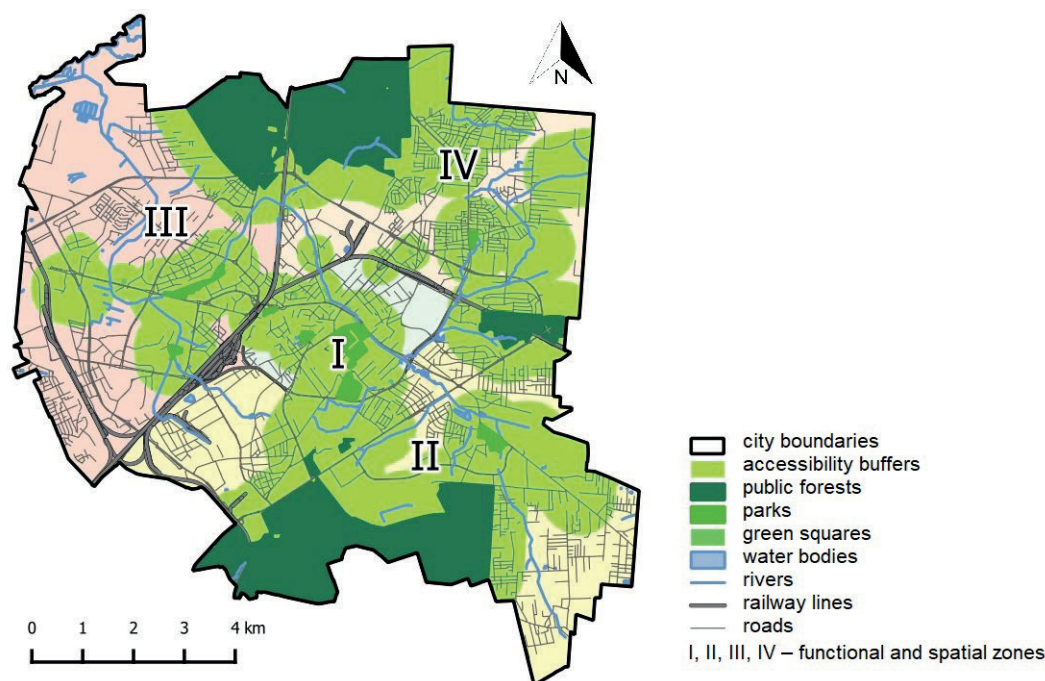


Fig. 5. Accessibility of the analyzed categories of public urban green spaces (PUGS) in the city of Białystok
Source: own elaboration.

in Central and Eastern zones, and the absence of accessibility buffers was noted in only 25% of their area. Accessibility buffers spanned the smallest area in the Western zone which is most deficient in PUGS (37%). This is a highly unsatisfactory result because the Western zone has the largest population (116,300). However, the Western zone abounds in farmland that could be converted to PUGS. The accessibility buffers of PUGS cover 64% of Białystok's total area, which is a satisfactory result relative to that reported in a study of municipal parks in Gdańsk [Korwel-Lejkowska & Topa, 2017]. In Gdańsk, nearly 78% of the city's area does not have access to parks within a walking or commuting (public transport) distance of 20 minutes.

The Central zone has the smallest percentage of PUGS in total area (7.9%) and the smallest area of PUGS per resident (9.2 m^2). This zone is also characterized by the highest population density ($8,600/\text{km}^2$) due to the prevalence of apartment buildings (33.8%). In the Central zone, the accessibility buffers of the examined PUGS often overlap and occupy 73% of the zone's area. More satisfactory results were reported by

Senetra et al. [2018] in Tczew, where the area of PUGS per resident was determined at 37.2 m^2 in the town's greenest Old Town district (with similar functions to Białystok's Central zone).

In the Southern zone, PUGS occupied an area of 961.18 ha (26.2% of the zone's area), with a predominance of public forests (946.8 ha). The area of PUGS per resident was determined at 180.0 m^2 . This zone features one park and the accessibility buffer of a park located in the Central zone. Residential districts in the Southern zone feature mostly single-family homes (14.0% of the zone's area). The local inhabitants rely mostly on their home gardens for relaxation and recreation, which is why extensive municipal parks and green squares are not required in this zone.

The Western zone is characterized by the highest population and the smallest area of PUGS per resident (9.0 m^2). Parks and green squares occupy an area of 19.96 ha, and public forests are the main category of PUGS (269.87 ha). Apartment buildings and single-family homes cover around 10% of the zone's area each.

Accessibility buffers cover only 37% of the Western zone, which suggests that new PUGS should be planned in this part of the city.

In the Eastern zone, PUGS occupy 517.85 ha and cover 20.5% of the zone's area, which can be attributed to very high forest cover (511.84 ha). New PUGS are not required in this zone due to small population (39,600), low population density (1,600/km²) and a predominance of single-family homes (13.2% of the zone's area).

CONCLUSIONS AND RECOMMENDATIONS

An analysis of the structure of the urban natural environment in the city of Białystok demonstrated that the area of PUGS is sufficient to meet local community's needs. However, the examined PUGS have an undesirable structure and are unevenly distributed in the city. In the studied city, green space provision is limited by its accessibility. The area of PUGS per resident was determined at 65.6 m², which meets WHO recommendations. However, forests account for a large proportion of PUGS in the city, and the area of the remaining categories of PUGS is insufficient. The present findings indicate that Białystok is relatively deficient in parks and green squares. The Western zone and the central part of the Eastern zone feature the highest number of areas where the distance to the nearest PUGS exceeds 700 m. In the remaining parts, only individual areas are located more than 700 m away from PUGS. Białystok is characterized by considerable fragmentation of PUGS. New open spaces should be designed to guarantee the optimal distribution of PUGS in the city, i.e. a ring-radial pattern, which will contribute to the continuity of green infrastructure and will promote the exchange of air between the urban core and the surrounding areas. Both the area and the number of PUGS that serve recreational purposes should be increased. The analysis of the accessibility buffers surrounding the examined PUGS indicates that new PUGS should be introduced in Białystok's functional and spatial zones:

- Central zone – this zone is characterized by the highest number of parks and green squares, and the highest population density. Public urban green areas and their accessibility buffers cover 73% of the zone's area. New PUGS could be difficult to establish in the Central zone due to the low availability of vacant land (farmland) that could be utilized for this purpose. There is no need to incorporate new PUGS into this zone, but they should be introduced in the neighboring Southern zone;
- Southern zone – PUGS and their accessibility buffers occupy around 68% of the zone's area. This zone is characterized by the lowest population density (1,500/km²). Farmland that could be potentially converted to green infrastructure covers 18.4% of the zone's area. New PUGS should be designed in the proximity of the border with the Central zone;
- Western zone – this zone is characterized by the largest population and relatively high population density (3,600/km²). Public urban green spaces and their accessibility buffers cover only 37% of the zone's area. Farmland accounts for 28% of the zone's area; therefore, new PUGS could be relatively easily established. The demand for green infrastructure in the Western zone is relatively high because apartment buildings occupy 10.4% of the zone's area;
- Eastern zone – this zone is characterized by low population density (1,600/km²), the largest area of PUGS and their accessibility buffers (78% of the zone's area). The Eastern zone abounds in farmland (23.6%) that could be converted to public services, in particular PUGS. New PUGS should be established in the vicinity of the border with the Central zone.

It should be noted that the use of smaller or larger accessibility buffers would change the size of areas that are excluded from access to PUGS in each zone. The current study demonstrated that PUGS and their accessibility zones occupy 64% of Białystok's area.

The proposed method of calculating the accessibility buffers of PUGS supports the identification of areas that do not have access to green infrastructure in the urban fabric. This approach can be used to iden-

tify areas and districts where new urban green spaces should be created to improve the quality of life and promote the exchange of air between the urban core and the surrounding areas. The described method can be applied to evaluate the accessibility of urban green spaces in cities with a similar size, spatial structure, and social and cultural environment.

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