

## An analysis of the spatial distribution, influence and quality of urban green space – a case study of the Polish city of Tczew

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**Abstract.** Rapid urban growth can exert negative effects on the natural environment due to the loss of naturally vegetated areas, loss of biological diversity, deforestation and soil erosion. The condition of cities is inherently linked with the natural environment which has a positive influence on health, social relations, human welfare and economic activity. Urban areas should abound in green spaces, and should also be easily accessible to the general public. The aim of this study was to determine the spatial distribution, influence and quality of urban green spaces on the example of the city of Tczew in northern Poland. The proposed methodology can be applied in cities of a similar size and urban structure to promote rational management of urban green space in line with the principles of sustainable development and spatial order. The Green-Space Record, a useful tool for inventorying urban green spaces, was developed to pursue the main research goal. The information accumulated in the Record constitutes valuable input data for further analysis, including the determination of the area, distribution, influence and quality of urban green spaces. The results of the analysis revealed that urban green spaces occupy more than 19% of Tczew's territory, which is equivalent to 70.6 m<sup>2</sup> per resident. Managed green spaces span the area of only 66.75 ha (11.31 m<sup>2</sup> per resident) and are unevenly distributed in the city. More than half of these areas are found in the Stare Miasto (Old Town) district, whereas two residential districts (Gdańska, Prątnica) are completely devoid of public greens. The quality of urban green spaces is generally satisfactory in Tczew; however, not all residents have equal access to high-quality public greens.

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**1. Introduction**

Green space is a crucial element of urban systems, and it delivers environmental, social and economic benefits. Natural ecosystems play a variety of roles in urban areas (Keniger et al., 2013; Hunter, Luck, 2015; Ives et al., 2017; Aronson et al., 2017). Urban green space contributes to social cohesion and local identity (Kim, Kaplan, 2004; Roberts, 2017).

The quantity, quality and availability of urban green spaces influence living standards in a city. The availability of public greens in Germany was evaluated by Wüstemann (2017) who observed that according to the recommendations of the European Environment Agency (EEA), the distance to urban green spaces should not exceed a 15-minute walk or 900–1000 m. Wüstemann surveyed the availability of urban green areas in large German cities (with a population greater than 100,000) and found that 92.8% of the population had access to green spaces within 500 m from the place of residence. The average distance to green spaces was 183 m, and the average green space had an area of up to 4.4 ha. There was 8.1 m<sup>2</sup> of green spaces per inhabitant. An analysis of buffer zones covering a 500-m radius from the place of residence revealed considerable variations in green space supply, ranging from 2.5 m<sup>2</sup>/resident (Schwerin city) to 36.3 m<sup>2</sup>/resident (Bergisch Gladbach city). According to Wüstemann et al. (citing Roo, 2011), the recommended green space area per inhabitant within a 500 m radius from the place of residence was 60 m<sup>2</sup> in the Netherlands. Coles and Bussey (2000) observed that the size of urban green spaces should be linked with their distance from the place of residence. They noted that at least 2 ha of urban green

spaces should be accessible within a five-minute walk (a distance of approximately 600 m). The importance of accessibility to public green spaces was also emphasized by Van Herzele and Wiedemann (2003) who argued that urban residents should be able to reach green spaces of 1–10 ha within a walking distance of 300–400 m (five-minute walk).

Handley et al. (2003) described the key premises for the development of urban green spaces. As part of the Accessible Natural Green Space Standard (ANGSt) model:

green spaces with an area of minimum 2 ha should be located within a distance of up to 300 m from the place of residence,

urban areas should feature Local Nature Reserves with a minimum area of 1 ha per 1000 inhabitants,

at least one green space with an area of 20 ha should be available within a 2-km radius from the place of residence,

at least one green space with an area of 100 ha should be available within a 5-km radius from the place of residence,

at least one green space with an area of 500 ha should be available within a 10-km radius from the place of residence.

The above standards have been introduced to promote daily contact with nature in a safe location that does not require extensive travel. The standards also emphasized the significance of urban green spaces in the protection of the natural environment and geological features as well as in environmental education.

Žlender and Thompson (2017) evaluated the accessibility of green spaces in the outskirts of two cities: Ljubljana (population of more than 272,000)

and Edinburgh (population of more than 486,000). They emphasized the importance of green corridors connecting the evaluated cities with their suburbia, and they analysed the factors that influenced the accessibility of green spaces and the impact of distance on the frequency with which public greens were used by members of the local community.

Rojas et al. (2016) evaluated the potential availability of open spaces in two medium-sized cities in Chile: Valdivia and Temuco. Temuco has a population of more than 311,000, and the population of Valdivia exceeds 161,000. The availability of green spaces in medium-sized Chilean cities had not been previously researched. Both cities are surrounded by suburbia with green spaces. The availability analysis was based on the daily mobility patterns of local residents, including the travelled distance and means of transport, with special emphasis on walking. The study revealed that the availability and use of green spaces were significantly correlated with the inhabitants' well-being. The authors also analysed the availability of green spaces for cyclists. Cycling and walking are essential physical activities whose popularity is often determined by the availability of green spaces (Kain et al., 2002; Rojas et al., 2016).

Research results indicate that the size of urban green spaces should be linked with their location relative to the place of residence. Contemporary urban development often takes place at the expense of urban green space (Krzyżaniak et al., 2018). Green spaces in medium-sized cities (with a population of up to 100,000) are rarely analysed, which justifies the undertaken research.

The type of green space determines its functions in the urban fabric, and the significance of green spaces increases with the expansion of the urban core. Green spaces provide city residents with access to nature, thus improving their physical and mental well-being. They promote the development of recreational activities, filter out harmful pollution, offer a refuge from noise and hot weather and enhance the aesthetic appeal of cities (Li et al., 2017; Sun, Chen, 2017). Green spaces are functional components of urban ecosystems, and they feature a combination of carefully selected plant species. In the broader context, urban green space also comprises

open landscapes such as national parks, landscape parks and rural parks (Haber, Urbański, 2010).

Researchers often identify different components of urban green space. Głąbiński and Duda (2017) analysed the tourist potential of Gryfino powiat in the Zachodniopomorskie voivodship in Poland. They identified local resources that enhance the tourist appeal of the studied area, including components of green spaces such as forests, national parks, landscape parks, geoparks, municipal parks, botanical gardens and arboreta.

Markevych et al. (2014) analysed the presence of correlations between limited access to green space and behavioural problems of 10-year-olds living in Munich and its vicinity. The availability of green spaces was determined based on the distance between a child's place of residence and the nearest urban green space. The study demonstrated that children living more than 500 m away from green spaces had more behavioural problems than children living within a 500-m radius of green spaces.

In the Polish Environmental Protection Act, urban green spaces are defined as intentionally managed and maintained areas that are covered by vegetation, are open to the public and feature the accompanying infrastructure and buildings, in particular parks, pocket parks, promenades, boulevards, botanical gardens, zoos, playgrounds, monumental gardens, cemeteries as well as roadside trees and vegetation in squares, historic fortifications, buildings, storage facilities, airports, railway stations and industrial sites. The concept of urban green space has different definitions in ecology, urban planning and architecture (Szumański, 2005). In ecology, urban green space is defined as areas covered by native vegetation. In urban planning, it denotes naturally vegetated areas that fulfil different functions in the urban fabric. In landscape architecture, urban green space constitutes a "green structure" composed of carefully selected plant species. In Polish legislation, the concept of urban green space is somehow ambiguous (Giedych, 2009) because the term has different definitions in various areas of activity, such as the construction industry, urban planning, geodesy and environmental protection.

The aim of this study was to determine the spatial distribution, influence and quality of urban green space on the example of the city of Tczew in northern Poland. The variations, change trends and

the area of urban green space per capita were determined in residential districts. The influence of green spaces was analysed, and their overall quality was evaluated based on their availability, purpose, infrastructure and condition. The analysed green spaces were parks, pocket parks, ornamental squares, boulevards and promenades. The results of the analysis were used to formulate recommendations for improving the structure and quality of green spaces in Tczew. Strategic goals and guidelines for urban planning were described. The proposed methodology can be used to promote rational management of urban green space in line with the principles of sustainable development and spatial order.

## 2. Research materials and methods

The following research methods and analytical techniques were used in the study:

1. Analysis of urban planning documents and strategic documents relating to urban green spaces in the city of Tczew.
2. Field inventory of urban green spaces in Tczew with the use of Green-Space Record.
3. Statistical and comparative analyses.
4. Graphic presentation of collected data.

The study was conducted in the following stages:

I. Collection of information relating to the type and area of urban green spaces in the city.

The sources of data were: the Local Land Use Plan of Tczew (an obligatory document in the Polish urban planning system which defines the goals of municipal planning policies), Register of Green Spaces kept by the urban gmina of Tczew, and local zoning plans. Urban green spaces were inventoried with the use of the classification method proposed by Czarnecki (1961) with certain modifications. In the said methodology, the nomenclature relating to different categories of green space became obsolete in the 1970s, and it was updated to meet contemporary standards (Table 1).

II. Development of the Green-Space Record.

The authors designed the Green-Space Record to perform an inventory of urban green spaces in Tczew and to analyse their distribution, area, in-

fluence and quality. The Green-Space Record was developed based on a review of the literature, the results of a survey conducted among scientists and professionals dealing with urban green spaces, and local planning documents. The Green-Space Record is composed of three parts (Tables 2, 3 and 4). Basic information for classifying the evaluated green spaces is collected in the first part of the record. Information about the number and area of green spaces in residential districts was collected in this way. The terms and concepts describing the significance of urban green spaces are defined in Table 2.

Information about the vertical structure, area covered by trees and understory vegetation, predominant tree species and stand age is gathered in the second part of the Green-Space Record (Table 3).

Green spaces in need of improvement, including specific features that require modification, are indicated in the third part of the Green-Space Record. The quality of urban green space is evaluated on a scale of “poor” to “very high”. Access to green space and its purpose are awarded 0 points or 1 point. The evaluated elements and classification criteria are presented in Table 4.

The maximum number of points in each of the above categories was:

Access – 4 points.

Purpose – 11 points.

Quality of infrastructure – 24 points.

Quality of vegetation – 6 points.

A consolidated point-grading scale (0-4) was introduced to compare the four elements in the quality evaluation. Based on the results of the survey, all elements were given equal weight. The allocated scores were recalculated based on the point conversion table in Table 5, and new point-grading scales for the evaluated elements were defined in Table 6.

The Green-Space Record is presented in Table 7.

III. Field inspection.

The gathered data were validated, and the quality of green spaces was evaluated. Only areas accessible to the general public were selected for detailed analysis. The results were noted in the Green-Space Record. The following information was input:

- type and area of green space: park, pocket park, boulevard, promenade, ornamental square (Table 1),

Table 1. Classification of urban green spaces

CATEGORY	TYPE
Public green spaces	Parks Pocket parks Boulevards and promenades Ornamental squares
Special-purpose green spaces	Cemeteries Allotment gardens Green belts
Accompanying vegetation	Roadside trees Residential greens
Agricultural land and forests	Orchards
Recreational areas	Forests

Source: Own elaboration based on Czarnecki (1961)

Table 2. Terms and concepts used in the evaluation of urban green spaces

GENERAL INFORMATION	
Role in the urban structure	
<b>Surface element</b>	Green spaces with an area larger than 1 ha
<b>Linear element</b>	Green spaces with significant disproportions in length and width, regardless of area
<b>Pointelements</b>	Green spaces with an area smaller than 1 ha
Influence	
<b>Municipal</b>	Parks, pocket parks, boulevards and promenades larger than 5 ha, which are used for recreational purposes on daily basis, on weekends and during special events and which serve a different purpose than other types of urban green spaces
<b>District</b>	Parks, pocket parks, boulevards, promenades and ornamental squares with an area of 1 ha to 5 ha, which are used for recreational purposes on daily basis and on weekends and which do not serve a different purpose than green spaces in neighbouring districts
<b>Local</b>	Parks, pocket parks, boulevards, promenades and ornamental squares with an area of up to 1 ha which are used for recreational purposes on a daily basis

Source: Own elaboration based the modified methodology proposed by Czarnecki (1961)

Table 3. Concepts relating to vertical structure and plant cover in green spaces

VEGETATION DATA	
<b>Vertical structure</b>	The preferred structure is a 3-layered system composed of turf, perennial plants and trees. A 3-layered structure contributes to biodiversity and enhances the aesthetic appeal of urban areas.
<b>Plant cover</b>	Percentage distribution of plants in each of the three biological layers. Variations in vertical structure and plant cover are determined to evaluate the biological intensity of green spaces. Plant cover is analysed based on the information collected in the Register of Green Spaces.
<b>Tree stand age</b>	Uneven-aged stands contribute to biodiversity and enhance the aesthetic appeal of urban areas. Differences in plant age contribute to the preservation of species with moderate replacement levels. Tree age is evaluated based on the information collected in the Register of Green Spaces.

Source: Own elaboration based on Sitarski et al., 2011 and Sitarski et al., 2012

Table 4. Criteria for evaluating urban green spaces

<b>EVALUATION OF URBAN GREEN SPACES</b>	
<b>ACCESS</b>	
<b>Positive score</b>	
<b>Public transport</b>	Urban green space is situated at a distance of 150 m from a public transport route.
<b>Bike path</b>	Urban green space can be accessed directly via a bike path or it is situated at a distance of 200 m from a bike path due to spatial constraints (e.g. the roadway is too narrow to accommodate a bike lane).
<b>Car park</b>	Car park is available along the limits or in the vicinity of urban green space.
<b>Disabled access</b>	At least one dedicated hard-top lane is available for disabled visitors, without differences in elevation (low curbs, wheelchair ramps, etc.).
<b>PURPOSE</b>	
<b>Positive score</b>	
<b>Pavements and roads</b>	Hard-top pedestrian pavements, pedestrian/vehicle crosswalks, roads for vehicular traffic.
<b>Representative sites</b>	Features that emphasize the representative character of urban green space, including monuments, ornamental structures, fountains, ornamental alleys and promenades, usually centrally located and featuring decorative plants.
<b>Passive recreation options</b>	Visitors can relax and admire the landscape in secluded spots separated by vegetation or other noise barriers; Benches, reclining chairs or picnic spots are available.
<b>Sports facilities</b>	Outdoor gyms, street workout equipment, sports fields, piers, platforms, etc.
<b>Playgrounds</b>	Attractions for children from various age groups .
<b>Scenic viewpoints</b>	Elevated sites for admiring the local landscape.
<b>Educational facilities</b>	Natural monuments, historic parks, protected tree alleys, educational trails.
<b>Public event options</b>	Public events can be organized outdoors on grass (based on information about concerts, festivals and picnics organized in the past).
<b>Dog access</b>	Dogs are allowed inside.
<b>Dog parks</b>	Fenced off-leash enclosures for dogs.
<b>Water bodies and water features</b>	Ponds, pools, small lakes and other water features.
<b>QUALITY OF INFRASTRUCTURE</b>	
<b>Evaluated features:</b> 1. Roads/pavements, 2. Car parks, 3. Sports equipment, 4. Playgrounds, 5. Benches, 6. Trash cans, 7. Lamps, 8. Sculptures, fountains, chapels, monuments.	
<b>Point scores</b>	
<b>0</b>	None – the evaluated feature does not exist.
<b>1</b>	Needs improvement – the evaluated feature is not fully functional and is in poor technical condition. The feature does not blend into the surroundings.
<b>2</b>	Average – the evaluated feature is functional, but it is somewhat neglected (rust, minor damage, etc.). The feature blends into the surroundings.
<b>3</b>	High – the technical condition and the appearance of the evaluated feature are satisfactory. The feature is fully functional and blends into the surroundings.
<b>Terminology</b>	
<b>Composition and functionality</b>	Green spaces appear to be well maintained, they enhance the appearance of streets and squares and introduce spatial order. Plants have been carefully selected, there are no plant species that disrupt free movement (poplars, mountain-ashes, maple trees, fruit trees).
<b>Aesthetic appeal</b>	Plants enhance the aesthetic appeal of the area and the local landscape. Plants form an attractive background for buildings, shield unattractive structures and bring out architectural features.

Table 4. Continuation

<b>Condition</b>	There are no dry boughs in tree crowns, trees do not pose a threat to the public, there are no weeds, the area is clean and orderly.
<b>Point scores</b>	
<b>0</b>	Poor – the area is devoid of pleasing floristic compositions and plant structure, it has low aesthetic value, weeds are not controlled, plants are in poor condition.
<b>1</b>	Average – floristic composition and plant structure do not fully meet expectations. Landscape design needs improvement, some plants obstruct free movement. Plants do not enhance the local landscape and do not shield unattractive structures. Weeds are not effectively controlled. Plants are in relatively good condition.
<b>2</b>	High – plants are well arranged and do not create functional barriers. There are no aesthetically displeasing elements. Ornamental plants are well exposed. Plants are in good condition and are well maintained. Weeds are adequately controlled.

Source: Own elaboration based on survey results

Table 5. Quality criteria for evaluating urban green spaces in on the consolidated point-grading scale

Quality criteria	Conversion of points in the consolidated scale				
	0	1	2	3	4
Access	0	1	2	3	4
Purpose	0-1	2-4	5-6	7-8	9-11
Quality of infrastructure	0-4	5-9	10-14	15-19	20-24
Quality of vegetation	0	1-2	3-4	5	6

Source: Own elaboration based on survey results

Table 6. General evaluation of the quality of urban green spaces – summary

Evaluation criteria	Grading scale
Access	0-4
Purpose	0-4
Quality of infrastructure	0-4
Quality of vegetation	0-4
Total	16
Overall evaluation of the quality of urban green spaces	
Poor	0-4
Average	5-8
High	9-12
Very high	13-16

Source: Own elaboration

- location: district, street, plot number,
- role in spatial structure: surface element, linear element or point element (Table 2),
- influence: municipal, district, local (Table 2),
- vertical structure: 1, 2 or 3 layers of vegetation (Table 3),
- plant cover – percentage distribution of plants in each biological layer: TREES (<10%, 10-30%, 30-60%, >60%), SHRUBS (<10%, 10-30%, 30-60%, >60%), TURF/PERENNIAL PLANTS (<10%, 10-30%, 30-60%, >60%) (Table 3).

- tree species,
- stand age: up to 15 years, 16-30, 31-60, above 60 years.

Access, purpose and composition were evaluated according to the criteria described in Table 4. The overall quality of vegetation was evaluated on the consolidated point-grading scale (Tables 5 and 6).

#### IV. Data analysis.

1. The availability of green spaces in residential districts and the area of green spaces per capita in the evaluated districts were calculated.

The city of Tczew is not formally divided into residential districts, therefore, the relevant calculations were based on the distribution of urban planning units proposed in the Tczew city delimitation procedure of the Local Revitalization Plan 2015 (Delimitation of degraded... 2016). The proposed division consists of 14 residential districts where the distribution and quality of green spaces were analysed. Two indicators were calculated:

- WZO – proportion of district area occupied by green spaces:

$$WZO = \frac{\Sigma \text{Green spaces in residential district}}{\text{Area of residential district}} \times 100\%$$

- WZM – area of green spaces per capita in residential district:

$$WZM = \frac{\Sigma \text{Green spaces in residential district}}{\text{Number of residents}}$$

## 2. Influence of different types of green spaces.

The location of green spaces is determined by their function, influence, environmental factors, managing authority and access to public transport. According to Niemirski (1973), green spaces can be divided into four groups based on their sphere of influence:

**Group I** – green spaces used on a daily basis for passive recreation, situated within a walking distance of 600 m, accessible to the general public: district parks, strolling and recreational parks, community parks, pocket parks, boulevards, promenades and vegetation in residential districts, playgrounds, schools, community centres, centres of art and culture, health care facilities, welfare facilities and sports facilities.

**Group II** – green spaces used on a daily basis and during special events for passive and active recreation, situated in the vicinity of a public transport route or a walking distance of 2 km: strolling and recreational parks in the centre of an urban area, community parks, boulevards, promenades, roadside trees, educational gardens, allotment gardens.

**Group III** – municipal green spaces situated in the vicinity of a public transport route or a walking distance of 3 km: municipal forests, cemeteries, agricultural land, forests.

**Group IV** – green spaces used occasionally and during special events, including national parks, landscape parks, suburban forests, situated in the

vicinity of municipal, regional and national public transport routes.

The proposed division does not adequately reflect the structure of green spaces in Tczew which abounds in pocket parks. The above methodology also fails to account for the area of green spaces in the city. For this reason, a method for describing the influence of green spaces was developed based on their area, distance, accessibility and significance in the urban structure. The analysis involved the green spaces listed in the Green-Space Record. The influence categories proposed by Niemirski (1973) were modified as follows:

**Zone 1** – maximum walking distance of 300 m, local green spaces, including ornamental squares and pocket parks with an area of up to 1 ha, used for recreational purposes on a daily basis.

**Zone 2** – maximum walking distance of 600 m, district green spaces, including ornamental squares and pocket parks with an area of 1 to 5 ha, used for recreational purposes on a daily basis and on weekends, with a similar purpose to other green areas in the neighbourhood.

**Zone 3** – maximum walking distance of 1200 m, municipal green spaces, including pocket parks, parks and boulevards with an area larger than 5 ha, used by local residents and tourists, with a different purpose than other types of urban green space.

3. Evaluation of the quality of green spaces in Tczew. The evaluation was performed with the use of the methods described in points II and III of the Research materials and methods section.

4. Formulation of conclusions regarding green spaces in Tczew.

Sources of data:

- Study of the conditions and directions of spatial development in Tczew ([www.bip.tczew.pl](http://www.bip.tczew.pl), DoA: 26.09.2017),

- Register of Green Spaces kept by the Urban Gmina of Tczew (an internal document for the employees of the Municipal Affairs Department),

- local zoning plans (planning documents available in the municipal office).



Table 7. Green-Space Record

GREEN-SPACE RECORD					
GENERAL INFORMATION					
<b>Area</b>	..... [ha]	<b>Category</b>	Park <input type="checkbox"/> Promenade <input type="checkbox"/>	Square <input type="checkbox"/> Ornamental square <input type="checkbox"/>	Boulevard <input type="checkbox"/>
<b>Location</b>	District/street/plot no. ..... .....				
<b>Role in spatial structure</b>	Surface element <input type="checkbox"/> Linear element <input type="checkbox"/> Point element <input type="checkbox"/>	<b>Influence</b>	Local <input type="checkbox"/> District <input type="checkbox"/> Municipal <input type="checkbox"/>		
VEGETATION					
<b>Vertical structure</b>	1 layer 2 layers 3 layers	<b>Plant cover</b>	<b>Trees</b> - <input type="checkbox"/> <10% <input type="checkbox"/> 10-30% <input type="checkbox"/> 30-60% <input type="checkbox"/> >60% <b>Shrubs</b> - <input type="checkbox"/> <10% <input type="checkbox"/> 10-30% <input type="checkbox"/> 30-60% <input type="checkbox"/> >60% <b>Turf, perennials</b> - <input type="checkbox"/> <10% <input type="checkbox"/> 10-30% <input type="checkbox"/> 30-60% <input type="checkbox"/> >60%		
<b>Predominant tree species</b>	..... ..... .....				
<b>Tree age</b>	<input type="checkbox"/> >15 years <input type="checkbox"/> 16-30 years <input type="checkbox"/> 31-60 years <input type="checkbox"/> 60 years				
QUALITY OF URBAN GREEN SPACES – open to the general public					
ACCESS (A)					
<b>Criteria</b>	Yes(1)	No(0)	<b>Criteria</b>	Yes(1)	No(0)
Public transport			Car park		
Bike path			Disabled access		
PURPOSE (P)					
<b>Criteria</b>	Yes(1)	No(0)	<b>Criteria</b>	Yes(1)	No(0)
Pavements and roads			Educational facilities (natural monuments, historic parks, educational trails)		
Representative sites			Public event options		
Passive recreation			Dog access		
Sports facilities			Dog parks		
Playgrounds			Water bodies and water features		
Scenic viewpoints					
QUALITY OF INFRASTRUCTURE (QI)					
Scores: 0 - none, 1 – needs improvement, 2 - average, 3 - high					
Roads/pavements			Benches		
Car park			Trash cans		
			Lamps		
Sports equipment			Sculptures, fountains, chapels, monuments		
Playgrounds					
QUALITY OF VEGETATION (QV)					
Scores: 0 – needs improvement, 1 - average, 2 - high					
Composition and functionality					
Aesthetic appeal					
Condition					
SUMMARY					
<b>Criteria</b>	<b>Total score</b>		<b>Partial score</b>		<b>Overall evaluation</b>
ACCESS					
PURPOSE					
QUALITY OF INFRASTRUCTURE					
QUALITY OF VEGETATION					
<b>NOTES</b>	..... ..... .....				

Source: Own elaboration

## 2.1. Description of the analysed city

By Polish standards, Tczew is a medium-sized city with an area of 2,238 ha. It is situated in northern Poland in the Pomorskie Voivodship (Fig. 1), on the left bank of the Vistula River, below the bifurcation created by the Nogat River, an eastern delta branch of the Vistula. According to statistical data, in 2016 Tczew had a population of 60,276. The proportion of the pre-working age (19.0%) and working age population (60.8%) is relatively high, and it significantly exceeds the post-working age population (20.2%) (Local Data Bank, DoA: 14.06.2017).



Fig. 1. Location of the analysed city on a map of Poland  
Source: Own elaboration

Table 8. Structure and area of green spaces in Tczew

Category	Type	Area	% city area
		[ha]	
Public green space	Parks	23.75	1.06
	Pocket parks	32.86	1.47
	Boulevards and promenades	7.20	0.32
	Ornamental squares	1.96	0.09
Special-purpose green space	Cemeteries	11.12	0.50
	Allotment gardens	145.91	6.52
	Green belts	5.33	0.24
Accompanying vegetation	Roadside trees	45.96	2.05
	Other vegetation in residential districts	41.21	1.84
Agricultural land and forests	Orchards	101.40	4.53
Recreational areas	Forests	9.00	0.40
<b>TOTAL</b>		<b>425.70</b>	<b>19.02</b>

Source: Own elaboration based on the Study of the conditions and directions of spatial development in Tczew

## 3. Research results

### 3.1. Spatial distribution and influence of green spaces in Tczew

The following types of green spaces were identified and inventoried with the use of the modified classification method proposed by Czarnecki (Table 8).

The spatial distribution of green spaces in Tczew is presented in Figure 2.

When the total area of green spaces in Tczew (425.70 ha) is divided by the city's population (60,276), the area of green space per capita amounts to 70.6 m<sup>2</sup>. According to the World Health Organization (WHO), the recommended green area per capita is 50 m<sup>2</sup>, whereas the minimum prescribed area is 9 m<sup>2</sup> (Łukasiewicz, 2016). The relative scarcity of forests in Tczew is compensated by a high proportion of allotment gardens in the city's green space. Allotment gardens deliver environmental and health benefits, but their availability is limited by property rights.

The influence of green spaces was evaluated based on areas that are open to the general public. This category consists of 4 parks, 33 pocket parks, 4 ornamental squares, 1 boulevard and 1 promenade in 12 of the city's 14 residential districts. Public green space in Tczew has a combined area of 66.75 ha. It was inventoried during a field study, and the



Fig. 2. Spatial distribution of green spaces in Tczew  
 Source: Own elaboration

results were described in 43 Green-Space Records. The values of WZO and WZM indicators were calculated for every residential district. The types and area of public green spaces in Tczew's residential districts and the values of the calculated indicators are presented in Table 9.

Stare Miasto (Old Town) has the highest number (13) of public green spaces which have a combined area of 28.11 ha and occupy more than 30% of the district's area. The district has 37.2 m<sup>2</sup> of

green space per capita, which exceeds the city average (11.1 m<sup>2</sup>) more than threefold. The calculated values were also high in the Górki district. Above-average results were also noted in the Bajkowie district with 19.9 m<sup>2</sup> of green space per capita. The remaining districts were characterized by below-average values. Zatorze was most deficient in public green space (0.5 m<sup>2</sup> per capita).

Public green space is not available in all of Tczew's residential districts; therefore, the influence

Table 9. Public green spaces in Tczew

Residential district	Type of green space	Detailed location (street)	Area [ha]	Percentage of district area (%)	
				WZM	WZO
Górki	Pocket park	Modrzewskiego	3.50	37.1	7.7
	Pocket park	Solidarności	4.65		
	Pocket park	Kossaka	1.23		
Kolejarz	Strzelnica Park	Przemysłowa	1.34	14.6	4.8
Bema	Pocket park	Sychty	0.52	4.1	1.6
Czyżykowo	Pocket park	Bałdowskiego	0.21	11.5	15.0
	Pocket park	Orzeszkowej	0.80		
	Czyżykowo Park	Orzeszkowej	4.40		
Za Parkiem	Pocket park	30-go Stycznia	0.16	3.2	1.8
	Pocket park	Nabrzeżna	0.95		
Stare Miasto (Old Town)	Municipal Park	Bałdowska	14.50	37.2	30.6
	Konstytucji 3-go Maja pocket park	30-go Stycznia	0.57		
	Żołnierzy Radzieckich pocket park	30-go Stycznia	0.31		
	Kopernika Park	30-go Stycznia	2.86		
	Pocket park	Wąska	0.58		
	Pocket park	Kościuszki	0.04		
	Schefflera pocket park	Łazienna Hallera	0.17		
	Gen. Hallera Square	Hallera Plac św. Grzegorza	0.16		
	Św. Grzegorza Square	Plac św. Grzegorza	0.31		
	Pocket park	Zamkowa Wyszyńskiego	0.50		
	Pocket park	Wyszyńskiego	0.65		
	Boulevard	Jana z Kolna	6.79		
	Bohaterów Szymankowa pocket park	Nowa	0.67		
Nowe Miasto (New Town)	Sports pocket park	Warsztatowa	3.45	4.1	9.6

Table 9. Continuation

Garnuszewskiego	Pocket park	Sobieskiego	0.08	5.0	11.5
	Pocket park	Aleja Zwycięstwa	0.29		
	Garnuszewskiego pocket park	Aleja Zwycięstwa	1.00		
	Pocket park	Jedności Narodu	1.44		
	Pocket park	Jedności Narodu	0.68		
	Patriotów Square	Wojska Polskiego	0.66		
Bajkowie	Pocket park	Andersa	1.17	19.9	12.9
	Pocket park	Jagiellońska	1.84		
	Pocket park	Kubusia Puchatka	1.38		
	Papieski Square	Jagiellońska	0.83		
	Pocket park	Kociewska	1.20		
	Pocket park	Jana Brzechwy	0.41		
Suchostrzygi	Pocket park	Żwirki	0.06	3.5	6.0
	Pocket park	Żwirki	1.40		
	Pocket park	Harcerska	0.86		
	Pocket park	Hass	2.47		
	Promenade	Armii Krajowej	0.65		
Zatorze	Pocket park	Łąkowa	0.12	0.5	0.2
Abisynia	Pocket park	Spółdzielcza	0.89	3.4	0.8
Gdańska*	-	-	-	0	0
Prątnica*	-	-	-	0	0
<b>Total</b>			<b>66.75</b>	<b>11.31</b>	<b>100.0</b>

\* - residential districts without green spaces

Source: Own elaboration based on the Register of Green Spaces kept by the Urban Gmina of Tczew and the field inventory

of the identified green spaces was analysed to determine whether the evaluated districts are served by green spaces in the neighbourhood. Spheres of influence were analysed with the use of the method proposed by Niemirski (1973) with certain modifications. In the modified methodology, the spheres of influence were reduced and adapted to the size of the city and the updated categories of green space (the Research materials and methods section).

Spheres of influence were mapped from the geometric centre of green spaces with an area of up to 1 ha. The influence of green spaces larger than 1 ha and green spaces with elongated or irregular shape was mapped along their external borders to prevent spheres of influence from appearing inside the analysed green spaces. Spheres of influence were determined for public green spaces in every residential district.

To illustrate the adopted methodology, the spheres of influence of green spaces in the district

of Stare Miasto (Old Town) are presented in Figures 3, 4 and 5.

The mapped spheres of influence of every public green space in each residential district reveal the presence of districts with limited access to green space as well as districts where green spaces are abundant. The greatest overlap of the mapped spheres of influence was observed in Stare Miasto (Old Town) which is characterized by the highest density of local green spaces. Stare Miasto (Old Town) also features one district green space and two municipal green spaces—the Municipal Park and Nadwiślański Boulevard. The area of green spaces in different parts of the district was relatively small (excluding the Municipal Park and Nadwiślański Boulevard), the inhabitants have access to outdoor recreational areas and the boulevard on the bank of the Vistula river, which considerably enhances the residential appeal of Stare Miasto (Old Town). The districts of Garnuszewskiego,

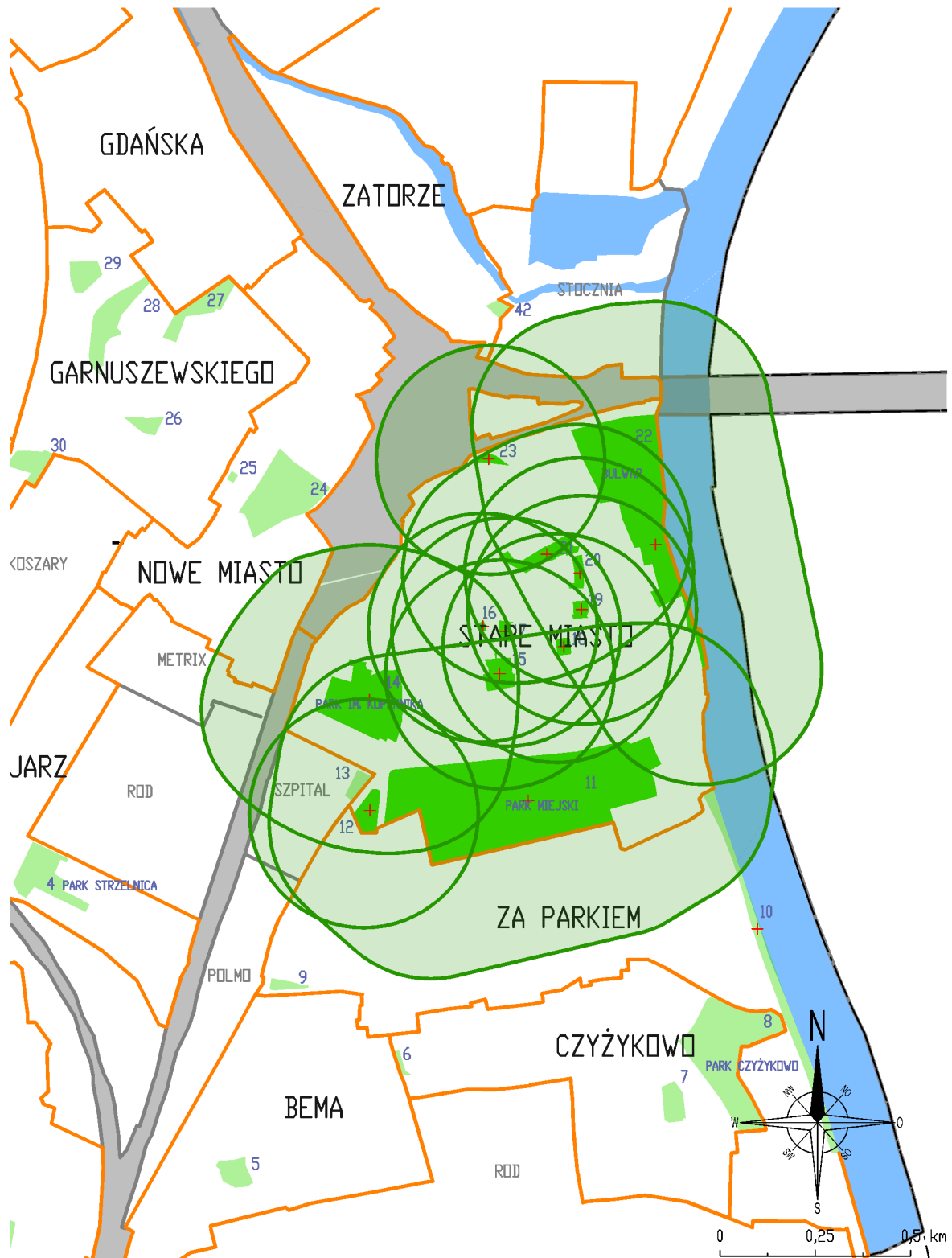


Fig. 3. Spheres of influence of local green spaces  
 Source: Own elaboration

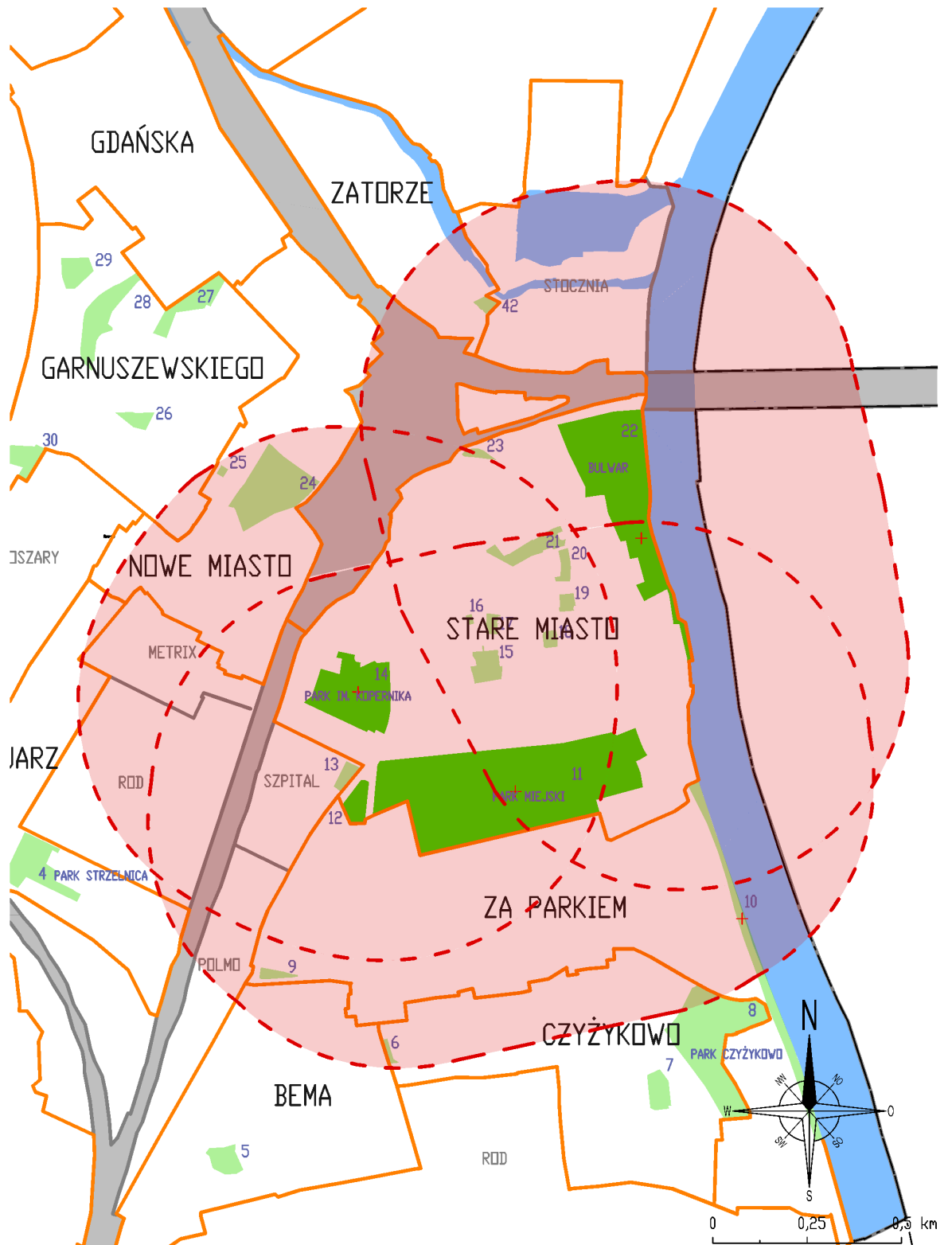


Fig. 4. Spheres of influence of district green spaces  
Source: Own elaboration

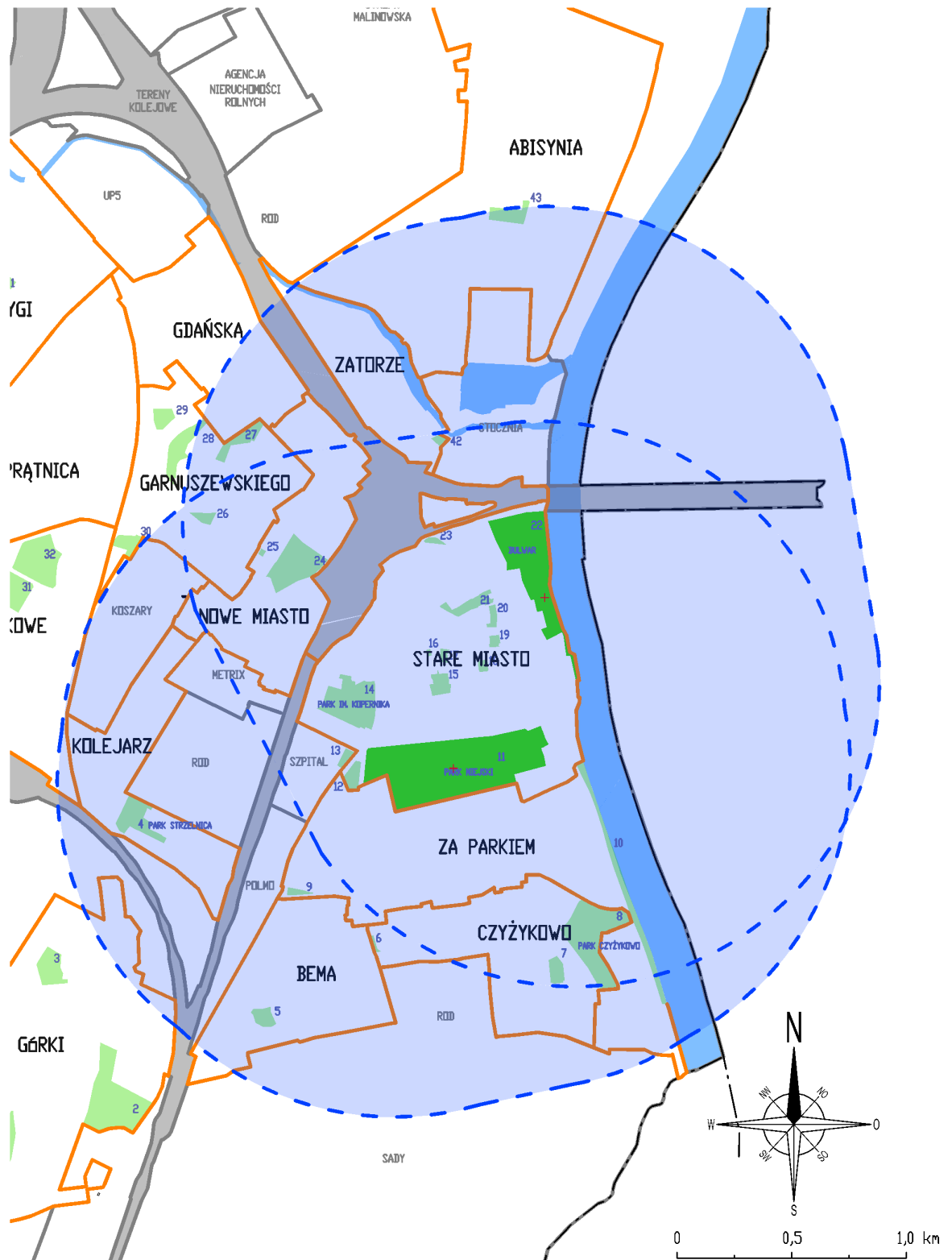


Fig. 5. Spheres of influence of municipal green spaces  
 Source: Own elaboration



Suchostrzygi and Bajkowe also have relatively high green space coverage.

Public green spaces were least accessible in the district of Zatorze which is characterized by multiple-family housing. The local inhabitants do not have gardens that could compensate for the shortage of green spaces in the area. The district is delimited by Młyński Canal, and it is adjacent to railway tracks in the south and east, which obstructs access to other districts in the city, in particular for elderly inhabitants and families with children.

Green space coverage was also low in the district of Abisynia which has one local green space that caters to the needs of around half of the existing buildings. It should be noted that Abisynia features only single-family homes, and its inhabitants have access to private gardens. A flood embankment in the district is also used for recreational purposes. However, the embankment is relatively tall and steep, and it may not be easily accessible to all inhabitants.

### 3.2. Evaluation of the quality of public green spaces in Tczew

The quality of public green spaces in Tczew was evaluated based on the information collected in Green-Space Records. Ten of the 43 analysed green spaces had a two-layered vertical structure. The analysed areas featured trees, turf and perennial vegetation. In most green spaces, trees covered less than 10% of the area. Tree coverage was estimated at 10–30% in 14 green spaces. The highest tree coverage was noted in three parks (Municipal Park, Strzelnica Park and Kopernika Park). Half of the analysed green spaces had 60% grass and perennial coverage. Grass cover was less than 10% in only two areas (pocket park on Kościuszki street and Gen. Hallera square) due to spatial constraints and a high percentage of artificial surfaces and buildings.

The age of tree stands was diversified in the majority of the evaluated green spaces (26), which has positive implications. Even-aged stands were found in the remaining 17 green spaces. The predominant tree species were small-leaved lime and Norway maple, and other popular species included acacia, silver birch, horse chestnut and black poplar.

The quality of green spaces was evaluated with the use of the methodology described in the Research materials and Methods section based on the information collected in Green-Space Records during the field survey. The following criteria were evaluated: access (A), purpose (P), quality of infrastructure (QI) and quality of vegetation (QV). The scores awarded to each of the above criteria were pooled in the final analysis. Scores indicative of low quality were not awarded to any of the analysed green spaces. In general, the quality of the examined green spaces was evaluated as average to very high. The maximum number of points was awarded to four green spaces: Nadwiślański Boulevard, the pocket park at Jedności Narodu street, Papieski Square and the pocket park on Żwirki street. The quality of green spaces was average in the Abisynia, Nowe Miasto (New Town), Kolejarski and Bema districts, and it was evaluated as high or very high in the Stare Miasto (Old Town), Za Parkiem, Garnuszewskiego and Suchostrzygi districts. The quality of green spaces in Tczew was evaluated as very high in 4 areas, high in 18 areas and average in 14 areas. The results of the quality evaluation and the number of points awarded to different criteria are presented in Table 10.

In general, green spaces in Tczew received relatively high scores, and most of them were characterized by high or very high quality. However, access to green spaces varies considerably between the city's districts. Green spaces are sporadically available and are characterized by relatively low quality in the districts of Kolejarski, Nowe Miasto (New Town), Bema and Zatorze. These green spaces should be regarded as priority areas for improvement, in particular in Zatorze and Nowe Miasto (New Town) which have a predominance of multi-family residential buildings. Improvement measures would level out the quality of green spaces in Tczew and increase the attractiveness of residential districts. An analysis of individual evaluation criteria supported the formulation of specific measures which are required to improve the quality of selected green spaces. Green spaces with high and very high quality should be routinely maintained and monitored to preserve their high quality. The Municipal Park deserves special attention in this analysis. It is one of the most popular green spaces in the city with relatively high quality of vegetation. However, the quality of the park's in-

Table 10. Quality of green spaces in Tczew

No.	District	Area	A	P	QI	QV	Total	Overall quality
1	Górki	3.50	3	3	4	3	13	HIGH
2		4.65	1	2	3	2	8	AVERAGE
3		1.23	4	3	3	2	12	HIGH
4	Kolejarz	1.34	1	2	3	3	9	AVERAGE
5	Bema	0.52	1	2	2	1	6	AVERAGE
6	Czyżykowo	0.21	3	2	2	2	9	AVERAGE
7		0.80	2	2	3	3	10	HIGH
8		4.40	2	3	2	2	9	AVERAGE
9	Za Parkiem	0.16	2	2	3	3	10	HIGH
10		0.95	1	3	3	3	10	HIGH
11	Stare Miasto (Old Town)	14.50	4	4	2	3	13	HIGH
12		0.57	3	2	3	3	11	HIGH
13		0.31	2	2	2	3	9	AVERAGE
14		2.86	4	3	2	3	12	HIGH
15		0.58	1	3	3	3	10	HIGH
16		0.04	2	2	3	3	10	HIGH
17		0.17	2	2	3	3	10	HIGH
18		0.16	3	2	2	3	10	HIGH
19		0.31	2	2	3	3	10	HIGH
20		0.50	1	3	3	3	10	HIGH
21		0.65	3	3	3	2	11	HIGH
22		6.79	4	4	4	3	15	VERY HIGH
23		0.67	1	2	3	3	9	AVERAGE
24	Nowe Miasto (New Town)	3.45	2	3	2	2	9	AVERAGE
25	Garnuszewskiego	0.08	2	2	2	3	9	AVERAGE
26		0.29	4	2	2	3	11	HIGH
27		1.00	3	3	2	2	10	HIGH
28		1.44	3	3	4	4	14	VERY HIGH
29		0.68	3	2	3	1	9	AVERAGE
30		0.66	2	2	3	3	10	HIGH
31	Bajkowe	1.17	2	2	1	2	7	AVERAGE
32		1.84	3	3	4	3	13	HIGH
33		1.38	4	2	2	3	11	HIGH
34		0.83	4	2	4	4	14	VERY HIGH
35		1.20	4	2	3	4	13	HIGH
36		0.41	2	1	1	3	7	AVERAGE
37	Suchostrzygi	0.06	4	2	3	4	13	HIGH
38		1.40	4	4	4	4	16	VERY HIGH
39		0.86	4	3	3	3	13	HIGH
40		2.47	3	3	2	3	11	HIGH
41		0.65	3	2	3	4	12	HIGH
42	Zatorze	0.12	1	2	2	2	7	AVERAGE
43	Abisynia	0.89	2	2	3	1	8	AVERAGE

Source: Own elaboration

infrastructure was evaluated as low, which decreased its overall score.

Most of the analysed green spaces had a three-layered vertical structure, which is a positive trend. Shrubs were generally absent in areas with a two-layered structure, and they should be introduced to increase biodiversity, in particular in areas neighbouring busy roads. Most green spaces had uneven-aged stands, which is also a desirable trend. New plants should be introduced and felled trees should be replaced to create a visually balanced composition. Native species, including small-leaved lime and Norway maple, are recommended to preserve the resiliency of urban green spaces in the city.

#### 4. Conclusion

The proposed method for determining the spheres of influence of urban green spaces can be used to evaluate their distribution in cities with a similar area and function. The described method can also be used to supplement vegetation cover in the identified areas. The coverage of urban green spaces should be analysed to determine whether districts deficient in public greens have reasonable access to green areas in the neighbouring districts.

The size of green spaces determines their significance in the urban structure and their sphere of influence, which is directly linked with public access to recreation in a natural setting. Local green spaces have a smaller sphere of influence than municipal green spaces. To increase their accessibility for the general public, urban green spaces should have partially overlapping spheres of influence to ensure even coverage for all locations in a city. The above goal can be reached by planning large green spaces that are available to the general public or a higher number of local or residential green spaces. The planning solutions adopted by the local authorities are determined by their financial capabilities and the availability of undeveloped land.

The developed Green-Space Record is a useful tool for inventorying urban green spaces. The Record has a structured layout, and it supports data collection in an organized manner. The proposed Record can be used by:

- managers of urban green spaces for gathering information about the type, area and location of the analysed green space, vertical structure, age and quality of plant cover, use characteristics and quality of infrastructure. These types of data are essential for effective management of green spaces (maintenance, revitalization, monitoring),

- urban planners for analysing the availability of green spaces, their sphere of influence and role in the structure of a city.

The proposed method for determining the spheres of influence of urban green spaces can be used to evaluate their distribution in cities with a similar area and function. It is a valuable resource for identifying urban areas that are deficient in green spaces and have poor access to such facilities. The described tool is also helpful in the process of planning municipal projects, in particular residential estates with accompanying services. The developed method can be applied in cities with a similar size and spatial structure.

The analysis of the district of Stare Miasto (Old Town) presented in Figures 3, 4 and 5 was performed on local, district and municipal green spaces in Tczew. An evaluation of the influence of every type of green space in the examined districts demonstrated that:

- Stare Miasto (Old Town) is characterized by the highest density of local green spaces, including one district green space and two municipal green spaces, and its residents have the best access to urban vegetation,

- green spaces are also relatively abundant in the Garnuszewskiego, Suchostrzygi and Bajkowe districts,

- public green space is least accessible in the districts of Zatorze and Abisynia.

All municipal green spaces are situated in the eastern part of the city, therefore, a park or a public garden with similar coverage should be created in the western part of Tczew.

The results of this study can be used to formulate the following recommendations for the analysed green spaces in Tczew:

1. An analysis of the influence of various types of green spaces in every residential district indicates that Tczew could benefit from two new green areas that would provide full coverage for the districts of Zatorze and Abisynia. New green areas would im-

prove the standard of living and would enhance the aesthetic appeal of the above districts.

2. A municipal recreational park is recommended in the district of Bajkowie in western Tczew.

Three neighbouring pocket parks could be combined into a large municipal park with an area of 4.39 ha. The recommended solution addresses the general scarcity of green space in this part of the city. Two municipal parks are found in the district of Stare Miasto (Old Town) in eastern Tczew. The consolidation of pocket parks would significantly increase the coverage of municipal green space in the city.

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