
Generic and Functional Structure of Urban Green Areas of Poland's Provincial Cities

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Abstract:

Purpose: The purpose of the article is to indicate the importance of green areas in the urban tissue, based on the comparative characteristics of the generic and functional structure of urban green space resources of provincial Polish cities, as well as to classify the analyzed cities in terms of their green space resources. In addition, to indicate urban greenery as an important factor affecting the quality of life of residents in the context of sustainable urban development.

Design/Methodology/Approach: For the realization of the intended objective, the following desk research: namely content analysis and statistical data analysis. The subject of the study is selected types of green areas based on their purpose, located within the administrative boundaries of 18 (provincial) cities of Poland. Quantitative data were taken from the resources of the Local Data Bank of the Central Statistical Office. Basic statistical parameters and cluster analysis were used to assess the diversity of green areas.

Findings: Green areas perform functions in the urban fabric that directly translate into living conditions in the city, among the most important are ecological, social, recreational and aesthetic functions. It is not only the size of green areas that matters, but also their structure and distribution in space to fully realize the indicated functions, in the context of the quality of living conditions of residents and the principles of sustainable urban development.

Practical Implications: The results of the study and conclusions can become valuable material pointing out the problems of land management in relation to urban green spaces, which is closely related to sustainable development at the local level. As well as paying more attention to the spatial planning process, which establishes the principles of comprehensive land use and is an effective tool for implementing environmental policies.

Originality/Value: The article presents the results of our own research. The presented issue is worth correlating with similar studies in the international arena. Jointly identifying and solving problems of spatial management in terms of sustainable development can be reflected in raising the quality of life of residents of settlement units now and in the future.

Keywords: Urban green spaces, functions of green spaces, sustainable urban development, cluster analysis.

JEL codes: Q26, Q56, R11, C19.

Paper type: Research article.

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1. Introduction

Urban green spaces are an important part of the urban layout of any city. They are one of the elements that create its image in the minds of residents and visitors. The term greenery should include all those forms of vegetation that are or can be permanent natural uses or introduced and controlled by man to affect the environment (Hejmanowski, 1989).

According to Haber (2001), green areas are areas located mainly in urban agglomerations, planned to be planted with vegetation to improve the aesthetics and biological function of the environment, having an urban character. In turn, the Law on Nature Protection of April 16, 2004 defines green areas as lands arranged (together with technical infrastructure and buildings functionally related to them), covered with vegetation and performing public functions, in particular parks, greens, promenades, boulevards, botanical, zoological, Jordanian and historic gardens, cemeteries, greenery accompanying roads in the development area, squares, historic fortifications, buildings, storage yards, airports, railroad stations and industrial facilities (Dz. U. 2004 No. 92).

This definition indicates two essential features of these areas: the form of organization that such an area should exhibit, forming a certain complex/complex of greenery, and its public use and accessibility, due to the performance of various functions, including ecological, social, aesthetic, recreational, health or sheltering functions.

Green areas, therefore, play a special role in improving the quality of life in the city, and their development and multifunctionality is an important contribution to the process of sustainable urban development. Greenery is not only an important component of the urban structure in places of residence and work, but also important for the development of commerce, recreation and other commercial activities.

A broad understanding of the quality of green areas that links environmental, social, economic and urban planning dimensions helps to define the character of a given city. That's why green areas are such an important part of the urban layout and are the showpiece of any city.

The distribution of green areas in the urban tissue depends on many factors, resulting in systems of various forms (systems: radial, ring, strip, spot or combined). Currently, the preferred system is the organic one, based on

physiographic analysis, which links the greenery system to the broad natural structure of the city (Mieszkowska, 1996).

The division of green spaces is carried out according to various criteria, most often based on their purpose. Thus, green spaces include, first of all, parks, lawns, promenades, boulevards, greenery of sports facilities, family allotment gardens, cemeteries, Jordan gardens, isolation green belts and traffic routes, cultivated areas, permanent grassland, forests, etc., (Haber, 2001).

In the literature, you can also find other criteria for division, which include: ownership and accessibility of use, the degree of provision of facilities (mainly water and electricity), methods and costs of investment, operation and maintenance (relevant to municipal management), the diversity of vegetation, the state of development, or the division into green spaces for active and passive recreation (Mydłowska, 2006).

The purpose of this paper is to conduct a comparative study of the generic and functional structure of the green space resources of provincial cities of Poland and, on this basis, to classify the analyzed cities. In addition, to identify urban greenery as an important factor affecting the quality of life in the context of sustainable urban development.

2. Data and Methods

In the conducted research and development of the material, the desk research method was used, which is a resultant of two groups of methods, namely content analysis and statistical data analysis. In this regard, at the outset, studies of the literature on the subject were carried out at the outset, primarily in the field of urban spatial planning with regard to the formation of green areas and the functions and tasks performed by green areas in the spatial structure of cities.

For the purpose of the comparative study, 18 cities of Poland were selected. The selected territorial units are the capitals of 16 provinces (voivodeships), namely: Wrocław (Dolnośląskie voivodeship), Lublin (Lubelskie voiv.), Łódź (Łódzkie voiv.), Kraków (Małopolskie voivodeship), Warszawa (Mazowieckie voiv.), Opole (Opolskie voiv.), Rzeszów (Podkarpackie voiv.), Białystok (Podlaskie voiv.), Gdańsk (Pomorskie voiv.), Katowice (Śląskie voiv.), Kielce (Świętokrzyskie voiv.), Olsztyn (Warmińsko-mazurskie voiv.), Poznań (Wielkopolskie voiv.), Szczecin (Zachodniopomorskie voiv.), in two cases, two cities each were selected, Gorzów Wielkopolski and Zielona Góra (Lubuskie voiv.) and Bydgoszcz and Toruń (Kujawsko-pomorskie voiv.). This is due to the fact that the seat of the provincial governor and provincial assembly are located in different cities of the listed provinces.

The listed territorial units, on the basis of the European Nomenclature of

Territorial Units for Statistics (NUTS), are assigned to the NUTS 4 level including districts [powiats] and cities with district rights within five levels of hierarchically and territorially related units in Poland (Klóska, Ociepa-Kicińska, Czyżycki, and Szklarz, 2020).

The subject of the study/analysis is selected types of green areas based on their intended use and includes: public green areas (i.e., strolling-recreational parks, lawns, street greenery, green area of the housing estate, cemeteries) and public forests (Table 1).

Table 1. Urban green areas

Type of green area	description
Cemetery	A place intended for burial of the deceased (people or animals) regardless of the legal status, owner/manager of the land or size of the area where greenery elements are located.
Public forests	Forest area of urban greenery significance, located in principle within or adjacent to the administrative boundaries of cities, specially adapted to meet the health and leisure needs of the urban population by the provision of equipment for recreation.
Green area of the housing estate	Green area accompanying housing development; serving a recreational, insulating and aesthetic function. The green area of the housing estate consists of lawns, flowerbeds, as well as park greenery arrangements with elements of tree and shrub plantings. The green area of the housing estate additionally includes pitches, playing fields, etc. structures overgrown with greenery.
Lawn	An area of less than 2 hectares whose main function is recreation. This category additionally includes greenery accompanying squares, historic fortifications, civic buildings, monuments, etc. as well as boulevards and promenades. The lawn may consist of low shrub arrangements (e.g. flowerbeds) and elements of tree and shrub plantings.
Street greenery	Greenery accompanying the roads in the built-up areas.
Strolling-recreational park(s)	The area with high and low vegetation of at least 2 hectares, arranged and maintained for recreational purposes, with roads, walking paths, benches, playgrounds, etc.

Source: Own elaboration based on: *Pojęcia stosowane w statystyce publicznej, 2020; Ciesielska and Cisielski, 2017.*

Statistical data analysis was used to assess the diversity of green areas of provincial cities of Poland, using basic statistical parameters and taxonomic method. The algorithm of this method was subordinated to cluster analysis using the agglomeration method with analysis of variance.

The entire statistical procedure was carried out using the STATISTICA.pl program, according to the following algorithm (Runge, 2006) defining the data matrix, carrying out standardization of variables (characteristics measured in

different units), choosing a similarity measure (Euclidean distance), calculating the elements of the matrix of taxonomic distances between spatial units (cities), agglomeration of clusters (according to the chosen binding principle - Ward's Method) until obtaining a dendrite, and analysis and verification of the dendrite. Characterization of the structure of each of the separated clusters was based on the method of arithmetic averages.

3. Results

Green areas are an important element of a city's spatial structure, directly influencing the conditions and living standards of its residents. Defining the place of green areas in the land use structure makes it possible to indicate the position of provincial cities in terms of their abundance of green areas.

In the studied set of cities - Warsaw (the capital of Poland) with a population of 1,863,056 (as of December 31, 2021) is the most populous and largest urban center in Poland's settlement system. The population density in the capital at the end of 2021 was 36.02 persons/ha (i.e., 3602 persons/km²). The share of green areas in the capital was 18.42%. Zielona Gora had the lowest population density of 5.02 people/ha (i.e., 502 os/km²). At the same time, the city boasted the largest share of green areas in the city's area (53.70%), while Gorzów Wielkopolski had the smallest share (10.33%).

The rate of the share of publicly accessible green areas was highest in Rzeszow, i.e., 15.53% of the city's area, mainly due to green spaces. The median for the surveyed set of cities was 7.04%. Also in the lead were Warsaw and Lublin. Mainly due to the relatively high share of neighborhood greenery and street greenery. Compared to other cities, Zielona Gora fared the worst, with only 1.46% of the city's area.

However, this city compensates for the low share of public greenery with the highest share of forest area, 52.24%. In contrast, the lowest forest cover is in the city of Rzeszow, which has only 1.34% of the share of forests in the total area. The analysis shows that cities with a high share of public green areas have a relatively small share of forested areas. The relationship characterized is confirmed by the value of Spearman's correlation coefficient (-0.63, with an assumed significance level of 0.05).

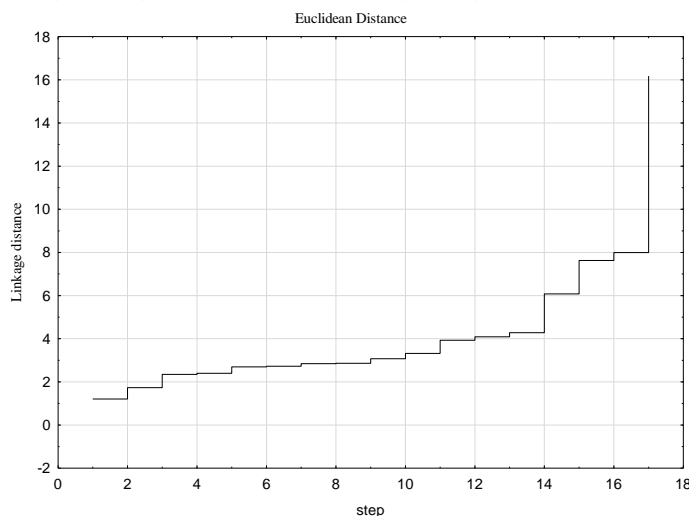
In terms of ecological population density (number of residents per hectare of green areas), the most favorable situation was in Zielona Góra, about 9 people per hectare of green areas, the median value was about 87 persons/ha, while the least favorable situation was in Krakow (199 person/ha).

The study of the structure of green areas in the studied set of cities, allows us to conclude that the largest variation in terms of percentage share in the total area

of the city is characterized by the category of green areas (the coefficient of variation was as high as 233.54%), while the smallest dispersion is shown by the category of cemeteries (coefficient of variation 34.67%).

Using cluster analysis with the agglomeration method, the provincial cities of Poland were aggregated in relation to the factors determining the attractiveness of these cities in the context of green areas (Appendix 1A). Based on the agglomeration flow chart, the cities were assigned to 5 clusters (groups) (Figure 1, and Figure 2).

Figure 1. Plot of linkage distances vs. linkage stages



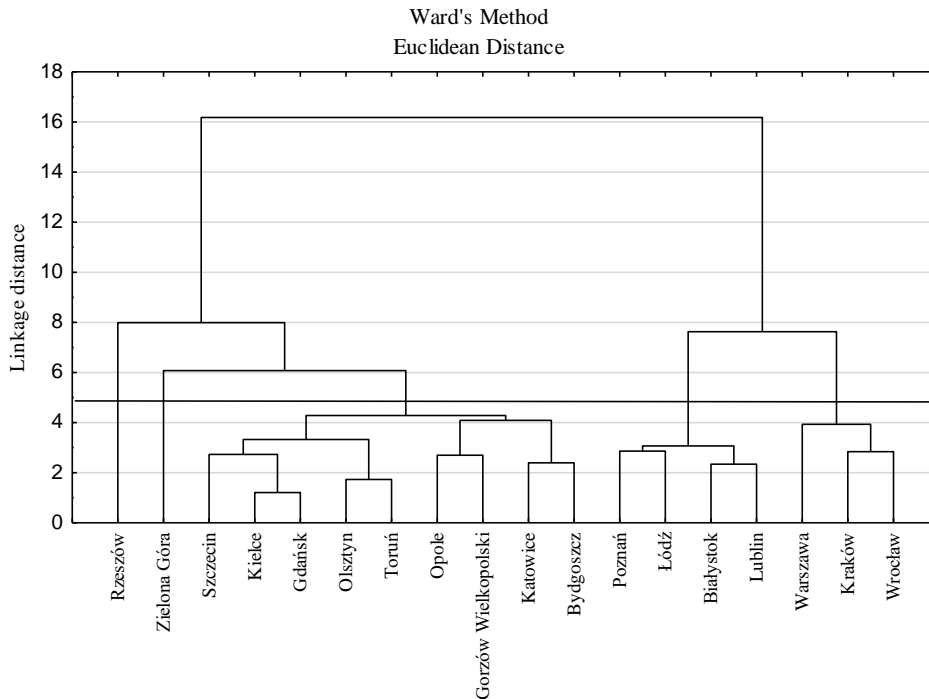
Source: Own study

The cities, based on their green resources, were classified into one of five clusters, which can be characterized, based on the method of arithmetic averages, as follows (Appendix 1):

- I group (1-element cluster: Zielona Gora) - a large share of public forests, a small percentage of other types of green areas, low traditional and ecological population density.
- II group (1-element cluster: Rzeszów) - cities rich in lawns, both in terms of their number and area occupied, a negligible proportion of public forests.
- III group (4-element cluster: Lublin, Łódź, Białystok, Poznań) - cities with a high share of street greenery and cemeteries in terms of area.
- IV group (3-element cluster: Wrocław, Kraków, Warszawa) - cities with high population density and high ecological density, characterized by a large number of strolling-recreational parks and cemeteries, and a relatively high percentage of the area of strolling-recreational parks and green area of the housing estate.

- V group (9-element cluster: Bydgoszcz, Toruń, Gorzów Wielkopolski, Opole, Gdańsk, Katowice, Kielce, Olsztyn, Szczecin) - moderate share of all forms of public greenery (both in number and area) and public forests.

Figure 2. Hierarchical tree



Source: Own study.

The analysis of variance conducted showed that almost all variables (except the percentage of strolling-recreational parks in the total area) statistically tested contributed to the formation of clusters, with the area and number of lawns and ecological density playing the largest role.

4. Discussion

A city is an internally interconnected system that includes nature and man with his culture, activities and creations. In principle, it is an anthropogenic product, but remains inextricably linked to the natural environment, on which the stability of this system depends (Markowski and Stawasz, 2001).

The destructive impact on urban nature is caused by those human activities that cause the disappearance of the biological structure of the city and are the cause of its imbalance. Depriving built-up areas of greenery and open spaces means completely depriving man of his natural environment, which poses a threat to

human health and life (Pęski, 1999). Therefore, a particularly important element in urban planning should be the designation of green and recreational areas, as well as the creation and maintenance of so-called "ecological corridors" connecting the interior of the city with open areas beyond the city (Chàfer, Pisello, Piselli, and Cabeza, 2020).

The diversification of the forms of green areas, due to their purpose, is conducive to maintaining the biological balance of the city. However, not only the structure of land use in the city, but also the size and distribution of green areas, are of great importance for the quality of living conditions in the city, and above all for sanitary and hygienic (ecological) conditions.

Taking into account the typological properties of the isolated clusters, it can be seen that the group of nine cities assigned to cluster V has the greatest diversity in terms of the form of use of green areas. The presence of various forms of green areas is conducive to their performance of various functions in the urban tissue. In addition, it should be mentioned that the developed vertical structure of green areas has a beneficial effect on the climate of the city, and primarily on such components as air temperature and humidity, wind speed and precipitation. It also plays an important role in reducing air pollution.

A large share of natural green areas is characterized by the I group, to which Zielona Góra is assigned. However, the center of the city is basically devoid of greenery, while in its peripheral zone there are larger in area and relatively dense green areas of forest character. First and foremost, these are productive and protective forests, for the city's residents they perform recreational and social functions, aimed at both passive and active recreation and for the acquisition of undergrowth resources (Greinert and Drozdek, 2015).

Group II with the city of Rzeszów is rich in green areas, which have recreational and aesthetic functions. Indirectly, they also perform ecological (biological) functions by reducing CO₂ content in urbanized areas. Rzeszów has a spotty green system, which is particularly detrimental to the city's areosanitary conditions (Gajdek and Wójcik, 2017).

The cities of Lublin, Łódź, Białystok, Poznań form cluster III dominant type of green areas (street greenery) realizes mainly aesthetic and sheltering functions. These types of green areas provide protection from noise, are used for snow shielding or shade. They also function as a so-called "aesthetic screen," affecting the physiognomy and beauty of the city's spatial structure. Cities of this cluster are also characterized by a large percentage of cemeteries.

Polish law equating them with green areas recommends their design and maintenance on a par with park areas (Długozima and Kosiacka-Beck, 2020). Group IV is represented by the cities of Wrocław, Kraków and Warsaw, which

are rich in strolling-recreational parks and green area of the housing estate, although high population density (both traditional and ecological), may adversely affect their availability. These organized forms of greenery mainly perform leisure, isolation and aesthetic functions.

5. Conclusions

Three interdependent systems can be separated in the spatial structure of the city: natural, economic and social (Mydłowska, 2017). The natural system creates the conditions for the functioning of the other two, at the same time it is under pressure from the constantly developing economic system, which affects its condition.

The social system, with the goal of constantly improving the quality of life, strives to maintain homeostasis between the natural and economic systems. The inefficiency of one of the system's elements hinders the operation of the others by limiting the use of their capabilities and creates the need for the entire structure to adjust to the worst performing link.

Green areas, treated as a natural system, therefore play an important role in the city's functional system. Their appropriate composition in the spatial structure of the city optimizes the activities of the economic and social systems in such a way that they do not cause environmental hazards or are at least limited.

Therefore, the development of green areas, as well as their maintenance, management and protection are particularly important for the sustainable development of any city.

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Appendix 1.

A. Characteristics of environmental conditions of provincial cities of Poland 2021

City	Area [ha]	Population [in 10 thou.]	Strolling-recreational park(s)		Lawn		Street greenery % area	Green area of the housing estate % area	Cemetery		Public forests % area	Population density [population per ha]	ecological
			No.	% area	No.	% area			No.	% area			
Białystok	10213	29,34	13	1,23	21	0,17	2,68	3,37	23	0,92	16,15	28,73	117,22
Bydgoszcz	17598	33,4	42	2,22	96	0,33	2,02	1,98	18	0,53	27,07	18,98	55,58
Gdańsk	26196	48,63	23	0,83	196	0,62	1,08	2,08	9	0,36	17,11	18,56	84,08
Gorzów Wielkopolski	8572	11,8	10	1,97	141	1,41	0,86	1,32	9	0,50	4,27	13,77	133,42
Katowice	16464	28,28	11	1,28	94	0,54	1,35	1,74	25	0,47	39,48	17,17	38,28
Kielce	10965	18,55	8	0,63	8	0,06	1,28	2,25	12	0,44	17,57	16,92	76,13
Kraków	32685	80,26	45	1,44	781	1,25	1,85	3,16	34	0,57	4,07	24,56	199,09
Lublin	14747	33,29	11	1,26	53	0,71	3,59	3,42	11	0,62	8,79	22,57	122,74
Łódź	29325	66,49	43	2,27	57	0,28	2,14	3,14	27	0,77	5,80	22,67	157,49
Olsztyn	8833	16,93	18	1,17	62	0,32	2,06	2,53	7	0,92	19,64	19,16	71,95
Opole	14888	12,68	7	1,30	10	0,03	1,45	0,76	25	0,42	9,73	8,52	62,21
Poznań	26191	54,51	52	1,38	123	0,30	3,63	2,22	22	0,96	12,03	20,81	101,42
Rzeszów	12901	19,64	15	0,65	762	10,79	1,86	1,81	16	0,42	1,34	15,22	90,24
Szczecin	30060	39,45	31	0,57	149	0,36	0,82	0,91	7	0,71	16,78	13,12	65,13
Toruń	11572	19,71	5	0,71	33	0,43	1,39	2,48	16	0,73	22,69	17,03	59,90
Warszawa	51724	186,31	91	1,89	321	0,47	2,56	4,16	40	0,74	8,59	36,02	195,55
Wrocław	29282	67,43	65	2,73	555	0,86	1,92	2,05	42	0,58	7,60	23,03	146,18
Zielona Góra	27826	13,97	8	0,12	19	0,03	0,46	0,64	15	0,21	52,24	5,02	9,35
Median	17031	31,32	17	1,27	95	0,40	1,86	2,15	17	0,58	14,09	18,77	87,16

Source: own study based on Bank Danych Lokalnych GUS

B. Cross-sectional statistics

Cluster membership	Strolling-recreational park(s)		Lawn		Street greenery		Green area of the housing estate		Cemetery		Public forests		Population density [population per ha]	
	No.	% area	No.	% area	% area	% area	No.	% area	No.	% area	% area	normal	ecological	
I	8,00	0,12	19,00	0,03	0,46	0,64	15,00	0,21	52,24	5,02	9,35			
II	15,00	0,65	762,00	10,79	1,86	1,81	16,00	0,42	1,34	15,22	90,24			
III	29,75	1,54	63,50	0,36	3,01	3,03	20,75	0,82	10,69	23,70	124,72			
IV	67,00	2,02	552,33	0,86	2,11	3,12	38,67	0,63	6,75	27,87	180,27			
V	17,22	1,19	87,67	0,45	1,37	1,78	14,22	0,56	19,37	15,91	71,85			

Source: own study