

# Chapter 18

## Green Infrastructure and Social Perception of Its Ecosystem Services Within Spatial Structure of the City – Examples from Poznań, Poland



Iwona Zwierzchowska and Małgorzata Stepniewska

**Significance Statement** The structure of the city and related composition and configuration of green infrastructure (GI) translate into supply and distribution of ecosystem services (ES). Therefore, we aimed to recognize the social perception of ES at the background of the spatial structure (from the dense centre to the rural-like suburbs) based on a case study of Poznań city in Poland. The findings revealed that although distribution and types of GI vary among main urban zones, inhabitants appreciate the cultural ES of GI regardless of its type or location. They expressed the demand for enhancement of recreational ES and the importance of accessibility to the green spaces. The study also emphasised the complex trade-offs between cultural and regulating ES highlighting the role of ES-oriented planning.

**Keywords** Cultural ecosystem services · Urban green · Parks · River valley · Post-industrial areas

### 1 Introduction

The ongoing processes of urban densification (EEA, 2016) and urban sprawl (Hennig et al., 2015; Patacchini et al., 2009) are common for many cities that face the challenge of developing policies that ensure the continuous delivery of key ecosystem services (ES) to maintaining resilience and vitality in urban areas (Grêt-Regamey et al., 2020). In some urban areas, mixed processes of depopulation in less favourable areas and urban development in other areas of the urban region can be observed. These complex processes contribute to the creation of an urban-rural continuum, which can be observed both within and outside the administrative boundaries of the city. Łowicki and Walz (2015) see the differences in the pattern of the rural-urban gradient as a result of legal aspects of spatial planning. Indeed,

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I. Zwierzchowska (✉) · M. Stepniewska  
Department of Integrated Geography, Adam Mickiewicz University, Poznań, Poland  
e-mail: [iwona.zwierzchowska@amu.edu.pl](mailto:iwona.zwierzchowska@amu.edu.pl)

spatial planning determines the distribution of green infrastructure and the availability of its individual elements, which translates into the level of ecosystem services in cities (Zwierzchowska & Mizgajski, 2019). The concept of green infrastructure (GI) is widely studied by science and practice, as it can bring multiple benefits to nature and humans alike. The GI covers diverse areas of terrestrial, aquatic and water-dependent ecosystems transformed by humans to varying degrees. The above diversity translates into differences in the type and level of ES provided by GI. This overlaps with various demands for ES from society. For this reason, in order to support more ecosystem services-oriented land-use planning not only recognition of spatial composition and configuration of ecosystems is needed but also an understanding of GI users' preferences is desired.

The complexity and diversity of spatial relationship that varies in different scales and change in time are reflected in the urban-rural gradient analysis of ES. Rall et al. (2017) found that the density of cultural ES perceived decreased from the inner to the outer edges of the city of Berlin, wherein the inner-city is a place of recreational, social and cultural heritage and identity services concentration, while perceived biodiversity and spiritual, inspirational, and nature experience and educational services are more scattered. Calderón-Contreras and Quiroz-Rosas (2017) demonstrated that growing pressures of urban development results in reduction of service-providing units at the regional scale, and their low quality at the local scale.

Larondelle and Haase (2013) point out that there is no typical urban-rural gradient of ES provisioning nor a uniform urban spatial pattern of ES provisioning. What is more, Grêt-Regamey et al. (2020) highlighted that ES supply is highly dependent on the urban form and there is no simple linear relation between ES supply and green area coverage. They also highlight the importance of trees for supporting regulating ES in built-up neighbourhoods. Similarly, studies of Larondelle and Haase (2013) showed that even core cities with a high degree of imperviousness do not necessarily provide fewer ES compared to their regions because of presence of mature trees which contribute to ES. However, the regulating ES bound to trees and forest cover are higher outside the city boundaries. The local zoom-in is particularly important for more densely built-up areas. Zwierzchowska et al. (2021) found at a local scale of multifamily housing areas a variety of green space types and solution that can improve nature-based outdoor activities. They also highlight that the potential of GI to provide ES is not yet fully used.

The above discussion indicates that both quantitative and qualitative approaches to GI need to be taken into account while studying ES resulting from mixture of green and man-made infrastructure of different composition and configuration. This chapter aims to present the variety of GI and its ES at the background of the spatial structure of the city on the example of Poznań. First, we consider the diversity in the distribution and structure of urban GI from the dense centre to rural-like suburbs. Then, we discuss the social perception of GI and its ES based on the existing case studies covering different types of GI – urban parks, river valley, and post-industrial revitalized area.

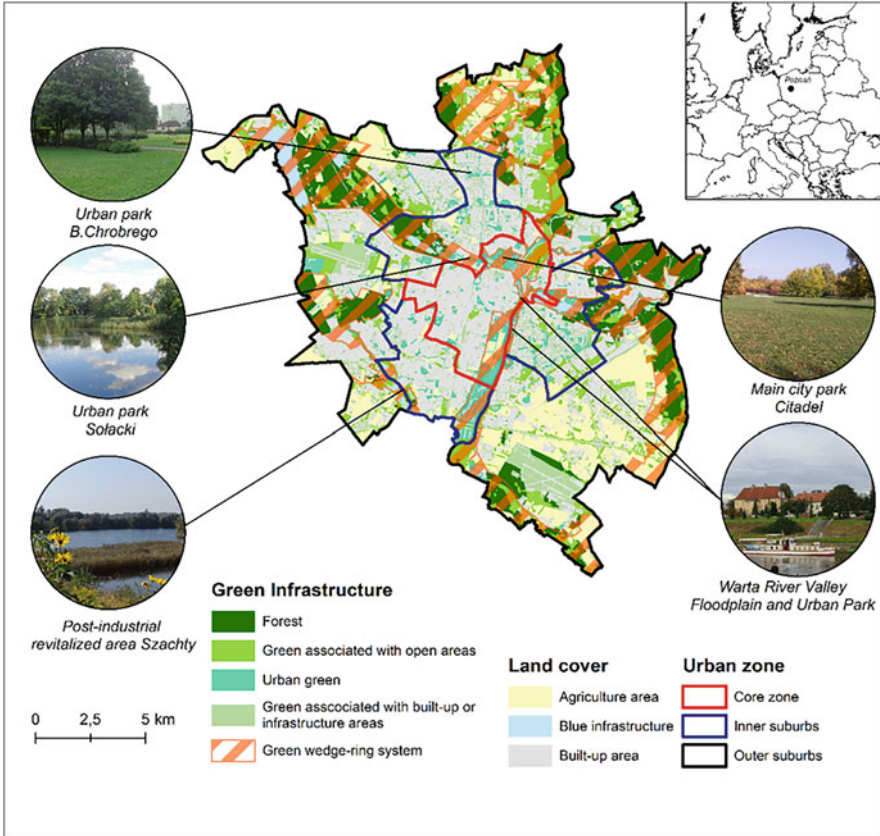


Fig. 18.1 Distribution and diversity of green infrastructure of Poznań

## 2 Study Area

We have analysed GI and its ES based on case study of Poznań in Poland (Fig. 18.1). The city is 0,5 M inhabitants and covers an area of 262 km<sup>2</sup>. It is an interesting example, as the city structure was shaped through the different periods of time reflecting various patterns of development and respecting wedge-ring green system shaped from XIX century and preserved in large part in plans since 1930s. The ES of Poznań are subject of various studies and were one of the case studies within the 4th Mapping and Assessment of Ecosystem Services (MAES) report concerning urban ecosystem (Maes et al., 2016) as well as EnRoute City Lab (Maes et al., 2019). Currently Poznań is a front runner city in the project Connecting Nature (within European Union Programme Horizon, 2020) focusing on multiplication of nature-based solutions.

### 3 Methods

First, the quantitative GIS analysis has been applied to diagnose distribution and diversity of GI along urban core and rural-like suburbs in the administrative units functioning for local decision-making. The analysis was based on BDOT10k<sup>1</sup> database (2019) and Urban Atlas<sup>2</sup> (2018), which provide relevant land use and land cover data. The data were processed using ArcGIS 10.5.1 software. The distribution and diversity of GI have been analyzed within three main urban zones including: (1) core zone – representing historical areas characterized by dense development of tenement houses and urban villas; (2) inner suburbs – covering development areas around the city center, including both multi-family and single-family housing estates from the twentieth century; (3) outer suburbs – peripheral areas consisting of single-family housing estates and new multi-family buildings in a mosaic with industrial and agricultural areas.

Secondly, we applied quantitative and qualitative assessment of social perception and demand for ES based on a comparative analysis of surveys conducted among users of various GI categories in Poznań (Table 18.1). Data for the analysis were obtained from available original datasets supplemented with data from journal articles and theses. The scope of the individual surveys was subordinated to specific research objectives concerning ES. Hence, in spite of different sources, the questions in the surveys are partially convergent, while in some respects, they differ. On the one hand, this creates an opportunity to identify general patterns of ES for the city, and on the other hand, to show some specific aspects for GI sites located in different spatial, ecological and social conditions.

## 4 Results and Discussion

### 4.1 Distribution of Green Infrastructure in Urban Zones

In general, distribution of GI in Poznań reflects the spatial structure of urban-rural gradient (Fig. 18.2).

The core zone is predominantly characterized by high share of built up area at the level >70%. Inner suburbs show the built-up areas between 27 and 71%, while outer suburbs are in general less built-up (<35%). In the peripheral zone only few

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<sup>1</sup>BDOT 10 k, (2019). Polish official land cover classification according to Regulation of Minister of Infrastructure and Development from 17 November 2011 concerning database of topographical objects and database of general geographic objects and standard cartographic works (Dz.U. 279 poz. 1642).

<sup>2</sup>Urban Atlas, (2018). European Environment Agency, Directorate-General Enterprise and Industry (DG-ENTR), Directorate-General for Regional Policy, Retrieved May 13, 2019 from <http://www.eea.europa.eu/data-and-maps/data/>

**Table 18.1** Surveys concerning ES of green infrastructure in Poznań

Study site	Survey characteristic	Survey sample	Author/s
Old City – within the medieval city walls (core zone)	The amount of green spaces and their availability, the way of use, types of activity, factors limiting the use, factors encouraging to visit green spaces, the motives for using green areas away from inhabitants' place of residence.	70	Poniży et al. (2017)
Warta River Valley – floodplain (core zone)	Cultural ES (CES) of urban floodplain – identification of users' interactions with the river, the degree of satisfaction from the existing site arrangement, expectations for further site management.	231	Stępniewska and Sobczak (2017)
Main city park: Citadel (core zone)	The capacity of urban park for providing regulating and cultural ES versus their social perception – benefits from park, main threats and overall risk of reducing the ES, expectations for further land development.	179	Stępniewska (2021)
Urban parks: Sołacki, B. Chrobrego (inner suburbs)	Cultural ES demand and flow as reflected in park visitors' perception and behaviour at the local and city level – frequency of visits, length of stay and quality of experience in the park, perception of CES and uses of urban green spaces, CES accessibility.	99	Zwierzchowska et al. (2018) and Zurski (2018)
Warta River Valley – urban park: Warta Park (inner suburbs)	Cultural ES in the opinion of park users – the way of spending time there, preferences for changes in terms of improving park functionality.	100	Sławuta (2019)
Post-industrial revitalized area: Szachty (outer suburbs)	Social perception of ES on municipal post-mining land – reasons for choosing the area as a place of recreation, the ES used by visitors, the range of impact of ES, current site's arrangement in the eyes of users.	204	Stępniewska and Abramowicz (2016)

administrative units are characterized by higher rate of built-up. Share of GI in urban core is lower than in other parts of the city (below 30%), however, there are some exceptions, where despite densely built-up higher share of GI is observed. These are areas that benefit from the city's green wedge-ring system that is based on the physiographic conditions of Warta River Valley and its' tributaries. The wedges run from suburbs through the centre of the city and are supplemented by the ring of greenery of the historical fortifications (including Citadel Park). Green infrastructure is more abundant in suburbs, while in the outer suburbs the share of agriculture land is visibly higher than in other zones of the city. The preliminary mapping and assessment of provisioning and regulating ES in Poznań has been presented in

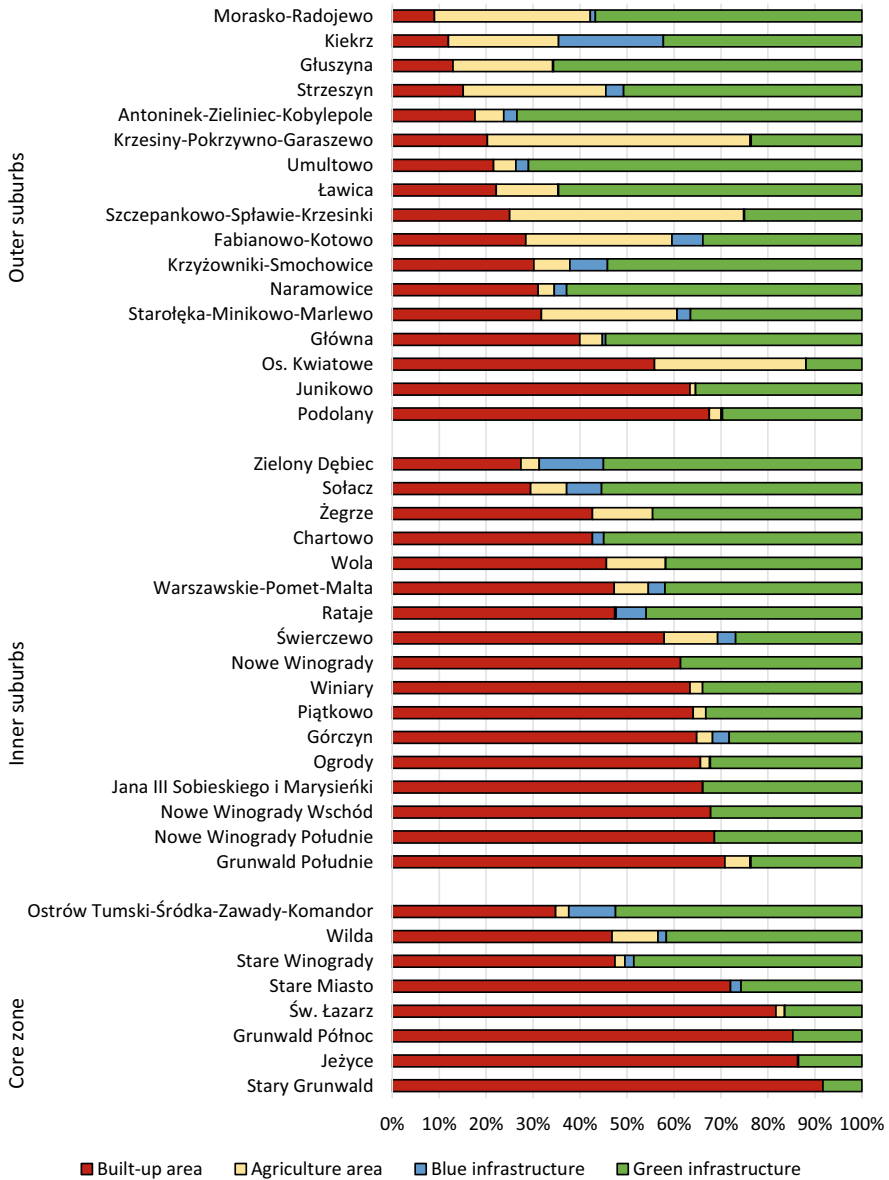
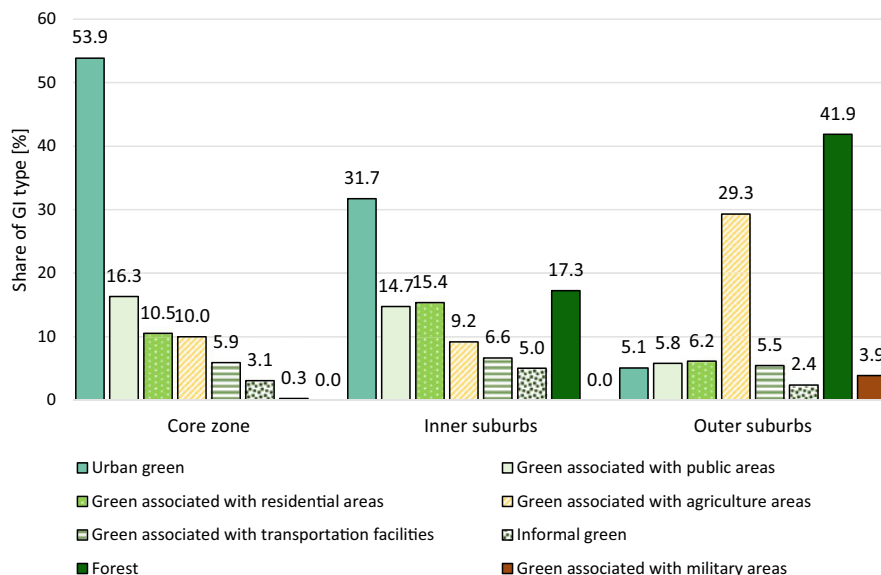


Fig. 18.2 Share of the main types of land use in basic administrative units by urban zones

Zepp et al. (2016), underlying connectivity of urban ecosystems and its richness in peripheral areas. The distribution of the main ecosystems forming wedge-ring system mirrors their crucial role in supplying regulating ES such as potential cooling effect at the city scale (Maes et al., 2016). However, more detailed view is needed to



**Fig. 18.3** Diversity of the green spaces and its distribution by urban zones

capture and assess the diversity of GI and its potential to deliver ES on the local level (Zwierzchowska et al., 2021).

Green infrastructure varies across the urban zones (Fig. 18.3). Urban green dominates in the core zone and is also the most abundant type in the inner suburbs. The core zone and the inner suburbs are also more rich in green spaces associated with public spaces and residential areas (multi-family estates). In contrast, forested areas are the most extensive type of GI in the outer suburbs, still present in the inner zone, but absent from the core zone. Different pattern is visible of the green spaces associated with the agriculture land. The largest share of this type of GI is in the outer zone, but thanks to the location of Warta river in the city centre it is also present in the form of a riverside grassy areas in the core and inner zones.

#### 4.2 Social Perception of Green Infrastructure and Its Ecosystem Services

The surveys have showed that – regardless of the location of GI site in the urban tissue – their users attach the greatest importance to its cultural ES. Among the benefits of cultural ES, the most important were those related to outdoor recreation and aesthetic values of the landscape (Stępniewska, 2021; Stępniewska & Abramowicz, 2016; Stępniewska & Sobczak, 2017; Zwierzchowska et al., 2018). Findings for the cities around the world confirm the importance of cultural services

of urban GI (e.g. Bertram & Rehdanz, 2015; Sirina et al., 2017; Swapan et al., 2017). The results of the surveys concerning GI and its ES in Poznań show that regulating ES are less obvious to the citizens (Stępniewska, 2021; Stępniewska & Abramowicz, 2016). In the case of Szachty – respondents perceived only improving the quality of air (Stępniewska & Abramowicz, 2016), while in Citadel Park – reduction of air pollution, improvement of acoustic climate and microclimate regulation, as well as provision of habitats for bats (Stępniewska, 2021).

As an important reason for choosing the urban GI as a place of rest and recreation, the respondents usually quoted its high accessibility. Direct vicinity of GI with housing estates, well-developed road network, including bike paths and the proximity of the public transport stops make urban green and blue spaces relatively easy to reach (Stępniewska & Abramowicz, 2016; Stępniewska & Sobczak, 2017). The accessibility to GI is inevitably a crucial factor that influences the flow of ES, however, the power to attract visitors vary among green spaces. These differences are visible between urban parks of inner suburbs. As much as 79.6% of respondents visiting B. Chrobrego Park (local park) came from the park's service zone of 800 m (Zwierzchowska et al., 2018). Warta Park is used mainly (62%) by visitors coming from a distance up to 900 m (Sławuta, 2019). However, in the case of the Sołacki Park (representative city park), 85.4% of respondents came from areas more distant than 800 m (Zwierzchowska et al., 2018). The proximity to green spaces encourages as much as 88.2% of visitors of Szachty in outer suburbs and only 16% of respondents visiting the Warta River Valley. Those results indicate that representative GI located in the core zone or inner zone is accessible not only for the local community but also for visitors from more distant areas, while GI of outer suburbs can be recognized as less accessible.

Ensuring sufficient green spaces is particularly challenging in the densely built-up city's core zone. The survey conducted among inhabitants of Old City revealed that the vast majority of the respondents notice the shortage of green spaces associated with housing and street-side greenery. That corresponds with a high (over 75%) percentage of build land development of the overall area and only several small public squares and green spaces associated with housing (lawns, trees, playgrounds, etc.) in the tenement backyards (Poniży et al., 2017). However, at the same time, 53% of respondents assess that there is a sufficient area of urban parks (which inhabitants use most) within a 800 m buffer zone (Poniży et al., 2017), which mirrors the location of elements of city's green wedge-ring system. Deficits in the quantity of GI in strongly urbanized core zone cause that even unspectacular blue-green spaces arouse a feeling of beauty and pleasure (Sławuta, 2019; Stępniewska & Sobczak, 2017) due to their perceived naturalness, the presence of greenery and wildlife. As it was highlighted by one of the visitors to the Warta River Valley in the centre of Poznań: 'Yeah, it's just a bit of water and greenery, but still it's in contrast to the overwhelming concrete' (Stępniewska & Sobczak, 2017).

Comparison of green space users' common activities (Table 18.2), shows that in general most frequent way of interacting in nature is walking (47.6%), meeting with other people (33.3%), getting sun or fresh air or passive rest in nature (30.1%), observing nature (23.9%), picnicking or barbecuing (18.9%), and cycling,



**Table 18.2** The most frequent activities reported by green space users

Urban zone	Case study <sup>a</sup>	N	Walking [%]	Social meetings	Enjoying sun or fresh air/passive rest	Picnicking / barbequing	Nature observation	Cycling, rollerblading, skateboarding etc.	Site specific activity
Core zone	Warta River Valley – floodplain	231	44.6	80.5	13.0	22.1	11.3	15.6	
	Citadel – main city park	179	63.1	–	–	63.7	16.2	21.1 <sup>b</sup>	
	Old City – parks	70	50.0	17.0	56.0	–	36.0	4.0	Visiting playground/ playing with children – 16.0
	Old City – green associated with housing	70	22.0	19.0	39.0	–	25.0	0.0	Visiting playground/ playing with children – 13.0
	<b>Total</b>	<b>410</b>	<b>58.4</b>	<b>44.0</b>	<b>20.1</b>	<b>34.4</b>	<b>20.4</b>	<b>8.1</b>	
Inner suburbs	B.Chrobrego – urban park	50	58.0	16.0	46.0	–	38.0	16.0	Mediate in nature – 28.0 Playing with children – 18.0
	Solacki – urban park	49	61.2	18.4	57.1	–	44.9	18.4	Mediate in nature – 40.8
	Warta River Valley – urban park	100	44.0	43.0	43.0	–	36.0	59.0	
	<b>Total</b>	<b>199</b>	<b>51.8</b>	<b>30.2</b>	<b>47.2</b>	<b>–</b>	<b>38.7</b>	<b>38.2</b>	
Outer suburbs	Szachty – post-industrial revitalized area	204	25.0	11.0	37.0	–	18.0	11.0	Admiring landscape – 19.0 Inspiration of nature – 16.0
	<b>Total</b>	<b>204</b>	<b>25.0</b>	<b>11.0</b>	<b>37.0</b>		<b>18.0</b>	<b>11.0</b>	

(continued)

**Table 18.2** (continued)

Urban zone	Case study <sup>a</sup>	N	Walking	Social meetings	Enjoying sun or fresh air/passive rest	Picnicking / barbequing	Nature observation	Cycling, rollerblading, skateboarding etc.	Site specific activity
			[%]						

**Note:** The percentages in the table present the share of respondents who indicate one or more answers from the multiple-choice question, therefore the percentages do not sum up and can exceed 100%. In italics – most frequent answers in each case study

<sup>a</sup>Old City – activities conducted often; Warta River Valley – floodplain – 3 most frequently reported activities; Citadel Park – the most common purpose of visit; Warta River Valley – Warta Park – activities reported as very frequent or frequent; B. Chrobrego Park and Solaeki Park – activities conducted always or often; Post-industrial area of Szachty – activities conducted at least several times a week;

<sup>b</sup>Sport in general

rollerblading, skateboarding, etc. (15.5%). In the core zone, there is a clear distinction between representative green spaces such as Citadel Park and Warta River Valley and local green spaces. The former is mostly used as places for a walk or social meetings with particularly popular picnicking or barbecuing. For inhabitants of the old city, the green spaces in the core zone serve predominantly as a place for enjoying fresh air and walking. High engagement in children's outdoor activities is also characteristic. In comparison to other urban zones, visitors of green spaces from the inner zone more frequently appreciate passive rest as well as doing sports such as cycling, rollerblading, skateboarding, etc. They also put the highest attention to observe nature. In outer zone, Szachty are most frequently used for enjoying the fresh air and walks and valued for landscape and nature.

Anthropogenic contributions influence the possibility of interaction with ecosystems (Costanza et al., 2014). For this reason, the structure and level of ES do not depend only on natural capital, but also on the site arrangement. The results of the surveys from Poznań show preferences of citizens regarding GI development focus on improving the conditions for recreation. Insufficient infrastructure for leisure and recreation is one of the most important factors which according to the respondents limits the green space usage in each considered urban zone.

The value associated with experiencing cultural ES and the related use creates a strong pressure on the urban GI. The trade-offs between cultural and regulating ES are not perceived at all or are hardly perceived by citizens. Threats to GI related to the intensification of its recreational use concern not only sites located in core zone (Stępniewska & Sobczak, 2017), but also green spaces outside the city center (Abramowicz & Stępniewska, 2020).

## 5 Conclusions

Our findings highlight that although distribution and types of GI vary among the main urban zones, the inhabitants appreciate the GI and its CES regardless its location in the urban tissue. The common finding from the analyzed surveys on GI is the inhabitants' perception of mainly cultural ES and the expectation of further development of infrastructure enhancing recreational opportunities. That expresses the need for contact with nature despite its character and highlights the importance of accessibility to green spaces as well as need for enhancement of their recreational ES.

The composition and configuration of GI elements and its usage contribute to the complex trade-offs between cultural and regulating ES. Therefore, it is necessary to undertake a place-based analysis of the effects of various development scenarios, which will allow to optimize the decisions made in relation to individual GI sites.

Ensuring equality of accessibility to urban GI and its capacity for providing a bundle of ES requires ES-oriented planning. In Poland, planning arrangements made at the local level have the largest influence on spatial changes (Stępniewska et al., 2017). Therefore, the local government has basic tools that can be used for balancing

land use decisions toward sustainable ES provision. However, the implementation of available tools is often voluntary, not imposed by law (Zwierzchowska et al., 2021). Shaping GI towards provisioning of a wide range of ES should take into account the diversity of its quality, spatial composition and configuration, as well as residents' demands and perception.

In the case of Poznań, the urban core zone is characterized by a limited number of small green spaces although they are relatively rich in urban recreation facilities. Therefore, the informal green spaces (especially along Warta River Valley) and parks in the core zone are of particular importance for inhabitants. In turn, in the inner suburbs there is a high potential in parks and neighbourhood green spaces. As for the outer suburbs – they are abundant in forests and agriculture areas, although not equally distributed.

The GI development in the dense urban core should include revitalization and multiplication of small-scale interventions such as nature-based solution (NBS) with the preferences to include trees in the urban fabric. Activities around GI in inner suburbs should focus on maintaining its existing resources (including avoidance of over-compaction) and improving its multifunctionality. With regard to outer suburbs, the combination of reasonable density of development with protection of existing green spaces and its connectivity from transformation is the key issue.

The findings of the study can provide valuable support in developing policies aimed at ensuring the continuous provision of all ES of GI that are key to the maintenance of resilience and vitality along gradient of core-peripheral urban areas.

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