Abstract:
While ecosystem services (ES) provided by green areas receive increased recognition, there is a shortage of knowledge on the role of blue spaces to contribute to the delivery of ES. The aim of this paper is to investigate ES provided by the urban floodplain of the Warta River in Poznań, Poland. To achieve this, we used a set of methods, including a field survey, spatial analysis, and analysis of source materials. The paper documents both the services of public interest, as well as ones that can be overlooked by the public due to their "hidden nature". The results strengthen the idea that assessment of social and ecological benefits from urban floodplains should be conducted jointly to account for the different categories of ES. A complex exploration of the ES delivery may help to better weight the synergies and trade-offs between different management options and to tie the local needs with preservation the integrity and ecological stability of the whole river corridor.

1. Introduction

A lot of cities are situated in river valleys, which constitute significant factors for their development. Moreover, urban sections of river valleys are a component of green infrastructure (EEA, 2011; Tzoulas et al., 2007) and a place of particular investment pressure (Polish Urban MAES, 2015).

Provisioning, regulating and cultural ecosystem services (ES) associated with urban rivers can substantially contribute to fulfilling the needs of urban citizens and help improve their quality of life (Maes et al., 2016; Zepp et al., 2016). While services provided by green spaces receive increased recognition (Hegetschweiler et al., 2017; Pulighe et al., 2016), there is a shortage of knowledge on the role of the blue component to contribute to the delivery of ES (e.g. Prescott and Ninsalam, 2016; Weber and Ringold, 2015; Aberg and Tapsell, 2013; Eden and Tunstall, 2006; Gobster et al., 1998). Addressing the multi-layered benefits of freshwaters require integration of socio-cultural and environmental information and using a mixed-methods approach (Luederitz et al., 2015; Lundy and Wade, 2011) and pose a great challenge in describing the complex relation in the urban socio-ecological system (Kremer et al., 2015).

The presented paper considers ES of the urban section of floodplain, including the river, in the light of the study for the Warta River Valley in Poznań, Poland. Place-based perspective can help better understand issues of multi-functionality and is seen as the basis of the successful application of the ES concept (Vollmer et al., 2016; Church et al., 2015; Potschin and Haines-Young, 2013). The main objectives of the study included: (1) assessing cultural ecosystem

services (CES) of the Warta River Valley used by visitors; (2) recognizing the regulating ecosystem services (RES) (3) identification of possible bundles, synergies, and trade-offs between CES and RES (4) providing recommendations to policy-makers for further management of the river site.

In relation to the CES, we concentrate on recreational service as highly related to the study area. An assessment of the RES took into account habitats for wildlife and connectivity, local climate regulation (mitigation of urban heat island) and flood control. It should be stressed that other services could also be supplied by the urban rivers, such as water provision, commercial fish production, and sewage purification (Elmqvist et al., 2015; Maes et al., 2014; Zhao et al., 2013). However, these services do not occur at the study site; thus, we do not consider them in our research.

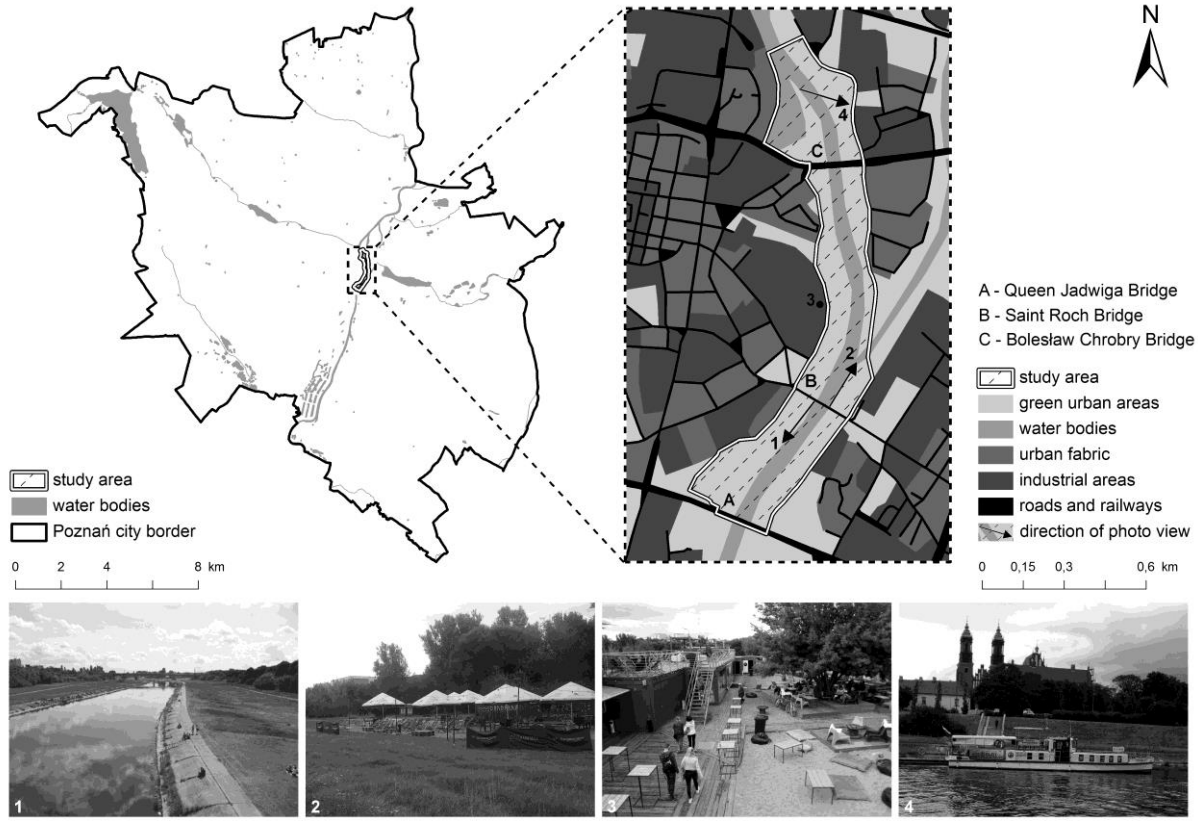
2. Study area

The study site is located within the city center of Poznań. With about 542,300 inhabitants, it is the fifth-largest city in Poland (Statistical Yearbook, 2016). Its administrative area covers 262 km^2, of which about 57% is green and blue (Urban Atlas, 2012). The Warta River is the hydrographic axis of Poznań. This third longest river in Poland (the total length of 795 km) runs through Poznań from south to north for a distance of 20.2 km (from km 230.8 to km 251.0 of the river). The city's history is inseparably connected with the river. The oldest settlement in Poznań was established on an island at the fork of the Warta River and its tributary Cybina no later than at the beginning of the 9th and 10th century (Kóčka-Krenz, 2007). For centuries, the Warta River has been used for fisheries, drinking, cleaning, and processing, as well as for military defense and transportation (Kaniecki, 2004). However, together with the spatial development of the city, the intensive link between Poznań and Warta River has been lost. For the past several decades, the Warta River and its floodplain were perceived by its inhabitants as an uninteresting and unattractive part of the city. This has resulted in many areas around the river becoming deserted or neglected. Nowadays, the improvement in the quality of riverside became a very important goal of development strategies in Poznań, which aspire to create new living, recreational, and working zones in this previously unappealing urban environment (Development strategy for the city of Poznań to 2030; Development strategy for the Warta River 2012-2030).

We chose for analysis a 2 km-long section of the Warta floodplain between the Queen Jadwiga Bridge and the Bolesław Chrobry Bridge (Fig. 1). The width of the Warta's riverbed reaches from 53 to 61 m, while the floodplain's width reaches from 119 to 209 m. The study

area covers 42 hectares and is the most intensely used section of the Warta Valley in Poznań. It is located close to the city center and the Cathedral Island, which are important heritage sites of Poland's medieval history. The floodplain is composed of sand, gravel and partially of aggregate mud (Kaniecki, 2004). Its geomorphology has been strongly transformed. The slopes of the Warta Valley have been profiled, while the floodplain has been elevated by a few meters in comparison to the original state. The riverbed has been straightened, and the riverbanks have been covered with concrete slabs. The last river regulation works were conducted between 1969-73. At that time, the cavities in the riverbed were filled up, and most of the trees and bushes were cut down, shaping a flat area that slopes down evenly towards the riverbed (Kaniecki, 1994). Presently, the study site can be characterized as a large open space in the middle of a densely built city center. The landscape of the floodplain seen from a distance is monotonous, dominated by grass vegetation. However, little fluvial forms, such as natural levees, point bars, alluviums and groynes could be seen from close-up, especially when the water level in the riverbed is low. The mosaic of fluvial forms is a result of natural alluvial processes differentiating the morphology of the floodplain since the time of river regulation (Borysiak, 1994).

Fig. 1. Study area



Source: Maps - prepared by the authors on the basis of Urban Atlas; photographs – own resources.

The mean water within the analyzed section of the Warta River reaches 261 cm; a bank-full water depth reaches 375 cm (Poznań City Office, 2015). The ecological state of the river is assessed as good, which takes into account the biological, hydro-morphological and physicochemical characteristics (Regional Inspectorate of Environmental Protection, 2015). However, the chemical state of Warta does not fulfill the higher requirements for the areas of water supply. Upstream, a few kilometers from the study area, there is a "Dębina" municipal water intake. Its functioning is based on the artificial infiltration of water from the Warta River. The standards exceed such river water quality indicators as total suspension, BOD_5, COD-Cr, Kjeldahl nitrogen, nitrates, volatile phenols and surface active agents. The biggest threat to the quality of water in Warta are discharges of urban wastewater and agricultural pollution (Regional Inspectorate of Environmental Protection, 2016) to which the catchment of the Warta River located above the study area is exposed.

Until recently, the study site was used for leisure and recreation only to a small extent. However, in recent years, citizens have been visiting this blue-green space situated within walking distance from their houses, schools, or work more and more often. In the direct vicinity of the study site, residential and commercial facilities are being built; the historical buildings located nearby are more and more often adapted for this kind of function. An infrastructure increasing the recreational opportunities has been introduced within the research area. A temporary river harbor (on the west riverbank) and a water tram stop (on the east riverbank) have been located in the neighborhood of the Bolesław Chrobry Bridge. Each year from May to October, the area on the west riverbank between the Boleslaw Chrobry Bridge and the Saint Roch Bridge is used by KontenerArt. It is a seasonal art and culture center with a small gastronomic zone built from containers. A city beach with multi-functional sports field, grill zone (covering stationary grills and benches) and a water tram stop is also located here. Along both riverbanks, there are sections of the Wartostrada network, which ultimately is supposed to be a system 10-kilometre-long pedestrian and bike trails, improving the accessibility of the riverside areas.

The Warta River is not economically used within the study area. The city attempts to develop pleasure cruising. This aim is supposed to be achieved, thanks the temporary river harbor and the project of future transformation of the harbor into a modern marina for boats, motorboats and sailing yachts (Development strategy for the Warta River 2012-2030). In the spatial policy of the city of Poznań, the study area fulfills an important flood control function.

Even though there are no typical flood protection facilities, the limitation of investment is supposed to assure the safe passage of the floodwater during overbank flow (SCDSD, 2014).

3. Methods

To achieve the aims, we used a set of methods, including a field survey, spatial analysis, and analysis of source materials.

In the case of CES, we used the data collected primary from the valley users during the field survey. The purpose of survey was to understand how users currently use and perceive the Warta Valley and how they would like to see this area improved for recreation. The questionnaire was designed based on intensive literature studies on CES and considering the specific situation of the study site. It contained a brief introduction to inform respondents about the survey objectives and four sections containing both open and closed questions. Participants were asked to provide:

1. Demographic information (age, sex, education, occupation, place of residence).
2. Interactions with the local river: how, why, and how frequently they use the study area. These issues were investigated by the following closed questions:
   - How often do you visit the Warta Valley in the city center during spring/summer (from April to September)?
   - How much time do you usually spend on your visit?
   - What makes you choose the Warta Valley as your recreational place?
   - How do you spend your time here?
3. The degree of satisfaction from the existing site arrangement (on a scale of 1 to 5).
4. Expectations for further site management.

   In the last case, we asked our respondents an open question: What kind of new recreational facilities do you expect to be introduced to?

The inspiration for the part of questionnaire related to the current perception and use of the river valley were taken from the studies of Doherty et al. (2014) for water bodies in Ireland and Westphal (1998) for Chicago waterways. For the investigation of future prospects, the most inspiring for us were the results of studies of Weber and Ringold (2015) on priority river metrics for urban residents, Gobster (1998) on the ideal setting for river recreation, and Aberg and Tapsell (2013), Eden and Tunstall (2006) on the social and ecological benefits of urban river restoration. We identified the key issues of managerial interests based on the recommendation of the European Union (Maes et al., 2016; Maes et al., 2014), the results of the Polish Urban MAES project (2015) and the findings of the strategic documents of the city of Poznań (Study

of conditions and directions of spatial development of Poznań, 2014; Development strategy for the city of Poznan to 2030; Development strategy for the Warta River 2012-2030).

The terms of ES were not used in the questionnaire, as the interviewers were not familiar with them. Structure and wording of the questionnaire have been elaborated during a two-step procedure. The first draft had been proofed on a small population (20 people) and then improved. The proper face-to-face interviews took place in the study area from July to September 2016 (n=231). July, August, and September are months when the river valley is used the most frequently. Approximately one half of the annual public outdoor events in the study site occur during these months (Poznań City Office, 2017). Interviews were conducted on weekends and weekdays at different times of the day – on weekends from 10 a.m. to 8 p.m. and on weekdays from 4 p.m. to 8 p.m. The largest number of interviews (almost ⅔) covered the late afternoon, which is due to the fact that our respondents have been visiting the Warta Valley after work or after finishing housework. The questionnaire was carried out beyond the periods of public events in order to capture the ways of spending time within the study area during typical days. The weather conditions were from sunny to cloudy. We interviewed randomly-selected respondents; however, we did not interview minors (under the age of 18).

To examine the RES, we used numerous secondary sources, including expert reports, cartographical data and statistical information obtained from public authorities. Thus, while recognizing the habitats for wildlife, apart from our own unstructured field observation, we made use of the existing inventory of flora (Matuszkiewicz 2008, Ratyńska 2001, Borysiak 1994). We have determined the importance of the study site for the maintenance of the ecological connectivity on the basis of the scientific papers dedicated to the green infrastructure system in Poznań (Mizgajski and Zwierzchowska, 2016; Raszeja and Gałecka-Drozda, 2015; Poniży and Jawgiel, 2013; Chorążewicz, 2010). Assessment of local climate regulation service took into account the mitigation of the urban heat island. We determined the cooling effect of the study area using the existing data concerning the influence of land use and land cover on the temperature differentiation in Poznań (Majkowska et al., 2017; Polish Urban MAES, 2015). In order to present the flood control service, we used the information concerning the flood risk collected by the national and local authorities (National Water Management Authority, 2015; Poznań City Office, 2015; Poznań County Office, 2010).

We carried out the CES analysis at the site level. However, as for the RES, a broader spatial context is very important. That is why, in this case, we have been considering the study area as a part of bigger natural structures of the city such as the system of green infrastructure

and hydrological system. However, the structures and phenomena that occur outside the study area were presented on a far more general level of detail.

4. Results

4.1. Cultural ecosystem services

Interviews with study-site users were conducted with 120 female and 111 male respondents. Socio-demographic data for respondents are presented in Table 1. Concerning age distribution, most respondents were people up to the age 25, pupils, or students. A large group of respondents consisted of white and blue-collar workers between the ages of 26 and 35. The share of participants over 35 was only 12%. Most of the respondents (84%) reside in Poznań, 10% in municipalities directly adjacent to Poznań, and 6% in other places all over Poland. In total, nearly ⅓ of the respondents live no more than the 2-kilometer distance from the study site. A further ⅓ cover a distance between 2 and 5 kilometers to reach the Warta Valley.

We do not claim that the sample has been the statistically representative of the study site' visitors. However, the structure of respondents is similar to the findings of other researchers concerning the use of this area (Mazur, 2016).

Table 1. Characteristics of the respondents

Variable	**Total (n=231)**
Gender	
Male	111 (48%)
Female	120 (52%)
Age	
18 to 25	147 (63%)
26 to 35	57 (25%)
36 to 45	13 (6%)
46 to 60	10 (4%)
> 60	4 (2%)
Education	
Lower secondary	5 (2%)
Vocational	12 (5%)
Secondary	95 (41%)
Higher	119 (52%)
Employment	
Pupil or student	113 (49%)
White-collar worker	67 (29%)
Blue-collar worker	25 (11%)
Self-employed	16 (7%)
Retired	5 (2%)
Unemployed	5 (2%)
Residence	
Poznań	193 (84%)

Other	38 (16%)

The attractiveness of the study site as a place of recreation is related to the perceived naturalness of river landscape (37% of responses, Tab. 2). Many of the respondents (23%) appreciated the fact that alcohol consumption was allowed. In our opinion, this results from a large percentage of young people in the group of users. They choose an outdoor place as a rest and recreation site where they can spend their free time together without limitations related to alcohol consumption. They choose an outdoor place as a rest and recreation site where they can spend their free time together without limitations related to alcohol consumption. According to the applicable law, the prohibition of alcohol consumption in Poland includes such public spaces as streets, squares, parks (Act on raising youth in sobriety …, 1982) and in Poznań it extends also to swimming areas, beaches and recreational areas for children and teenagers (Poznań City Council, 2008). Other important factors for respondents were the proximity to the place of residence (16%) and the existing site arrangement (12%). These results indicate that users appreciate a combination of the aesthetic beauty of nature with the high accessibility and availability of leisure features (for similar results, see Polizzi et al., 2015; Aberg and Tapsell, 2013; Westphal, 1998).

Table 2. Motives for choosing the Warta River Valley as a recreation place

Motives*	**Total (n=231)**
River landscape	85
Allowed alcohol consumption	52
Proximity to the place of residence	38
Existing site arrangement	28
Lack of alternative in the neighborhood	14
Clean air	12
Other	2

* Closed question with included option "Other, please specify".

Different forms of use of the study site by visitors represent its cultural ecosystem services. Activities carried out by users are varied (Tab. 3). Most people visit the Warta Valley for activities that do not lead to direct contact with water, such as socializing, walking, grilling, or playing sports. A much smaller portion of respondents engages in water-based activities. Without a doubt, it results from the fact that the concrete reinforcement of the riverbed excludes the possibility of swimming. The city beach located between the Bolesław Chrobry Bridge and the Saint Roch Bridge does not have any bathing area. Despite the possibility of water sports equipment rental in near proximity, the canoeing and boating are not very popular. As it was

suggested by Doherty et al. (2014) on the basis of Irish residents' preferences for water-based ES, having access to rivers for water recreation is less important for the majority of users than having access to visual amenity recreation.

Table 3. Warta River Valley use by activity

Activities reported by respondents *	
Non-water recreation	Dog walking (14)
Socializing, getting together, talking (186)	Workplace (10)
Walking (103)	Other (5)
Grilling (51)	**Water recreation**
Cycling (36)	Boating (10)
Sunbathing (30)	Angling (5)
Jogging (26)	Canoeing (3)
Observing the nature (26)	Other (2)
Reading (25)	

* Closed question with included option "Other, please specify". The respondents were asked to mark at most 3 answers; thereby, the sum of responses is higher than the number of respondents; 532 answers were given in total; the frequencies of responses are given in brackets.

In the spring and summer period, a large number of respondents (27% in total) visit the study site a few times a week; a further 25% of respondents declared visits 1-3 times a month (Tab. 4). A small percentage of daily visits can be observed (13%). The majority of users spend a few hours there during a one-time visit. Shorter visits (lasting less than 1 h) mostly apply to people doing sports involving fast movement such as cycling and jogging. Thus, visits of such persons are short but regular (a few times a week).

Table 4. Visit frequency and length

Frequency	**Length**
Every day (30)	Less than 1 h (18)
4-6 times a week (12)	1-2 h (46)
2-3 times a week (51)	2-3 h (85)
Once a week (44)	> 3 h (81)
1-3 times a month (57)	
Less than once a month (37)	

Frequencies of responses are given in brackets.

Anthropogenic contributions influence the possibility of interaction with ecosystems (Burkhard et al., 2014; Costanza et al., 2014). For this reason, the structure and level of CES do not depend only on natural capital, but also on the existing site arrangement. At the Warta Valley, the general level of satisfaction with existing facilities is high (Tab. 5). On a 5-point Likert scale, respondents most often chose "5", which means "I am very satisfied".

Table 5. Users' satisfaction with the current arrangement of the site

Likert Scale	Total (n=231)
1 - Very dissatisfied	23
2 - Dissatisfied	6
3 - Neither	7
4 - Satisfied	32
5 - Very satisfied	163

New facilities proposed by respondents mostly included small infrastructure facilities, which would improve the conditions for recreation on the riverside (Tab. 6). Higher numbers of benches, tables, waste bins, food stands, and toilets were mentioned the most often. The respondents also expected the development of bike paths, without which it is difficult to get to the Warta Valley area. The minority of participants wanted the development of an infrastructure for water-based recreation. Generally, major new investments do not seem to be as important to respondents as changes to better accommodate the most popular activities, particularly socializing, walking, sunbathing, and grilling.

Table 6. Site arrangement expected by users

Facility Type *	
Non-water recreation	Greenery arrangement (11)
Benches and tables (67)	Playground (10)
Waste bins (53)	Place for bonfire, grilling (9)
Food stands (32)	Sport center (6)
Toilets (25)	Maintenance of existing infrastructure (6)
Bike paths (21)	Other (16)
Footpaths (15)	**Water recreation**
Outside gym (14)	Water recreation infrastructure (15)
Bathing beach, deckchair rental (13)	Water sports equipment rental (6)
Stairs to the river (12)	

* Open question. The respondents were asked to propose any number of expected new facilities; thereby, the sum of responses is higher than the number of respondents; 330 answers were given in total; the frequencies of responses are given in brackets.

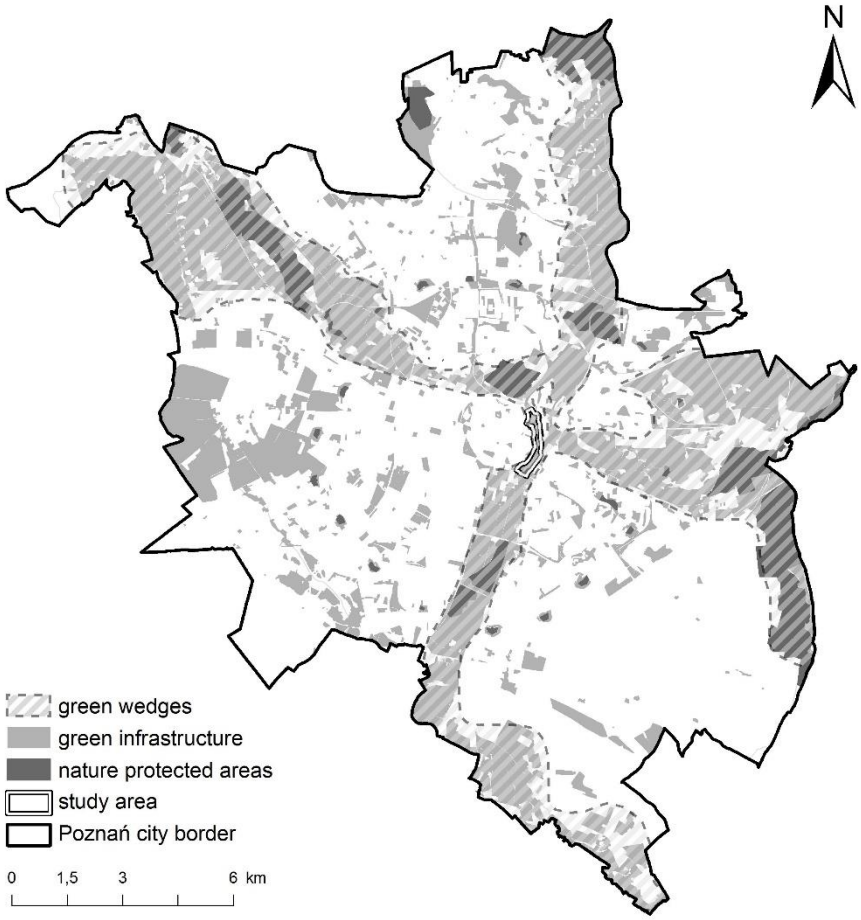
4.2. Regulating ecosystem services

4.2.1. Habitats for wildlife and connectivity

The hydrographical system is the frame of green infrastructure (GI) in Poznań. Implemented in the 1930s, the network of green spaces in the city focuses on green wedges formed along Warta River (north-south) and its tributaries - Cybina and Bogdanka (east-west) (Fig. 2). This large connected system of green areas is of great importance for wildlife. It provides habitats for plants and animals representing the most natural parts of the city landscape. It also serves as an ecological corridor, which does not only link different elements

of GI in Poznań, but also the inner urban green areas with the natural surroundings of the city (Mizgajski and Zwierzchowska, 2016; Office of Spatial Planning of the Wielkopolskie Voivodship, 2015; Balcerkiewicz i in. 1991).

Fig. 2. Study area in the green infrastructure system of Poznań



Source: Prepared by the authors on the basis of Urban Atlas and SCDSD (2014).

The system of green wedges, designed in accordance with physiographic conditions, is characterized by a high diversity of preservation as compared to the original concept (Raszeja and Gałecka-Drozda, 2015; Chorążewicz, 2010). The leanest GI resources can be found within the study area, i.e. at the city center section of the Warta River surrounded by dense developments of Poznań's oldest districts. At this location, the ecological corridor is significantly narrowed. Belts of green areas that accompany the Warta River are much broader both north and south of the city center (Poniży and Jawgiel, 2013). The potential natural vegetation of the study area consists of a riparian woodland composed of willows and poplars from Salicetea purpureae (Matuszkiewicz 2008). The actual vegetation is influenced both by natural factors related to the morphogenetic activity of the river waters and anthropogenic

factors related to the recreational use of the valley. The area is regularly mowed in order to maintain an open landscape with a higher frequency on the west riverbank. The result of the mowing is the occurrence of semi-natural biotopes with Molinietalia. Recreation entails high mechanical pressure – trampling and rolling over the grassy areas. Within the area of the dense network of walking and biking trails, the plant cover is formed by carpet communities with Trifolio repentis-Plantaginetalia maioris. Turfless, trampled fishing spots are overgrown by annual pioneer nitrophilous vegetation of the Chenopodion rubri and Isoëto durieui-Juncetea bufonii. The concrete reinforcement along the riverbank disenables the development of littoral biotopes. The plants that are characteristic for Phragmitetea grow in the cracks of the concrete slabs. Beyond the mowed area there are some bushes and trees, mainly on the slopes of the valley. They are crucial for the development of the ornithofauna of the valley (Ptaszyk 2003). The dendroflora of the floodplain consist of planted native trees and bushes as well as alien species that have been appearing spontaneously as a result of secondary succession. The native plants belong mostly to the characteristic species of Salicetea purpureae and Querco-Fagetea. On the borders of bush and tree areas, there are Hydrophilous tall herb fringe communities from Convolvuletalia sepium (Borysiak 1994, Ratyńska 2001).

4.2.2. Local climate regulation

The city is located within the transition zone between oceanic and continental temperate climate zones with mainly oceanic influences (Woś, 2010). The average annual temperature in Poznań is 8.3°C, with the hottest month as July (18.1°C) and the coldest as January (-1.6°C). The freshwaters are an important factor shaping the climate conditions of the city. Zwierzchowska (2017) indicates their priority importance for urban heat island mitigation, which is becoming more important to handle extreme summer temperatures (McPhearson et al., 2015). The study of Półrolniczak et al. (2017) shows that the urban heat island is a common occurrence in Poznań, and its occurrence is possible at all hours of the day throughout all seasons of the year. The mean annual intensity of the urban heat island reaches 1°C, and its highest values are observed in the city center (above 2°C). The cooling effect of the green infrastructure was investigated under Polish Urban MAES (2015), which was shown partly in a case study for Poznań (Maes et al., 2016). According to results, freshwaters, besides forests, belong to the coolest areas within a city; on summer mornings, the differences in the average radiation temperature between bodies of water and highly urbanized areas such as continuous urban fabric, industrial and commercial units ranges from 4.9 to 7.4° C. According to Majkowska et al. (2017), the average annual differences between the Warta River Valley and

adjacent areas in the city center reach 1-2°C. Therefore, it can be concluded that on warm and sunny days, users of the study site can enjoy distinctly cooler and more humid air, which significantly improves the quality of rest and their physical well-being.

4.2.3. Flood control

The study area can be assigned a significant role in flood protection, as the natural valley retention is perceived as an alternative for traditional, technical flood-control measures (Brody and Highfield, 2013; Liao, 2012). Nearly one half (47%) of the study site is situated in an area with a high likelihood of flooding (once in 10 years) (National Water Management Authority, 2015). The mean annual flow in the Warta at the Saint Roch Bridge is 101 m^3/s. However, seasonal variations in river flows can be quite large; for example, the difference between the mean low-water flow (34 m^3/s) and the mean high-water flow (356 m^3/s) is more than ten times (Poznań County Office, 2010). As a result, water levels of the Warta are subject to high variations as well. Historical records of floods in Poznań date back to 1501 A.D. and show that, since that time, the city has been flooded more than 60 times, mainly during the spring. Civil engineering works as regards flood control (the construction of dikes and regulation of the river bed since the last decades of the 19th century; the construction of upstream reservoirs in the second half of the 20th century) have led to a decrease in flood frequency (Poznań City Office, 2015). Starting from the last decades of the 20th century, no major floods occurred in Poznań. However, the discharge of peak flows in the Warta River is still critical along the section between the Lech and Saint Roch Bridges (which include the study site). The weak spots in the flood defenses were identified last time in 2010 when the water level of the Warta River had exceeded the alarm level. High water caused local flooding resulting from leakages under the dikes and the inefficiency of drains in some areas adjacent to the west riverbank. Thus, reducing the risk of the uncontrolled floodings of Warta became an important goal of the city's policy. The possibility of free water flow along the entire width of the floodplain is supposed to decrease the height of the flood wave and, in consequence, to limit the risk of economic damage (The study of conditions and directions of spatial development of Poznań, 2014; Development strategy for the Warta River 2012-2030). This applies particularly to the spring floods that prevail over the summer floods in the catchment of the Warta River (Olejnik, 1995). The results of hydrological modeling carried out for the needs of elaboration of the flood protection plans for the city of Poznań indicate that Warta's floodplain in the city center could receive about 6 times the mean flow during the overbank stage (Poznań City Office, 2015).

5. Management of multiple ecosystem services

Our results highlight the need for holistic consideration of the urban floodplains and their services in the management process. A complex exploration of the ES delivery may better reveal the synergies and trade-offs between multiple services and help to address negative consequences (Stępniewska, 2016).

The study confirms that the riverscapes are appreciated by urban dwellers as areas for relaxation and recreation. The attractiveness of the rivers is intimately related to their perceived naturalness, the presence of greenery and wildlife (Aberg and Tapsell, 2013). Despite the fact that the floodplain of the Warta River in the city center looks rather unattractive from a point of view of common aesthetic norms, most of the respondents considered it as eye-catching; as it was stated by one of the users: "Yeah, it's just a bit of water and greenery, but still it's in contrast to the overwhelming concrete". The results of interviews suggest that, in the case of strongly urbanized surroundings, even those blue-green spaces that are far from spectacular arouse a feeling of beauty and pleasure.

The activities carried out by users of Warta Valley vary from typically stationary to across-space. The former are enjoyed in a limited, particular space, and the most popular of these include socializing, grilling, and sunbathing. However, such users spread all over the entire available area. For example, those who barbecue, due to large numbers of people, move somewhere else to find a relatively calm, separate place; the scattering results in collisions with other users, such as those who are walking or tanning. Across-space users, on the other hand, (e.g. cyclists, joggers) usually move along certain permanent – formal or informal - routes. Collisions with other users result from the fact that they cross areas used by many other people while moving.

Minimization of conflicts between various CES users can be achieved by the appropriate spatial organization. The infrastructure introduced in recent years is an encouragement to engage in certain activities in particular places. For example, the city beach and KontenerART on the west riverbank promote socializing and sunbathing. On the other hand, the pedestrian and bike routes along both banks (part of the Wartostrada network) attract sports fans who use these designated and well-tended surfaces more and more willingly.

It should be however noticed that with specific site arrangements and restrictions on usage, different social groups could be attracted or repelled (Riechers et al., 2016; Church et al., 2015; Voigt and Wurster, 2015). Young people - pupils and college students - predominate among users of the study area. This specific socio-demographic group needs places for hanging out, picnicking, or festivals. Other users have different expectations with respect to the study site, e.g. a playground for children, a dog exercise area. As space is limited, meeting the diverse

demands of users is not easy. However, a failure to take into account the views of one of the groups can lead to conflicts between users. For example, letting dogs run off-leash by dog owners was mentioned as unacceptable by parents with children. The differences between the expectations and needs of the dog walkers and other visitors of urban green spaces were similar to those recorded in other studies (Ioja et al., 2011; Lee et al., 2009).

The value associated with experiencing river landscapes and the resulting recreational use create a strong pressure on the urban floodplains (Sanon et al., 2012). An increase in the number of visitors has a negative impact on sensitive habitats and species. Borysiak (2006) highlights that in the city center, the function of the Warta River as an ecological corridor is significantly disturbed. The high pedestrian traffic basically eliminates the vegetation from many paths. In order to maintain the ecological connectivity, it is necessary to mitigate the anthropopressure and to take actions to restore the structural and functional cohesion of the migration corridor for animals and plants. Wiśniewski (2006) highlights, in turn, that an increase in the surface sealing in the Warta Valley reduces the potential of the floodplain to convey and store floodwater and sediments. According to this author, the pursuit of the permanent construction on the floodplain, in which the flood waves move through Poznań, would in the long-term lead to damage to the infrastructure and would generate serious losses for the society. This is due to the fact that on the prevalent river stretch within the city, there is only one riverbed in which the flood wave can move around.

The trade-offs between CES and RES may not be perceived at all or be hardly perceived by urban dwellers. For most of our respondents, the Warta Valley was not considered as a long corridor that travels the agglomeration; instead, they perceived it as the place to which they have close personal ties, e.g. the stretch of riverbank they enjoy while picnicking or bicycling. The role of decision-makers is to help the inhabitants see the big picture by tying the local desires to overall strategies for the protection and enhancement of the river corridor (Gobster and Westphal, 1998). Final relations between the structure and level of CES and RES will be shaped by the adopted strategy of urban floodplain management. 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 a basic tool that can be used for balancing land use decisions toward sustainable ES provision. The study of conditions and directions of spatial development of Poznań (SCDSD, 2014) designates the study area as organized green spaces with an extended recreational function. According to the provisions of SCDSD, the leading intended use - organized green space - is to be complemented by service facilities with

recreational, sports, catering, cultural and entertaining functions, garden architecture, communication areas (boulevards, pedestrian and cycling paths), and technical infrastructure.

Striving after simultaneous preservation of the integrity and ecological stability of the floodplain and allowing inhabitants to access it can generate spatial collisions (Raszeja and Gałecka-Drozda, 2015; Mizgajski et al., 2010). Without a doubt, there is an increasing social pressure for the so-called "returning Warta River to Poznań", i.e. increasing the role of the river for the inhabitants of the city. A part of the stakeholders strives to locate the urban fabric as close to the river as possible. A good example is the location of a densely built-up housing estate with two underground floors within the area of Bielniki in the southern neighborhood of the study area (Wiśniewski, 2006). However, the nature-based solutions trend, which takes into account the maintenance of natural processes and ensuring the use of the valley during low water-level periods through sport and recreational facilities, is more and more visible. A great influence on the mitigation of potential negative effects of spatial development will have both proper location decisions and implementation of the appropriate technical solutions (Chorążewicz, 2010). In the 1970s, an attempt was made to assess the possibility of development of the recreational function on the floodplains on the entire length of the Warta River in Poznań in the background of environmental conditions (Wojterski et al., 1973). According to this study, protection of the Warta Valley in the city center should consist of a reduction of tourist traffic intensity to, at most, an average level and on the construction of a rational network of walking and biking trails. Undoubtedly, an anthropogenically-deformed landscape, deprived of valuable natural elements, allows one to propose within the floodplain certain projects with a relatively low impact on the environment and supporting at the same time the regeneration of the natural river landscape. It is possible to locate the recreational facilities expected by our respondents if they meet the following requirements: they will not disturb the function of the ecological corridor; they will not worsen the conditions of the flood water flow; and they will not generate significant economic damages as a result of flooding. The enhancement of the function of the ecological corridor may be performed through appropriate shaping of the greenery within the area of the designed facilities – with respect to the natural alluvial vegetation with an integration of all biocenosis that are vital for the maintaining of regional and national biodiversity (Borysiak, 2006). Areas that are located in close proximity of the river are particularly exposed to a long-term submersion as well as siltation and accumulation of river sand. Such a situation does not favor the preservation of permanent vegetation. Wojterski et al. (1973) recommend the introduction of turfs and riparian meadows that are less impressive from an aesthetic point of view, but they stabilise the surface

well. In the context of flood control service, it is worth pointing out that the recreational facilities that have been introduced up until now were designed as floodable (e.g. mobile artistic and gastronomical zone built from containers, metal stairs to the river). However, it has not yet been possible to check the effectiveness of the adapted solutions, e.g. by strong ice phenomena that did not occur on the river at that time. The following should be considered as crucial tasks for maintenance of a high level of flood protection: keeping areas that can receive and retain water in the case of flooding; and ensuring the safe passage of floodwater over the floodplain by introducing grass plants that reduce the roughness of the surface (Polish Urban MAES, 2015).

Despite the fact that complex interactions between RES and CES provided by urban floodplains pose a challenge for management, CES could be a way to raise ecological awareness of urban residents. CES are intimately known by people; RES are less evident (Grizzetti et al., 2016; Kremer et al., 2015). Thus, informing on the biophysical underpinning of CES delivery may be used as a starting point for increasing engagement of the public in the protection of other services (Riechers et al., 2016).

6. Conclusion

This paper strengthens the idea that assessment of social and ecological benefits from urban floodplains should be conducted jointly to account for the different categories of ES. Synthesis insights from various research perspectives ensure that the full range of ES is considered, and the management decisions comprehensively capture the relation between floodplain ES and human well-being.

The results provide input for urban river management by documenting both ES of public interests as well as services that can be overlooked by the public due to their "hidden nature". Without such insights, it would be difficult to judge whether the scope of actions considered in a management strategy is overly broad or overly narrow, as well as to weigh the trade-offs and synergies between different management options.

Transferability of our results to another site highly depends on multiple contextual factors, such as location, spatial configuration of elements, and individual perception (Kremer et al., 2015; Luederitz et al., 2015); however, in the authors' opinion, the insights from the case study can provide valuable support in creating policy targeted to guarantee and enhance of optimal bundle of urban floodplains ES.

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References

- Aberg, E.U., Tapsell, S., 2013. Revisiting the River Skerne: The long-term social benefits of river rehabilitation. Landsc. Urban Plan. 113, 94-103.
- Act on raising youth in sobriety …, 1982. Act on raising youth in sobriety and prevention of alcoholism. Journal of Laws of 2012, item 1356 (in Polish).
- Balcerkiewicz, S., Borysiak, J., Wojterska, M., 1991. A map of real vegetation as a basis for landscape typology and evaluation for the creation of a system of protected areas. Phytocoenosis 3, 279-286 (in Polish).
- Borysiak, J., 2006. The environmental and legal conditions of spatial development in the Warta Valley in Poznań, in: Dreszer, W. (Ed.), The Warta River in Poznań. The attempt to bring a river back to the city. The Physiotectonics Studio of Poznań Academy Science of Fine Arts, Poznań, pp. 80-81 (in Polish).
- Borysiak, J., 1994. The structure of the alluvial land vegetation in the middle and lower course of the Warta River. Adam Mickiewicz University Press, Poznań (in Polish).
- Brody, S.D., Highfield, W.E., 2013. Open space protection and flood mitigation: A national study. Land Use Policy 32, 89-95.
- Burkhard, B., Kandziora, M., Hou, Y., Muller, F., 2014. Ecosystem Service Potentials, Flows and Demands - concepts for Spatial Localisation, Indication and Quantification. Landsc. Online 34, 1-32.
- Chorążewicz, M., 2010. The role of landscape ecological aspect of spatial planning in Poznań. Prob. Landsc. Ecol. XXVIII, 85-89.
- Church, A., Fish, R., Ravenscroft, N., Stapleton, L., 2015. Cultural ecosystem services, water, and aquatic environments, in: Martin-Ortega, J., Ferrier, R.C., Gordon, I.J., Khan, S. (Eds.), Water Ecosystem Services. A global Perspective. Cambridge University Press, Cambridge, pp. 148-155.
- Costanza, R., de Groot, R., Sutton, P., van der Ploeg, S., Anderson, S.J., Kubiszewski, I., Farber, S., et al., 2014. Changes in the Global Value of Ecosystem Services. Glob. Environ. Chang. 26, 152-158.

- Development strategy for the Warta River 2012-2030. Poznań City Office, KuiperCompagnons, DHV and SwedeCenter. http://www.dorzeczni.pl/upload/articles/pdf/strategy_en.pdf (accessed 19.06.2017).
- Doherty, E., Murphy, G., Hynes, S., Buckley, C., 2014. Valuing ecosystem services across water bodies: Results from a discrete choice experiment. Ecosyst. Serv. 7, 89-97.
- Eden, S., Tunstall, S., 2006. Ecological versus social restoration? How urban river restoration challenges but also fails to challenge the science-policy nexus in the United Kingdom. Environ. Plann. C 24, 661-680.
- EEA, 2011. Green infrastructure and territorial cohesion. The concept of green infrastructure and its integration into policies using monitoring systems. European Environment Agency, Technical Report 18/2011, Publications Office of the European Union, Luxembourg.
- Elmqvist, T., Setala, H., Handel, S.N., van der Ploeg, S., Aronson, J., Blignaut, J.N., Gomez-Baggethun, E., Nowak, D.J., Kronenberg, J., de Groot, R., 2015. Benefits of restoring ecosystem services in urban areas. Curr. Opin. Env. Sust. 14, 101–108.
- Gobster, P.H., Westphal, L.M. (Eds.), 1998. People and the River: Perception and Use of Chicago Waterways for Recreation. Department of the Interior, National Park Service, Rivers, Trails, and Conservation Assistance Program, Milwaukee, Wisconsin.
- Gobster, P.H., Westphal, L.M., 1998. Summary of People and the River, in: Gobster, P.H., Westphal, L.M. (Eds.), People and the River: Perception and Use of Chicago Waterways for Recreation. Department of the Interior, National Park Service, Rivers, Trails, and Conservation Assistance Program, Milwaukee, Wisconsin, pp. 183-192.
- Grizzetti, B., Lanzanova, D., Liquete, C., Reynaud, A., Cardoso, A.C., 2016. Assessing water ecosystem services for water resource management. Environ. Sci. Policy 61, 194-203.
- Hegetschweiler, K.T., de Vries, S., Arnberger, A., Bell, S., Brennan, M., Siter, N., Olafsson, A.S., Voigt, A., Hunziker, M., 2017. Linking demand and supply factors in identifying cultural ecosystem services of urban green infrastructures: A review of European studies. Urban. For. Urban Gree. 21, 48-59.
- Ioja, C.I., Rozylowicz, L., Patroescu, M., Nita, M.R., Vanau, G.O., 2011. Dog walkers' vs. other park visitors' perceptions: The importance of planning sustainable urban parks in Bucharest, Romania. Landsc. Urban Plan. 103, 74-82.
- Kaniecki, A., 2004. Poznań - the history of the city written with water. The Poznań Society of Friends of Sciences, Poznań (in Polish).

- Kaniecki, A., 1994. The transformation of water relations within the area of Poznań in historic times. Physiogr. Stud. West. Poland A45, 121-145 (in Polish).
- Kóčka-Krenz, H., 2007. The oldest history of Poznań, in: Kóčka-Krenz, H. (Ed.), Here Poland began ... Municipal Publishing House of Poznań, Poznań, pp. 7-18 (in Polish).
- Kremer, P., Andersson, E., Elmqvist, T., McPhearson, T., 2015. Advancing the frontier of urban ecosystem services research. Ecosyst. Serv. 12, 149-151.
- Lee, H.S., Shepley, M., Huang, C.S., 2009. Evaluation of off-leash dog parks in Texas and Florida: A study of use patterns, user satisfaction, and perception. Landsc. Urban Plan. 92, 314-324.
- Liao, K.H., 2012. A Theory on Urban Resilience to Floods—A Basis for Alternative Planning Practices. Ecol. Soc. 17, 48.
- Luederitz, C., Brink, E., Gralla, F., Hermelingmeier, V., Meyer, M., Niven, L., Panzer, L., Partelow, S., Rau, A.L., Sasaki, R., Abson, D.J., Lang, D.J., Wamsler, C., von Wehrden, H., 2015. A review of urban ecosystem services: six key challenges for future research. Ecosyst. Serv. 14, 98-112.
- Lundy, L., Wade, R., 2011. Integrating sciences to sustain urban ecosystem services. Prog. Physic. Geog. 35, 653-669.
- Maes, J., Zulian, G., Thijssen, M., Castell, C., Baró, F., Ferreira, A.M., Melo, J. et al., 2016. Mapping and Assessment of Ecosystems and their Services. Urban Ecosystems. Publications Office of the European Union, Luxembourg.
- Maes, J., Teller, A., Erhard, M., Murphy, P., Paracchini, M.L., Barredo, J.I., Grizzetti, B. et al., 2014. Mapping and Assessment of Ecosystems and their Services. Indicators for ecosystem assessments under Action 5 of the EU Biodiversity Strategy to 2020. Publications Office of the European Union, Luxembourg.
- Majkowska, A., Kolendowicz, L., Półrolniczak, M., Hauke, J., Czernecki, B., 2017. The urban heat island in the city of Poznań as derived from Landsat 5 TM. Theor Appl Climatol 128, 769–783.
- Matuszkiewicz, J.M., 2008. Reference map of potential natural vegetation of Poland at the scale 1:300 000. Institute of Geography and Spatial Organization Polish Academy of Sciences. https://www.igipz.pan.pl/Roslinnosc-potencjalna-zgik.html (accessed 28.08.2017).

- Mazur, N., 2016. www.poznan.wyborcza.pl/poznan/1,36037,20828822,kto-tak-naprawde-siedzial-latem-nad-warta-zbadali-to-dokladnie.html#BoxLokPozLink (accessed 20.06.2017).
- McPhearson, T., Andersson, E., Elmqvist, T., Frantzeskaki, N., 2015. Resilience of and through urban ecosystem services. Ecosyst. Serv. 12, 152-156.
- Mizgajski, A., Zwierzchowska, I., 2016. Green infrastructure, in: Kaczmarek, T., Mikuła, Ł. (Eds.), The conception of spatial development of Poznań metropolis, Metropolitan Research Center, Poznań, pp.51-58.
- Mizgajski, A., Bródka, S., Fagiewicz, K., Kijowska, J., Łowicki, D., Markuszewska, I., Poniży, L., 2010. Natural conditions as a premise for the development of the Poznań urbanised area. Prob. Landsc. Ecol. XXVIII, 91–100.
- National Water Management Authority, Warszawa**,** 2015. Map of flood risk. http://mapy.isok.gov.pl/imap/ (accessed 20.06.2017).
- Office of Spatial Planning of the Wielkopolskie Voivodship, 2015. Ecophysiographic study for the Wielkopolskie Voivodship. Bogucki Scientific Press, Poznań (in Polish).
- Olejnik, K., 1995. Variability of water levels and water flows in the Warta River in Poznań, in: Kaniecki, A., Rotnicka, J. (Eds.), Surface waters in Poznań. Water problems in urban areas. Sorus Press, Poznań, pp. 153-168.
- Polish Urban MAES, 2015. Urban MAES - Ecosystem Services Urban Areas. The study commissioned by the Ministry of the Environment according to the agreement no. DLP /4/2015. Mizgajski, A., Zwierzchowska, I., Stępniewska, M., Zajączkowski, D., Adam Mickiewicz University, Poznań. http://es-partnership.org/wp-content/uploads/2016/06/Urban-MAES-for-Poland-abstract_Poland-introduction_objectives.pdf (abstract in English) (accessed 20.06.2017).
- Polizzi, C., Simonetto, M., Barausse, A., Chaniotou, N., Känkänen, R., Keränen, S., Manzardo, A., Mustajärvi, K., Palmeri, L., Scipioni, A., 2015. Is ecosystem restoration worth the effort? The rehabilitation of a Finnish river affects recreational ecosystem services. Ecosyst. Serv. 14, 158-169.
- Poniży, L., Jawgiel, K., 2013. The role of planning documents in retaining the urban green infrastructure (Poznan Warta River valley case study). Prob. Landsc. Ecol. XXXVI, 5-14 (in Polish).
- Potschin, M., Haines-Young, R., 2013. Landscapes, sustainability and the place-based analysis of ecosystem services. Landsc. Ecol. 28, 1053-1065.

- Poznań City Council, 2008. Resolution No. XLIV/565/V/2008 of the Poznań City Council of 4 November 2008 on: prohibition of the sale, serving and consumption of alcoholic beverages in indicated places, not listed in the Act on raising youth in sobriety and prevention of alcoholism (in Polish).
- Poznań City Office, 2017. www.rzekawartapoznania.pl (accessed 20.06.2017).
- Poznań City Office, 2015. The operational plan of flood protection for the city of Poznan. http://www.poznan.pl/mim/wos/analiza-zabezpieczenia-przeciwpowodziowego-miasta-poznania,doc,2136/analiza-zabezpieczenia-przeciwpowodziowego-miasta-poznania,26207.html (in Polish) (accessed 20.06.2017).
- Poznań County Office, 2010. Flood in Poznań county in 2010. http://www.bip.powiat.poznan.pl/2952,materialy-do-pobrania?&nobreakup#pliki_7028 (in Polish) (accessed 20.06.2017).
- Półrolniczak, M., Kolendowicz, L., Majkowska, A., Czernecki, B., 2017. The influence of atmospheric circulation on the intensity of urban heat island and urban cold island in Poznań, Poland. Theor Appl Climatol 127, 611–625.
- Prescott, M.F., Ninsalam, Y., 2016. The synthesis of environmental and socio-cultural informationin the ecological design of urban riverine landscapes. Sustain. Cities Soc. 20, 222-236.
- Ptaszyk, J., 2003. The birds of Poznań – qualitative and quantitative condition and its changes in the period 1850–2000. Adam Mickiewicz University Press, Poznań (in Polish).
- Pulighe, G., Fava, F., Lupia, F., 2016. Insights and opportunities from mapping ecosystem services of urban green spaces and potentials in planning. Ecosyst. Serv. 22, 1-10.
- Ratyńska, H., 2001. The vegetation of the Poznań Gorge of the Warta River and its anthropogenic transformations. Bydgoszcz Academy Press, Bydgoszcz (in Polish).
- Raszeja, E., Gałecka-Drozda, A., 2015. A contemporary interpretation of the concept of the Poznań urban green system in view of the sustainable city strategy. Urban Stud. 19, 75-86 (in Polish).
- Regional Inspectorate of Environmental Protection, 2016. The state of environment in the Wielkopolskie Voivodship in the years 2013-2015. Environmental Monitoring Library, Poznań (in Polish).
- Regional Inspectorate of Environmental Protection, 2015. The state of environment and control activities of Regional Inspectorate of Environmental Protection in Poznań in 2014. Environmental Monitoring Library, Poznań (in Polish).

- Riechers, M., Barkmann, J., Tscharntke, T., 2016. Perceptions of cultural ecosystem services from urban green. Ecosyst. Serv. 17, 33-39.
- Sanon, S., Hein, T., Douven, W., Winkler, P., 2012. Quantifying ecosystem service trade-offs: The case of an urban floodplain in Vienna, Austria. J. Environ. Manage. 111, 159-172.
- Study of conditions and directions of spatial development of Poznań. Resolution No. LXXII/1137/VI/2014 of the Poznań City Council of 23 September 2014 (in Polish).
- Statistical Yearbook, 2016. Statistical Yearbook of the Republic of Poland. Central Statistical Office, Warszawa.
- Stępniewska, M., 2016. Ecosystem Service Mapping and Assessment as a Support for Policy and Decision Making. Clean 44, 1414-1422.
- Stępniewska, M., Zwierzchowska, I., Mizgajski, A., in press. Capability of the Polish legal system to introduce the ecosystem services approach into environmental management. Ecosyst. Serv. (2017) http://dx.doi.org/10.1016/j.ecoser.2017.02.025
- Tzoulas, K., Korpela, K., Venn, S., Yli-Pelkonen,V., Kaźmierczak, A., Niemela,J., James, P., 2007. Promoting ecosystem and human health in urban areas using Green Infrastructure: a literature review. Landsc. Urban Plan. 81, 167–178.
- Urban Atlas, 2012. European Environment Agency, Directorate-General Enterprise and Industry (DG-ENTR), Directorate-General for Regional Policy. http://www.eea.europa.eu/data-and-maps/data/urban-atlas (accessed 20.06.2017).
- Voigt, A., Wurster, D., 2015. Does diversity matter? The experience of urban nature's diversity: Case study and cultural concept. Ecosyst. Serv. 12, 200-208.
- Vollmer, D., Pribadi, D.O., Remondi, F., Rustiadi, E., Grêt-Regamey, A., 2016. Prioritizing ecosystem services in rapidly urbanizing river basins: A spatial multi-criteria analytic approach. Sustain. Cities Soc. 20, 237-252.
- Weber, M.A., Ringold, P.L., 2015. Priority river metrics for residents of an urbanized arid watershed. Landsc. Urban Plan. 133, 37-52.
- Westphal, L.M., 1998. Use patterns and user preferences of on-site river recreationists, in: Gobster, P.H., Westphal, L.M. (Eds.), People and the River: Perception and Use of Chicago Waterways for Recreation. Department of the Interior, National Park Service, Rivers, Trails, and Conservation Assistance Program, Milwaukee, Wisconsin, pp. 49-78.
- Wiśniewski, J., 2006. The spatial development of the river valleys, in: Dreszer, W. (Ed.), The Warta River in Poznań. The attempt to bring a river back to the city. The Physiotectonics Studio of Poznań Academy Science of Fine Arts, Poznań, pp. 82-85 (in Polish).

- Wojterski, T., Balcerkiewicz, T., Leszczyńska, M., Piaszyk, M., 1973. Vegetation as the basis for recreation purpose in the Warta Valley in Poznań. Physiogr. Stud. West. Poland B24, 143-163 (in Polish).
- Woś, A., 2010. Polish climate in the second half of the twentieth century. Adam Mickiewicz University Press, Poznań (in Polish).
- Zepp, H., Mizgajski, A., Mess, C., Zwierzchowska, I., 2016. A Preliminary Assessment of Urban Ecosystem Services in Central European Urban areas. A Methodological Outline with Examples from Bochum (Germany) and Poznań (Poland). Ber. Geogr. Landeskd. 90, 67-84.
- Zhao, J., Liu, Q., Lin, L., Lv, H., Wang, Y., 2013. Assessing the comprehensive restoration of an urban A map of real vegetation as the basis for landscape typology and evaluation for the creation of a system of protected areas river: An integrated application of contingent valuation in Shanghai, China. Sci. Total Environ. 458-460, 517-526.
- Zwierzchowska, I., 2017. Urban ecosystem services – assessment of potential at the different spatial scale: an example of Poznań. Econ. Environ. 60, 207-225.