

Reconstruction of the Old Bydgoszcz Canal buried section as a potential direction for development of green and blue infrastructure in Bydgoszcz city center

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Abstract. This paper tackles the possibility for the reconstruction of the buried section of the Old Bydgoszcz Canal, as a potential direction for the development of green and blue infrastructure in Bydgoszcz city center. As a result of the literature review, archival query, field works, and social research in the form of a public survey and interviews with local experts, the concept for reopening the buried section of the Old Bydgoszcz Canal was drawn up. It takes into account local spatial conditions and social expectations and shows how the project complies with the current municipal strategic and planning documents. This work also presents historic and contemporary practices for the development of urban water areas, and concepts of ecosystem services, climate change adaptation, and urban quality of life, which are important for the development of urban green infrastructure. The results of this research lay the foundations for a broader discussion on the possible reconstruction of the Bydgoszcz Canal, as well as the implementation of similar projects in other cities.

Keywords: urban planning, waterway restoration, inland waterways, urban regeneration, sustainable development.

1. Introduction

Since the beginning of civilization, access to fresh water has been a key factor determining the location of settlements, as it provided water resources for the population, crops and livestock. Rivers were also a convenient transport route and they provided defence from aggressions (Gan, 1978; Pancewicz, 2003; Kowalczyk, 2011), as well as performing spiritual, religious, cultural and political roles (Januchta-Szostak, 2018). Ancient civilizations were building their might based on water resources, which they adapted to their needs through development of irrigation, sewage, and water supply systems (Kotkin, 2006; Kowalczyk, 2011). Location on the river not only provided access to water as a resource, but along with economic, political, social and cultural aspects, it determined development and the spatial and functional structure of the cities (Pancewicz, 2003).

To increase trade, navigation canals were built at the places where terrain and water resources allowed for that. These new water routes contributed greatly to the development of industrial centres in the 18th century (Gan, 1978).

With rapid industrialization and urbanization, sanitary conditions in the cities worsened. This, together with changes in spatial and functional structure of the cities, and declining importance of the inland water transport due to development of railways, led to burying or piping parts of canals and natural watercourses (Kowalczyk, 2011). The above-mentioned factors also forced the development of communal infrastructure, such as sanitary systems, public baths, laundries and parks (Kotkin, 2006).

The economic transformation of the post-industrial era has led to the relocation of factories and harbours. This led to degradation of vast waterfront areas in the city centres. However, these brownfield sites often lent themselves to major landmark projects, which through their scale, were intended to benefit the development of the whole city (Tölle, 2010). Besides former harbours, other areas along rivers, canals, and lakeshores are also redeveloped (Muszyńska-Jeleszyńska, 2013). This restorative trend, described by Januchta-Szostak (2018) as a period of return, ending the purely exploitative attitude towards water areas and resources, is a result of transition in societal values and striving towards increasing quality of life and environment.

The origin of urban planners' efforts to improve quality of life and environment may be credited to the Howard's idea of the garden city (Howard, 1902), in which elements typical of rural areas would be implemented within the cities to solve problems of the industrial era urbanization. Currently, this idea has evolved into the concept of green infrastructure, which also includes blue infrastructure, defined by the European Commission (2013) as a planned network of natural and semi-natural areas and other components of the environment, designed and maintained for providing a broad range of ecosystem services. These services are defined as benefits, amenities or profits for people, which are the result of functioning of the ecosystems (Zepp et al., 2016). Following Zepp et al. (2016), the biggest potential for providing ecosystem services in urban areas is through agricultural and semi-natural areas, wetlands, forests and water bodies. Reducing these areas by anthropogression resulting from urbanization and changing land use leads to a number of adverse effects, such as increase of surface runoff, increase of temperatures or decrease in biodiversity (Pauleit & Breuste, 2011).

Development of green and blue infrastructure was identified by the Intergovernmental Panel on Climate Change (IPCC, 2014) as one of the possible methods for mitigation of climate change effects in urban areas, which are classified as vulnerable sectors. As climate models show (Gill et al., 2007), a 10% increase in the green urban surface area could successfully compensate the temperature increase forecast for the next 50 years, even with the high greenhouse gas emission scenario. Rainfall retention capacity could also increase. Green areas and surface waters are an important element of the strategies for reducing the urban heat island effect (Damyanovic et al., 2016).

Actions towards improving the quality of life in cities are also connected to the critique of urban planning focused on the development of mobility with private vehicles (Jacobs, 1961; Gehl, 2008, 2010; Montgomery, 2013). Designing a city on a scale adapted to the speed of cars led to the creation of low-density monofunctional zones, which forced more car journeys. To make these possible, more space needed to be dedicated to road infrastructure, which distorted the scale of the city perceived by humans and made public spaces unattractive for social activities. As research by Appleyard and Lintell (1971) shows, the smaller the car traffic, the more inhabitants engage in neighbour-like interactions and spend time in the public space. There are a few proposed solutions to reduce the need for long-distance travel, including an increase in building density in multifunctional neighbourhoods and attractive design of public spaces, expanded by reducing road infrastructure (Jacobs, 1961; Gehl, 2008, 2010; Montgomery, 2013).

Postulates towards improvement of the quality of life and environment in urban areas and adaptation to climate change are expressed in several framework documents such as: The New Charter of Athens (ECTP-CEU, 2003), Leipzig Charter (European Commission, 2007) or Pact of Amsterdam (European Commission, 2016), which shows how important these issues have become in modern urban planning.

Projects for reconstruction of urban waterways, earlier buried for expansion of the road network (Lee, 2006; Huisman, 2007; van der Toorn Vrijthoff & Heurkens, 2008; Wojnarowska, 2011), are the embodiment of the above-mentioned conceptions. Reconstruction of the water network is treated as an important element of spatial and functional redevelopment projects, aimed at the revitalization of the urban centres, through bringing back the historic identity of the place, creating high-quality public spaces, improving water resource management and increasing biodiversity. Those projects often lead to economic development in real estate, services and

tourism. Striving towards recreating old waterways often engages local communities, and leads to creation of international networks for cooperation and sharing experiences (Huisman, 2007).

The research presented in this paper aims to achieve both theoretical and practical goals. Based on the author's earlier interactions with local experts and the community on the topic of urban planning and inland waterways, the following research questions were formulated:

- How does the historic and spatial context of the Old Bydgoszcz Canal infilling fits into broader urban development patterns in other countries and how does it compares with their experiences?
- How can the reconstruction of urban waterways impact the quality of the environment and public spaces?
- What are the roles of urban green and blue infrastructure in the opinion of the inhabitants?
- What do the inhabitants and local experts know about the buried canal, how do they perceive the possibility for its reconstruction, and what obstacles do they identify?

How can public concerns be addressed to create a feasible and socially acceptable solution for waterway reconstruction?

2. Methods and data sources

Data gathering was initiated by archival query in the local and regional planning and administrative institutions, together with acquiring digital data from them. A complex review of the strategic and planning documents was undertaken, to determine the role of the researched area in municipal policies, and to check whether canal reconstruction fits into their scope. Simultaneously, a literature review was conducted to showcase the historic context of urban water areas, as well as the concepts of ecosystem services, climate change mitigation and urban quality of life, which the author considers important for green and blue infrastructure development.

As part of the social research, a public survey was conducted during August and September of 2018. 173 people took part in the survey, including 106 on-site interviews with users of waterside areas in the Bydgoszcz city centre. The remaining questionnaires were answered in digital form, published on social media groups for Bydgoszcz inhabitants and enthusiasts. Participants were asked to answer questions about the importance and functions of

green and water areas in the city, and how they spend their time at the waterside areas in Bydgoszcz city centre. The knowledge about the Old Bydgoszcz Canal buried section was checked, and respondents were asked to give their opinion on the decision which led to its infilling, and on its possible reopening. Collected data was then analysed statistically, including multivariate analysis.

The research process also included interviews with local experts, to get to know their opinion about the role and functions of the Bydgoszcz Water Junction, in particular the Bydgoszcz Canal, and possibilities for its reconstruction. In-depth interviews were conducted with representatives of the Kuyavian-Pomeranian Marshal Office for Inland Waterways, the City of Bydgoszcz Urban Planning Bureau, Kazimierz Wielki University Waterways Revitalization Department, and Bydgoszcz Canal Museum. Interviews were conducted taking into account the innovative character of the researched issue, to include experts' opinion on the conceptual project for the reconstruction of the Old Bydgoszcz Canal buried section.

From August to October 2018, field works were conducted, which included a land use survey and photographic documentation, to verify and update the data acquired from the local administration.

In-house studies included processing of acquired data, using Geographic Information System (GIS) software. Using GIS, archival cartographic materials were georeferenced to allow comparison between them and contemporary data. In cases where precise georeferencing was impossible, due to low resolution of available earliest historic maps showing the Bydgoszcz Canal, data was interpolated based on identifiable reference points and preserved remains of the original route identifiable on later materials., GIS was also used to undertake spatial analysis of urban planning and environmental data, to characterize current conditions of the research area..

Case studies of urban waterways reconstruction projects from different countries were also analysed comparatively, including their historic, spatial, and environmental context, and impact. Patterns and similarities were thus sought both within this sample of cases with the local case of the Bydgoszcz Canal, thereby suggesting the possible impact of Bydgoszcz Canal reconstruction

Based on the spatial and social research, and analysis of similar projects completed in other countries, and taking into account historic routes of the Bydgoszcz Canal, the author drew up the conceptual design for spatial and functional changes, allowing for reconstruction of the

canal's buried section, together with developing additional elements of green and blue infrastructure.

3. Study area

To prepare the spatial analysis of the corridor of the Old Bydgoszcz Canal, it was necessary to determine the borders of the corridor. As the road grid and land plot boundaries did not allow definition of a cohesive, functionally connected area, additional delimitation criteria were needed. Natural boundaries were taken into account, together with the spatial and functional cohesion. Including these criteria, the research area was determined with Bydgoszcz Canal as the central axis (Fig. 1). The area is limited by the Brda river and New Bydgoszcz Canal to the north, the edge of the Southern Slope, which is the part of the Brda river valley, to the south. To the east, Mill Island was included, together with its functional connections to the Old Town.

Building of the Bydgoszcz Canal, the history of which is described in detail by Winid (1928), was a turning point in the city's history. Construction works began in 1773 and the canal was completed already in 1774. Substantial reconstruction was conducted in the 19th century. The timber locks were replaced by brick locks, and a park was created beside the canal. In the years 1910-1915, to meet the needs of the larger vessels and decrease lockage time, a new 600 metre-long canal section with two locks was built, bypassing what is known since then as the Old Bydgoszcz Canal.

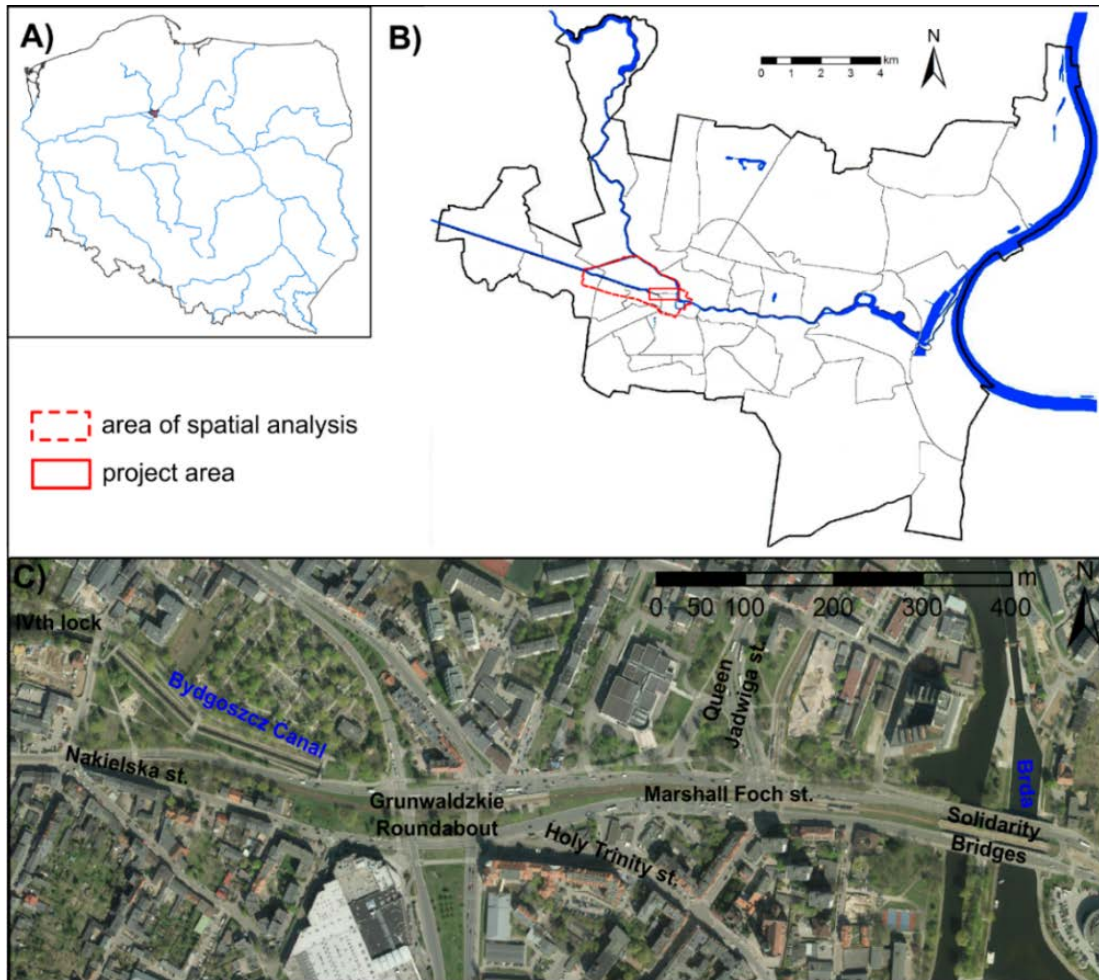


Figure 1. Location of the research area. A) Location of the City of Bydgoszcz in Poland, B) Location of the analysis area, C) Project area close-up; Base layer from geoportal.gov.pl WMS service

The old section of the Bydgoszcz Canal was an important element of the social life for the Bydgoszcz inhabitants (Jeleniewski, 2008). It offered possibilities for water recreation, and in the winter it was turned into an ice rink. Next to the locks, many restaurants were established, and the canal was a popular subject of many photographs and postcards. After construction of the New Canal and diversion of water transport, the Old Canal started to present problems of a sanitary nature, as not enough water passed through, but it was left as a reserve line of the waterway (Winid, 1928). Part of the Old Bydgoszcz Canal, from the IVth lock on Wrocławska street to the Brda river was then infilled at the end of 1960s, to make space for the new road development, as shown in Figure 2.



Figure 2. Historic and current view on the Bydgoszcz Canal buried section. A) and C) view towards IInd lock, B) and D) – view towards Władysław IV bridge; Source: A) and B), Bydgoszcz Canal Museum, C) and D), author’s archive

According to data acquired in the Bydgoszcz Canal Museum, precise technical plans for the original Bydgoszcz Canal are not available. Therefore, it was necessary to interpret its precise route based on cartographic materials. Maps from the end of the 18th century suggest that the canal followed a relatively straight course, and this is confirmed by the city plans made just after its first reconstruction, which show vestiges of the old canal adjacent to the new locks. As possible inaccuracies in the historic map projection made it hard to determine the canal’s width on this first attempted reconstitution, parameters from the existing sections were assumed. Location of the first locks was assumed based on the placement of the new ones, built parallel to the old ones. The route of the canal after its first reconstruction can be mapped with more accuracy thanks to the availability of precise plans (*Lageplan des Bromberger Kanals*, 1899) (Fig. 3).

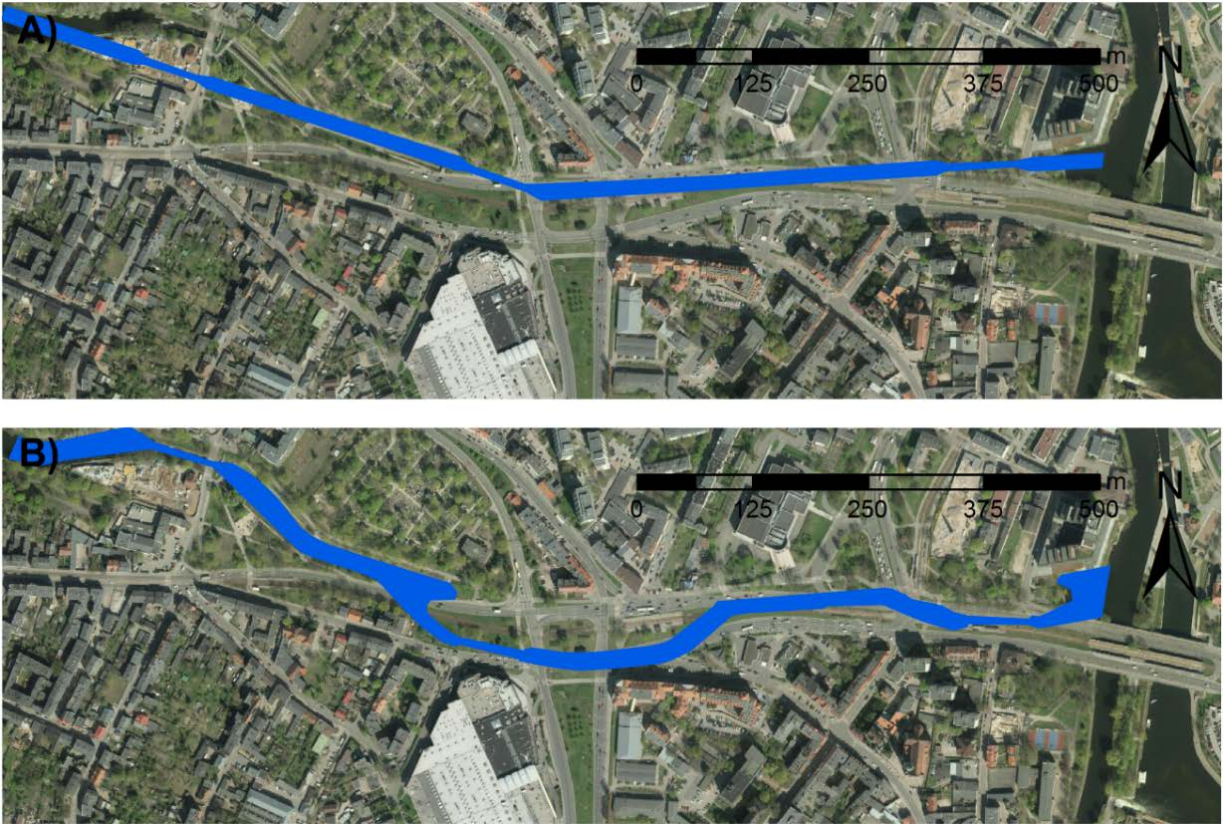


Figure 3. Historic routes of the Bydgoszcz Canal from the IVth lock to the Brda river. A) Probable route from 1774 to the end of 18th century, B) Route from the end of 18th century to infilling in 1960s; Base layer from geoportal.gov.pl WMS service

4. Results

4.1. Functional and spatial structure, nature, and cultural heritage in the Old Bydgoszcz Canal zone

Based on the conducted land survey (Fig. 4), three main spatial and functional structure types were defined. In the east, the dominant form is downtown-type tenement housing, in some places mixed with some contemporary buildings. In this zone, many cultural and administrative institutions of municipal and regional importance are located. In the north, the urban structure is more industrial in character, and in the south-west single-family detached housing is the main form. There is a highly visible impact of transport infrastructure, especially railways and roads, which fragment the whole spatial structure. The linear character of the green areas, alongside the watercourses, is also clearly visible.

Green areas make up 22.4% of the surveyed zone. Their layout is highly connected with the Brda river, the Old and New Bydgoszcz Canals, and the Southern Slope. Among the

managed green areas, the Old Bydgoszcz Canal Park is the biggest, covering an area of 34.7 ha, which makes up almost 41% of all green space.

Brda Embankments are fully developed on the left bank, from the city centre to the railway bridges. On the right bank, they end at Solidarity Bridges. The field survey showed that there is a high public demand for further development of embankments on the right bank, as many informal trails have been created through green areas and they often consist of steep, unprotected slopes down to the water.

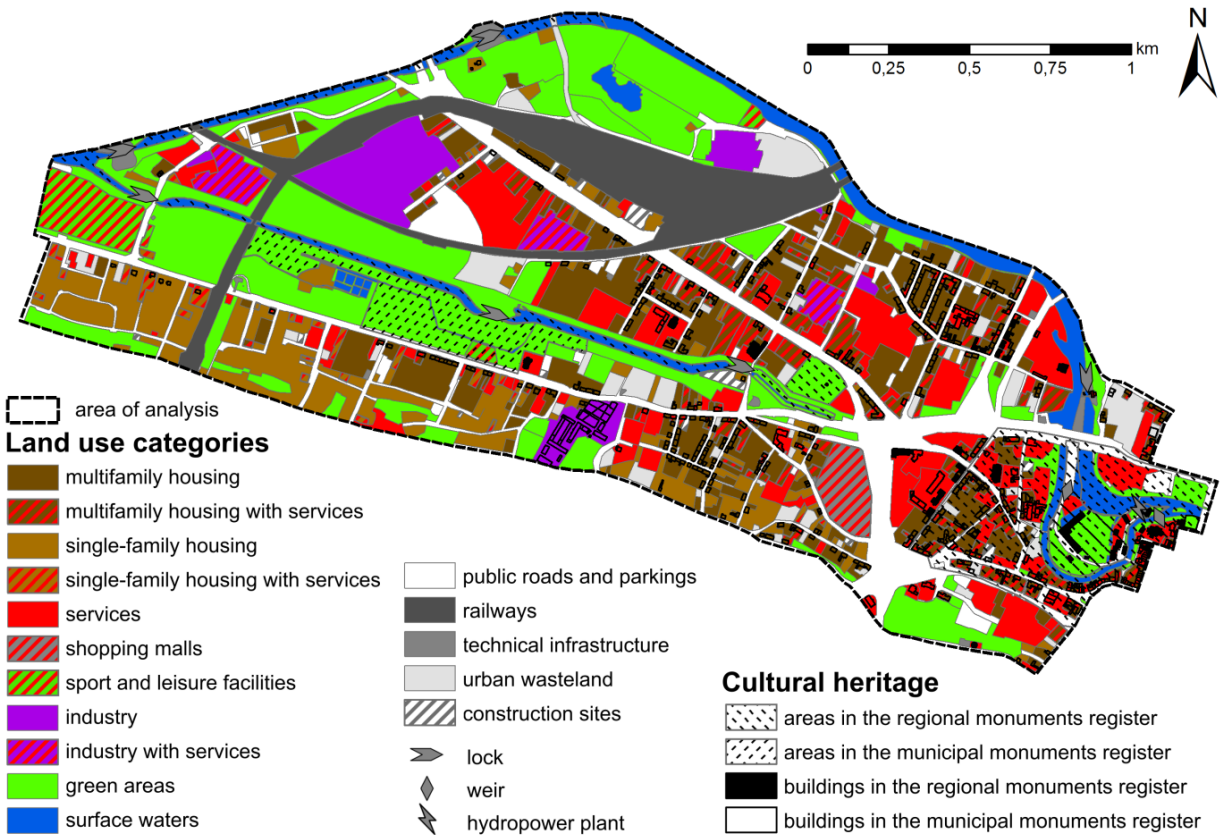


Figure 4. Land use and cultural heritage in the researched area

According to the Head Environmental Protection Directorate (GDOŚ, 2018), in the researched area, there are 44 trees with the status of natural monuments. They are grouped mostly in the Old Bydgoszcz Canal Park. Green areas near the water in the city center, are recognized as important habitats for birds (Zieliński, 2009), bats (Koziróg et al., 2012), and amphibians (Rybacki, 2010). Near the Brda river and the Bydgoszcz Canal, several protected plant species have been observed (Korczyński, 2009), and Eurasian beaver has been spotted (Kilon, 2016).

As the area of research included parts of the historic city centre, it is largely covered by the heritage protection zone, and it is rich in cultural monuments (Fig. 4). The municipal monument register includes 683 buildings and parts of the Old Bydgoszcz Canal Park, and the regional monument register lists 45 buildings and 4 areas: Old and New Bydgoszcz Canals, Old Parish Cemetery, Old Town, and Mill Island (NID, 2019). According to the information acquired in the Bydgoszcz Canal Museum, efforts have been made to include Bydgoszcz Canal in the UNESCO World Heritage List. Important cultural monuments of hydraulic engineering include three locks on the Old Bydgoszcz Canal, two locks on the New Bydgoszcz Canal and the Bydgoszcz Water Node, formed by the lock, two weirs, the fish pass and a small hydropower plant.

4.2. Area of research in the municipal strategic and planning documents

Waterways and surrounding greenery, due to their importance and multitude of functions, were included in 7 out of 15 thematic programmes of the Bydgoszcz Development Strategy (Bydgoszcz City Council, 2013), with one of them specially dedicated to the Bydgoszcz Water Junction. Development of the symbolic functions, forging the international character of the city, and strengthening the city's image as an important water hub, were included, together with improvement of the quality of life and environment.

Important records, from point of view of the analysed area, are included in the diagnosis of the current state and directions for development of the sport and leisure areas in Bydgoszcz (MPU, 2012), which classifies areas alongside Brda river and Bydgoszcz Canal as climate amelioration channels. Interestingly, the land stretch between the Old Bydgoszcz Canal Park and Mill Island, which corresponds closely to the infilled canal section, has been identified as a climate melioration channel for reconstruction. The document also classified both the above-mentioned areas as among the most precious maintained green zones in the whole city.

The Bydgoszcz Water Junction has its own dedicated Programme for Revitalization (MPU, 2006). It characterizes all of the natural and technical elements and distinguishes five types of waterside landscapes in the city, of which downtown Brda and Bydgoszcz Canal types are present in the area of research. The Bydgoszcz Canal type was recognized as an important cultural heritage site, architectural monument, and of specific value thanks to its impact on nature and the local climate.

The Study of Conditions and Directions of Spatial Development (MPU, 2009), together with above-mentioned documents, designates areas alongside the Bydgoszcz Canal and Brda river as sport and leisure areas, and suggests building a new harbour at their confluence, which should also perform the functions of an educational, leisure, and science centre.

Bydgoszcz also has its Plan for climate protection and adaptation to climate change (Bartocha et al., 2010). although it is focused on actions towards reducing greenhouse gas emissions and water is only mentioned in the context of the efficient use of resources. More water-focused, while supporting climate change adaptation, is the Green and Blue Infrastructure Catalogue (Adamowski et al., 2017), drawn up at the initiative of the Municipal Water and Sewage Company (MWiK). It presents sample solutions for small retention projects in urban settings, which may be implemented by both public institutions and private landowners.

High potential and social expectations towards further development of waterside areas are expressed in the Municipal Revitalization Plan (Bydgoszcz City Council, 2018), especially considering that a lot of neighbouring zones suffer from negative social, economic, environmental, functional, spatial and technical conditions.

4.3. Water areas and Bydgoszcz Canal buried section in the opinion of Bydgoszcz inhabitants

The majority of the survey participants evaluated both green and water areas as very important or important (Fig. 5). The grading by the city centre inhabitants was generally lower than that by people living in other parts of the town, for both green and water areas. Water also had significantly less importance for commuters from the suburbs. These differences may be explained by the size and location, and therefore accessibility to the recreational areas, and by their level of development and maintenance.

In case of green areas, people living in the city centre more often pointed out biodiversity (96%) and landscape (100%). Residents of the suburbs, more often chose sport and leisure functions (92%), which could be connected to the relative benefits perceived by commuters.

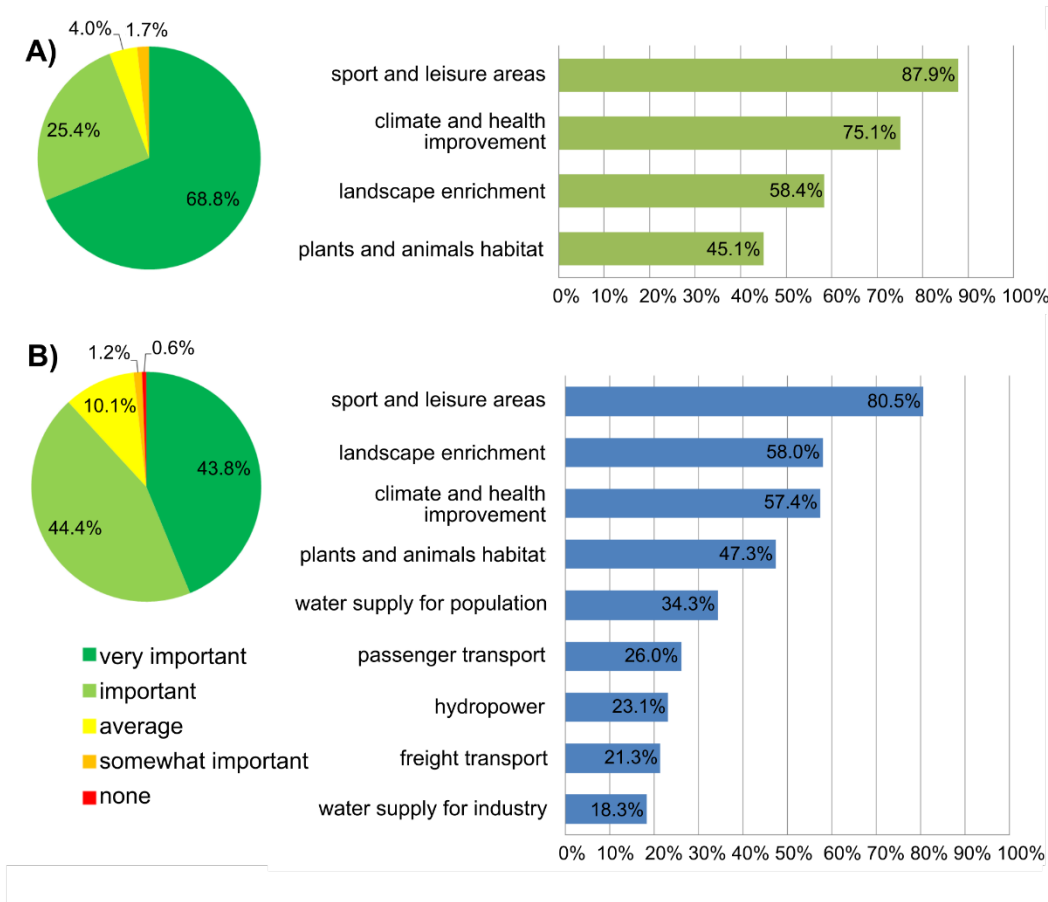


Figure 5. Importance of the green and water areas in Bydgoszcz and their main functions in the survey participants' opinion. A) Green areas, B) Water areas

Functions of water areas were seen similarly to urban greenery. The biggest difference was in the category of local climate impact. Respondents also pointed out the economic importance of water resources, such as water supply, transport, and power generation. Older and long-term inhabitants more frequently indicated these functions as important, which could be connected to their memories of the more intense use of urban water in the past, especially as commercial waterways.

A large proportion of the survey participants regularly spend their time at waterside areas in the city centre, which include Mill Island, the Brda embankments and the Old Bydgoszcz Canal Park (Fig. 6). Most of the respondents declared that they spend time at more than one of above-mentioned areas. In 68.6% of cases, all areas were visited, and 21.3% visited two locations.

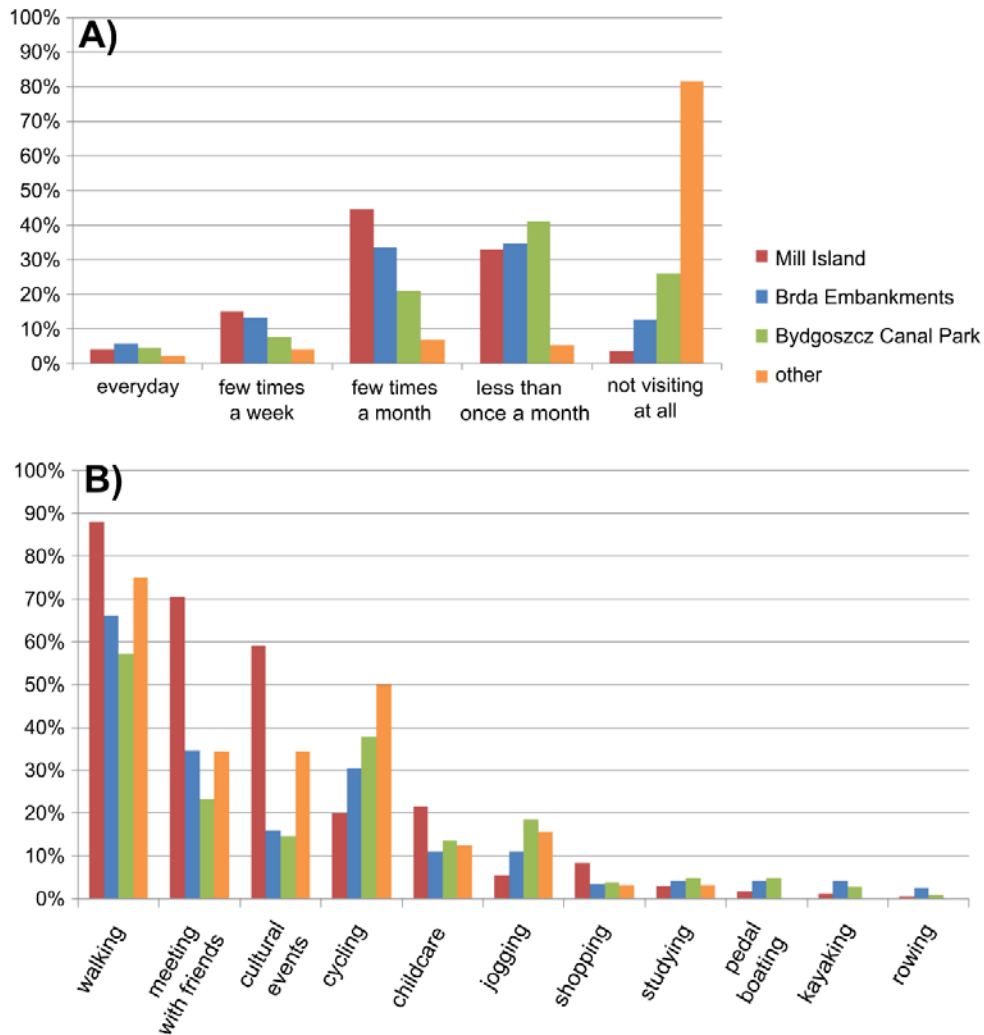


Figure 1. Use of the recreational zones in Bydgoszcz city centre. A) Frequency of visits, B) Forms of activity

Relatively less frequent visits to the Canal Park could result from its distance from Mill Island and lack of spatial and functional continuity between these two areas. At the same time, embankments are often treated as a transit route to Mill Island. Regarding other recreational destinations in the city, respondents listed parks or forest areas close to their homes. Mill Island is so appealing that it attracts people from all over the city at a similar rate. In the case of the Canal Park, distance starts to play a role.

Taking into account the overall activities in all of the mentioned areas, the low-intensity ones dominated on Mill Island, and sports activities took place mostly in the Canal Park, on the Brda embankments, and the other areas mentioned by respondents (Fig. 6). Most of the survey

participants (92%) declared multifunctional use of the recreational areas in the city centre, and most mentioned multiple activities: three (26%), four (25%) and five (17%) types of activity.

Most of the respondents were aware about existence of the Old Bydgoszcz Canal buried section (Fig. 7). People who live closer to the Bydgoszcz Canal buried section, as well as long-term inhabitants, who still remember the functioning Canal, were more knowledgeable about it.

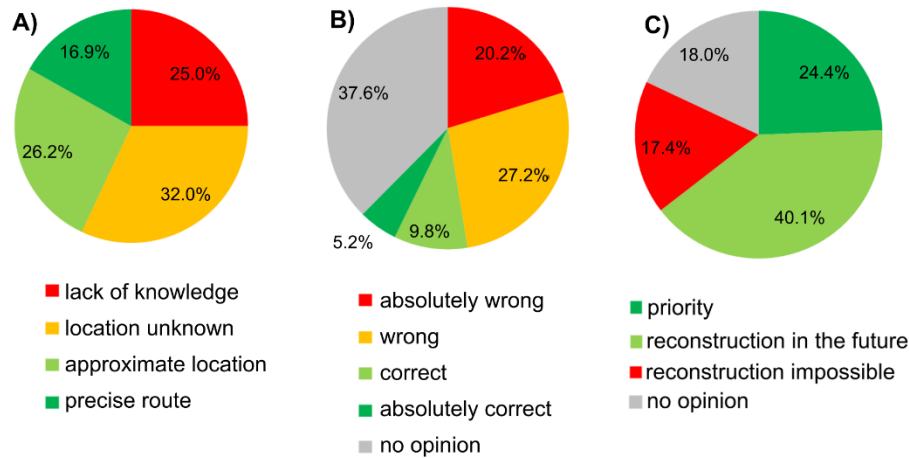


Figure 7. Old Bydgoszcz Canal buried section in inhabitants' perception. A) Knowledge about location, B) Opinion on validity of the burying, C) Expectations towards reconstruction

When asked about validity of the decision to fill in the Canal (Fig. 7), most respondents with an opinion on that topic declared that the city had lost an important part of its history and identity, of which over half (27.2% overall) stated that the expansion of the road network could have been carried out without damaging the canal. Respondents who on the contrary approved this decision, said that at this time it was right, and that it reflected the city's growing communication needs. Of these, one third (5.2% overall) stated that the existing road is still needed today. Approval of infilling was more often expressed by people living in the more distant neighbourhoods (8-13%, compared to 4% elsewhere), which could result from a higher demand for commuting to access the city centre and its services. Also, there was a big difference between people born in Bydgoszcz (2.4%), and people who moved there later in life (12.2%).

Survey participants also spoke about their expectations of possible canal reconstruction (Fig. 7). Almost two thirds expressed their support for reconstruction, but 40.1% felt, that at the moment the city has more pressing issues. Public expectation rates were similar across the whole city, no matter where the respondents live. Even 60% of interviewees who had never heard about the infilling of the Bydgoszcz Canal section were in favour of its reconstruction.

The most often mentioned obstacle for canal reconstruction and overall development of green and blue infrastructure in its zone, was the lack of space, currently occupied by the main road. At the same time, people voiced the need for protection of the existing green areas, and managing them, not only for recreational purposes, but also to support biodiversity. There were also comments about the expected calming of traffic on Marshal Foch street, as new road investments will be completed.

4.4. Bydgoszcz Canal buried section in the opinion of local experts

Local experts, asked about the role of Bydgoszcz Water Junction, unanimously admitted that it is an important asset for the city. They highlighted its tourism potential, although still not fully utilized, and expressed appreciation for the revitalization efforts made so far, at the same time pointing out that a lot of investments are still needed. They pointed out that the Water Junction should become a flag marketing product for the city, and that it is not sufficiently promoted. Some considered that the municipal authorities had been unsuccessful in fulfilling earlier adopted strategies, and that they were searching for new ideas for the city all the time, without realizing such an obvious direction.

The Bydgoszcz Canal was described as a key element of the Water Junction, that could not exist without it. All the experts highlighted the significant historic and cultural importance of the canal, as well as its tourism potential, although not fully utilized, due to the recurring issue of lock repairs and the resulting interruptions to navigation.

The location of the Bydgoszcz Water Junction at the intersection of international waterways, together with historic values of the hydraulic engineering and nature of the waterside zones, were named as its biggest strengths. As the biggest weakness, they pointed to the many years of neglect of the water transport infrastructure in Poland, which currently leads to long-lasting and costly renovations. Both opportunities and threats were connected to the legal and planning processes. The urban planning regulations were pointed out as especially harmful, by allowing many exemptions to developers, which makes it harder to control and implement municipal spatial policies.

Asked about the decision to infill the Bydgoszcz Canal section, all experts admitted that from the current perspective it was wrong, and sometimes referred to it as “cultural savagery”. The city has lost an important element of its identity, together with the most attractive and

interesting canal section, which was referred to as the “Bydgoszcz equivalent of [New York’s] Central Park”. They stated that despite the priority given in the past to road infrastructure development, it should be adjusted to the existing water network. The lack continuity of the Bydgoszcz Canal also makes it more difficult to obtain listing as a UNESCO World Heritage site.

Commenting on the possible development of green and blue infrastructure in the zone of the Old Bydgoszcz Canal buried section, experts were concerned about lack of space for such a project.

Asked about knowledge of the projects for waterways restoration completed in other countries, experts were at pains to cite specific examples. Mentions were made of the cities of Seoul and Leipzig, and the countries Ireland and the Netherlands, but with no more information. This lack of knowledge about similar projects could affect their stance on the possibilities for Bydgoszcz Canal reconstruction.

All of interviewed local experts stated that under current conditions reconstruction of the canal is impossible, mainly due to the existing road artery. At the same time, they expressed the hope that restoration could become feasible in the future, and admitted that it would have many benefits in the cultural, environmental, social and economic dimensions. Just the project alone could be used as a marketing tool at an international scale, due to its unique character. They all agreed that the project could be possible once traffic in the city centre has been calmed, which would allow for redesign of the road network.

4.5. Conceptual design for reconstruction of the Old Bydgoszcz Canal buried section

In their opinions about possible reconstruction of the Old Bydgoszcz Canal section, both local inhabitants and experts were assuming that its route would be the same as directly before its infilling, which, as they observed, largely coincided with the alignment of the existing road infrastructure.

Taking into account the current land use of the area, it is impossible to restore the canal without spatial and functional intervention. To keep the necessary infrastructural interventions at an acceptable level, historic canal routes, both the original line and that existing before infilling, were used to prepare two project variants (Fig. 8).

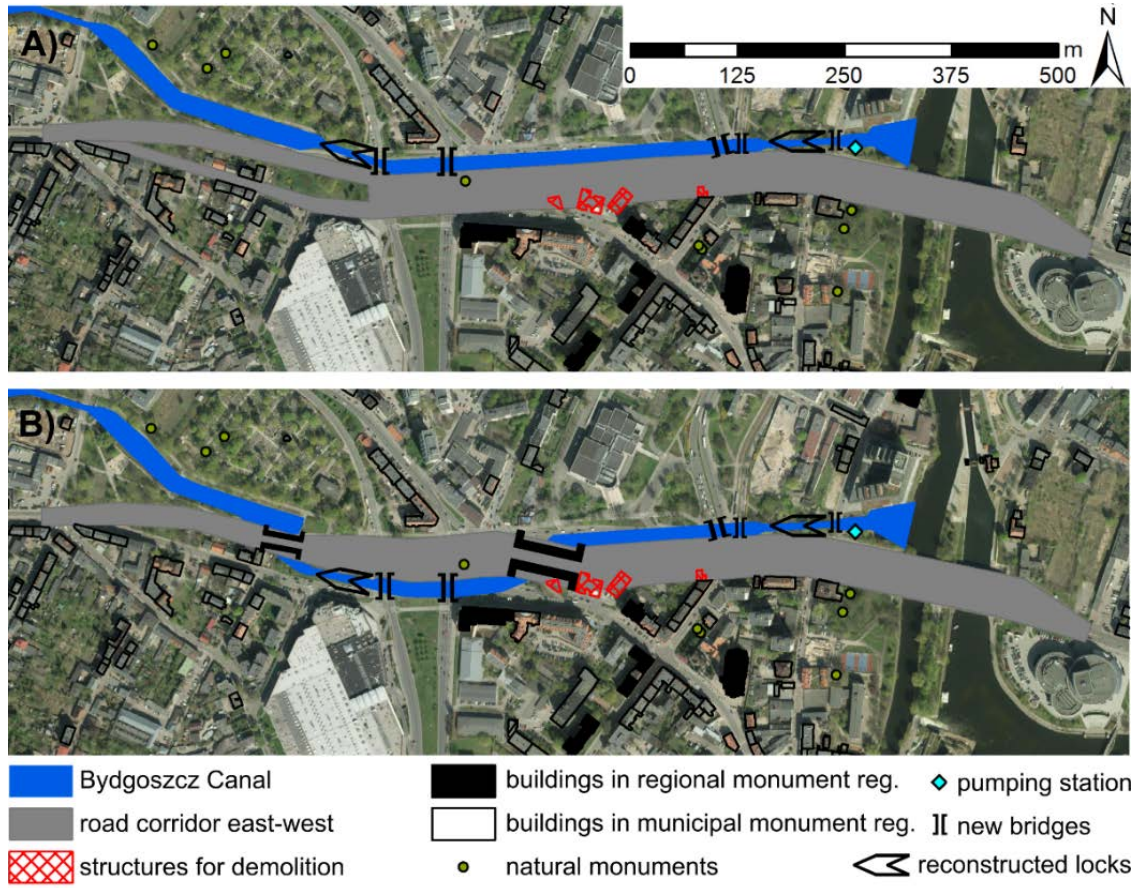


Figure 8. Proposed variants for the reconstruction of the Bydgoszcz Canal buried section. A) Variant I, B) Variant II; Base layer from geoportal.gov.pl WMS service

In both cases it was decided to keep the existing section from lock IV to the Grunwaldzkie Roundabout, which needs only an increase in the water level, as well as construction of a new lock II in the place of the original wooden one. The variants differ in the location of lock III, which could be at the same location as the original timber-built lock (variant I), or at that of the later brick structure (variant II). The final canal route should be determined by further analyses in the field of road engineering, which will point to the preferable variant based on optimal locations for the new bridges.

Considering that the social research identified the existing road network as the main obstacle to canal restoration, the attempt was made to redraw corridors for road infrastructure (Fig. 8). In the analysis, the reference width of the existing road at Solidarity Bridges was used.

The key element allowing the whole project to be implemented would be the relocation of service pavilions, which have questionable aesthetics, do not have historic value and can

easily be moved to alternative nearby locations. It will also be necessary to rebuild underground infrastructure, including the pumping station near the canal outlet to the Brda river.

Assuming that the restored canal will be open to navigation, the adjustments of the road network allowing for the new bridges would be the biggest challenge. In adapting the road network, it will be also necessary to take into account an old oak tree, which has the status of a natural monument (Fig. 8). In case of variant II, it is also recommended that the southbound lane of the Nakielska street, north of the existing buildings, be moved with built-in tram tracks, leaving the existing road for access to the bordering properties.

It is important to note that the proposed east-west transport corridor leaves room for possible corrections of the geometry. Abandoning the strict reproduction of the historical alignment of the canal would also leave some room for adjustments.

In addition to the reconstruction of the Bydgoszcz Canal, it is advised to implement other green and blue infrastructure solutions, both in connection to the main restoration project and independently.

To decrease the impact of the Marshal Foch street as a spatial and environmental barrier, taking into account that its width exceeds most of the similar roads with this and even higher categories in the city, and the projected decrease of traffic volume by the year 2050, no matter what development strategy city will adopt (Szczuraszek et al., 2012), it is recommended that its profile from Solidarity Bridges to the Grunwaldzkie Roundabout be reduced from three to two lanes in each direction. The space thus reclaimed could be used for new green areas.

Tram tracks could be reconstructed as green tracks, which would improve their aesthetic appearance, microclimate and water balance, decrease noise levels, recapture some of the pollution, and become a habitat for some plant and insect species (Schreiter, 2010).

The large building surface areas of the nearby cinema complex and shopping mall could also be used for green infrastructure development. Depending on structural capabilities, which should be assessed by additional expert evaluations, it could be possible to use part of the wall surfaces to form green walls. At the same time, roofs also could be used as extensive green roofs, or for solar panels.

Among the green areas located north of the reconstructed canal, a demonstration park for green and blue infrastructure, showing in practice elements from the existing catalogue (Adamowski et al., 2017), could be established. Solutions such as retention ditches, storm

gardens, water squares and more could be shown, each of them with an informational board about how they work and how they could be applied in other settings. Since infrastructure reconstruction during canal restoration would require the felling of some trees, replacement trees should be planted alongside the restored canal.

In case of opening the canal for recreational navigation, clearing the whole route will be needed, and this would impact water plants currently colonising the unused section between locks V and VI. To compensate for this, it is suggested that the terrain next to these locks, where the original canal was, be used to create new water habitats. To increase biodiversity, one of them could be arranged as a still water pond, while the other one, using the difference in level at the lock, could be laid out as a stream. Both of these habitats could be use also for educational purposes.

5. Discussion

Bydgoszcz's spatial and functional relations towards water areas, with its exploitative period and current shift in paradigm towards improving quality of waterside spaces, fits into broader models (Tölle, 2010; Januchta-Szostak, 2018). With its section of waterway buried for expansion of the road network and for sanitary reasons, the city shares a similar story with many other cities such as Breda, Gent (Huisman, 2007), Utrecht (van der Toorn Vrijthoff & Heurkens, 2008), Potsdam (Wojnarowska, 2011) and Seoul (Lee, 2006), to list but a few. Burying waterways for road development is an example of the focus on the car transport in urban design, which has been criticized broadly by multiple authors (Jacobs, 1961; Gehl, 2008, 2010; Montgomery, 2013), and of encroaching urbanization resulting in several adverse effects on environment (Pauleit & Breuste, 2011). Its negative impact on the historic identity, spatial structure and quality of life and environment has been noticed by many municipalities (Lee, 2006; Huisman, 2007; van der Toorn Vrijthoff & Heurkens, 2008; Wojnarowska, 2011). Similarly to these examples, in Bydgoszcz, the absence of the buried section of the canal is also noticeable in the spatial and functional structure of the city centre.

As the survey results shows, inhabitants are aware of the importance of the both urban greenery and water areas, which fits into the broader ecosystem services potential stated by Zepp et al. (2016). They are also popular recreational destinations, especially when they are easily accessible and multiple possible activities are offered, reflecting their high quality as a public

spaces (Jacobs, 1961; Gehl, 2008, 2010; Montgomery, 2013). The existence of the major road artery separating the Bydgoszcz Canal Park from Mill Island, which is the most popular recreational area in the city centre, could be one of the factors limiting the number of visitors; this is especially true of calmer activities such as strolls or meeting with friends, as heavy traffic discourages from outside activities and social interactions (Appleyard & Lintell, 1971), thereby decreasing user transfers between these two areas. At the same time, the more linear character of the Canal Park still presents noticeable potential for sport activities such as jogging or cycling.

The strong support for canal reconstruction among Bydgoszcz inhabitants aligns with similar results in Breda, where people even demanded an increase in the scope of restoration (Huisman, 2007).

Despite high public support for reconstruction, even among people who have never heard about the canal infilling before, there are concerns about its feasibility due to the existing road network. Similar situations arose during projects already completed in other cities, where it was addressed by broader traffic policies, including increasing public transport coverage and general traffic calming in the project areas (Lee, 2006; Huisman, 2007; van der Toorn Vrijthoff & Heurkens, 2008).

Even local experts in the field of urban planning and inland waterways either could not name similar projects of buried waterways restoration at all or were limited to vague mentions of some locations but without being able to provide details, which seems to be a major obstacle for furthering public discussion and putting a reconstruction project on the municipal agenda.

Reintroducing watercourses and developing adjacent green areas in the city centres to replace impermeable road surfaces and restore more natural and semi-natural types of land use counteracts various adverse effect of urbanization (Pauleit & Breuste, 2011) and provides more ecosystem services, as they have one of the biggest potentials for that (Zepp et al., 2016). This also has significant potential for climate change adaptation by combating the urban heat island effect (Gill et al., 2007; Damyanovic et al., 2016) and improving water retention (van der Toorn Vrijthoff & Heurkens, 2008). Those positive impacts on local temperature, air quality, and biodiversity were confirmed by monitoring conducted in Seoul after the Cheong Gye Cheon river restoration (Lee, 2006). Municipalities that complete projects to reconstruct their lost waterways, besides environmental effects, reported increases in land value and business activity. This was attributed to the high quality of public spaces created by such projects. The

municipalities also highlighted the importance of the projects for place identity and heritage (Huisman, 2007). It is expected that the Old Bydgoszcz Canal reconstruction will have similar effects. Interestingly, despite the lack of knowledge on waterway reconstruction projects among local experts, when asked about the potential effects of restoration, their answers aligned with observed results from other cities.

Urban waterways restoration aligns with the broader goals of international frameworks aimed at improving quality of life and environment, such as The New Charter of Athens (ECTP-CEU, 2003), Leipzig Charter (European Commission, 2007) or Pact of Amsterdam (European Commission, 2016).

Although reconstruction of the Old Bydgoszcz Canal buried section is not included in municipal policies, it is well aligned with the general goals of several of them, including seven sectoral programmes of the Municipal Development Strategy (Bydgoszcz City Council, 2013). The re-established canal section, together with adjacent greenery, would also become a climate melioration channel, recommended for restoration (MPU, 2012). The project would also be part of the Programme for Revitalization of the Bydgoszcz Water Junction (MPU, 2006), expanding it and giving additional possibilities for tourism and cultural development. The additional elements of green and blue infrastructure proposed in the project could be implemented as being in line with the plan for climate protection and adaptation to climate change (Bartocha et al., 2010). Restoration of the Bydgoszcz Canal buried section could be used to increase international presence and cooperation with cities with similar experiences (Huisman, 2007), being a unique marketing tool at the international level.

The research faced time and resource constraints, so its scope had to be limited. As a next step, consultations on the conceptual design could be conducted, both with the public and with experts. These consultations could take the form of workshops and on-site visits, together with presentations of similar successful projects of waterway restoration in other cities to check whether there would be a change in attitude towards the general idea of the Old Bydgoszcz Canal reconstruction and the obstacles it faces.

The methods used in this research could be adapted to other, similar settings, especially where there is not yet an advanced project for recovering a buried waterway. Public surveys and interviews with local experts could provide insights into public expectations and, more importantly, identify concerns and perceived major obstacles regarding reconstruction. The

preparation of a conceptual design based on historic and current spatial social, and environmental conditions, and the attempt to consider all stakeholders' needs, show potential for mitigating those concerns. This research could act as a starting point for further discussion and analyses to find a socially acceptable and technically feasible method of waterway reconstruction in urban settings.

6. Conclusions

The example of the Old Bydgoszcz Canal buried section relates to many cities with similar historic relations towards their watercourses and present itself as a missing link in the city centre's spatial structure.

As successful projects for urban waterways restoration show, such projects could be used as a method for developing blue and green infrastructure in a city centre and improving quality of life and environment.

The survey conducted among Bydgoszcz inhabitants confirms that people often use urban green and water zones as important recreation areas, and that they are aware of their importance for ecosystems and quality of life.

Even local experts have limited awareness about waterway restoration projects successfully completed in other cities. That lack of knowledge, which also manifests in public concerns about canal restoration, seems to be a limiting factor for putting this project on the municipal agenda.

The proposed conceptual design shows the possibility for reconstruction of the Old Bydgoszcz canal buried section in a form that addresses major concerns by taking into account the spatial and social context.

Studies could be advanced by consulting on the proposed design via workshops that would include presentations of similar projects completed abroad in order to check any change in attitudes towards the possibility of the canal's reconstruction.

The studies presented in this paper, which combine public surveys and interviews with local experts, could help identify major concerns towards the reconstruction of urban waterways, which could be addressed by conceptual designs.

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