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THE ROLE OF RIVERS IN CREATING A BLUE-GREEN CITY ECONOMY ON THE EXAMPLE OF WROCLAW AND GDAŃSK

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ABSTRACT: The article aims to analyse and critically evaluate the use of blue-green infrastructure in the city. The study was conducted on the example of the Wrocław and Gdańsk rivers. An essential element of the analysis is to determine the possibilities of introducing and improving blue-green infrastructure by using good practices in these urban units, particularly those relating to the role of rivers. During the study, the following research questions were formulated: What megatrend of urban development is defined by current conditions, and what do urban units gain in this way? Is the blue-green potential of the examined cities effectively used? What is the state of development of blue-green zones in and around the river? The methods used to write the article are desk research, case study, analysis of the researched areas using up-to-date cartographic materials, IDI, literature, and legal status analysis. The study supports the exchange of information between cities and the management of the river in the city.

KEYWORDS: blue-green infrastructure, river, city, megatrends, development of land by the river

Introduction

In the modern world, cities face many challenges. Urban centres, in their strategies, often emphasise the need to strive for sustainable development (Zakrzewska-Półtorak & Pluta, 2022). However, the possibilities of implementing sustainable development are different and depend on the socio-economic situation in which the urban centre is located, what resources it has, what has been achieved so far in terms of sustainable development, and what advantages it can develop (Adamiczka, 2022). Many scenarios for implementing sustainable development are considered and introduced in the literature and practice. However, in the conditions of global climate change, environmental pollution, and changes in the preferences of city dwellers, aspects related to environmental protection, securing and creating green areas, spatial order, and maintaining the environment in at least intact or better condition become a priority for the city's economy (Griffiths & Sovacool, 2020). Thus, greenery, access to water, environmental protection, and care for the climate are increasingly becoming the guidelines for strategic urban development planning. In these conditions, the aspects of cities' green areas and the presence of rivers (with the necessary infrastructure for both) and their development are becoming critical. The article aims to analyse and critically evaluate the use of blue-green infrastructure in a city. The study was conducted on the example of Wrocław and Gdańsk. The selection of research objects was made due to the river's resources and green areas in riverside spaces in both cities as well as the approach to those resources in those centers. An essential element is determining the possibilities of introducing and improving blue-green infrastructure using good practices in these urban units.

During the study, the following research questions were formulated:

- What megatrend of urban development is defined by current conditions, and what do urban units gain in this way?
- Is the blue-green potential of the examined cities effectively used?
- What is the state of development of blue-green zones in and around the river? Can good blue-green infrastructure practices be transferred to other cities, and how?

The article examines Wrocław and Gdańsk – cities that have a blue-green resource, but their development scenarios are not similar, due to different conditions and resources. At the same time, both cities have been at the forefront of the Water City Index ranking for several years (Ćmielewski et al., 2021), evaluating Polish cities in crucial areas of water management in the city.

The methods used to write the article (desk research, case study, analysis of the researched areas using up-to-date cartographic materials, IDI, literature, and legal status analysis) are described below.

An overview of the literature: blue-green development as a megatrend in the global economy

The global economy is undergoing profound changes, resulting in new challenges being created for the world. New megatrends are emerging in the economy, and the previous ones are evolving. Changes in trends are due to many factors: the use of new technologies and techniques, technical progress, faster and more effective communication, virtualisation of economic phenomena and individual areas of life, the increasing level of innovation, investment, etc. (Griffiths & Sovacool, 2020). The consequences of these factors are of two types: positive (progress, quality, etc.) and negative (climatic and environmental changes, lifestyle diseases, etc.). Megatrends are complex phenomena that occur globally, concerning various spheres, and indicate directions of potential changes. Their modelling takes place over a long period and dramatically impacts the economy and the people providing guidelines for the future. People can influence the changes taking place, enhancing or weakening their effect. Adapting to these trends is essential, allowing one to use changes to achieve success. If such adaptation does not take place, it poses a threat to the functioning of the system and the human beings in it. Correct determination of trends allows one to identify threats and select tools with which one can try to remedy the situation. The attempt at anticipation helps to understand what may happen in the future. We make decisions from a pool of various possibilities, creating a projection of the future. In this way, we gain preparation for the conceptualisation of thinking about the future in the macro dimension. However, it is not an actual picture of the future, but a potential one. Megatrends have consequences at different levels, e.g., regional and local.

The transition from the industrial economy to the information civilisation has stimulated intensive changes in both economic and social, cultural, and political aspects, as well as emerging network connections. Contemporary climate challenges, migrations, polarisation, pandemics, etc., compound this. Therefore, the currently indicated megatrends are:

- world population growth,
- increasing population migrations,
- ageing of societies in developed countries,
- growing social polarisation,
- the growing middle class,

- increase in urbanisation,
- growing demand for energy,
- digitisation and automation of work,
- climate change,
- environmental pollution and loss of biodiversity,
- declining food security, rising international tensions,
- crisis of democracy and new models of governance (Polskie Towarzystwo Studiów nad Przyszłością, 2022).

Classifications of megatrends can be varied, and megatrends are also indicated within individual domains. The analysis of global megatrends can also be conducted from different angles. The impact of megatrends on the environment of Europe and its countries was defined by the European Environment Agency (EEA) in the methodological study “Mapping Europe’s environmental future: understanding the impact of global megatrends at the national level”, which, as part of issues related to ecosystems, food, water, energy, materials, and land has identified eleven global megatrends relevant to Europe (Eionet, 2017):

- the widening divergence of world population trends,
- towards a more urbanised world,
- changing disease burden and pandemic risk, ever-faster technological changes,
- steady economic growth,
- an increasingly multipolar world,
- intensifying global competition for resources,
- increasing pressure on ecosystems,
- increasingly severe effects of climate change,
- increasing environmental pollution,
- changing approach to governance (Główny Inspektorat Ochrony Środowiska, 2017).

Against the background of the classification of megatrends, the following aspects become particularly visible: environmental and climate change, which determines the concentration of actions of authorities, organisations, and people around these challenges. Therefore, the pursuit of sustainable development becomes the primary aspiration. Sustainable development is a concept defined in various ways. It refers to durability and immutability (emphasised by H.C. von Carlowitz (Lusawa, 2009)) and, according to the German school, economic benefits and ecological care (Veith, 2004). The Brundtland Report of the World Commission on Environment and Development entitled *Our Common Future* (United Nations, 1987) emphasises that development should meet today’s needs without compromising future generations’ ability to meet their needs (Morżoł, 2006). This approach is designed to ensure economic development, while maintaining social and

environmental balance. Therefore, a traditional approach to sustainable development has been based on three pillars: economy, society, and environment. In various periods, emphasis was placed on individual pillars but, in the face of unfavourable conditions, the economy and the profits resulting from it give way to environmental goals that are to serve society. Sustainable Development Goals evolve as challenges and threats to the world grow. In 2015, the U.N. member states adopted the 2030 Agenda by a resolution of the General Assembly – a global development strategy until 2030 (Transforming our world: the 2030 Agenda for Sustainable Development), which included 17 Sustainable Development Goals, defined in 5 areas: people, planet, prosperity, peace, partnership (UN, 2015). The goals of the 2030 Agenda are the end of poverty, zero hunger, good health and quality of life, good quality education, gender equality, clean water and sanitation, clean and accessible energy, economic growth and decent work, innovation, industry, infrastructure, fewer inequalities, sustainable cities and communities, responsible consumption and production, climate action, life underwater, life on land, peace, justice, and strong institutions, and partnerships for goals (Kampania 17. Celów, 2022).

The goals indicated in the 2030 Agenda directly or indirectly demonstrate the need to implement green and blue development. The blue-green megatrend affects the creation of space in which people can live better, and in the conditions of a deepening crisis, it can contribute to sustaining life. The crisis, mainly due to climate change, leads to droughts and constant water shortages, with the possibility of floods (including flash floods), which can be catastrophic for humanity.

In cities rich in rivers, unique development opportunities are created based on this resource. The blue resource of the city provides additional opportunities to survive crises, both spatial and climate-related. (Breś, 2019; Udas-Mankikar & Driver, 2021). The blue space is a place for the development of industry, transport, entrepreneurship, real estate, tourism, culture and art, sports, as well as fauna and flora. At the same time, it is a social space integrating various social groups; it can be a place of relaxation, respite, training, etc. The basis for implementing these functions is the appropriate development of rivers, coastal areas, and their surroundings. In cities rich in river resources, blue spaces are often associated with green areas; those units usually create a common policy towards these ranges due to the overlapping challenges in the blue-green conditions of how the city functions. From this perspective, green economy is one that affects the well-being of the population, the quality of its life, and social equality. At the same time, the environmental risk and consumption of natural resources are not increased; it is a more integrated and comprehensive approach to adapting the environment into economic processes (Janiszek, 2015). Hence, green development

assumes the economic development of the present generation without destroying the environment, without exhausting non-renewable resources, and preserving them for future generations – this means using efficient and environmentally friendly technologies and focusing on mitigating the effects of climate change. In turn, the blue economy refers to sectors related to the sea (European Commission, 2020) and, in a broader sense, also to rivers and other surface waters. Blue development of cities uses their potential to implement sustainable development. One of the elements of green and blue development is the introduction of green and blue infrastructure. Green Infrastructure (GI) is a nature-based system designed to regulate surface energy processes (achieved through evaporation, shading and emissivity regulation); it positively affects air movement and heat exchange (Almaaitah et al., 2021). Blue infrastructure (BI) consists of various types of water (natural and artificial) introduced in the city to slow down runoff, provide temporary storage, emit longwave radiation to cool surfaces, and effectively absorb short-wave radiation and release it through evaporation (Almaaitah et al., 2021). The blue-green infrastructure (BGI) is a network of areas covered with greenery and water-containing solutions based on natural functions (Sobol, 2021). These solutions positively affect the preservation of biodiversity, eliminating urban heat islands, absorbing CO₂, and also enable water storage, retention and recycling (Kus & Felski, 2018; Sobol, 2021). Moreover, solutions in the field of blue-green infrastructure (such as allocating part of the land for flooding, preserving wetlands, introducing various types of urban greenery – gardens, parks, greenery on the streets, parking lots, etc., introducing green roofs and vertical gardens, rain gardens, water retention facilities and others) are aimed at preventing floods and reducing their effects (Europejska Agencja Środowiska, 2019; Pietryka, 2020).

In these conditions, it is crucial to build a blue-green infrastructure. These investments become methods of preventing consequences in terms of climate change, weather anomalies, and droughts. In addition, in many places, periods of water shortage become continuous and worsen each year. Therefore, actions that increase resistance to these negative phenomena are essential. The potential of investment in blue-green infrastructure provides the basis for indicating it as a tool for preventing and counteracting adverse climate change, which is often indicated in the literature (Januchta-Szostak, 2020; Janiszek, 2015). Therefore, implementation of blue-green development strategies in urban space becomes particularly important.

In various divisions and approaches to megatrends pertaining to cities, the tendency towards urbanisation, climate change, and health threats becomes visible. In this context, the megatrend of the blue-green economy is developing in the cities (Adamiczka, 2022). Under this megatrend, the activities undertaken by urban centres are to serve as an antidote to threats to

those units. The green and blue development of cities is intended to lead to better air and environmental quality, improved health, creating space for rest and recreation, increased flood safety, counteracting droughts and flash floods, reducing the threats from heat waves, developing river quays and improving the quality of life (Spiller, 2020). Green and blue infrastructure should also prevent and/or reduce the likelihood of destruction of material goods, a threat to human life and health, the occurrence of strong winds and the consequences of their appearance. It could also stop the «concreting» of cities, or lead to their «un-concreting». The blue-green strategy of cities should serve as a «panacea» for climate change, inadequate spatial development, surface sealing, lack of green areas, and developing rivers and coastal areas, as well as function as a way to adapt to new weather conditions. The development of rivers and coastal areas can be multi-directional: while anti-flood measures are taken, a space for rest and recreation can also be created, which – in turn – can also be used for economic, communication, and art and culture purposes. The focus of the centres on implementing the blue-green approach is to introduce, develop and rebuild the blue-green infrastructure concerning reducing the adverse effects of heat and heavy rains in the city. These green spaces with trees, shrubs, and lawns, as well as blue spaces, e.g., water reservoirs, watercourses, and wetlands, function like a sponge and catch excess water that accompanies torrential rains; during dry periods they are a source of water for the surrounding areas. The water vapour above this surface improves the local microclimate, irrigates the vegetation, and enables water circulation in the environment. Water retention during torrential rainfall is also conducive to maintaining the ability of sewage systems to function. Concrete spaces heat up intensively, creating hot islands in the city; much cooler green areas lower the temperature and give respite to people and animals. Tall greenery, especially trees with broad crowns, provide shade, making it easier to survive periods of heat. They also shelter animals, especially birds and other organisms, creating conditions for biodiversity in urban spaces (Chmielewski et al., 2018). Trees can dissipate wind energy in their branches, serving as a protective barrier for urban buildings which can be destroyed during storms. All those elements build the resilience of cities to climate change.

Rivers are watercourses that can (and should) be a natural element of blue-green infrastructure in cities. However, their management in Poland is complex due to the division of competencies – they flow through the city managed by the local government, while being the property of the State Treasury under the management of the State Water Holding Polish Waters (Adamiczka, 2022). At the same time, comprehensive actions regarding mitigation and adaptation to climate and environmental changes are crucial for the proper functioning of modern cities.

Research methods

The river card¹ was used to carry out the study – a tool to study river policy in the city. The first section, which was used in this study, deals with climate and environmental action and contains ten topics. According to the card's instructions, when reflecting on a given aspect, one should mark the degree of agreement with the given statement on a five-point scale where:

- 1 – definitely not,
- 2 – rather not,
- 3 – partially,
- 4 – rather yes,
- 5 – definitely yes.

Based on individual in-depth interviews (IDI) with representatives of Gdańskie Wody (November 23, 2022) and the desk research method (including literature studies, research of documents, source materials, and legal acts), the method of chamber work using the results of direct and detailed inventory analysis of the studied areas using current cartographic materials, the first part of the card for the city of Gdańsk was completed. Then, the results were summarised in a table with the results for Wrocław (river chart completed based on information from the coordinator for river policy in Wrocław, representatives of the Department of Water and Energy, and representatives of the Department of Safety and Crisis Management; the data was supplemented with the results of the IDI research – with Coordinator for River Policy in Wrocław of July 7, 2021, and April 21, 2022, in-depth interviews among Wrocław residents, focus group interviews among students of the Wrocław University of Economics and two online surveys) [1]. For the surveyed cities, the indicator of the use of river potential (River Potential Utilisation Index – RPUI) was calculated in the climate and environment section, using the following formula:

$$RPUI = \frac{\text{sum of scored points}}{\text{sum of points possible to obtain}} \quad (1)$$

The card has been modified to allow for a comparison of cities. The data prepared in this way allowed the authors to conclude the possibilities of benchmarking and cooperation between Wrocław and Gdańsk to develop and improve their river policy.

¹ The river card was published in Adamiczka, H. (2022). *Wykorzystanie rzeki w kształtowaniu rozwoju społeczno-gospodarczego miasta* [Doctoral dissertation]. Uniwersytet Ekonomiczny we Wrocławiu.

Results of the research

The objects of the study are Wrocław and Gdańsk. Wrocław is the capital of the Lower Silesia Voivodeship; its area is 292.8 km², and the population numbers 642.9 thousand (Urząd Statystyczny we Wrocławiu, 2021). It is located in the south-western part of Poland, in the basin of the Middle Odra – the river Odra, together with its tributaries, forms a hydrographic network of over 100 km (LEMITOR, 2016). The main Wrocław's rivers are: Odra, Ślęza, Oława, Widawa and Bystrzyca.

Gdańsk is the capital of the Pomeranian Voivodeship; it is Poland's principal seaport. Its area is 262 km², and the population numbers 470,8 thousand (Urząd Statystyczny w Gdańsku, 2021). It is located in the northern part of Poland, on the southern edge of Gdańsk Bay. Gdańsk, Gdynia, and Sopot (located close to each other) form a metropolitan area. The main Gdańsk's rivers are: Martwa Wisła, Wisła Śmiała, Motława, Kanał Raduni (called Nowa Radunia), Stara Radunia (Rada Miasta Gdańska, 2018).

In the course of the research conducted in Wrocław and Gdańsk, the following results were obtained (Table 1):

Table 1. Ratings received by Wrocław and Gdańsk in the first section of the card of river

Aspect	Wrocław	Gdańsk
The degree of flood protection is sufficient	4	4
The degree of implementation of meanders, floodplains, and wetlands is sufficient	1	4
The degree of implementation of blue-green infrastructure is sufficient	3	4
Buried rivers are being restored to the city	None of the cities in question have buried rivers.	
The water collection system is sufficiently dispersed	2	5
The city implements a rain policy appropriate to climate change	5	5
Subsidies for water-saving solutions fulfil their role	5	5
Investments related to the river (e.g., regulation, hydro-technical structures, etc.) are carried out with responsibility for the natural environment (including the ecosystem)	5	5
The condition of the natural environment of river and riverside areas (including the ecosystem) is good	4	No data
Educational campaigns related to the river are organised in the city	5	4

The blue-green megatrend is one of the primary development directions of both cities.

The actions taken are based on age, and the scores obtained for Wrocław and Gdańsk are high.

Actions in the field of investments in flood defences aimed at protecting cities received a rating of 4, which indicates excellent progress in this area, but further work is also needed. In Gdańsk, part of the floodplains is located in built-up areas, which is the city's main problem. In Wrocław, a flood protection section was created, thanks to which protective actions are possible four days before the wave arrives.

Significant differences in the examined centres occurred in terms of the degree of implementation of meanders, floodplains, and wetlands is sufficient. Rating 1 for Wrocław and 4 for Gdansk. Such a low rating of Wrocław is caused by the earlier investment process and the city's „turning its back” on rivers. In Gdańsk, the economy, in this regard, respects the river and its significant importance for the city's development. Meanders, floodplains, and wetlands are not only of importance in terms of flood protection, but they also maintain air humidity in the long term, providing a lower temperature and shelter for organisms.

The degree of implementation of blue-green infrastructure is sufficient, although these cities received different ratings (Wrocław 3; Gdańsk 4). The degree of implementation of blue-green infrastructure is better in Gdańsk than in Wrocław.

The problem of Gdańsk is the uneven distribution of greenery, which means that not all residents have comfortable pedestrian access to these areas. However, a plan is in place to equip selected allotment gardens with basic recreational infrastructure and make them available as urban spaces. A similar solution could be implemented in Wrocław, especially since allotment gardens in this city cover an area of over 1.4 thousand square metres.

In addition, blue-green infrastructure is being created in Gdańsk through a modern approach to rainwater management. The urban retention system is exceptionally developed and consists of a reservoir, field, street, household, and urban green retention. All these elements complement each other and create a blue-green infrastructure protecting against floods and droughts. Wrocław should develop a retention system, especially at home, to maintain the „blue” part of the discussed infrastructure, especially since the „green” part is being systematically expanded in this city. Despite the poor result, Wrocław's movements towards developing blue-green infrastructure can be observed. Among others, two acts of local law are in force – on rainwater management in Wrocław and on standards for planning and designing streets in the green and blue infrastructure field. New urban investments are designed considering the green and blue infrastructure, and catalogues of good rainwater management practices are available on the website. Provi-

sions regarding green and blue infrastructure are also introduced in updated and new local plans.

In Wrocław the water collection system is insufficiently dispersed, while Gdańsk received the highest score in this area.

Both urban centres received the highest marks regarding the appropriate implementation of the rain policy to climate change, which significantly directs them to implement tasks related to green and blue development.

Care for the green and blue development of cities means that investments related to the river (e.g., regulation, hydro-technical structures, etc.) are carried out with responsibility for the natural environment (including the ecosystem) and the condition of the natural environment of river and riverside areas (including the ecosystem).

An essential element of the policy of green and blue development of Wrocław and Gdańsk are educational campaigns related to the river, which are to make city users aware of the need to have high-quality green areas and rivers along with riverside areas. Wrocław's rating in this respect is higher than Gdańsk's.

Discussion/Limitation and future research

All activities in shaping and planning blue and green infrastructure and other projects make up the city's blue-green economy. The aspects of the city's effective economy in terms of blue and green infrastructure indicated in the literature need to provide a complete picture of the challenges faced by city authorities. Trying to ensure development, they should consider that the environment is changing rapidly and anticipate the negative character of those changes. At present, these needs should be emphasised in the literature. At the same time, the literature often considers individual challenges related to the city's blue and green economy. However, it disregards other factors (which makes those studies incomplete). On the one hand, this has advantages due to the multithreading of the topic. On the other hand, such an approach to the issue of the city's blue and green economy requires a holistic view and can often lead to ignoring the effects of synergy.

Research on blue-green urban development is currently being conducted extensively. However, tools for a holistic analysis of river and riverside development have yet to be developed. The proposed tool in the form of the river card and the developed indicator of the use of river potential allow not only to carry out the following assessment, but also to make comparisons between cities. In today's conditions, city policies towards greenery and rivers should be considered as fundamental challenges, so research should be continued and extended to other cities. The conducted study is qualitative; therefore, it

is necessary to conduct a quantitative study in subsequent analyses. In addition, due to various research possibilities, not all procedures performed in Wrocław (e.g. focus group study) were carried out simultaneously in Gdańsk. In further research, the research should be detailed.

Conclusions

The following conclusions were drawn from the study:

In the current global economic climate, the blue-green economy is becoming a significant development trend. About 55% of the global population already live in cities, and it is forecast that, by 2050, it will be 68% (Nosarzewska, 2021). These conditions indicate the particular importance of green and blue urban development. Cities' green areas, rivers, and riverside areas are becoming multifunctional. The investment process in the field of green and blue infrastructure is therefore necessary.

Wrocław and Gdańsk are active in the green and blue development fields, but the effects of these activities vary.

The essential deficiencies in Wrocław concern the degree of implementation of meanders, floodplains, wetlands, the degree of implementation of the blue-green infrastructure, and the water collection system.

Gdańsk received a score not lower than 4 in all the aspects examined, indicating intensive actions taken by the authorities in the green and blue development field using the river.

Wrocław and Gdańsk should continue activities related to green and blue development, with Wrocław paying particular attention to the resource and the potential of the river.

The contribution of the authors

Concept, D.R. and H.A.; literature review, D.R.; acquisition of data, H.A.; analysis and interpretation of data, D.R. and H.A.

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