

THE STATE AND DEVELOPMENT NEEDS OF THE TRICITY AGGLOMERATION INFRASTRUCTURE FACILITIES

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Purpose: The paper aims to examine the state of infrastructure facilities and its impact on the prosperity of Tricity.

Design/methodology/approach: A literature review was carried out, monitoring and analysis of statistical data on the condition of infrastructure facilities in the Tricity agglomeration, as well as some other regions of Poland, was carried out, which also made it possible to compare the situation in Tricity with that places.

Findings: The analysis of statistical data shows the problems of traffic congestion and the need to develop the road network in the Tricity agglomeration, as well as the need to develop the cycleway network. An analysis of the characteristics of the water and wastewater infrastructure of the Tricity agglomeration shows its good condition and revealed the presence of a reserve of capacity to unlock the economic potential of the region.

Practical/social implications: Identifying the needs for the development of road networks in the region is of practical importance for both local authorities and local society. The presence of a problem should pose a task to find its optimal solutions, which requires both physical capabilities and financial resources.

Originality/value: This study emphasizes the importance of analyzing the state of the infrastructure of a specific region, in this case, the Tricity agglomeration. The ratio of the population to the quantitative indicators of certain types of infrastructure facilities, as well as other methods of analyzing available statistical data, made it possible to identify both problems and development prospects.

Keywords: infrastructure, Tricity agglomeration, road network, cycling routes, water consumption.

Category of the paper: Research paper.

1. Introduction

An essential prerequisite for fully unlocking the potential of the regional economy and ensuring its competitiveness is a well-developed infrastructure. Infrastructure as a set of conditions ensuring the development of entrepreneurship in the main sectors of the economy

and meeting the needs of the entire population is a complex and multifaceted system consisting of many elements.

There are various types of infrastructure, including transport, multimodal, water supply and sanitation, communications, technical, innovation, security and others. The peculiarity of infrastructure is its interconnectedness with almost all other sectors and economic actors. The importance of minimising transport costs for the development of regional economies is emphasised by Krugman (1991). Transport infrastructure connects producers, suppliers and consumers, thereby creating opportunities for other sectors of the economy. Insufficient transport capacity, on the other hand, hinders regional development when goods cannot be delivered at all or in the required quantities. Puślecki (2023) notes that the need for efficient management of transport and energy costs for businesses defines and shapes regional supply chains. Infrastructure development is designed to achieve both economic and social outcomes. Water availability is not only a vital resource for the population, but also for the development of industry and the economy as a whole, which reflects the scale of risks in case of imbalances in the state of water supply and wastewater infrastructure.

Considering the issue of infrastructure factor from an economic point of view, the main objective of infrastructure is to enable, facilitate and streamline the movement of goods and services in the national economy. An important aspect of the infrastructure issue is also its direct relationship with the pace of technological and economic development, and as a result of a mismatch between the pace of infrastructure development and the pace of economic growth, the potential of the economy may be blocked.

Therefore, the contribution of the infrastructure factor to economic activity is an important issue, which determined the purpose of this study. The state of infrastructure in particular regions depends on a number of determining factors such as, for example, the efficiency of infrastructure management, the ability to finance capital-intensive infrastructure investments and the long-term development plans of the region. The aim of the study is to examine the state of infrastructure facilities and its impact on the prosperity of Tricity.

2. Literature review

Providing efficient and adequate infrastructure plays an important role in economic and social development. "There is broad consensus among economists and politicians that public infrastructure for firms is an important aspect of competitive location policy" (Egger, Falkinger, 2006, p. 1994). Developed infrastructure in the region and the country in general has many obvious as well as hidden positive effects (Rana, Bhatti, e Saqib, 2017; Gao et al., 2019; Ishikura, 2020; Klapita, 2024). Longo et al. (2015) noticed an increase in physical activity and a qualitative change in health attitudes with improved walking infrastructure. Giacomantonio,

Mitra & Ravensbergen (2024, p. 1) linked gender to decision-making under different cycling infrastructure conditions and found that “women likely cycle more frequently in neighbourhoods with a bicycle facility”. According to Kempa & Banasik (2023), for the comfort of the inhabitants and the creation of smart cities it is necessary to analytically approach the provision of bike-sharing stations. Also “residing near social infrastructure is positively associated with subjective wellbeing” (Zahnow, 2024, p. 1). He et al. (2024) emphasise the importance of infrastructure resilience in relation to climate change and increased risk of natural disasters.

Medury, Zhang & Durango-Cohen (2015) point out that even when infrastructure is developed, special attention needs to be paid to its state and its management, as infrastructure may be reaching the end of its useful life and may need to be replaced or reconstructed. With the spread of digitalisation, the idea of smart cities, where the management of infrastructure, energy and other systems is optimised with the help of advanced technologies, is becoming relevant (Gajdzik et al., 2024; Wolniak, Stecuła, 2024).

The results of the study on the current trend of rapid urbanisation and agglomeration growth showed the emergence of a “significant detrimental interactive effect between governance and urban infrastructural services on human well-being” (Maket, Kanó, Vas, 2024, p. 1). “The quality of accessing urban infrastructural services such as water, energy, and sanitation plays a pivotal role in enhancing the human well-being of the urban population and the entire economy” (Maket, 2024, p. 12). Ramaswami (2020) argues for the critical importance of providing the necessary level of various types of infrastructure to create livability in the realities of the appearance of more and more agglomerations.

Poland is also undergoing urbanisation processes, and the consolidation of cities into agglomerations creates additional benefits for residents and economic development in the region. The synergy of merging cities creates additional potential, which “attracts investors from home and abroad, offers modern workplaces and diverse educational opportunities at every level of education” (Balcerowicz, 2023, p. 11). However, in addition to positive features, agglomerations face additional risks to urban resilience, many of which are related to the infrastructure factor. For example, Wojewnik-Filipkowska, Gierusz-Matkowska, & Krauze-Maślankowska (2023, p. 248) highlight the following problems in the agglomeration of Tricity:

- “lagging adaptation of the transport system and technical infrastructure systems, transport problems in the areas of transit, integration hubs, parking systems, interconnectivity of transport systems and their coherence for the cities of TriCity, and exhaustion of transport potential;
- uncontrolled urban sprawl”.

There are many studies on infrastructure in the Tricity, most of which deal with maritime infrastructure and energy infrastructure (Wojewnik-Filipkowska, Koszarek-Cyra, Nawrocka, 2023; Trzciński, Próchniak, 2023; Płoska et al., 2023; Czernański et al., 2024; Dąbrowski, Klimek, Rolbiecki, 2023). Soldatke, Sydorów & Żukowska (2024) have assessed the

accessibility of public transport in the Tricity, which is of particular importance for achieving sustainable development in the region.

Studies on transport and transport infrastructure in the regions and in Poland as a whole allow assessing the efficiency and identifying difficulties in specific areas of activity (Fajczak-Kowalska, Tokarski, 2023, 2024). The research that Jurczak (2024, p. 448) carried out regarding different regions of Poland has confirmed “the thesis on the pro-development role of railway infrastructure and air transport infrastructure.” When considering the level of development of different regions of Poland, the accessibility of various types of infrastructure for persons with special needs is of particular importance, to which Wolniak & Skotnicka-Zasadzień (2021) devoted their study.

While most authors emphasise the importance of having an improved, well-designed infrastructure for the well-being and development of regions, specific characteristics and features are also an important aspect (Cieśliński et al., 2024; Stepanok, Kędzińska-Szczepaniak, 2023; Krukowicz et al., 2021). Comparison with other regions of the country provides an opportunity to identify some country-wide trends and to identify the specificities inherent in individual locations.

3. Selection of regions for comparison

Szreder (Szreder, 2022, p. 45) emphasises that “data and numerical measurements - although they are considered accurate and unambiguous - are only an imperfect reflection of reality, a simplified picture of the real phenomenon they characterise”, but narrative, analysis as well as comparison of data provide additional opportunities for understanding the real economic situation. For a general definition of the economic situation in different regions of Poland, the share of individual voivodships in the gross domestic product (GDP) of the country will first be compared (Figure 1). Due to some limited information regarding infrastructure facilities, data for 2021 is taken for comparison.

The Pomeranian Voivodeship, in which the Tricity region is located, has a significant contribution to the country's GDP, ranking in the middle of other voivodeships. Comparing the share of voivodeships in the country's GDP, it should be noted that the largest contribution (22.7%) comes from the Mazowieckie Voivodeship, where the capital of Poland is located, while the smallest (2%) comes from the Opolskie Voivodeship, whose population in 2021 is only 948,583. The Pomeranian Voivodeship has a 6% share of the country's GDP, as does the Łódzkie Voivodeship, and these voivodeships rank 6th among all voivodeships. The Lesser Poland Voivodeship, with a population of 3,430,370 in 2021, ranks 5th.

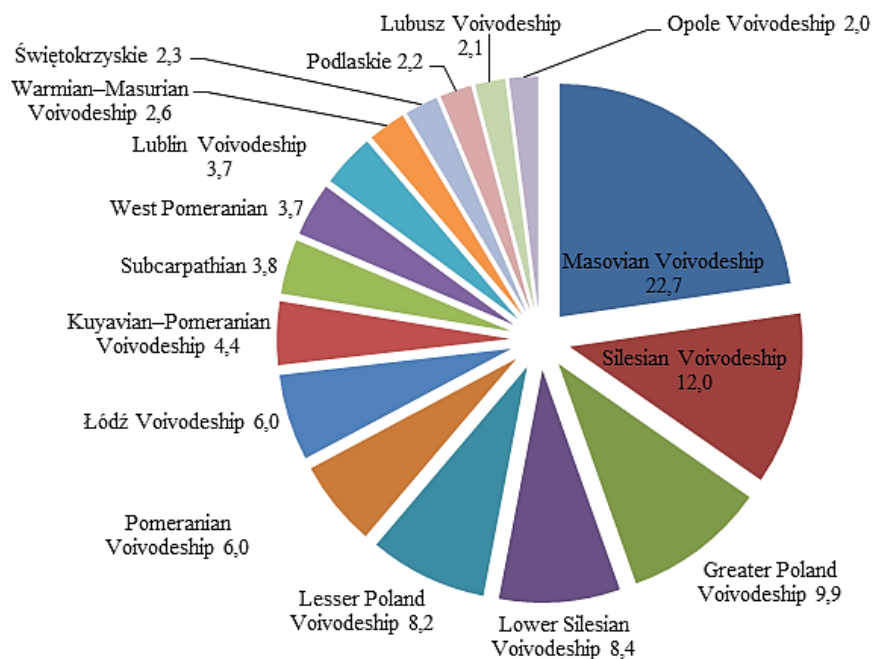


Figure 1. Share of voivodships in Poland's GDP in 2021, %.

Source: Statistics Poland, Local Data Bank, own compilation.

However, given that the population of the voivodships is different, it is also worth considering and comparing the GDP per capita of the voivodships in 2021 (Figure 2). When comparing GDP per capita, the Opolskie Voivodeship ranked 10th out of 16 voivodships, the Mazowieckie Voivodeship retained the first place, and the Pomeranian Voivodeship overtook the Łódź and Małopolskie Voivodeships and ranked 5th. The lowest value of GDP per capita in 2021 was in Lubelskie Voivodeship.

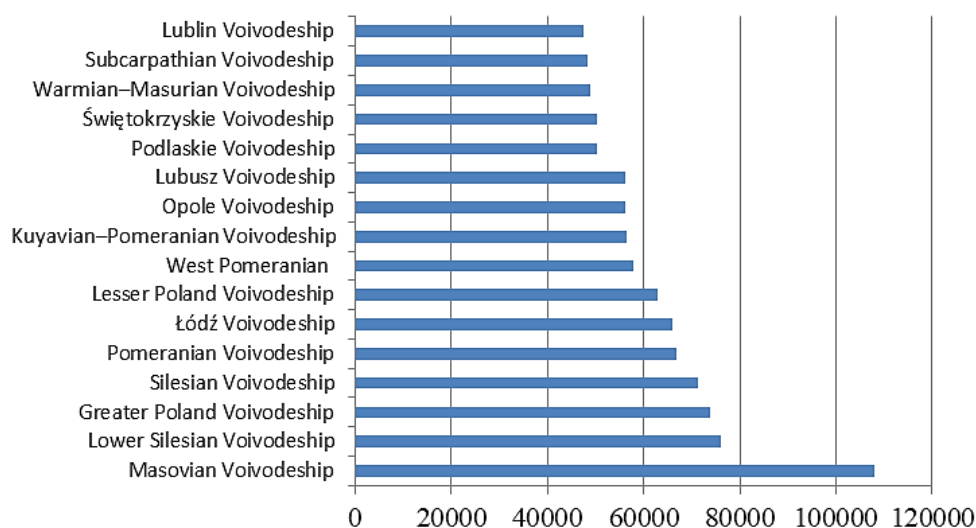


Figure 2. Gross domestic product per capita (current prices) in PLN, 2021.

Source: Statistics Poland, Local Data Bank, own compilation.

In this study, the Tricity region refers to the urban complex of Gdańsk, Gdynia and Sopot, which will also be referred to as the Tricity agglomeration. Due to the fact that rural areas may have specific problems and infrastructure needs that are not typical for cities, rural areas will be excluded from the comparison with the Tricity region. The Tricity agglomeration includes the regional capital, coastal port cities, well-known resorts, industrial and innovation centres. The Tricity agglomeration is a combination, partnership, co-operation and synergy of very different cities, indicating the need to select a broad group of different cities for comparison.

According to the criterion of similarity of GDP in Łódź, Lesser Poland Voivodeship and Pomeranian voivodships, the capitals of these voivodships, i.e. Łódź and Kraków, were selected for comparison with Tricity. The lowest value of GDP per capita in 2021 was in Lubelskie Voivodeship, so the state of infrastructure in the capital of this voivodeship is of interest. Mazowieckie Voivodeship, on the contrary, had the highest value of GDP per capita in 2021, which also indicates a possible special state of infrastructure in the capital of this voivodeship. Thus, Lublin and Warsaw are included in the group of cities for comparison. The share of Opolskie Voivodeship in the country's GDP in 2021 was the lowest, but in terms of GDP per capita the situation in the Voivodeship was more attractive, which is the reason for selecting Opolskie in the group of cities for comparison. The Podkarpackie Voivodeship is no less interesting, whose GDP share is not the lowest in the country, but in terms of GDP per capita it is on the penultimate place. The capital of Podkarpackie Voivodeship Rzeszów and the town with powiat rights Przemyśl were chosen to a comparison group. Due to the probability of specific effects in the functioning and use of infrastructure due to the merging of cities into agglomerations, the Bydgoszcz-Toruń agglomeration (which in this study includes only Bydgoszcz and Toruń) was selected for comparison. The study includes Szczecin, which is a port city and the capital of the West Pomeranian Voivodeship, and Swinoujście, which, like Sopot, is a small town and a popular holiday resort.

4. The state and role of infrastructure in Tricity and selected regions

The competitiveness of regions depends on the balance between structures and industries, which requires identifying imbalances and removing bottlenecks (Kotlewski, 2022). Transport infrastructure plays a crucial role in the development of regional and national economies. Since time immemorial, geographically favoured regions have thrived because of their ability to pool resources efficiently, which increases their productivity and leads to economic growth and prosperity. A well-developed transport infrastructure expands economic space and enables the potential of many other sectors of the economy to be harnessed. In addition to indirectly influencing regional prosperity, transport infrastructure provides

significant employment and creates value added in the transport sector (Meersman, Nazemzadeh, 2017; Clark, 2007; Guerra, 2015).

Transport infrastructure includes networks and systems that create opportunities for the operation of all possible modes of transport. An important condition for the development of passenger and freight transport is the quality and quantity of roads, which also affects the convenience, comfort and journey time. An analysis of the factors determining car ownership in Poland has shown that "apart from factors of purely economic nature, the number of registered cars is influenced by spatial factors such as population density, type of construction and daily daily traffic flows" (Kudlak et al., 2023, p. 167).

A synthesis study of the spatial syntax and hierarchical linear model of Tsou et al. (2015) showed the great importance of the spatial impact of different road networks on the scale of local development, highlighting the importance of road network issues and regional transport planning (Yang et al., 2017).

Figure 3 shows the calculation of the number of inhabitants per 1 km of hard-surfaced district roads, for the years 2012-2021 in the Tricity Agglomeration and the regions under consideration. The calculation of the growth rate of the number of inhabitants per 1 km of hard-surfaced roads for 2021 in relation to 2012 showed a value of 8.1% in the Tricity Agglomeration, which may be indicative of insufficient road capacity and congestion. Almost all other regions had a negative value for the growth rate, which indicates the need to pay special attention to the road problem in the Tricity Agglomeration compared to other regions. The best dynamics were in Opole (-30.6%), Przemyśl (-15.6%), Lublin (-14.7%) and Warsaw (-11.5%).

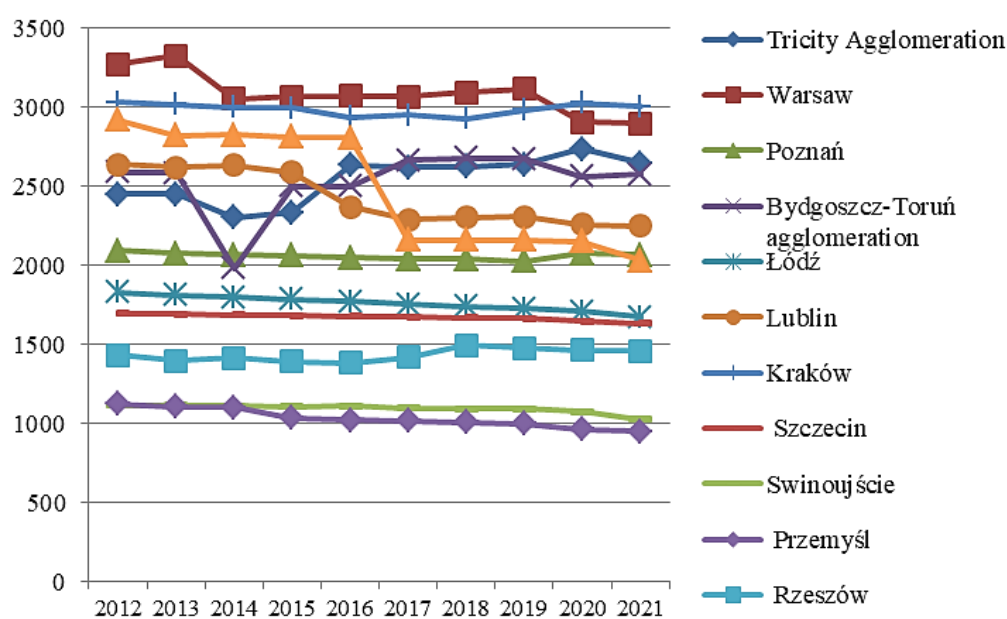


Figure 3. Number of inhabitants per 1 km of hard-surfaced district roads, pers./km.

Source: own calculations based on data at www.stat.gov.pl (Local Data Bank).

Figure 4 shows the calculation of the number of inhabitants per 1 km of improved hard-surfaced district roads, for the years 2012-2021 in the Tricity Agglomeration and the considered regions. The situation for this type of road is almost identical to that for hard surfaced roads in all regions under consideration. The calculation of the growth rate of the number of inhabitants per 1 km of improved hard-surfaced roads for 2021 in relation to 2012 showed a value of 8.4% in the Tricity Agglomeration, which is the worst result among the regions under consideration and which emphasises the need to expand the road network in the Tricity Agglomeration in comparison to other regions. At the same time, it should be noted that investments in infrastructure when there are infrastructure gaps lead to positive multiplier effects (Abiad et al., 2016). Capital investment in road systems and networks leads to direct and indirect economic benefits that influence regional economic development (Salim et al., 1999). Thus, the improvement of transport infrastructure, with a carefully designed economic and technical approach, will contribute to the synthesis of regional prosperity and development.

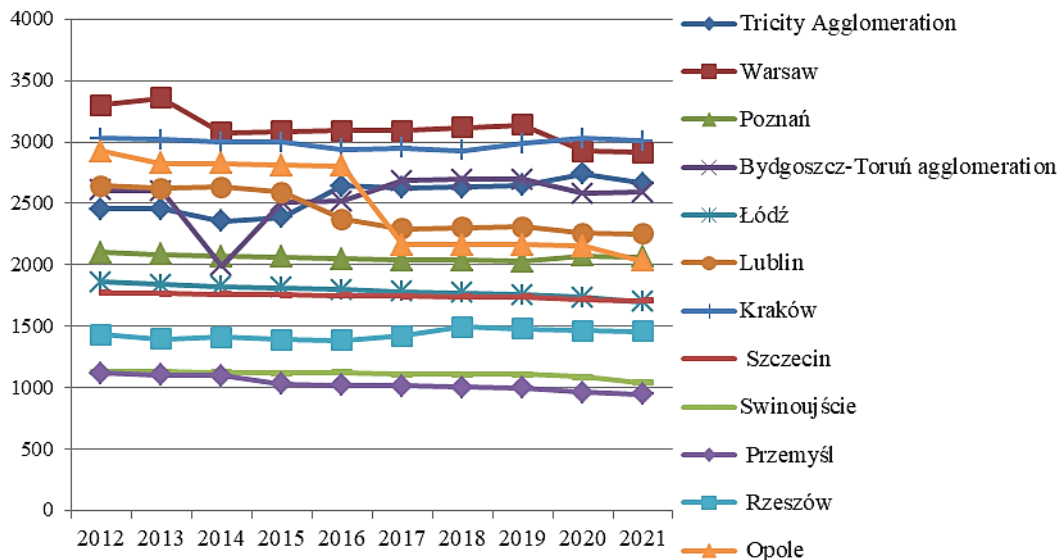


Figure 4. Number of inhabitants per 1 km of district roads with improved hard surfacing, pers./km.

Source: own calculations based on data at www.stat.gov.pl (Local Data Bank).

In the context of the modern concept of sustainable development, vehicles that are an alternative to internal combustion engine vehicles are becoming increasingly popular. The population chooses bicycles, electric scooters as an economical and healthy mode of transport (Hardinghaus, Weschke, 2022). The development and spread of cycling is largely dependent on cycling infrastructure, the basis of which is roads specifically dedicated and created for bicycles. Figure 5 shows how the availability of bicycle routes in the Tricity agglomeration and in the other regions considered has changed over the decade. The length of roads for cyclists increased during this period in all regions considered, where in the Tricity agglomeration - 1.7 times, in the Bydgoszcz-Toruń agglomeration - 1.9 times, and for comparison in the smaller cities of Opole and Przemysł - 3.3 times.

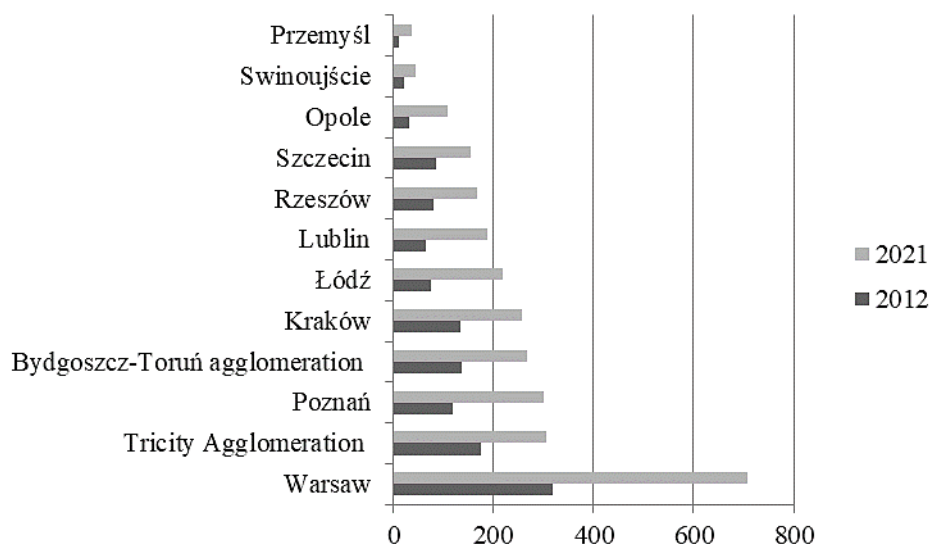


Figure 5. Length of cycling routes, km.

Source: Statistics Poland, Local Data Bank, own compilation.

Taking into account the rate of population per 1 km of cycling routes it is also important to emphasise its dynamics in the last decade in all regions under consideration. The data in Table 1 illustrate, that the availability of cycling routes for the population is higher in cities with smaller population. When considering the Tricity agglomeration against other regions in terms of that indicator it should be noted, that it does not belong to the outsiders. However, with one of the best lengths of cycling routes, their availability rate per population indicates the need for further development of the cycling network.

Table 1.

Accessibility of cycling routes to the public

	Tricity Agglomeration	Warszawa	Poznań	Aglomeracja bydgosko-toruńska	Łódź	Lublin	Kraków	Szczecin	Świnoujście	Przemyśl	Rzeszów	Opole
Number of inhabitants per 1 km of cycling routes in 2021, pers./km	2663	2916	2065	2591	1700	2251	3007	1708	1040	947	1457	2032
Dynamics of rate of number of inhabitants per 1 km of cycling routes, 2021 to 2012, %	59	51	60	52	68	67	45	46	54	73	47	68

Source: own calculations based on data at www.stat.gov.pl (Local Data Bank).

An important infrastructural factor influencing the prosperity and development potential of a region is the availability of water. Water and wastewater infrastructure is one of the priority areas for ensuring security, both socially and economically (Rising et al., 2022; Sun et al., 2023; Köster, 2021). Discrepancies between needs and water supply, technical constraints, failures in water supply networks carry the risk of water shortages, which are a dangerous threat to the population.

The comfort of residents largely depends on the availability of drinking water, including its free availability in public places, which is provided by street spigots. According to the Local Data Bank of Statistics Poland, in the TriCity Agglomeration in 2021 the number of street springs increased by 17.5% compared to 2020, while in other regions their number remained unchanged or even decreased. Figure 6 illustrates that household water consumption per capita in 2021 in the TriCity Agglomeration is neither economical nor excessively wasteful compared to other regions. Namely, in the Tricity Agglomeration, household water consumption per capita in 2021 was practically at the same level as in Poznań, Rzeszów and Łódź, 9% lower than in Kraków and 28% higher than in Przemyśl.

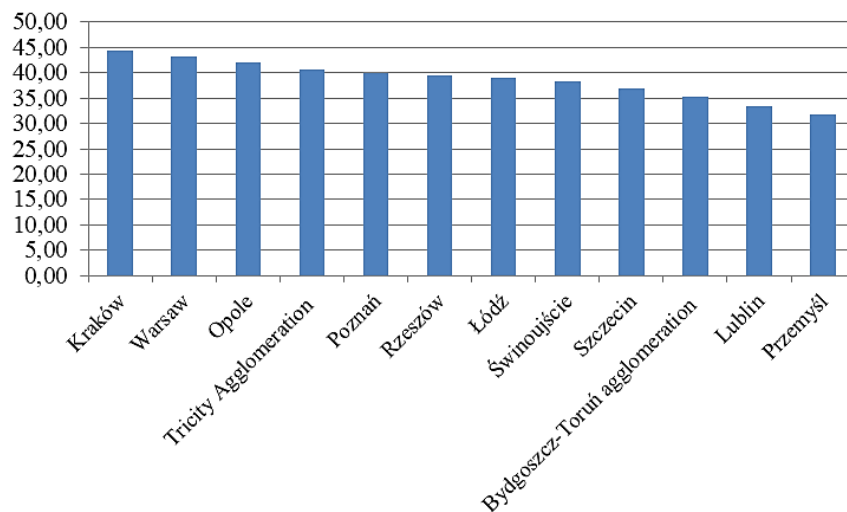


Figure 6. Household water consumption per capita in 2021, m³.

Source: Statistics Poland, Local Data Bank, own compilation.

An important indicator of water and wastewater infrastructure is the daily production capacity of operating facilities of the entire water supply system, which shows whether there are technical barriers to economic development and makes it possible to predict the risks of their occurrence in the event of an increase in demand for water in the future. The daily production capacity of the operating facilities of the entire water supply system in 2021 for the regions under consideration is shown in Figure 7. Comparison of this indicator in the TriCity Agglomeration with other regions indicates its high status and reflects a significant reserve for potential industrial development and growing water demand of the region's population.

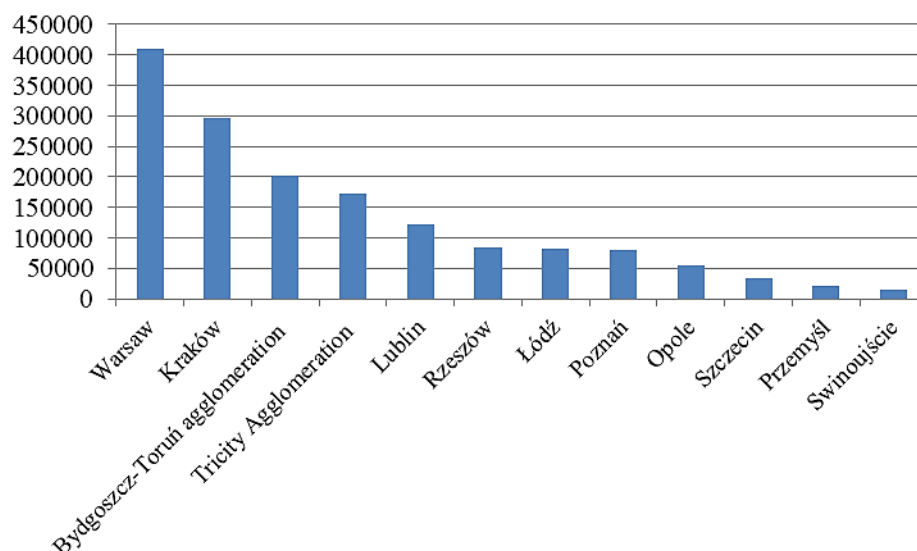


Figure 7. Daily operating capacity of the entire water supply system in 2021, m³/d.

Source: Statistics Poland, Local Data Bank, own compilation.

In order to analyse the qualitative condition of the water and wastewater infrastructure, it is also necessary to consider the indicators of the share of water losses in the total volume of water supplied and the number of water supply network failures per 1 km of water supply network (Table 2). Comparison with other regions shows that in the TriCity Agglomeration water losses are not high and the number of water supply network failures remains at an average level. The share of water losses in the total volume of water supplied is lower than in the Tricity Agglomeration only in Łódź, and the number of water supply network failures in the Tricity Agglomeration is 2 times lower than in Kraków and Przemyśl, but 2 times higher than in the Bydgoszcz-Toruń Agglomeration, Swinoujście, Rzeszów and Opole.

Table 2.

Indicators monitoring the status of water and wastewater infrastructure, 2021

	Tricity Agglomeration	Warszawa	Poznań	Aglomeracja bydgosko-toruńska	Łódź	Lublin	Kraków	Szczecin	Świnoujście	Przemyśl	Rzeszów	Opole
Share of water losses in the total volume of water supplied, %.	7,5	13,1	8,2	15,8	5,8	11,1	15,9	9,9	9,5	32,7	13,8	12,6
Number of water supply network failures per 1 km of water supply network, pcs.	0,4	0,35	0,29	0,2	0,50	0,53	0,81	0,50	0,19	0,88	0,20	0,18

Source: own calculations based on data at www.stat.gov.pl (Local Data Bank).

Water resources are crucial to the well-being of the region, which requires not only efficient management of water resources but also the maintenance of an adequate level of infrastructure (Vörösmarty et al., 2021). The analysis of the empirical data and its comparison with other selected regions showed that the water and wastewater infrastructure in the TriCity Agglomeration is at a fairly good level, does not create barriers to the current volume of consumption and even has some reserves for the future, which opens up prospects for the region's development.

5. Conclusions

The peculiarity of the contribution of the infrastructural factor to economic activity is its interconnection and penetration into all economic and social spheres of the region. A high level of infrastructure development is associated with prosperity and economic development of the region, but does not guarantee it. Therefore, identifying bottlenecks and gaps in infrastructure is of particular importance. At the same time, it is important to realise that if infrastructure development is sufficient and high, the nature of its financing should be supportive rather than incremental in order to avoid imbalances and irrational spending.

The analysis of the transport infrastructure of the Tricity agglomeration in comparison with other regions considered showed a relatively high congestion of hard-surfaced district roads and district roads with improved hard surfacing and an increase in the number of inhabitants per 1 km of those roads between 2012 and 2021, indicating the need for road network development there. The length of cycling routes has multiplied over this period and Tricity compares favourably with other regions considered for this indicator. However, the indicator of road accessibility for cyclists per number of inhabitants indicates the need for further development of the cycleway network in the Tricity agglomeration.

An important infrastructural factor affecting the prosperity and development potential of the region is the availability of water. An analysis of the characteristics of the water and wastewater infrastructure of the Tricity agglomeration showed its good condition and revealed the presence of a reserve of capacity to unlock the economic potential of the region. Tricity agglomeration is also favourably distinguished by the dynamics of growth in the number of street springs, which positively affects the comfort of life in the region.

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