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ANALYSIS OF THE LEVEL OF ACCESSIBILITY OF THE TRANSPORT INFRASTRUCTURE IN THE CITY AND WAYS TO IMPROVE IT

АНАЛІЗ РІВНЯ БЕЗБАР'ЄРНОСТІ ТРАНСПОРТНОЇ ІНФРАСТРУКТУРИ МІСТА ТА ШЛЯХИ ЇЇ ВДОСКОНАЛЕННЯ

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Summary. *The article examines the accessibility of transport infrastructure in Rivne, focusing on low-mobility groups, such as people with disabilities, the elderly, and those with temporary physical limitations. It identifies key barriers limiting mobility, including a lack of low-floor buses, inadequate public transport stops, and poor condition of sidewalks and pedestrian paths. These barriers lead to significant social and economic challenges. The research, based on a sociological survey, finds that the accessibility level of Rivne's transport infrastructure is 60%, which is average. The main issues are inaccessible public transport stops, sidewalks, and insufficient infrastructure for cyclists. To improve the situation, attention must be given to enhancing physical accessibility, upgrading stops, and implementing modern technologies. Achieving European accessibility standards requires a more inclusive approach to urban transport development, involving citizens in planning for equal opportunities.*

Keywords: *barrier-free, transport infrastructure, low-mobility groups, accessibility, public transport, bicycle infrastructure, barrier-free index.*

Introduction.

Transport infrastructure is an important component of the urban environment, which affects the quality of life of residents. Accessibility of public transport and transport facilities is a determining factor in social integration, especially for low-mobility groups of the population, including people with disabilities, elderly citizens, and people with temporary limitations of physical activity. The availability of a barrier-free environment contributes not only to mobility, but also to social equality, allowing all citizens to move freely and use transport services on equal terms.

However, despite the growing attention to the barrier-free access, the urban

transport infrastructure of many cities in Ukraine, including Rivne, remains insufficiently adapted to the needs of citizens with reduced mobility. The insufficient number of low-floor buses, the lack of properly equipped stops, and the unsatisfactory condition of sidewalks complicate the daily movement of a significant part of the population. These problems become even more relevant in the context of growing social challenges, in particular, given the changing demographic structure of the population and the need to create an inclusive urban environment.

Analysis of resent research and publications. The development of accessible transport infrastructure is essential for social equality and inclusivity in cities. Over 15% of the global population has a disability, and inadequate transportation conditions limit their participation in public life [1]. The EU has been implementing barrier-free standards for over two decades, improving urban transport for people with disabilities, the elderly, and parents with strollers [2].. In Ukraine, particularly in Rivne, transport accessibility remains a challenge. Only 20% of public transport meets barrier-free standards, with many stops lacking ramps and low-floor buses and trams being scarce [3]. This issue has social and economic implications, as limited mobility hinders employment, education, and regional economic development. To improve mobility, Ukraine needs to adopt European standards for barrier-free transport, including updating the transport fleet, adapting urban infrastructure, and increasing funding for inclusive transport [4-7]. World practices show that barrier-free infrastructure requires legal initiatives, technical solutions, and financial support. While progress is being made in Ukraine, more needs to be done to meet high European standards.

This research aims to analyze Rivne's transport infrastructure, identify key issues that hinder mobility for low-mobility groups, and suggest solutions for better social integration. Adapting infrastructure for these groups is an urgent task, as insufficient adaptation exacerbates social challenges.

Despite its importance, Rivne's transport infrastructure still does not meet modern barrier-free standards, creating difficulties for people with disabilities. Transport accessibility is not only a social issue but an economic one, as it affects participation in public life, employment, and education.

Studies emphasize the importance of integrating international experience and innovative technologies to ensure barrier-free transport. Research on transport accessibility in East Asia, the Pacific, the USA, and Europe highlights physical and social barriers and proposes solutions to improve access for people with disabilities. Moreover, advancements in autonomous vehicles and sensor networks show promise in improving road safety and reducing environmental impact.

In conclusion, an integrated approach combining technical, social, and regulatory aspects is crucial for creating effective, accessible transport infrastructure for all.

Formulation of the aim and article tasks. The aim of this research is to determine the level of accessibility of the transport infrastructure in the city and develop scientifically based recommendations for its improvement.

Main results of the study.

The city's transport system pays great attention to improving the accessibility of sidewalks, pedestrian crossings, and bicycle paths, which creates conditions for convenient and safe movement of residents. However, despite the gradual improvement of the situation, in some areas of the city the infrastructure for pedestrians and cyclists needs to be improved. Problems faced by residents include insufficient sidewalk width, poor coverage in some areas, and the lack of ramps and necessary amenities for people with reduced mobility.

To assess the level of accessibility of transport infrastructure for low-mobility population groups in the city of Rivne, a sociological survey was conducted [8]. The goal of the survey was to find out how residents assess the accessibility of urban transport and identify the main problems faced by low-mobility population groups.

The survey involved 800 Rivne residents and provided the representative data on the attitude of different age groups to the level of development of the city's transport infrastructure. The collected data allowed analyzing the situation with transport accessibility, as well as identifying the most urgent problems for low-mobility population groups.

To ensure the representativeness of the sample, the age distribution of respondents was observed, and the sample included five age groups. The largest share of

respondents fell into the groups of people aged 18–29 and 30–49, who are representatives of the working-age population and make up the biggest part of transport users. Among all respondents, 60% indicated that they travel around the city every day, and 30% several times a week. This indicates a significant share of the population that actively uses the Rivne transport system. The distribution of respondents by education level is as follows: higher education (college, institute, university): 60% of respondents; secondary specialized education (technical school, vocational school, college): 30%; secondary education (primary, incomplete secondary, or complete secondary): 10%.

The mobility of residents and their modes of travel are determined by the availability of transportation. Daily trips can be made by cars, bicycles, micromobility devices, public transport, or on foot. The choice of a particular mode depends on the availability of different transportation options and the personal preferences of each individual. The most popular means of transportation are public transport (81% of respondents); private cars (42.9%), less often – bicycles and walking. These data indicate that public transport is the main means of transportation for the majority of residents, which confirms the importance of ensuring its accessibility and comfort for all categories of the population, including low-mobility groups. At the same time, a certain proportion of people prefer private cars, which may indicate the need to develop infrastructure for motorists and reduce the burden on public transport. Less interest in cycling and walking may indicate the lack of proper conditions for these modes of transport, which also requires attention to improve accessibility and convenience of movement in the city.

However, as the research results show, not all city residents are satisfied with the accessibility of transport services, in particular the elderly, parents with small children, people with disabilities, etc. This indicates that ensuring barrier-free transport is a critically important component of creating an inclusive urban environment that guarantees equal access to transport for all social groups.

The obtained data emphasize the need to take into account the specific needs of the mentioned groups when planning and developing the city's transport infrastructure.

Most respondents noted that they encountered accessibility limitations in infrastructure, in particular the lack of ramps and high curbs. These physical barriers make it difficult for people with disabilities, parents with strollers, and the elderly to move around. According to the survey results, the respondents identified the most vulnerable population groups that face the biggest difficulties when moving around the city: people with disabilities – 100%; parents with strollers – 80%; and the elderly – 20%.

In Ukraine, the lack of ramps, high curbs and stairs are typical physical barriers that limit the accessibility of public places and transport for people with reduced mobility [9]. To improve the situation, it is necessary to implement inclusive solutions, such as installing ramps, lowering curbs, and adapting public places to ensure equal access for all citizens. For example, cities are actively lowering curbs and carrying out large-scale reconstruction of infrastructure facilities taking into account the principles of barrier-free access. Taking into account the needs of people with reduced mobility when designing and reconstructing infrastructure is an important step towards creating an accessible and inclusive environment for all city residents. The research results indicate that there are significant challenges in the transport accessibility of the city of Rivne, in particular for low-mobility groups. At the same time, residents express specific suggestions for improving the situation, which can become the basis for planning further changes.

One of the defining aspects of transport accessibility is the accessibility of infrastructure. The availability of ramps, lifts, low-floor transport, and specially equipped stops are basic elements that significantly facilitate movement. For example, the convenience of entering transport and the ability to move freely between transport nodes remain relevant issues for many cities. The main challenges for people with limited mobility are inadequate sidewalks – 30%, unadapted buses/minibuses – 25%, lack of ramps – 20%, lack of accessible parking – 20% [10]. To the question about the compliance of transport infrastructure to the needs of low-mobility groups, the following answers were given: “it meets fully” – 0%, “it meets partially” – 60%, “it does not meet at all” – 40%.

One of the approaches to assessing the level of barrier-free access is the integral indicator method [11]. This method takes into account all factors that affect the level of accessibility of transport infrastructure for low-mobility groups.

Based on the conducted research, we identified the basic components that directly affect the level of barrier-free transport infrastructure in the city, namely:

- pedestrian infrastructure (P_1). Based on the results of the survey on the availability and condition of sidewalks, curbs, ramps, the absence of obstacles in the way, and the quality of the sidewalk surface, we defined the level of accessibility for pedestrians at 70%.

- bicycle infrastructure (P_2). Based on the survey results, the accessibility of transport infrastructure for cyclists is 50%.

- public transport infrastructure (P_3). Based on the survey results regarding the accessibility of public transport, availability of low-floor buses and trolleybuses, wheelchair spaces, ramps, and climate control, it makes 80%.

- information accessibility (P_4). Based on the survey results regarding the availability of up-to-date information, accessibility of display (graphics, diagrams), navigation, accessibility for people with disabilities, it makes 60%.

- accessibility of public transport stops (P_5). Based on the survey results, the stops should be properly equipped with level sidewalks, ramps for people with disabilities, sufficient lighting, and rain and sun canopies. Attention should also be paid to comfort and safety at stops so that people feel protected. Currently, the residents rate the accessibility of stops at 40%.

To assess the accessibility of the transport infrastructure of Rivne using the integral accessibility index (AI) method, the following formula can be used:

$$AI = \frac{\sum_{i=1}^{n} W_i * P_i}{\sum_{i=1}^{n} W_i}, \quad (1)$$

W_i- weighting factor for criterion i, which determines its importance (e.g., in points or shares);

P_i - accessibility assessment according to criterion I (percentage);

n- number of criteria.

The resulting AI index is interpreted as the level of barrier-free transport infrastructure: 0.9–1.0 - high level of barrier-free transport; 0.7–0.89 – sufficient level; 0.5–0.69 - average level; less than 0.5 – low level.

The integral accessibility index for the city of Rivne is 60%, which corresponds to the average level of barrier-free transport infrastructure. This indicates that the city has certain problems with the accessibility of transport and infrastructure for low-mobility groups of the population, which needs to be improved. The main areas for improvement are improving the physical accessibility of vehicles and developing information and technological solutions to ensure equal access to transport for all residents.

The level of transport accessibility is visually presented in Fig. 1.

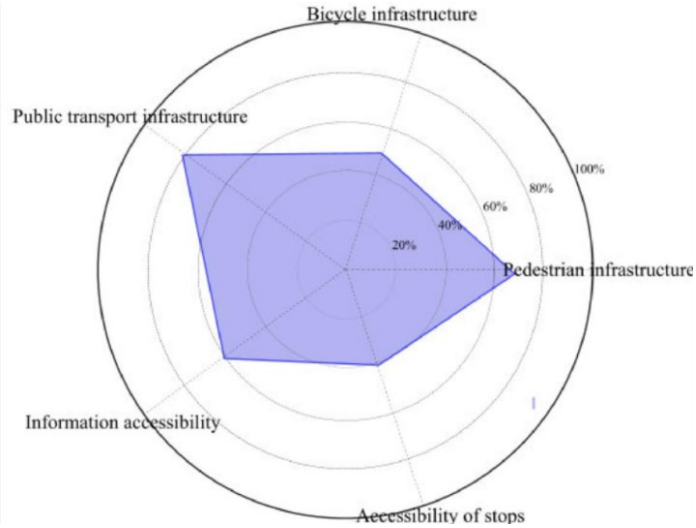

Fig. 1. Accessibility of transport infrastructure in the city of Rivne

This means that the level of the accessibility of the transport infrastructure in Rivne can be assessed as average, with noticeable needs to improve the accessibility of stops and bicycle infrastructure.

The results of calculating the integral index for the city of Rivne show that today the level of accessibility of infrastructure for people with limited mobility is at an average level (60%). The main problems are the insufficient accessibility of stops and infrastructure for cyclists. Various development scenarios, in particular the development of public transport infrastructure or pedestrian infrastructure, include an increase in the level of barrier-free access, but to achieve a high level of accessibility,

it is necessary to comprehensively improve all components of the transport system. Therefore, an important aspect is the creation of a unified inclusive approach to the development of urban infrastructure, which will ensure comfortable movement for all categories of the population.

Conclusion. The survey results showed high mobility of the population in the city of Rivne, as a significant part of the respondents use public transport regularly. 60% of respondents noted that they travel daily, and another 30% travel several times a week. This confirms the importance of accessible transport infrastructure for the majority of the population. However, one of the key problems is the lack of accessibility of transport for low-mobility groups. According to the survey, people with disabilities, parents with strollers, and the elderly have difficulties in moving around. All respondents noted problems for people with disabilities, 80% – for parents with strollers, and 20% – for the elderly. This indicates the need to develop barrier-free infrastructure, including ramps, convenient sidewalks, and accessible buses.

Public transport is the most popular means of transportation, with 81% of respondents using it regularly. This highlights the importance of improving infrastructure to ensure accessibility and ease of travel for all categories of the population, in particular for groups with reduced mobility. The survey also identified problems with insufficient sidewalk width, poor road surface, and lack of necessary amenities. However, positive changes in infrastructure development were also noted, which requires further efforts to ensure universal access to all public services.

We propose a number of recommendations to address these issues. First, it is important to increase the number of low-floor buses and provide convenient stops for people with disabilities. Installing special devices for boarding people with disabilities will facilitate their movement. Expanding the network of barrier-free sidewalks and pedestrian crossings is also a priority, as this will improve the accessibility of pedestrian routes and will make them safer for all users.

It is also advisable to actively involve the public in the process of planning the city's infrastructure, as this will help identify new needs and adjust development strategies. Investments in innovative technologies, such as autonomous vehicles and

sensor networks, will also contribute to improving safety and comfort on the roads, as well as to adapting the infrastructure to modern technologies.

Given the high level of the public transport use, it is also important to improve public awareness of the importance of accessibility and educate people on how to make travel easier for low-mobility groups. This will contribute to creating a more inclusive and accessible environment for all city residents.

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Анотація. *Стаття присвячена комплексному дослідженню рівня безбар'єрності і транспортної інфраструктури міста Рівне, з особливим акцентом на забезпечення доступності для маломобільних груп населення, таких як люди з інвалідністю, літні громадяни та особи з тимчасовими обмеженнями фізичної активності. У роботі здійснено детальний аналіз основних факторів, що обмежують мобільність цієї категорії громадян, зокрема недостатня кількість низькопідлогових автобусів, відсутність належно облаштованих зупинок громадського транспорту, а також незадовільний стан тротуарів і пішохідних доріжок. Технічні та організаційні перепони, які знижують рівень доступності, ускладнюють повсякденне пересування осіб з обмеженими можливостями, що веде до значних соціальних та економічних проблем, особливо в контексті зміни демографічної ситуації та зростаючої потреби в розвитку інклюзивного середовища.*

Проведено оцінку поточного стану безбар'єрності транспортної інфраструктури міста Рівне за результатами соціологічного опитування. В роботі застосовано метод інтегрального показника безбар'єрності, який враховує кілька ключових критеріїв: доступність інфраструктури для пішоходів, велосипедистів, громадського транспорту, інформаційну доступність та зупинки. Результати проведеного дослідження свідчать, що рівень безбар'єрності транспортної інфраструктури в місті Рівне становить 60%, що відповідає середньому рівню. Основними проблемними аспектами є недостатня доступність зупинок громадського транспорту, тротуарів, а також інфраструктури для велосипедистів. Для покращення ситуації необхідно зосередитись на підвищенні фізичної доступності транспортних засобів, створенні безперешкодних зупинок і вдосконаленні інформаційних та технологічних рішень для забезпечення рівного доступу до транспорту для всіх категорій громадян. Крім того, важливим є впровадження сучасних технологій та інформаційних систем для покращення доступності транспорту, що є важливим кроком на шляху до інклюзивного розвитку міської інфраструктури.

Для досягнення європейських стандартів доступності транспортної інфраструктури в Україні, необхідно прискорити впровадження інклюзивного підходу у розвиток міського транспорту, зокрема шляхом покращення фізичної доступності, вдосконалення зупинок і громадського транспорту, а також активного залучення громадян до обговорення та планування змін, що сприятимуть забезпеченню рівних можливостей для всіх груп населення

Ключові слова: *безбар'єрність, транспортна інфраструктура, маломобільні групи, доступність, інклюзивність, громадський транспорт, тротуари, велосипедна інфраструктура, соціальна рівність, стратегічний розвиток.*