GIS Odyssey Journal

2025 • Volume 5 • Number 2

https://doi.org/10.57599/gisoj.2025.5.2.235

Michał Bijata[1]

ANALYSIS OF ACCESS TO THE RAILWAY NETWORK USING GIS SPATIAL ANALYSIS IN THE MASOVIAN AND WARMIAN-MASURIAN VOIVODESHIPS

Abstract: This article is a two-case study, enriched with theoretical context, aimed at assessing access to the railway network in the Masovian and Warmian-Masurian voivodeships from the perspective of transport exclusion. The theoretical section includes a literature review on transport accessibility, with particular emphasis on its importance for socio-economic development and the shaping of territorial cohesion. In the empirical section, cartographic and spatial analysis methods using GIS tools were applied, covering both active and decommissioned railway infrastructure. The results reveal significant disparities in access to rail transport at both the interregional level and within individual voivodeships. The identified spatial inequalities indicate the need for a more balanced and territorially sensitive transport policy, as well as further local-scale research to support decision-making in the revitalisation of railway infrastructure.

Keywords: transport accessibility, rail transport, transport exclusion, spatial information systems, sustainable development

Received: 19 August 2025; accepted: 11 November 2025

[1] University of Warmia and Mazury in Olsztyn, Faculty of Geoengineering, Department of Land Management and Geographic Information Systems, Institute of Spatial Management and Geography, Olsztyn, Poland, ORCID ID: https://orcid.org/0009-0009-4793-6619, email: mp.bijata98@gmail.com

Introduction with analysis of the state of the problems

As part of the work carried out under the Integrated Railway Network project, commissioned by the Ministry of Infrastructure and implemented by Central Communication Port (CPK) in cooperation with Polish State Railways Polish Railway Lines (PKP PLK) and the Institute for Urban and Regional Development (Integrated Railway Network, 2024), it became necessary to identify municipalities and districts that require special attention in the next stages of railway network planning beyond 2035.

It was already apparent at the initial stage of the research that Poland is characterised by an uneven distribution of railway infrastructure (Office of Rail Transport, 2024), with many regions—especially peripheral ones—facing limited access to public transport (Kwarciński, 2019). Previous studies have primarily focused on the railway network at national and supra-regional scales or on the availability of connections between major urban centres (Bocheński, 2016; Mróz & Štraub, 2024). However, there is a lack of in-depth comparative analyses of accessibility at the municipality and district levels within regional or even local contexts.

This study adopts a research perspective focused on analysing access to the railway network at the level of local government units. This approach enabled the identification of administrative areas most at risk of transport exclusion. A detailed inventory of railway infrastructure was conducted, taking into account both existing lines used for passenger traffic and those used exclusively for freight or decommissioned for various reasons, as well as the availability of active passenger railway stations, which in practice determine the actual feasibility of using rail transport by residents.

The study encompassed two voivodeships: Masovian and Warmian-Masurian. Following the inventory, a comparative analysis of these regions was conducted, taking into account differences in the development of railway infrastructure: the generally less developed Warmian-Masurian Voivodeship (Białobrzeska, 2023) and the better-developed, yet still facing challenges, Masovian Voivodeship (Kościńska et al., 2021). As a result, municipalities and districts with the lowest level of access to the railway network were identified.

The aim of the study was to assess access to the railway network in the Masovian and Warmian-Masurian Voivodeships from the perspective of transport exclusion and to identify areas requiring planning or organisational interventions (Górny, 2016). The methodology adopted, focused on analysing access at the level of local government units, leads to the following research questions that structure the empirical part of this work:

– What is the current level of access to the active railway network and active passenger stations at the municipality and district levels in the two analysed voivodeships? The study conducted a detailed inventory of railway infrastructure and sought to identify administrative areas most at risk of transport exclusion.

– What significant spatial disparities exist in railway accessibility between the two voivodeships and within them, particularly affecting rural and peripheral areas? The results revealed significant disparities in access to rail transport at both the interregional level and within individual voivodeships.

– How does the picture of access to the railway network change when considering existing, yet non-operational, infrastructure compared to the currently operational network? The empirical section of the study included both active and decommissioned railway infrastructure.

Transport accessibility is crucial for sustainable regional development, spatial integration, and equalising development opportunities (United Nations, 2015). An insufficient level of accessibility may lead to reduced mobility, social exclusion, and slower local development (Majewski, 2021). In this study, access to the railway network is understood as the presence of railway lines and stations at two spatial levels: district and municipality.

Literature. Transport exclusion is a phenomenon that has gained increasing attention in recent years, particularly in the context of sustainable development (Majewski, 2021) and spatial planning (Wilkosz-Mamcarczyk et al., 2020; Kołoś & Taczanowski, 2018). Research on transport accessibility shows that lack of access to the transport network significantly limits residents' mobility, thereby affecting their quality of life and development opportunities (Lucas, 2012). Transport exclusion has been identified as one of the key drivers of socio-spatial marginalisation, especially in peripheral regions (Shergold & Parkhurst, 2012), such as the north-eastern parts of the Warmian-Masurian Voivodeship or the eastern areas of the Masovian Voivodeship.

The international literature also emphasises the role of public transport access in combating social exclusion (Delbosc & Currie, 2011). Some scholars argue that transport equity requires not only an assessment of spatial accessibility, but also consideration of infrastructure quality and the actual usability of the transport system for various social groups (Martens, 2016). Studies from the UK (Preston & Rajé, 2006), Australia (Currie & Delbosc, 2010), and China (Zou et al., 2022) clearly show that lack of effective public transport access leads to the social exclusion of rural and suburban populations (Burakowski & Lizińska, 2024).

In the Polish context, transport accessibility has been addressed in the works of, among others, Komornicki & Stępniak (2015), who developed detailed maps of accessibility in Poland, focusing mainly on access to large urban centres and time-based analyses for road transport. The research of Rosik et al. (2014) also analysed changes in spatial accessibility in Poland but omitted detailed coverage of the railway network and access to passenger stations at the local level. Rosik et al. (2017) focused on multimodal accessibility by public transport across Polish municipalities, but rail transport did not play a leading role in that publication. Bocheński (2018) addressed transport accessibility with particular attention to railways; however, his study of railway access in Warsaw was conducted on a national and supra-regional scale, lacking a holistic view of local and regional disparities. The access of Polish communes to rail transport has been examined in contemporary research, although such studies remain relatively scarce (Bocheński, 2024; Ciechański, 2023). It is worth noting that, in the context of transport exclusion, not only the operation of public transport services is of significance, but also the nature and quality of the transport offer itself (Bocheński 2021; Bocheński, 2011).

Cartographic analyses on the OpenRailwayMap web portal (2025) show that the density of railway infrastructure in Poland is significantly lower than in neighbouring Western European countries, which may lead to a growing number of areas affected by transport exclusion. Despite substantial infrastructure investments financed by EU funds, many regions still lack access to convenient railway connections (Komornicki & Goliszek, 2021).

Analyses of the quality of railway and related utility infrastructure (Sirbu & Cujba, 2022) – such as the number of tracks, electrification, and the availability of platforms, Park & Ride facilities, or bicycle paths – are an important complement to studies on transport accessibility (Arunkumar et al., 2025; Zoli et al., 2025; Kowalczyk, 2019; Massel, 2018; Brons et al., 2008). These works indicate that the mere presence of a railway line does not guarantee actual accessibility if the infrastructure's quality does not allow for efficient passenger service.

The present study aims to partially fill the existing gap in the literature by focusing on a detailed analysis of railway accessibility, including the actual number of available passenger stations at the municipality and district level in the two selected voivodeships. It also serves as a prelude to a more thorough and comprehensive study of the mentioned regions.

Material and methods

Study area. The Masovian Voivodeship (Fig. 1) is the largest administrative unit in Poland in terms of both area and population. It covers almost 36,000 km^2 and is inhabited by approximately 5.5 million people, resulting in an average population density of 155 inhabitants per km^2 (Statistical yearbook of the Masovian Voivodeship, 2024). Administratively, the voivodeship comprises 37 districts and 5 cities with district rights, including Warsaw, Radom, Płock, Siedlce, and Ostrołęka. At the lower administrative level, there are 314 municipalities: 35 urban, 64 urban–rural, and 215 rural (ibid.). The urbanisation rate of the voivodeship is 64.8% (Ludność:..., 2025). Thanks to its location and the presence of the national capital, Masovian plays a key role in both national and international transport systems, serving as a road, rail, and air hub (Rosik, 2021). However, the region also faces challenges typical of large-scale spatial units, such as dispersed and concentrated development (Yang et al., 2021; Sudra, 2020), internal disparities in development, uneven transport accessibility, and exclusion of peripheral municipalities (Masovian Office of Regional Planning, 2022). The Masovian Voivodeship thus combines metropolitan functions with vast, often less urbanised areas, making it one of the most complex and demanding regions in Poland in terms of spatial planning. Located in north-eastern Poland, the Warmian-Masurian Voivodeship (Fig. 2) is among the country's largest in terms of area, covering about 24,000 km^2. Despite its size, it has a relatively low population – nearly 1.5 million – resulting in a density of just 56 inhabitants per km^2 (Statistical yearbook of the Warmian-Masurian Voivodeship, 2024). This places the region among the least densely populated in Poland. The administrative structure includes 19 districts and 2 cities with district rights: Olsztyn, the voivodeship capital, and Elbląg, both of which serve key administrative, economic, and

transport functions. The voivodeship is divided into 116 municipalities: 16 urban, 34 urban–rural, and 66 rural (ibid.). The urbanisation rate is 58.8% (Ludność:..., 2025). The region's transport infrastructure has been shaped by both geographic and historical factors, with its current layout reflecting centuries of settlement and trade route development (Guzik et al., 2021). Current strategies for transport development focus on improving public transport, cycling infrastructure, and electromobility – complementing the region's distinctive "blue-green" identity (Strategic Planning Task Team..., 2020).

Source data. The basis for the analysis was the Topographic Objects Database (BDOT 10k) (Table 1), obtained from the Geoportal service (2025), and supplemented with open data from OpenStreetMap (2025), the Polish Railway Database (2025), and data made available by the Office of Rail Transport and Polish State Railways Polish Railway Lines (PKP PLK), specifically from the Interactive Railway Line Map (2025). Detailed information on the routes of railway lines and the locations of railway stations and passenger stops in the Masovian and Warmian-Masurian Voivodeships was collected and compiled. Additionally, geographic data on municipality borders, available from the National Official Register of the Territorial Division of the Country (TERYT), was used to assign railway stations precisely to administrative units. The integration of data from multiple sources and different time periods may have affected the accuracy and detail of the railway line classifications and the status of stations which is a common problem, as many places in Poland have not been inventoried in detail (Bieda et al., 2020).

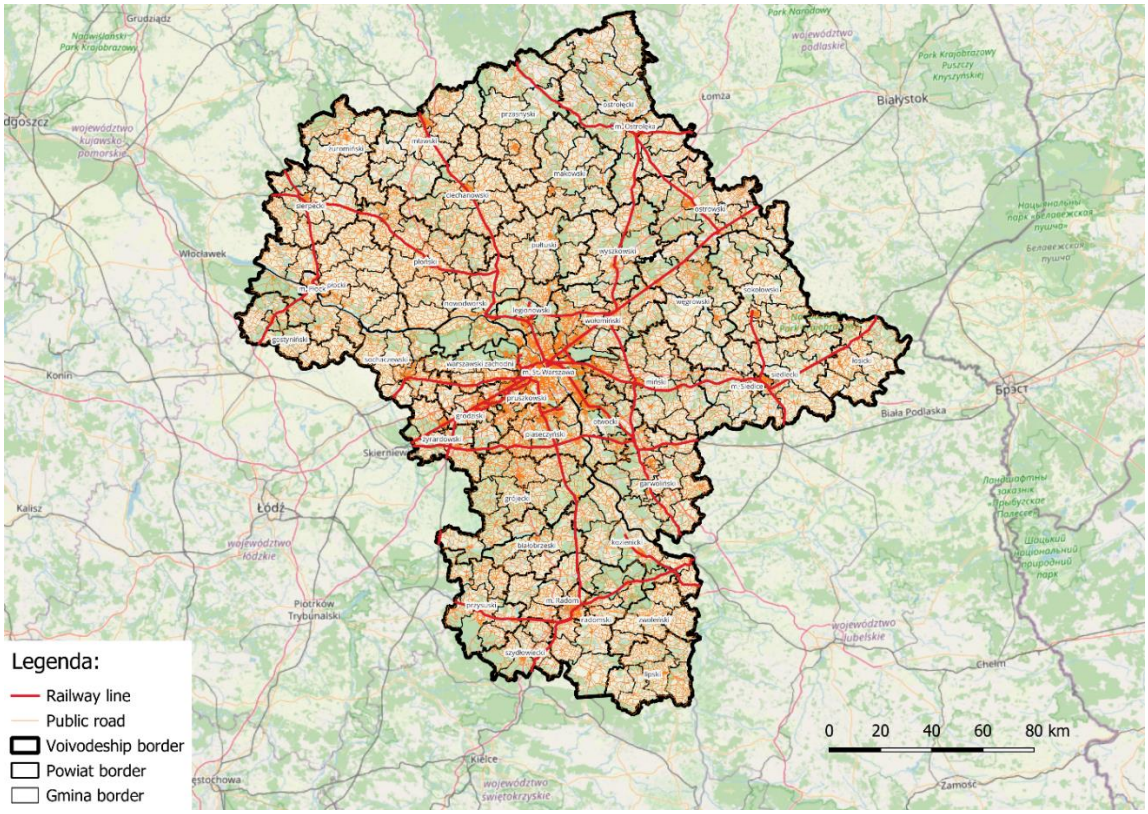

Fig. 1. Map of the rail and road infrastructure of the Masovian Voivodeship
Source: own study

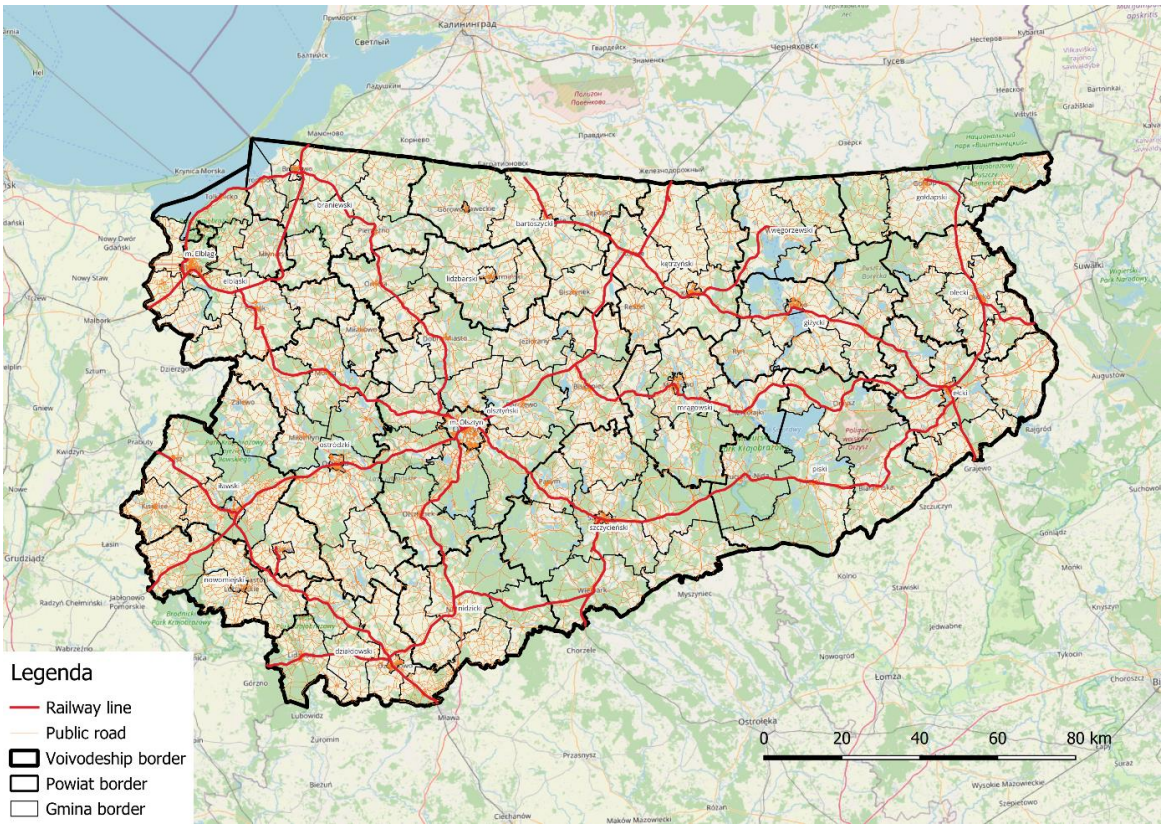

Fig. 2. Map of the rail and road infrastructure of the Warmian-Masurian Voivodeship
Source: own study

For the first analysis, only data on active railway lines and their respective passenger stations, served by scheduled services as of April 18, 2024, were considered. The second analysis also included freight lines, impassable sections, decommissioned railway segments, and stations or stops closed to passenger traffic. In both cases, railway sidings and most station tracks were excluded, with the exception of the mainline tracks. To ensure data reliability, station locations and railway routes were verified using online mapping services and timetables published by PKP PLK, as well as mobile applications such as PKP INTERCITY – Buy tickets, Masovian Railways, Howtogetthere – timetables and tickets, KOLEO – PKP timetable and tickets, and Google Maps. Manual verification of the generated maps was also conducted.

Table 1. Table of used data derived from BDOT 10k and OSM

BDOT10k (Baza Danych Obiektów Topograficznych w skali 1:10 000)	ADJA (Administracyjne jednostki), BUIB (Budynki i budowle), KUKO (Komunikacja kolejowa), OIKM (Obiekty infrastruktury komunikacyjnej miejskiej), SKTR (Sieć komunikacji transportowej drogowej)
OSM layers (OpenStreetMap)	Primary, Public Transport

Source: own study

Analysis methods. Spatial analyses in this study were conducted using QGIS 3.40 Bratislava. Spatial data were downloaded from the Geoportal in shapefile format (separately for the Warmian-Masurian Voivodeship – 28_SHP, and the Masovian Voivodeship – 14_SHP), then manually compiled from the previously mentioned sources. The data were processed, cleaned, and aligned to the PUWG 1992 coordinate system and saved in GeoPackage vector format.

Results and discussion

Results. In the Warmian-Masurian Voivodeship, both cities with district rights (Olsztyn and Elbląg) and 14 out of 19 districts have access to an active railway network – understood as the presence of both railway lines and passenger stations (Fig. 3). This situation may improve after the modernisation of Line 38 on the Korsze–Ełk section, which would integrate the Giżycki district into the active network (Modernisation of the Railway Line in the Voivodeship, 2024).

However, when shifting from the district to the municipality level, significantly lower access to the railway network becomes evident. Out of the 116 analysed municipalities, as many as 50 have no active passenger station within their territory. Moreover, direct access to an active railway line was recorded in only 52 municipalities, meaning that more than half of the voivodeship's municipalities lack passenger railway infrastructure in operation (Table 2).

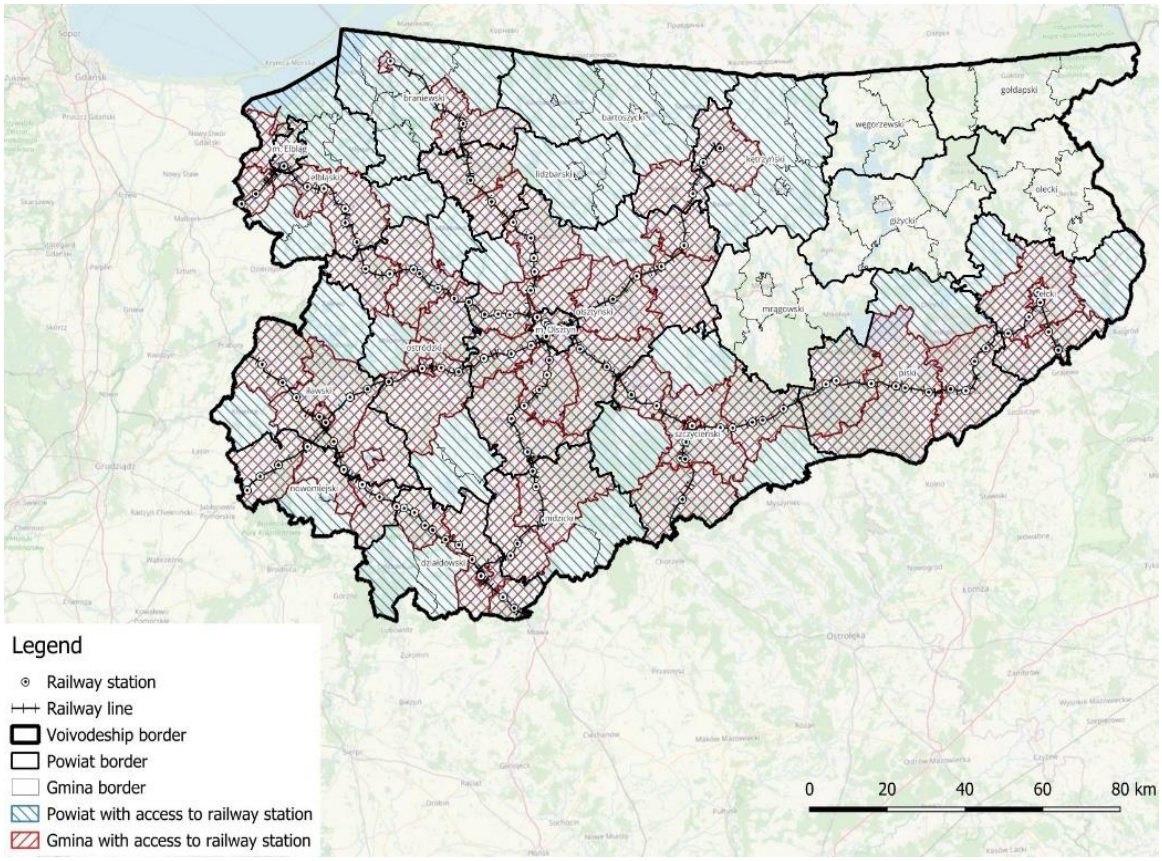

Fig. 3. Map of the operational rail infrastructure of the Warmian-Masurian Voivodeship
Source: own study

A different picture emerges when examining existing, but currently non-operational, railway lines (Fig. 4). In this scenario, all districts in the Warmian-Masurian Voivodeship have at least one passenger station within their area. At the municipality level, access to an existing passenger station was found in 71 out of 116 municipalities, which is significantly higher than for currently operational infrastructure. Access to existing railway tracks was recorded in 81 municipalities, indicating that 10 municipalities have railway tracks within their boundaries but no passenger station (Table 2).

In summary, districts in the north-eastern part of the voivodeship, as well as many rural and urban–rural municipalities throughout the region, remain most affected by railway transport exclusion in terms of physical access to the network.

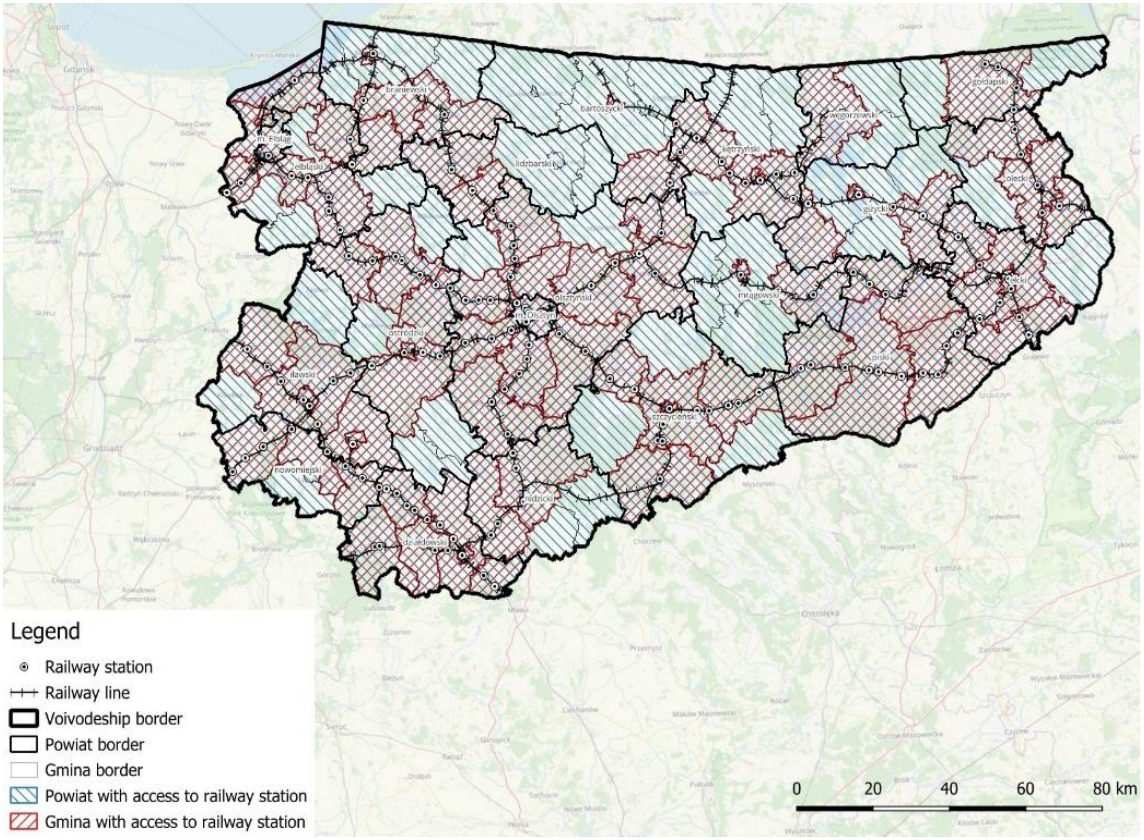

Fig. 4. Map of existing railway infrastructure of the Warmian-Masurian Voivodeship
Source: own study

In the Masovian Voivodeship, all five cities with district rights – Ostrołęka, Płock, Radom, Siedlce, and Warsaw – as well as 32 out of 37 districts have access to an actively operated railway network, meaning both railway lines and passenger stations are present (Fig. 5). Notably, Sokołowski district currently has only a freight railway line, which is planned for restoration to passenger service under the Rail+ programme (PKP PLK, 2023). When moving from the district level to that of the municipality, access to the railway network is significantly reduced. Out of 314 municipalities, 124 do not have a single active passenger station, while 140 municipalities have access to a railway line (Table 2). This means that more than half of the voivodeship's municipalities lack access to an operational railway network. Notably, seven municipalities bordering Warsaw – Marki, Łomianki, Izabelin, Raszyn, Konstancin-Jeziorna, Stare Babice, and Wiązowna – do

not have any railway access. Additionally, two Warsaw city districts – Wilanów and Bielany – are also without access.

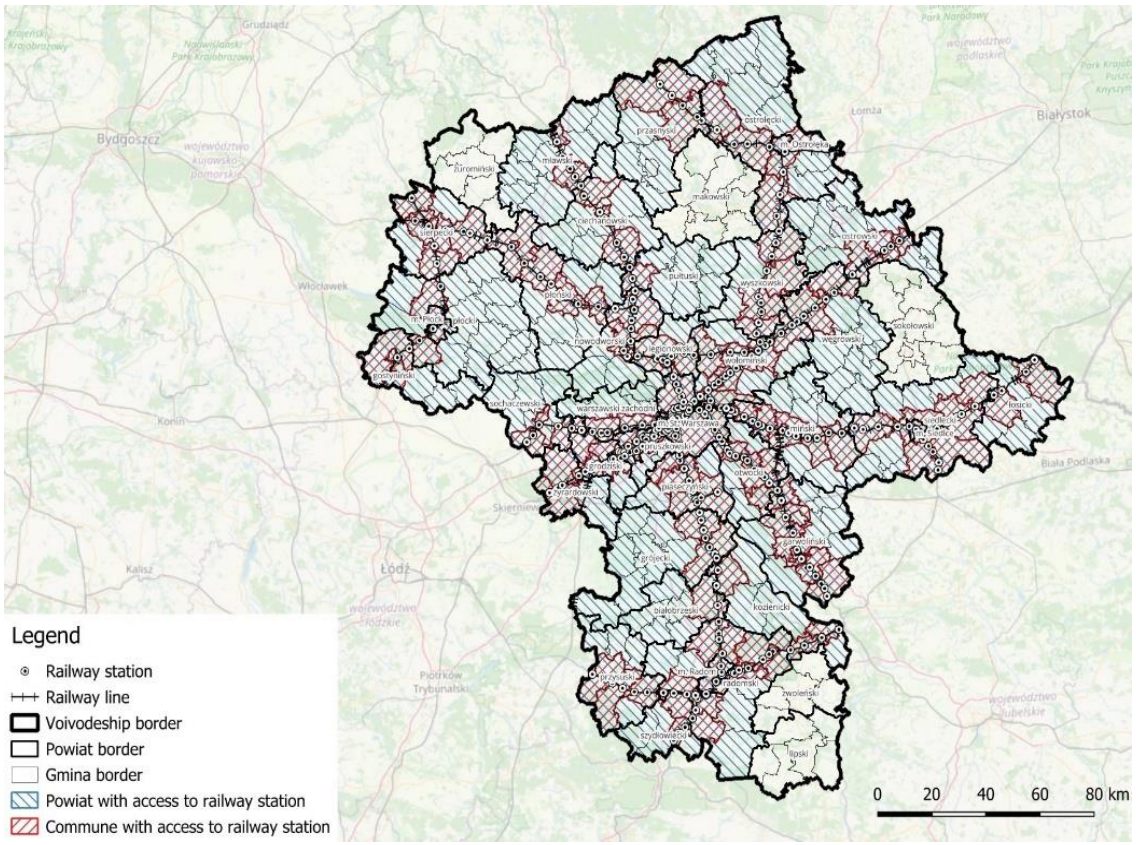

Fig. 5. Map of the operational rail infrastructure of the Masovian Voivodeship
Source: own study

The situation changes when analysing existing, yet non-operational, railway lines (Fig. 6). In this scenario, four districts in the Masovian Voivodeship remain without a passenger station. At the municipality level, 132 out of 319 municipalities have access to at least one existing passenger station – considerably more than those with access to operational infrastructure. Furthermore, 159 municipalities have existing railway tracks, meaning 27 municipalities contain railway lines but lack any passenger stations. Among municipalities bordering Warsaw, five – Marki, Łomianki, Izabelin, Raszyn, and Wiązowna – still lack railway access, as does the Wilanów city district of Warsaw (Table 2).
In contrast to the Urban Functional Area of the capital city of Warsaw, all municipalities bordering the voivodeship capital of Olsztyn in the Warmian-Masurian Voivodeship have access to the operational railway network – although they are isolated from neighbouring municipalities.

The railway network density in the Warmian-Masurian Voivodeship (with a total of 1,099 km of railway lines) averages 4.55 km of railway per 100 km^2. In comparison, the Masovian Voivodeship (1,797 km of railway lines) has a slightly higher density – 5.05 km per 100 km^2. In the Warmian-Masurian Voivodeship, nearly 73% of all railway lines are single-track and 55% are non-electrified. In contrast, in the Masovian Voivodeship, single-track lines account for 38%, and non-electrified lines 20% (Office of Rail Transport, 2024).

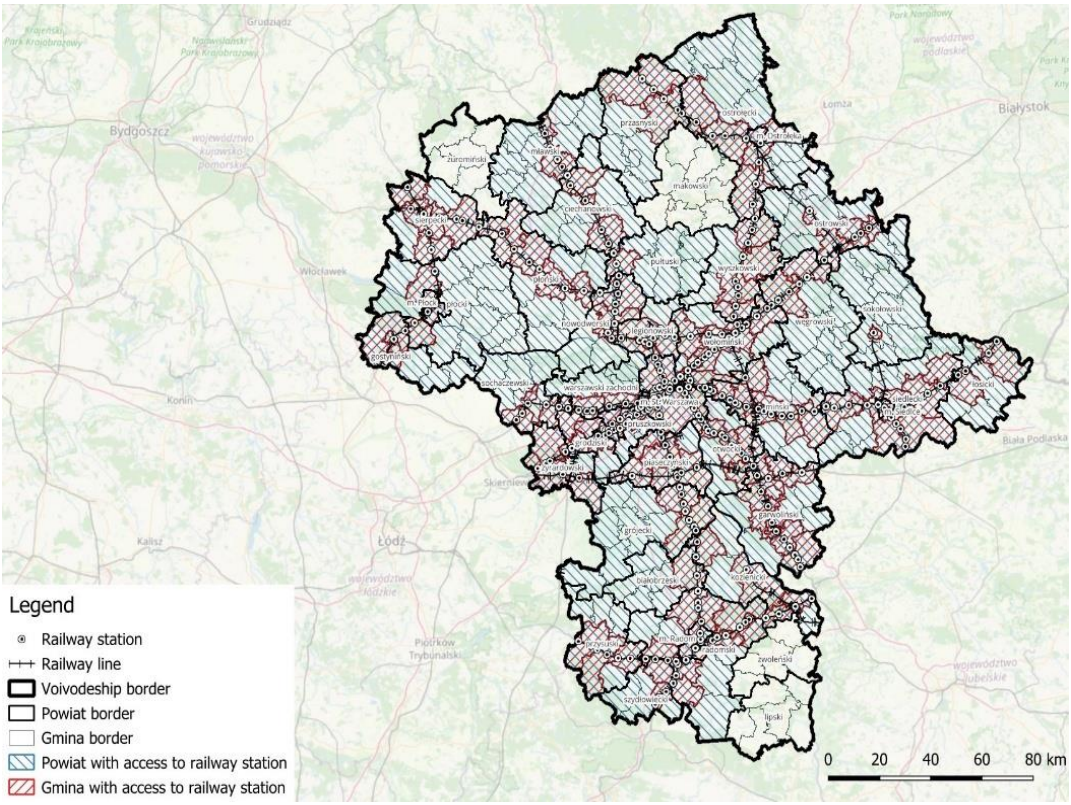

Fig. 6. Map of existing railway infrastructure of Masovian Voivodeship
Source: own study

Table 2. Classification of Districts according to their accessibility to the railway network

Railway Access	Warmian-Masurian Voivodship	Masovian Voivodship
Districts which have access to the operating railway network	bartoszycki, braniewski, działdowski, elbląski, ełcki, iławski, kętrzyński, lidzbarski, nidzicki, nowomiejski, olsztyński, ostródzki, piski, szczycieński	białobrzeski, ciechanowski, garwoliński, gostyniński, grodziski, grójecki, kozienicki, legionowski, łosicki, miński, mławski, nowodworski, ostrołęcki, ostrowski, otwocki, piaseczyński, płocki, płoński, pruszkowski, przasnyski, przysuski, pułtuski, radomski, siedlecki, sochaczewski, szydłowiecki, warszawski zachodni, węgrowski, wołomiński, wyszkowski, żyrardowski
Districts without access to an operational railway network	giżycki, gołdapski, mrągowski, olecki, węgorzewski	lipski, makowski, sokołowski, zwoleński, żuromiński
Districts with access to the existing railway network	bartoszycki, braniewski, działdowski, elbląski, ełcki, giżycki, gołdapski, iławski, kętrzyński, lidzbarski, mrągowski, nidzicki, nowomiejski, olecki, olsztyński, ostródzki, piski, szczycieński, węgorzewski	białobrzeski, ciechanowski, garwoliński, gostyniński, grodziski, grójecki, kozienicki, legionowski, łosicki, miński, mławski, nowodworski, ostrołęcki, ostrowski, otwocki, piaseczyński, płocki, płoński, pruszkowski, przasnyski, przysuski, pułtuski, radomski, siedlecki, sochaczewski, sokołowski, szydłowiecki, warszawski zachodni, węgrowski, wołomiński, wyszkowski, żyrardowski
Districts without access to the existing railway network	-	lipski, makowski, zwoleński, żuromiński

Source: own study

Discusion

The analyses conducted revealed both significant differences and noteworthy similarities in railway network accessibility between the Warmian-Masurian and Masovian Voivodeships. Addressing our first research question regarding the current level of access to operational rail networks and passenger stations, the study confirmed major differences between the two regions. Specifically, more than half of the municipalities in the Masovian Voivodeship (124 out of 314) lack a single active passenger station. In the Warmian-Masurian Voivodeship, this figure stands at 50 out of 116 municipalities. This highlights that a vast number of administrative units face limited physical access to infrastructure, forming the basis of transport exclusion.

The spatial analysis results show that in both regions, certain areas experience limited access to rail transport, and that accessibility to railway stations in rural areas of both Warmia and Masovia is noticeably lower than in urban areas. Furthermore, not all city districts of Warsaw or municipalities neighbouring the capital have access to the railway network – indicating that even proximity to major urban centres does not guarantee good railway access.

In response to the second research question concerning disparities in access and transport exclusion, the results show that the most significant differences in railway accessibility occur at the municipality and district levels. The Warmian-Masurian region is at a disadvantage not only due to fewer railway stations but also because of a higher proportion of single-track (73%) and non-electrified lines (55%) compared to Masovia (38% and 20%, respectively). This quality deficit limits the development potential of rail transport. The analysis confirms that the north-eastern part of the Warmian-Masurian Voivodeship and districts in Masovia, such as Lipski, Makowski, Zwoleński, and Żuromiński, are the most affected by exclusion in terms of physical access to the network.

Regarding our third research question on the impact of considering existing but non-operational infrastructure, the findings suggest that the nature of transport exclusion differs significantly between the two regions. In the Warmian-Masurian Voivodeship, the issue is primarily organisational, as the existing railway infrastructure is not sufficiently utilised. The number of municipalities with access to a station rises from 50 active to 71 existing, revealing significant potential for revitalization. In contrast, in the Masovian Voivodeship, the problem is more infrastructural – many districts lack even disused infrastructure. The minor increase in accessible municipalities (from 124 to 132) confirms that the potential for expansion through revitalization is more limited here.

This research contributes new insights into the detailed spatial distribution of railway stations and accessibility to the railway network, a topic not thoroughly examined at the municipality level in either voivodeship. Previous studies, such as those by Guzik (2014) or Szłapacki (2024), focused primarily on accessibility at national or regional scales, without addressing local disparities. The study also aligns with other research highlighting transport exclusion affecting seniors (Białobrzeska, 2023) and children and youth (Komornicki, 2024), but supplements those insights with detailed spatial data and visualisations that pinpoint the areas most affected.

The findings also highlight that in both voivodeships, districts lacking access to operational railway infrastructure often rely on less energy-efficient modes of transport (ProRail Foundation, 2021), which may exacerbate demographic (Sirbu & Cujba, 2020; Biegańska, 2013), social (Kaniowski & Pypłacz, 2025), and economic (Qi et al., 2023; Bacior et al., 2022; Zdzisław, 2018) challenges. Future research should include network-based accessibility analyses, such as walking or public transport distances to the nearest railway station and comparisons based on population size. Additionally, qualitative studies exploring residents' opinions and perceptions (Szopińska et al., 2022) would help identify real transport needs and perceived barriers.

In summary, the results of this study not only confirmed initial research assumptions but also provided in-depth knowledge about the scale and nature of transport exclusion in access to the railway network in the Warmian-Masurian and Masovian Voivodeships. Addressing this problem will require both infrastructure investments and more sustainable spatial and transport planning at the regional level.

Conclusions

1. Conclusions on Comparative Case Study Results and Transport Exclusion.
   1.1. Disparities in Municipal Access: The study confirmed that accessibility to railway stations in rural areas of both Warmia and Masovia is noticeably lower than in urban areas:
      1.1.1. In the Masovian Voivodeship, the problem is widespread, as more than half of the municipalities (124 out of 314) lack a single active passenger station. This exclusion affects even highly urbanized areas, including seven municipalities bordering Warsaw (Marki, Łomianki, Izabelin, Raszyn, Konstancin-Jeziorna, Stare Babice, and Wiązowna) and two Warsaw city districts (Wilanów and Bielany). Four districts in Masovia (Lipski, Makowski, Zwoleński, and Żuromiński) lack access even to existing passenger stations.
      1.1.2. In the Warmian-Masurian Voivodeship, 50 out of 116 municipalities have no active passenger station. The north-eastern part of the voivodeship is particularly characterized by limited access to the railway network.
   1.2. Nature of Exclusion (Organizational vs. Infrastructural): A key finding of the comparative study is that access to the existing railway network is not equivalent to access to the operational railway network. The analysis suggests that the nature of transport exclusion differs between the regions:
      1.2.1. In the Warmian-Masurian Voivodeship, the issue is primarily organizational, as the existing infrastructure is not sufficiently utilized. This is evidenced by the fact that the number of municipalities with access to a station rises significantly from 50 (active) to 71 (existing).
      1.2.2. In the Masovian Voivodeship, the problem is more infrastructural, as the inclusion of existing, non-operational lines only slightly improves accessibility, with the number of municipalities with a station rising from 124 (active) to 132 (existing).

1.3. Infrastructure Quality Disadvantage: The Warmian-Masurian region is at a disadvantage not only due to fewer railway stations but also due to poorer infrastructure quality. The region has a much higher proportion of non-electrified lines (55%) compared to Masovian (20%). Furthermore, 73% of lines in Warmia-Masuria are single-track, contrasting with 38% in Masovia. This poor quality limits the development potential of rail transport and underscores the need for territorial sensitivity in transport planning.

2. Methodological Conclusions on the Utility of GIS Tools.

2.1. Identification and Management: GIS tools allow for accurate inventorying and management of the railway network. The use of cartographic analyses made it possible to identify administrative areas most vulnerable to transport exclusion, providing detailed spatial data and visualisations.

2.2. Filling the Research Gap: By focusing on the municipality and district level, this study partially fills the existing gap in the literature, which previously lacked in-depth comparative analyses at these local scales.

2.3. Decision Support: By mapping both active and decommissioned infrastructure, the GIS methodology provided data essential for supporting decision-making in the revitalisation of railway infrastructure and identifying areas requiring planning or organizational interventions.

References

Arunkumar R., D.T T.S., D.T G.S., G. G., Mythreyan A.S. (2025). Low-Cost Smart Multipurpose Rail Guard: enhancing safety and accessibility at railway platforms. International Journal of Scientific Research in Science and Technology, 12(1), 101–105. https://doi.org/10.32628/ijsrst25121160.

Bacior S., Chmielowski K., Prus B. (2022). Assessment of Motorway Impact on Agricultural Land with a Simplified Method and GIS Data as a Tool for Selecting the Optimal Route. Sustainability, 14(24), 16410. https://doi.org/10.3390/su142416410.

Białobrzeska K. (2023). Wykluczenie transportowe seniorów (*Transport exclusion of seniors*). Studia Pedagogiczne. Problemy społeczne, edukacyjne i artystyczne. Article 41. https://doi.org/10.25951/9578.

Białobrzeska K., Maciejewska M., Kucz M. (2023). Społeczne aspekty wykluczenia komunikacyjnego w województwie warmińsko–mazurskim (*Social aspects of communication exclusion in the Warmian-Masurian Voivodeship*). Federacja FOSa. https://federacjafosa.pl/wp-content/uploads/2023/11/Spoleczne-aspekty-wykluczenia-komunikacyjnego-w-wojewodztwie-warminsko-%E2%80%93-mazurskim_raport-z-badan.pdf [access: 19.08.2025].

Bieda A., Bydłosz J., Warchoł A., Balawejder M. (2020). Historical underground structures as 3D cadastral objects. Remote Sensing, 12(10), 1547. https://doi.org/10.3390/rs12101547.

Biegańska J. (2013). Rural areas in Poland from a demographic perspective. Bulletin of Geography Socio-economic Series, 20(20), 7–22. https://doi.org/10.2478/bog-2013-0008.

Bocheński T. (2011). Pasażerskie połączenia kolejowe w Polsce (*Passenger rail connections in Poland*). Prace Komisji Geografii Komunikacji PTG, 18, 15–25.

Bocheński T. (2016). Dostęp wybranych miast w Polsce do kolei (*Transport accessibility studies with particular emphasis on railways*). Prace Komisji Geografii Komunikacji PTG. https://doi.org/10.4467/2543859xpkg.16.023.6321.

Bocheński T. (2018). Badania dostępności transportowej ze szczególnym uwzględnieniem kolei (*Transport accessibility studies with particular emphasis on railways*). In: S. Sitek (ed.). Stare i nowe problemy badawcze w geografii społeczno–ekonomicznej, pp. 103–121. Polskie Towarzystwo Geograficzne oddział Katowicki i Wydział Nauk o Ziemi Uniwersytetu Śląskiego. https://open.icm.edu.pl/items/84f658ba-51a9-4762-9f4d-dde7ed470e6c [access: 19.08.2025].

Bocheński T. (2021). Analiza porównawcza ruchu pociągów pasażerskich w Polsce w latach 2010 i 2020 (*Comparative analysis of passenger train traffic in Poland in 2010 and 2020*). Prace Komisji Geografii Komunikacji PTG, 24(2), 69–82.

Bocheński T. (2024). Potencjał i perspektywy rozwoju infrastruktury transportu kolejowego w Polsce w ujęciu przestrzennym (*The potential and prospects for the development of rail transport infrastructure in Poland in spatial terms*). Wydawnictwo Naukowe Uniwersytetu Szczecińskiego.

Brons M., Givoni M., Rietveld P. (2008). Access to railway stations and its potential in increasing rail use. Transportation Research Part a Policy and Practice, 43(2), 136–149. https://doi.org/10.1016/j.tra.2008.08.002.

Burakowski D., Lizińska W. (2024). Depopulation of rural areas as peripheral areas in the Warmian-Mazury voivodeship in comparison with the country. Annals of the Polish Association of Agricultural and Agribusiness Economists, XXVI(4), 18–31. https://doi.org/10.5604/01.3001.0054.8092.

Ciechański, A. (2023). Regres sieci transportu publicznego w powiatach Beskidu Niskiego i Bieszczad a wykluczenie transportowe młodzieży uczącej się (*The decline of public transport networks in the districts of Beskid Niski and Bieszczady and the transport exclusion of young people in education*). Instytut Geografii i Przestrzennego Zagospodarowania Polskiej Akademii Nauk.

Currie G., Delbosc A. (2010). Exploring the trip chaining behaviour of public transport users in Melbourne. Transport Policy, 18(1), 204–210. https://doi.org/10.1016/j.tranpol.2010.08.003.

Delbosc A., Currie G. (2011). Exploring the relative influences of transport disadvantage and social exclusion on well-being. Transport Policy, 18(4), 555–562. https://doi.org/10.1016/j.tranpol.2011.01.011.

Górny J. (2016). Samorząd wojewódzki jako organizator kolejowych regionalnych przewozów pasażerskich (*The voivodeship government as the organiser of regional*

passenger rail transport). Prace Komisji Geografii Komunikacji PTG. https://doi.org/10.4467/2543859xpkg.16.024.6322.

Guzik R. (2014). Dostępność transportowa wybranych miast małopolski 2014–2023 (*Transport accessibility of selected cities in Lesser Poland 2014–2023*). Małopolskie Obserwatorium Rozwoju Regionalnego. https://ruj.uj.edu.pl/server/api/core/bitstreams/5303cbe6-bbf7-4c8c-83a7-c16cb847cc66/content [access: 19.08.2025].

Guzik R., Kołoś A., Fiedeń Ł., Kocaj A., & Krzysztof Wiedermann. (2021). Dostępność komunikacyjna i relacje przestrzenne w województwie warmińsko–mazurskim (*Transport accessibility and spatial relations in the Warmian-Masurian Voivodeship*). Instytut Geografii i Gospodarki Przestrzennej UJ.

Integrated Railway Network – a new approach to railway development planning in Poland. (2024). https://www.gov.pl/web/infrastruktura/zintegrowana-siec-kolejowa---nowe-podejscie-do-planowania-rozwoju-kolei-w-polsce [access: 19.08.2025].

Interactive Railway Line Map. (2025). https://mapa.plk-sa.pl/ [access: 19.08.2025].

Kaniowski M., Pypłacz P. (2025). Transport infrastructure and mobility exclusion in urban and suburban areas: the case of Poland. System Safety Human – Technical Facility – Environment, 7(1), 63–78. https://doi.org/10.2478/czoto-2025-0007.

Kołoś A., Taczanowski J. (2018). Możliwości i dylematy rozwoju miejskiego transportu szynowego w Polsce (*Opportunities and dilemmas of urban rail transport development in Poland*). Prace Komisji Geografii Komunikacji PTG, 21(3), 31–44.

Komornicki T. (2024). Wykluczenie transportowe dzieci i młodzieży w Polsce (*Transport exclusion of children and young people in Poland*). UNICEF. https://unicef.pl/co-robimy/baza-wiedzy/raporty-unicef/wykluczenie-transportowe-dzieci-i-mlodziezy-raport-z-badan [access: 19.08.2025].

Komornicki T., Goliszek S. (2021). Inwestycje transportowe finansowane ze środków Unii Europejskiej (*Transport investments financed by the European Union*). In: P. Śleszyński, K. Czapiewski (ed.), Atlas Wyszehradzki, pp. 204–209. Instytut Współpracy Polsko–Węgierskiej im. Wacława Felczaka, Polskie Towarzystwo Geograficzne.

Komornicki T., Stępniak M. (2015). New investment projects in the road corridors and the improvement of the potential accessibility in Poland. Europa XXI, 28, 33–52. https://doi.org/10.7163/eu21.2015.28.2.

Kościńska J., Jarzynowski M., Mencwel J. (2021). Wykluczenie transportowe w województwie mazowieckim (*Transport exclusion in the Masovian Voivodeship*). https://mazowsze.miastojestnasze.org/resources/Wykluczenie-transportowe-w-wojewodztwie-mazowieckim-raport.pdf [access: 19.08.2025].

Kowalczyk K.W. (2019). Pasażerski transport kolejowy na obszarach aglomeracyjnych w Polsce a rozwiązania multimodalne w codziennych dojazdach do pracy (*Passenger rail transport in agglomeration areas in Poland and multimodal solutions in daily commuting*). Lublin, Wydawnictwo UMCS.

Kozłowski W. (2025). Wybrane aspekty dostępności transportowej województwa warmińsko–mazurskiego (*Selected aspects of transport accessibility in the Warmian-Masurian Voivodeship*). Zeszyty Naukowe, XXV, 93–106. https://doi.org/10.62961/fzeg9w47.

Kwarciński T. (2019). Rola publicznego transportu zbiorowego w zaspokajaniu potrzeb transportowych mieszkańców obszarów wiejskich w Polsce (*The role of public transport in meeting the transport needs of rural residents in Poland*). Studia i Prace Kolegium Zarządzania i Finansów, 166, 77–89. https://doi.org/10.33119/sip.2018.166.5.

Lucas K. (2012). Transport and social exclusion: Where are we now? Transport Policy, 20, 105–113. https://doi.org/10.1016/j.tranpol.2012.01.013.

Ludność. stan i struktura oraz ruch naturalny w przekroju terytorialnym w 2024 r. stan w dniu 31 grudnia (*Population: status, structure and natural movement by territory in 2024. Status as of 31 December*). (2025). https://stat.gov.pl/obszary-tematyczne/ludnosc/ludnosc/ludnosc-stan-i-struktura-ludnosci-oraz-ruch-naturalny-w-przekroju-terytorialnym-w-2024-r-stan-w-dniu-31-12,6,38.html [access: 19.08.2025].

Majewski J. (2021). Decarbonization of rail transport as an element of climate policy. Transportation Overview – Przegląd Komunikacyjny, 16–22. https://doi.org/10.35117/a_eng_21_12_03.

Majewski J. (2021). Rola infrastruktury transportu jako jednego z czynników rozwoju regionalnego (*The role of transport infrastructure as one of the factors of regional development*). Prace Komisji Geografii Komunikacji PTG, 24(3), 7–18. https://doi.org/10.4467/2543859xpkg.21.015.15042.

Martens K. (2016). Transport Justice. In: Routledge eBooks. https://doi.org/10.4324/9781315746852.

Masovian Office of Regional Planning w Warszawie. (2022). Strategia rozwoju województwa mazowieckiego 2030+ Innowacyjne Mazowsze (*Development strategy for the Masovian Voivodeship 2030+ Innovative Masovia*). Zespół Wydawniczy Mazowieckiego Biura Planowania Regionalnego w Warszawie. https://www.dialog.mazovia.pl/files/uploads/Strategia%202030/Strategia_rozwoju_wojewdztwa_mazowieckiego_2030_plus_Innowacyjne_Mazowsze_WCAG.pdf [access: 19.08.2025].

Massel A. (2018). Operational criteria in the justification of electrification of railway lines. MATEC Web of Conferences, 231, 06005. https://doi.org/10.1051/matecconf/201823106005.

Ministry of Funds and Regional Policy. (2022). Krajowy Plan Odbudowy i Zwiększania Odporności (*National Recovery and Resilience Plan*). https://www.funduszeeuropejskie.gov.pl/media/109762/KPO.pdf [access: 19.08.2025].

Modernisation of the Railway Line in the Voivodeship. (2024). https://www.gov.pl/web/uw-warminsko-mazurski/modernizacja-linii-kolejowej-w-wojewodztwie [access: 19.08.2025].

Mróz K., Štraub D. (2024). Powiązania komunikacyjne i dostępność transportowa polskich miast w nawiązaniu do aktualnej hierarchii osadniczej (*Communication links and transport accessibility of Polish cities in relation to the current settlement hierarchy*). Instytut Rozwoju Miast i Regionów. https://irmir.pl/wp-content/uploads/2024/06/Powiazania-komunikacyjne.pdf [access: 19.08.2025].

National Geoportal. (2025). geoportal.gov.pl. https://mapy.geoportal.gov.pl/imap/Imgp_2.html?gpmap=gp0 [access: 19.08.2025].

Office of Rail Transport. (2024). Sprawozdanie z funkcjonowania rynku transportu kolejowego 2023 (*Report on the functioning of the rail transport market 2023*). https://dane.utk.gov.pl/sts/sprawozdania-roczne/sprawozdania-z-funkcjon/21538,Sprawozdanie-z-funkcjonowania-rynku-transportu-kolejowego-w-2023-r.html [access: 19.08.2025].

OpenRailwayMap. (2025). https://www.openrailwaymap.org/ [access: 19.08.2025].

OpenStreetMap. (2025). https://www.openstreetmap.org/#map=15/52.31867/21.09581 [access: 19.08.2025].

Polish Railway Database. (2025). Railmap – Mapa Kolejowa. https://www.bazakolejowa.pl/index.php?dzial=mapa#9/51.9805/21.2129 [access: 19.08.2025].

Polish State Railways Polish Railway Lines (2023). Projekty zakwalifikowane na listę podstawową programu Kolej+ (*Projects qualified for the basic list of the Kolej+ programme*). https://www.plk-sa.pl/files/public/user_upload/pdf/Kolej_Plus/Kolej_Ranking_20230102.pdf [access: 19.08.2025].

Preston J., Rajé F. (2006). Accessibility, mobility and transport–related social exclusion. Journal of Transport Geography, 15(3), 151–160. https://doi.org/10.1016/j.jtrangeo.2006.05.002.

ProRail Foundation (2021). Kolej dla klimatu – klimat dla kolei polityka transportowa a ekologia (*Railways for the climate – climate for railways transport policy and ecology*).

Qi L., Yu F., Zhang F. (2023). The Spatial–Temporal evolution on county accessibility and economic impact of Baoding High–Speed Railway Network. Journal of Advanced Transportation, 1–12. https://doi.org/10.1155/2023/8144530.

Rosik P. (2021). Świat dostępności – metody i komponenty: przykłady analiz empirycznych przestrzeni Polski (*The world of accessibility: methods and components: cases of empirical analyses in Poland's space*). In Prace Geograficzne. https://doi.org/10.7163/9788361590767.

Rosik P., Pomianowski W., Goliszek S., Stępniak M., Kowalczyk K., Guzik R., Kołoś A., Komornicki T. (2017). Multimodalna dostępność transportem publicznym gmin w Polsce (MULTIMODACC) (*Multimodal accessibility by public transport of municipalities in Poland*). https://ruj.uj.edu.pl/xmlui/handle/item/48128 [access: 19.08.2025].

Rosik P., Stępniak M., Komornicki T. (2014). The decade of the big push to roads in Poland: Impact on improvement in accessibility and territorial cohesion from a policy

perspective. Transport Policy, 37, 134–146. https://doi.org/10.1016/j.tranpol.2014.10.007.

Shergold I., Parkhurst G. (2012). Transport–related social exclusion amongst older people in rural Southwest England and Wales. Journal of Rural Studies, 28(4), 412–421. https://doi.org/10.1016/j.jrurstud.2012.01.010.

Sirbu R., & Cujba V. (2020). Urbanization effects on land use changes within the urban agglomeration Chisinau. Acta Scientiarum Polonorum Administratio Locorum, 19(4). https://doi.org/10.31648/aspal.5408.

Sirbu R., Cujba V. (2022). Housing quality in the Republic of Moldova. Acta Scientiarum Polonorum Administratio Locorum, 21(1), 139–151. https://doi.org/10.31648/aspal.7105.

Statistical yearbook of the Masovian Voivodeship. (2024). Urząd Statystyczny w Warszawie. https://warszawa.stat.gov.pl/publikacje-i-foldery/roczniki-statystyczne/rocznik-statystyczny-wojewodztwa-mazowieckiego-2023,4,23.html [access: 19.08.2025].

Statistical yearbook of the Warmian-Masurian Voivodeship. (2024). Urząd Statystyczny w Olsztynie. https://olsztyn.stat.gov.pl/publikacje-i-foldery/roczniki-statystyczne/rocznik-statystyczny-wojewodztwa-warminsko-mazurskiego-2024,2,17.html [access: 19.08.2025].

Strategic Planning Task Team at the Marshal's Office of the Warmian-Masurian Voivodeship in Olsztyn. (2020). Warmińsko–Mazurskie 2030 Strategia rozwoju społeczno–gospodarczego (*Warmia-Masuria 2030 Strategy for social and economic development*). Zarząd Województwa Warmińsko–Mazurskiego.

Sudra P. (2020). Rozpraszanie i koncentracja zabudowy na przykładzie aglomeracji warszawskiej po 1989 roku (*Dispersion and concentration of built-up areas on the example of the Warsaw agglomeration after 1989*). In: Prace Geograficzne. https://doi.org/10.7163/9788361590057.

Szłapacki W. (2024). Dostępność transportu publicznego w wybranych średniej wielkości miastach Pomorza Środkowego (*Availability of public transport in selected medium-sized cities in Central Pomerania*). Rozwój Regionalny i Polityka Regionalna, 71. https://doi.org/10.14746/rrpr.2024.71.04.

Szopińska K., Cienciała A., Bieda A., Kwiecień J., Kulesza Ł., Parzych P. (2022). Verification of the Perception of the Local Community concerning Air Quality Using ADMS-Roads Modeling. International Journal of Environmental Research and Public Health, 19(17), 10908. https://doi.org/10.3390/ijerph191710908.

United Nations. (2015). Transforming our world: The 2030 Agenda for Sustainable Development. https://sdgs.un.org/2030agenda [access: 19.08.2025].

Wilkosz-Mamcarczyk M., Olczak B., Prus B. (2020). Urban features in rural landscape: A case study of the Municipality of Skawina. Sustainability, 12(11), 4638. https://doi.org/10.3390/su12114638.

Yang L., Eom S., Suzuki T. (2021). Measuring railway network performance considering accessibility levels in cities worldwide. Journal of Transport Geography, 96, 103211. https://doi.org/10.1016/j.jtrangeo.2021.103211.

Zdzisław N.W. (2018). Dostępność transportowa jako kategoria ekonomiczna (*Transport accessibility as an economic category*). Problemy Kolejnictwa, 179, 37–48. https://doi.org/10.36137/1795p.

Zoli A., Pazzini M., Vignali V., Imine H., Simone A., Lantieri C. (2025). Assessing Cyclists' Accessibility into Railway Stations Through a User-Centered Indicator. Sustainability, 17(2), 504. https://doi.org/10.3390/su17020504.

Zou M., Li C., Xiong Y. (2022). Analysis of Coupling Coordination Relationship between the Accessibility and Economic Linkage of a High-Speed Railway Network Case Study in Hunan, China. Sustainability, 14(13), 7550. https://doi.org/10.3390/su14137550.