



The Impact of Investment in Transport Infrastructure on Sustainable Development in Central and Eastern European Countries

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Abstract: In the countries of Central and Eastern Europe, which have undergone systemic transformation and are economically integrating with the European Union, the development of transport infrastructure has become one of the priorities of public policy, supported by significant financial resources from EU funds. The processes of globalization and the internationalization of enterprises have contributed to the fact that modern businesses face the challenge of achieving synergy between dynamic economic growth and the need for environmental protection and sustainable development. This article attempts to explain the impact of investment in transport infrastructure on sustainable development. The analysis conducted points to both positive effects, such as increased mobility, improved transport accessibility, and enhanced investment attractiveness, as well as negative consequences, including increased CO₂ emissions, environmental degradation, and the deepening of regional disparities. The article aims to highlight the implications of transport infrastructure in the context of sustainable development. Two research methods were used in the study: literature analysis and statistical analysis. The Pearson correlation analysis, although conducted for only one research period, showed that countries with more developed motorway networks often exhibit higher CO₂ emissions, which may be determined by multiple factors. It should be emphasized that infrastructure development can effectively support sustainable development, provided it is guided by responsible planning and a long-term strategic approach.

Keywords: transport infrastructure, sustainable development, Central and Eastern European countries

1. Introduction

Transport infrastructure in the EU is evolving towards sustainable development through the gradual integration of modern technologies and ecological solutions. Today, companies strive to optimize transportation costs to remain as competitive as possible in the market. This is primarily achievable thanks to modernization projects, particularly in the context of intermodal transport, which take into account climate goals and policies. In the development of infrastructure in Central and Eastern European countries, efforts are primarily focused on reducing asymmetries in the construction of rail and road networks. Transport infrastructure is beginning to play a key role, especially in the context of the energy transition. It is also expected to create the conditions necessary for productive activity and, although it does not directly generate added value, it is a crucial component of economic growth. Ongoing globalization, increasing consumer demands, the production of highly specialized goods, lean management approaches, shorter production cycles, and the rapid development of information technologies are placing growing demands on businesses (Ivanova et al. 2022). This study analyzes the impact of investments in transport infrastructure on sustainable development in Central and Eastern European countries, with particular emphasis on environmental protection. It examines how improved transport networks can contribute not only to economic growth and regional integration but also to reducing environmental degradation through enhanced energy efficiency, decreased emissions, and promotion of greener transportation modes. The research highlights the necessity of balancing infrastructure development with ecological considerations to ensure long-term sustainability.

2. Sustainable Development and Transport Infrastructure

Transport should be regarded as a key element in socio-economic development and considered on two levels, that of both a provider and a recipient (Rydzkowski 2008). On one hand, transport as an economic factor is an indicator of economic activity, while at the same time, it reflects that very activity. Transport is also a sector of the economy that has a significant impact on every segment of material production and services (Bełch 2019).



Transport should also be analyzed from the perspective of the transport system. It should be defined as a set of technical, economic, organizational, and legal factors involved in the process of mutual cooperation between different modes of transport, which determine the nature of interdependencies and connections between transport and other sectors of the national economy (Hofman 1962). Transport thus comprises several elements, including means of transport, people, and infrastructure, thereby forming a transport system (Rogaczewski 2018).

Transport infrastructure¹ is an integral part of the transport system of a city or a country and plays a crucial role in the global economy. According to Skorobogatov and Kuzmina-Merlino (2017), with the development of society and the increasing international activity of enterprises, the importance of transport as a determinant of economic and social development has grown. Transport infrastructure consists of the elements specific to various modes of transport, including rail, road, maritime, inland waterway, and air transport (Jacyna et al. 2011). Transport infrastructure is therefore public in nature, and its use is based on rules that are uniform for all users (Liberadzki & Mindur 2007). It should be noted that the concept of transport infrastructure encompasses two main components: linear elements (transport routes) and point elements (ports and transport hubs). Linear infrastructure includes roads and both natural and artificial pathways used by transport vehicles, while point infrastructure refers to all the elements within the network that facilitate the servicing of transport vehicles along the entire route (Ejdys 2023). According to Kaczyńska and Korycińska (2014), transport infrastructure consists of human-made, permanently located routes across all modes of transport, transport nodes, and auxiliary facilities designed to support the functioning of routes and transport points. According to Szymonik (2013), the main tasks of transport infrastructure include:

- meeting the needs of society (Chamier-Gliszczyński 2017) and the economy in overcoming spatial distances,
- implementing the objectives and actions set out in the transport policy,
- shaping the legacy of the future.

Contemporary requirements for planning and developing transport infrastructure demand that transport systems be environmentally friendly and economical, thus fulfilling the main principles of sustainable development. Sustainable development is understood as a socio-economic development process that integrates political, economic, and social actions while maintaining ecological balance and the durability of fundamental natural processes, to ensure the ability to meet the basic needs of individual communities or citizens of both the present and future generations (Act of April 27, 2001). This excerpt from the above law confirms that socio-economic sustainable development should be as environmentally friendly as possible. According to Mielczarek-Mikołajów (2021), sustainable development involves implementing the idea that the needs of the current generation should not cause negative consequences and can be met without reducing the chances of future generations to meet their own needs. A similar definition of sustainable development, but in the context of sustainable transport, is presented by Sakhapov and Nikolaeva (2021), who state that actions aimed at sustainable transport concern processes carried out in such a way as to meet the current transport needs of humanity without depriving future generations of the ability to satisfy their transport needs. A sustainable transport system does not threaten the health of societies or ecosystems while simultaneously meeting mobility needs (OECD, 1996). According to Poliński (2012), sustainable transport is a means of moving people and goods that satisfies human needs without threatening their health or posing a risk to ecosystems. The fundamental features of such transport are economic accessibility, high efficiency, low pollutant emissions (Fu et al. 2024), reduced congestion, and ensuring the smooth flow of transport means. As Woźniak (2015, 2016) writes, the above features can be implemented using advanced optimization algorithms in the process of planning and executing various transport orders. Brzeziński (2011) adds that sustainable transport development is possible thanks to technological and technical progress, which will contribute to reducing at least some components of the so-called external costs. Sustainable development primarily requires (Poliński 2012):

- defining the state's transport policy as a fundamental document shaping the principles of long-term development of individual transport sectors,
- establishing legal and organizational foundations for cooperation between scientific research, transport equipment manufacturers, authorities, and transport enterprises,
- implementing innovative organizational, technical, and technological solutions.

¹ Infrastructure is defined as the totality of basic facilities and institutions necessary for the proper functioning of the economy. These are permanently located public-use facilities that serve as the foundation of socio-economic life due to their functions (Gołomska 2013).

A relatively new concept, as emphasized by Marcinek (2018), is that of sustainable infrastructure. According to the author, infrastructure, on one hand, enables the proper functioning of society and the economy, on the other hand, it may cause unintended and unforeseen consequences in the immediate or more distant environment. Therefore, it is reasonable to design, implement, and operate transport infrastructure in a way that aligns with the principle of sustainable development (Chamier-Gliszczyński 2016).

It is also important to highlight the significance of the individual dimensions—social, economic, and environmental—regarding issues related to sustainable transport development (see Table 1). The proposed division clearly indicates that the transport of goods or passengers should be carried out in a manner that simultaneously takes into account these dimensions (Borys 2008).

Table 1. Dimensions of Sustainable Transport Development

Social dimension	Economic dimension	Environmental dimension
<ul style="list-style-type: none"> – mobility, – accessibility, – fluidity, – safety, – social cohesion, – transport system integrity. 	<ul style="list-style-type: none"> – competitiveness, – working conditions in the sector, – infrastructure, – intramodality. 	<ul style="list-style-type: none"> – environmental friendliness of transport, – prevention and mitigation of environmental hazards caused by transport.

Source: Borys (2009).

3. Investments in Transport Infrastructure in Central and Eastern Europe

Investments in transport infrastructure currently pose a significant challenge for governments. It should be noted that developing countries face important challenges, such as ensuring adequate land transport infrastructure. Countries with low or middle GDP per capita face an even more difficult task, as there is a considerable development gap in transport infrastructure (Gonzalez-Navarro et al. 2023). Today, due to the war in Ukraine and political-economic turbulence worldwide, countries often face the dilemma of how to allocate financial resources for various projects properly. According to Koźlak (2015), when financial resources for implementing infrastructure projects in transport are limited, it is crucial to allocate funds to those projects that will generate the greatest positive effects, including economic ones.

Investments in transport infrastructure impact the improvement of accessibility to regions and labor markets, reduction of congestion-related burdens, lowering of transport operating costs, and, above all, shortening of transport times. These actions, in turn, bring measurable benefits in the form of increased efficiency and productivity, as well as enhanced competitiveness of enterprises and regions (Łatuszyńska & Strulak-Wójcikiewicz 2013).

Due to globalization and internationalization processes, enterprises undertake numerous activities aimed at developing transport infrastructure. This area is particularly crucial and affects regional attractiveness. Well-developed transport infrastructure, characterized by sustainability, constitutes an attractive location for foreign direct investments by enterprises. For example, the PwC report (2015) projected that investments in transport infrastructure worldwide would grow by about 5% on average between 2014 and 2025. This report, however, did not foresee or account for events such as the COVID-19 pandemic or the war in Ukraine, during which some countries—especially in Central and Eastern Europe – were forced to redirect financial resources to other priorities at the expense of infrastructure investments.

It is therefore worthwhile to examine the development of transport in individual Central and Eastern European countries. Road transport plays a key role both in Poland and in other countries of the region. Additionally, the geographical location of these countries intensifies transit traffic between Western and Southern Europe. The widespread use of this mode of transport is evidenced by its speed and flexibility, which result from the extensive availability of linear and nodal infrastructure. The best tool to assess the development of transport infrastructure is the density of the road network. The road network density in selected Central and Eastern European countries was as follows (see Fig. 1)².

² Road network density is the ratio of the total length of roads to the area of the region in which these roads are located.

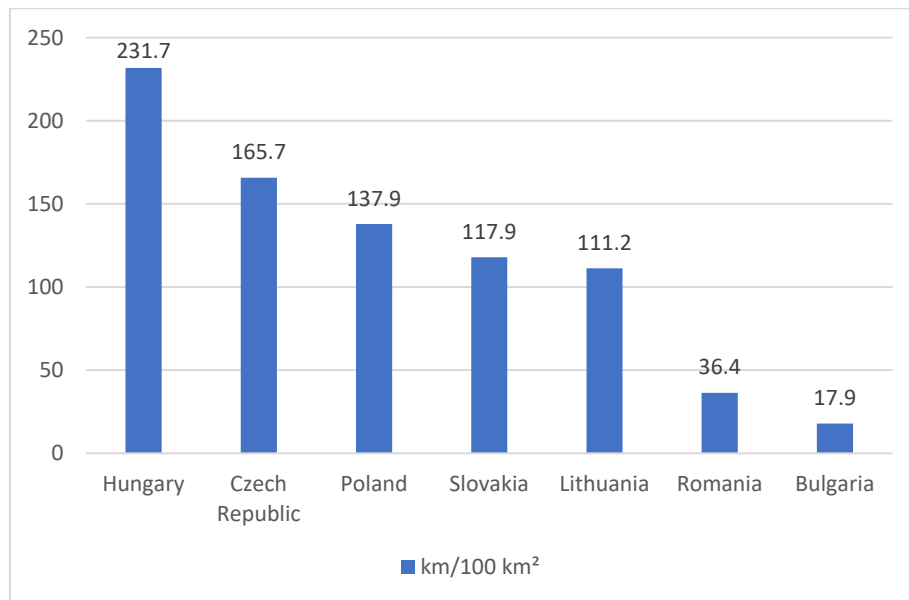


Fig. 1. Road Network Density in Central and Eastern European Countries in 2021 (km/100 km²).
Source: Eurostat (2023)

The highest road network density in 2021 was recorded in Hungary, amounting to 231.7 km/100 km². The lowest density levels were observed in Romania and Bulgaria, with 36.4 km/100 km² and 17.9 km/100 km², respectively. Currently, European policy is focused on reducing the dominance of road transport and is prepared to expand the pan-European network of transport corridors. When analyzing the railway network density (Fig. 2) in selected Central and Eastern European countries, it is important to note that the priority for each country is to maximize the use of rail transport while minimizing energy consumption and other resource expenditure.

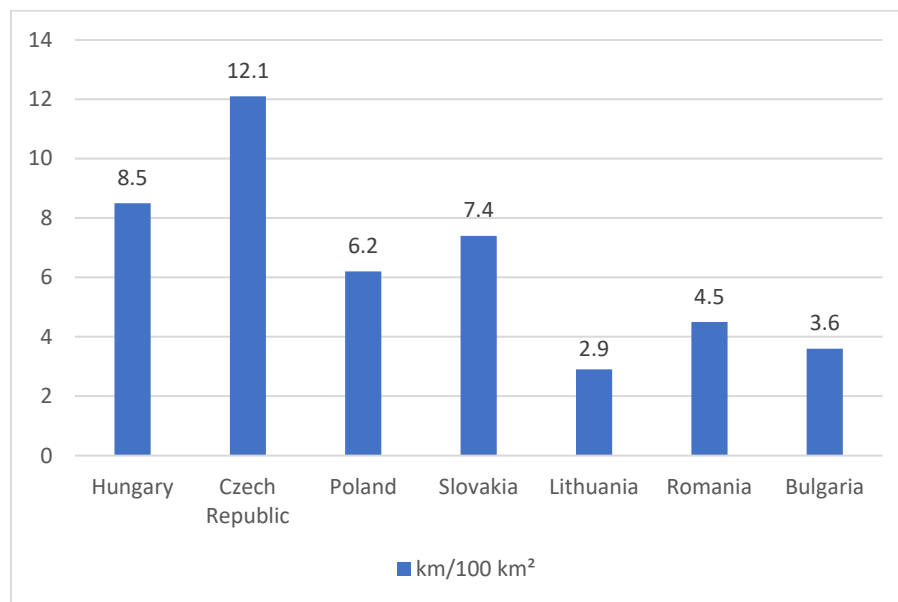


Fig. 2. Railway Network Density in Central and Eastern European Countries in 2022 (km/100 km²).
Source: European Commission (2022)

Among the analyzed European Union countries in 2022, the Czech Republic had the longest railway line length, while Bulgaria and Lithuania had the shortest, with only 3.6 km/100 km² and 2.9 km/100 km², respectively.

The actions undertaken by the EU within the framework of European railway transport policy aim to create a single railway area and, above all, to ensure fair competition as well as freedom to provide services. Therefore, it is necessary to take measures that will organize and harmonize technical, administrative, and safety regulations (Thematic Note on the European Union, 2025).

In the context of the development of intermodal transport in Central and Eastern European countries (Fig. 1), it is important to highlight the density of intermodal terminals in selected countries. For the development of intermodal transport, the Black Sea region is crucial for Bulgaria and Romania. It is worth noting the advantageous geographical location of Bulgaria, which constitutes a significant asset for the country. Bulgaria can successfully compete with other countries and deliver goods to Western Europe (Stępniewski 2018). Intermodal hubs such as Sofia, Burgas, Varna, as well as rail terminals in Ruse and Plovdiv, play an important role in ensuring the smooth flow of goods both domestically and to international markets. There is no doubt that investments are still necessary to develop infrastructure and modernize existing hubs to increase the competitiveness of this transport sector (Kłodawski et al. 2024). Romania, on the other hand, is crossed by three Pan-European corridors running north-south and east-west. According to Stępniewski (2018), this is undoubtedly a strategic location. It should also be mentioned that Romania, based on its integration document, has committed to developing its main transport infrastructure by 2030.

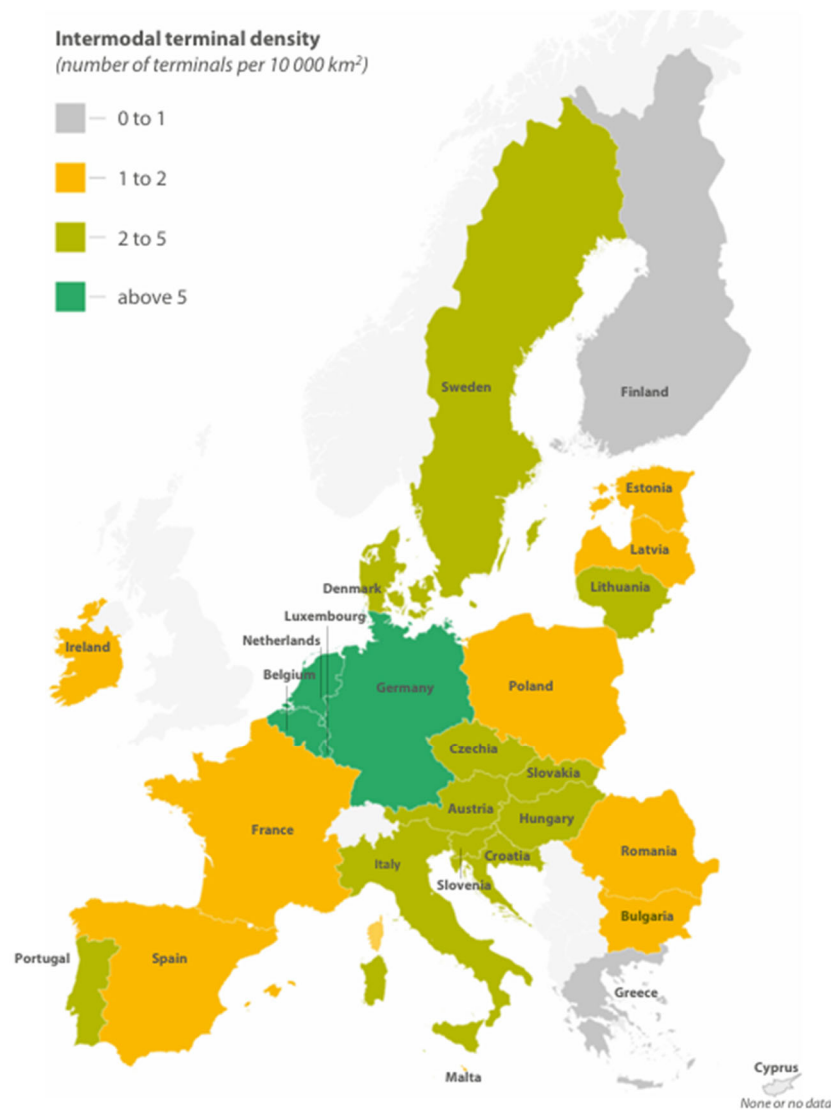


Fig. 3. Density of intermodal terminals in selected countries in 2020. Source: ECA (2020)

In Poland, in 2023, there were 39 active terminals (Fig. 4), of which 4 handled shipments in the sea-rail and sea-road relations (maritime terminals), and 35 handled shipments in the rail-road relation (inland terminals).

According to Kuś (2023), intermodal transport in Poland experienced more than a threefold increase in transported volume between 2012 and 2022; however, various macroeconomic factors indicate a slight slowdown in 2023. The following years are expected to contribute to a more intensive development of combined transport.



Fig. 4. Distribution of intermodal terminals in 2023. Source: Central Statistical Office (Główny Urząd Statystyczny) (2024)

It is assumed that in the coming years, intermodal transport will continue to develop further in Central and Eastern European countries. This growth will be influenced by the EU's climate and transport policies, infrastructure investments, the expansion and construction of new container terminals (Jachimowski & Kłodawski 2025), as well as investments by logistics operators.

Investments, especially in transport infrastructure, play a key role in shaping the future of Central and Eastern European countries. They impact sustainable development across three areas: economic, social, and environmental. Infrastructure investments should significantly contribute to sustainable development. In the longer term, the driving force behind the growth of intermodal transport in Central and Eastern Europe will be climate policy. At this point, it is worth highlighting several programs dedicated to the development of transport infrastructure. In Poland, among the key investment initiatives are the Government Program for the Construction of National Roads until 2030 (with a perspective extending to 2033) and the National Traffic Management System. The Road Construction Program aims to expand and modernize the national road network in Poland, including the creation of new motorways and expressways. Moreover, an important component of transport infrastructure development is its electrification, such as the installation of electric vehicle charging stations (Mazur et al. 2024) under the Electromobility Development Program, as well as the purchase of electric buses (for example, in Warsaw).

Various modernization programs have also been planned for rail transport. These include, among others, the Railway Development Program and the National Railway Program. These programs aim to support the development of sustainable public transport, including the modernization and construction of modern railway stations, the purchase of low-emission train sets, and the development of infrastructure for urban transport.

Other countries in Central and Eastern Europe have also planned numerous investment programs aimed at developing transport infrastructure. In the Czech Republic, mention should be made of the Expressway Construction Program (www.md.gov.cz, 05.04.2025) as well as railway modernization programs, including the construction of a high-speed rail line between Prague and Ostrava (www.cd.cz, 05.04.2025). Bulgaria is also undertaking significant investments in transport infrastructure. The leading operator in Bulgaria, BMF Port Burgas, set a new record in total trade turnover in 2023, reaching nearly 3 million tons. It is worth noting that the port recorded a 12% increase in container volume compared to 2022. Trade turnover already accounts for 49% of the Bulgarian market share. Additionally, BMF Port Burgas has started construction of the first deep-water quay for container ships in Bulgaria (Pawlak 2023). Bulgaria has also announced a tender for the technical design and construction of an intermodal terminal in Ruse, which will play a key role in the development of a rail freight corridor with Greece.

The Romanian government is also undertaking several investments, including the modernization of the railway infrastructure at the port of Constanta through the construction of a second rail access point (www.reuters.com). Lithuania is implementing a range of important transport infrastructure projects. Among the most significant is the construction of the Via Baltica section to the Polish border, which will undoubtedly improve not only road connections with Poland but also enhance military mobility and security in the region. Investments are also planned in new rolling stock, including electric and battery-powered trains (www.madeinvilnius.lt). Another key project in Lithuania is the development plan for infrastructure at the Rail Baltica hub in Panevėžys (www.nakolei.pl). Important railway infrastructure investments are also being carried out in Slovakia.

The primary goal of all programs aimed at improving transport infrastructure is to ensure the efficient functioning of both passenger and freight transport, enhance capacity, and enable faster and more cost-effective flow of goods and services. The implementation of planned investments will also meet citizens' expectations for fast and safe communication, which perfectly aligns with the concept of sustainable transport (Ejdys 2020).

Funding improvements in inland waterway transport infrastructure plays a key role in advancing sustainable development across Central and Eastern Europe. Upgrading navigational routes, modernizing port facilities, and renewing the fleet help create a more efficient and cost-effective transport system that is also environmentally friendly. Inland waterways serve as a greener alternative to road and rail, reducing traffic congestion and lowering carbon emissions. Promoting this mode of transport supports EU objectives for reducing the carbon footprint of logistics and encourages integrated multimodal transport solutions, contributing to economic progress while safeguarding the environment in the region. Key projects include the modernization of Danube River ports in Romania and Bulgaria, which are essential for strengthening trade connections along the Rhine-Danube corridor. Additionally, Poland has made significant progress in developing the Vistula River navigation system, aimed at improving cargo transport efficiency between the Baltic Sea and inland areas. Slovakia and the Czech Republic are also investing in upgrading their inland waterway infrastructure to enhance multimodal transport options and support sustainable logistics. These initiatives not only boost regional trade but also help reduce greenhouse gas emissions by shifting freight transport from road to waterways.

4. The Impact of Investments on Sustainable Development

Modern transport systems play a crucial role in promoting sustainable development by simultaneously considering social, economic, and environmental factors. This is especially significant in the context of Central and Eastern Europe – a region characterized by varying levels of infrastructure development. In light of the European Green Deal strategy and the United Nations' global Sustainable Development Goals, there is an increasing emphasis on promoting low-emission transport, developing intelligent logistics systems, and strengthening interregional connectivity.

Strategies related to sustainable transport development in Central and Eastern Europe mainly stem from the policies of the European Union and the United Nations. The most important among them are:

- The European Green Deal,
- The United Nations Sustainable Development Goals (SDGs),
- TEN-T (Trans-European Transport Network),
- The "Fit for 55" package.

The Green Deal, often criticized in public opinion, is a crucial EU strategy aimed at achieving climate neutrality by 2050.

Transport in the EU is responsible for one-quarter of the Union's greenhouse gas emissions. Regarding transport, the strategy includes, among others, a 90% reduction in greenhouse gas emissions from transport, the development of railways as a more economical and environmentally friendly alternative to road transport, support for electromobility including electric vehicles and charging infrastructure, as well as the promotion of public and alternative transport (European Commission, 2020).

Important assumptions regarding sustainable transport are included in the United Nations Sustainable Development Goals (SDGs). Transport plays a significant role in achieving many of the SDGs, both directly and indirectly. The main objectives by 2030 are:

- to ensure everyone has access to safe, affordable, accessible, and sustainable transport systems, thereby improving road safety,
- public transport should be low-emission to reduce air pollution (Chamier-Gliszczyński et al. 2024),
- increase funding for investments in intelligent transport systems (ITS) and mobility as a service (MaaS) (Dyczkowska et al. 2023),
- spatial planning and integrated transport support the creation of more accessible cities (United Nations, 2015).

The "Fit for 55" package also includes a range of guidelines regarding sustainable and eco-friendly transport. The main provisions are the ban on the sale of new combustion engine cars from 2035 onwards (after 2035, new cars must be zero-emission), and from 2027, the emissions trading system will also cover fuels used in road transport, which will gradually increase the prices of fossil fuels. The package also obliges EU member states to build electric vehicle charging stations and hydrogen refueling stations (European Commission, 2021).

It is also important to highlight the investments made in sustainable development in Central and Eastern Europe. One such example is the investments by the European Bank for Reconstruction and Development (EBRD), which invested a record €16.6 billion in 2024, representing a 26% increase compared to the previous year. Nearly 70% of all projects concerned low-carbon transformation, including renewable energy sources and green bonds. The largest investments were carried out in Poland, Ukraine, and Turkey (Strohecker 2025). In 2022, green bond issuance increased in Central and Eastern European countries. In the Czech Republic, the first green bond issuance took place, valued at €350 million (Global Finance, 2023). Numerous investments in the energy transition have also been undertaken. One notable project is the construction of the A7 motorway in Romania, stretching 500 km and connecting Bucharest with the border of Ukraine. This project is of key importance for improving transport connections and supporting Ukraine's export of grain (Monnot 2024).

When analyzing the impact of infrastructure investments on sustainable development, it is worth citing some statistical data confirming that the development of sustainable transport, including electric vehicles and public transport, contributes to CO₂ reduction. In 2023, the average CO₂ emissions of new cars in the EU amounted to 106.6 g/km, representing a 1.4% decrease compared to 2022 (European Commission, 2024). It is projected that by 2025, electric vehicles will account for 20-24% of the total passenger car fleet in the EU, which will undoubtedly impact CO₂ emission reduction. However, these assumptions may be overly optimistic due to political and economic turmoil as well as market uncertainty.

Considering the impact of transport infrastructure on sustainable development in selected Central and Eastern European countries, it is worth conducting a correlation analysis between highway length and CO₂ emissions. This study aims to understand whether the expansion of the highway network leads to an increase in CO₂ emissions, which could indicate the need to implement more ecological transport solutions such as electromobility or the development of public transport. To calculate the Pearson correlation coefficient, it is necessary to compile the following statistical data (Table 2).

Table 2. Length of Highways and CO₂ Emissions from Road Transport in Selected Central and Eastern European Countries in 2022

Central and Eastern European countries		Length of highways in km	CO ₂ emissions in million metric tons
Poland	PL	1676	73
Czech Republic	CZ	1276	30
Slovakia	SK	495	7,6
Hungary	HU	1723	22
Romania	RO	866	19
Bulgaria	BG	790	14
Lithuania	LT	403	8
Latvia	LV	–	7
Estonia	EE	161	6

Source: Road Network (2022), Tiseo (2024)

The calculations indicate a noticeable positive correlation between the length of highways and the amount of CO₂ emissions from road transport in Central and Eastern European countries. The correlation coefficient was 0.76 in 2022. Countries with a more developed highway network often exhibit higher CO₂ emissions, which may be related to greater traffic intensity, a larger number of vehicles, and generally higher levels of transport activity driven by economic development.

5. Conclusions and Recommendations

Investments in transport infrastructure in Central and Eastern European countries play a crucial role in their integration with the European economy. The construction and modernization of linear and nodal infrastructure, such as roads, highways, railways, and public transport systems, contribute to improved mobility for residents, attract investors, create new jobs, and support sustainable development. However, it is important to remember that intensive infrastructure development also poses challenges, especially in terms of environmental protection and social cohesion, which require responsible and long-term planning.

Therefore, responsible and long-term planning is essential to balance economic benefits with environmental sustainability and social well-being. It is recommended to prioritize actions for sustainable development, such as increasing funding for the development of low-emission transport modes within various transport sectors as an alternative to traditional road transport. This includes investments in electrified railways, expansion of cycling infrastructure, and enhancement of public transport networks to reduce reliance on private vehicles and lower greenhouse gas emissions. Additionally, the development of multimodal transport should be supported, alongside the maintenance and modernization of existing infrastructure.

The priority should be the implementation of solutions that minimize the negative impact of infrastructure investments on the natural environment, such as the protection of biodiversity, the reduction of air and noise pollution, and the sustainable management of natural resources.

Equally important is the maintenance and modernization of existing infrastructure to extend its lifespan, improve safety, and reduce resource consumption. Undoubtedly, greater engagement is needed from society and local governments, particularly in the context of the effective use of EU funds, to ensure that infrastructure investments align with the goals of climate neutrality and social equity.

Public awareness, stakeholder participation, and transparent decision-making processes are crucial to fostering sustainable transport systems that contribute positively to both the environment and quality of life in Central and Eastern Europe.

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