

# CRITICAL GREEN TRANSPORT INFRASTRUCTURE IN A DEVELOPMENT REGION OF ROMANIA

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## ABSTRACT:

The geographical position of Romania at the end of European Union, the Schengen Area and on the Eastern Flank of North Atlantic Treaty Organization creates the context of a highly exposed area. The European Union framework of organisation applied in Romania generated Regions and Macro Regions that are more punctually exposed. The paper approaches the most populated region of Romania – Development Region of Romania number three – North East Development Region, part of Macro Region Two of Romania for which the evolution of resident population is presented. The exposed region is researched in detail regarding the ecological transport infrastructure connections and critical points along the routes. The mapping of each critical point is being made for the region and extended to neighbouring regions to ensure a comprehensive view of the discovered critical routes for passengers and freight transport. Finally, discussion is made and conclusions are drawn, from which the most important resulted the need of an atlas of critical points along the ecological transport infrastructure of the region and lately, for the entire country.

## 1. INTRODUCTION

### 1.1 General context

The general context of the national regionalisation is based on the European Union framework which has developed a territorial classification by the name of "Nomenclature of territorial units for statistics" – NUTS (Nomenclature of territorial units for statistics), with the purpose to facilitate statistical comparability, uniform policy implementation, unique and uniform territorial administration, based mainly on population developed (European Union – Eurostat, 2025):

- NUTS 1: major socio-economic regions, with population between 3 and 7 million;
- NUTS 2: basic regions (for regional policies), with population between 800000 and 3 million;
- NUTS 3: small regions (for specific diagnoses), with population between 150000 and 800000.

In Romania, the European framework for regionalisation was transposed through Law no. 315 (Legea nr. 315, 2004), being developed according as follows: 41 counties – NUT 3, 8 development regions – NUTS 2 and 4 macro regions – NUTS 1.

### 1.2 Macro Regions of Romania – NUTS 1

At the NUTS 1 level, Romania is divided into four Macro Regions, each grouping two development regions. They are not administrative entities, but serve for statistical and comparative

purposes at the European level (European Union – Eurostat, 2025) and distributed as follows:

- Macro Region One – NUTS code RO1, which encompasses Development Region One – North - West Region and Development Region Two – Centre Region – a total surface area of approximately 68259 km<sup>2</sup> and total population of 4821511 (Regiunile de dezvoltare ale Romaniei, 2025)
- Macro Region Two – NUTS code RO2, which encompasses Development Region Three – North - East Region and Development Region Four – South - East Region – a total surface area of approximately 72612 km<sup>2</sup> and total population of 5575871 (Regiunile de dezvoltare ale Romaniei, 2025)
- Macro Region Three – NUTS code RO3, which encompasses Development Region Four – South – Muntenia Region and Development Region Six – Bucharest - Ilfov Region – a total surface area of approximately 36300 km<sup>2</sup> and total population of 5136002 (Regiunile de dezvoltare ale Romaniei, 2025)
- Macro Region Four – NUTS code RO4, which encompasses Development Region Seven – South - West Region and Development Region Eight – West Region – a total surface area of approximately 61240 km<sup>2</sup> and total population of 3531831 (Regiunile de dezvoltare ale Romaniei, 2025)

The analysis of statistical data at the level of Romania's Macro Regions is necessary and mandatory, as it constitutes an initial

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criterion for assessing trends in the resident population. The research methodology is based on two main criteria for the present study: the geographical and geopolitical position of the Macro Region—NATO’s Eastern Flank—and the distribution of the resident population within Romania.

Analysing the evolution of the resident population over a given period is necessary and essential, given the occurrence of major events during the period under review, namely: a major public health event - the COVID-19 pandemic (Qurat ul A.B, et al, 2025 ); a major military event - the war on Romania’s borders; and a major event for Romania at the European Union level—Romania’s accession to the Schengen Area (History of Schengen, 2025).

The total resident population of Romania has declined steadily by approximately 5% between 2012 and 2023. All Macro

Regions show a decline in population, with insignificant differences compared to the overall percentage.

The analysis of Romania's Macro Regions shows that the largest share of population is in Macro Region Two (Figure 1) with a constant percentage of approximately  $\approx 29.25\%$ , but declining, from  $\approx 5818277$  residents in 2012 to  $\approx 5575871$  in 2023, so a reduction of  $\approx 242406$  people. The covered surface is the largest with a share of 30.46% of Romania's total area. On the other hand, the Macro Region One, the western neighbour of Macro Region Two has a resident population of  $\approx 4957457$  in 2012 that decreases to 4821511 in 2023, so a reduction of  $\approx 135046$  people. The covered surface is the second largest with a share of  $\approx 28.63\%$  of Romania's total area.

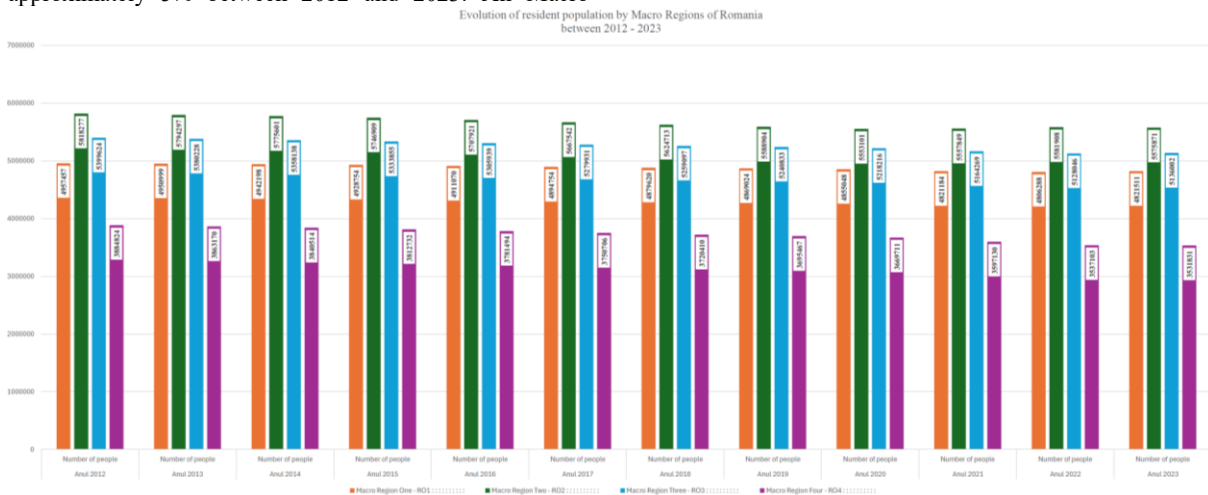


Figure 1. Evolution of resident population in Romania by Macro Regions (National Institute of Statistics Data)

### 1.3 Development Regions of Romania – DRR – NUTS 2

Romania has eight Development Regions (European Union – Eurostat, 2025), proposed from 1998, by the Law no. 151/1998 created in 1998 (Legea nr. 151, 1998). They are the key level for European cohesion policy and structural funds allocation, each representing approximately 10% – 15% of the national resident population and covered surface, as follows (Figure 2):

- Development Region One – NUTS code RO11 - North - West Region, which encompasses counties: Bihor - RO111, Bistrița-Năsăud - RO112, Cluj - RO113, Maramureș - RO114, Satu Mare - RO115, Sălaj - RO116;
- Development Region Two – NUTS code RO12 - Centre Region, which encompasses counties: Alba - RO121, Brașov - RO122, Covasna - RO123, Harghita - RO124, Mureș - RO125, Sibiu - RO126;
- Development Region Three – NUTS code RO21 - North - East Region, which encompasses counties: Bacău - RO211, Botosani - RO212, Iasi - RO213, Neamț - RO214, Suceava - RO215, Vaslui - RO216;
- Development Region Four – NUTS code RO22 - South - East Region, which encompasses counties: Braila - RO221, Buzau - RO222, Constanta - RO223, Galati - RO224, Tulcea - RO225, Vrancea - RO226;
- Development Region Five – NUTS code RO31 - South - Muntenia Region, which encompasses counties: Arges - RO311, Calarasi - RO312, Dambovită - RO313, Giurgiu

– RO314, Ialomita – RO315, Prahova – RO316, Teleorman – RO317;

- Development Region Six – NUTS code RO32 - Bucharest - Ilfov Region, which encompasses counties: Bucuresti - RO321, Ilfov - RO322;
- Development Region Seven – NUTS code RO41 - South - West Region, which encompasses counties: Dolj - RO411, Gorj - RO412, Mehedinti - RO413, Olt - RO414 Vâlcea - RO415;
- Development Region Eight – NUTS code RO42 - West Region, which encompasses four counties: Arad - RO421, Caraș-Severin - RO422, Hunedoara - RO423, Timiș - RO424.



Figure 2. Distribution of resident population (2023) and surface of Romania’s Development Regions

The analysis of the development regions shows that Macro Region Two (NUTS1) and the North-East Development Region (NUTS2), together with the South-East Development Region (NUTS2), are exposed on the Eastern Flank of NATO in Romania, which predispose and amplifies the issues from the point of view of social, economic and political, making it necessary to research the transport infrastructure connections that provide access to European Union, neighbours and development regions, taking into account:

- Geographical and geopolitical position
- Schengen area border
- European Union border
- Development level of Romania's Development Regions
- Position on NATO's Eastern Flank

The statistical data for resident population, analysed by Development Regions of Macro Region Two shows that the population of the North - East Development Region has a higher share than the South - East Development Region, with a share of  $\approx 58\%$ , the evolution being constant along years 2012 – 2023.

The resident population of the North - East Development Region of Romania, taking into account the statistical data of 2023 year (Figure 3) is distributed by County as follows: RO 211 - Bacau County – 19%, RO 212 - Botoşani County – 12%, RO 213 - Iaşi County – 24%, RO 214 - Neamt County – 14%, RO 215 - Suceava County – 20%, RO 216 - Vaslui County – 11%.

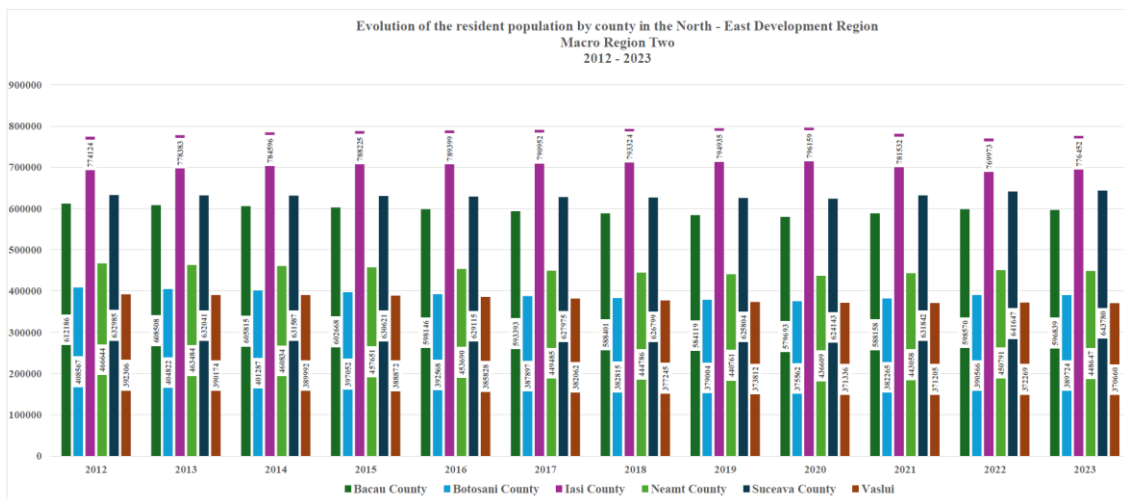


Figure 3. Evolution of resident population in North – East Development Region by County – MR2 (National Institute of Statistics Data)

In order to analyse the current situation, it is necessary to take a comprehensive view of the neighbours of the North – East Development Region which has the largest population in Romania.

The resident population of the North – West Development Region, taking into account the statistical data of 2023 year (Figure 4) is distributed among counties as follows: RO 111 - Bihor County – 22%, RO 112 - Bistrita Nasaud County – 12%, RO 114 - Maramures County – 18%, RO 115 - Satu Mare County – 13%, RO 116 - Salaj County – 8%

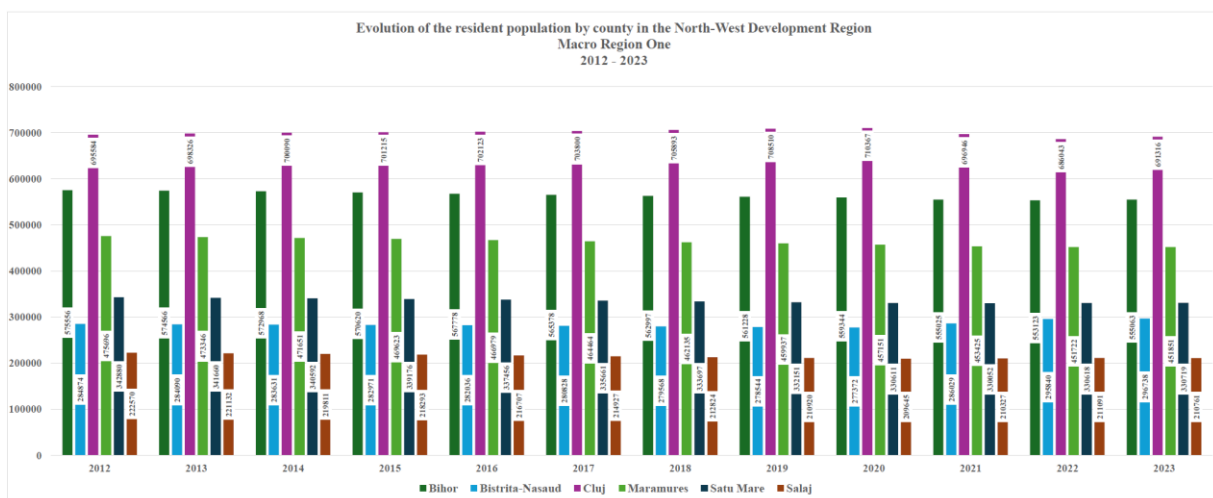


Figure 4. Evolution of resident population in North – West Development Region by County – MR 1 (National Institute of Statistics Data)

## 2. CRITICAL TRANSPORT INFRASTRUCTURES AND HAZARDS

According to national regulations and Ministry of Internal Affairs through the National Coordination Centre for Critical Infrastructure Protection, subsector Transport (Sectorul transportului, 2025), the critical transport infrastructure in Romania is managed by the Ministry of Transport and is divided into the main sectors:

- Road transport;
- Rail transport;
- Air transport;
- Water transport.

Green - ecological or environmentally friendly transport infrastructure is rail transport, and critical points are tunnels – rail tunnels, which are engineering structures that cannot be substituted or replaced within a reasonable time in the event of a hazard, compared to bridges that can be replaced with typical military bridges (Szelka, J., Wysoczański, A., 2022).

The priority set at the European Union level regarding the rail transport system is primarily to ensure an interoperable rail space, an action promoted by the European Union (On the interoperability of the rail system within the European Union, 2025) and technically implemented through the European Union Agency for Railways (Single programming document, 2025).

According to United Nations Office for Disaster Risk Reduction (UNDRR, 2025), of which Romania is a member, there are three types of hazards:

- Natural hazards – natural phenomena such as floods, earthquakes, or hurricanes;
- Anthropogenic hazards – caused by human activity, including armed conflicts;
- Technological hazards – caused by human activity, but referring to industrial accidents.

Managing transport infrastructure in terms of the risks generated by various types of hazards is necessary and mandatory because the implications for human life are significant, both socially and economically, and exposure is considerable.

## 3. ECOLOGICAL TRANSPORT INFRASTRUCTURE OF NORTH -EAST DEVELOPMENT REGION

The North – East Development Region of Romania – DRR3 is located on the border of European Union, Schengen Area and also on the Eastern Flank of NATO in Romania and European Union, having international neighbours: east side – Republic of Moldova country and on the north side – Ukraine country and national neighbours: Development Region North – West – DRR1 and Development Region Centre – DRR2, both on west side and Development Region South – East – DRR4 on the east side.

The ecological transport infrastructure of the region (Figure 5) has two railway magistral, almost parallel, both connecting the eastern side of Romania and three secondary railway lines as follows:

- Railway Magistral 500 - M500, from the ukrainian border - R – CB 8, Vicsani city, Suceava County to the development region border point, located on Sascut city, Bacau County, passing through Neamt County. The railway border crossing point (R – CB 8) has existing

double railway gauge, normal (1435 mm) and wide gauge (1520 mm) (CFR Border stations, 2025).

- Railway Magistral 600 – M600, from Dorohoi city, Suceava County to the development region border point, located on Tutova city, Bacau County, passing through Iasi County.
- Secondary railway line 511, starting from Suceava train station, located on Railway Magistral 500 – M500 and following the route through: Suceava (DRR 3) – Pojorata – Gradinita – Ilva Mica (Belu, 2001) - Apahida (DRR 2) with a total length of approximately 310 kilometres and a maximum gradient of 29.4%. (CFR Line gradients, 2025)
- Secondary railway line 610 and 605, starting from Pascani train station, located on Railway Magistral 500 – M500 and following the route through Iasi to Republic of Moldova, at railway cross border Ungheni Prut – R – CB 9, located in Iasi County, with a total length of approximately 98 kilometres (Feasibility study, 2019) and a maximum gradient of 19.29%. (CFR Line gradients, 2025). The railway border crossing point (R – CB 9) has existing double railway gauge, normal (1435 mm) and wide gauge (1520 mm) (CFR Border stations, 2025).
- Secondary railway line 607, starting from Zorleni train station, located on Magistral 600 – M600 and following the route through Falchiu to Republic of Moldova, at railway cross border Prut – R – CB 10, located in Vaslui County, with a total length of approximately 70 kilometres and a maximum gradient of 22.10%. (CFR Line gradients, 2025). The railway border crossing point (R – CB 10) has existing double railway gauge, normal (1435 mm) and wide gauge (1520 mm) (CFR Border stations, 2025).

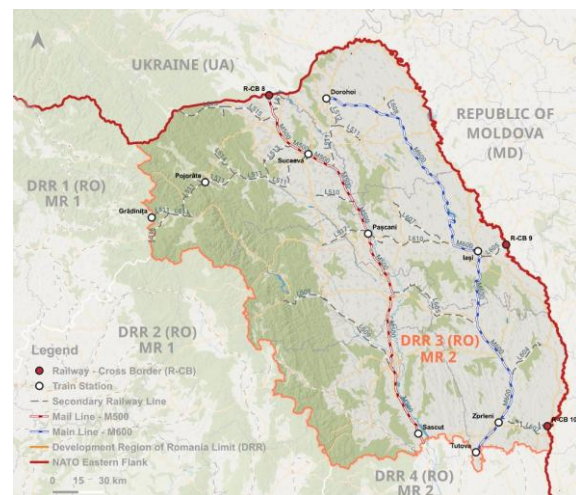


Figure 5. Railway connections of the Development Region Three (DRR3) – North - East

Following the existing railway transport infrastructure – ecological transport infrastructure, possibilities of connection of the entire North - East Development Region to the European Union is achieved uniquely through the secondary railway line 511. Taking into account that is the only one, the analyse will be extensively up to the cross-border points.

#### 4. MAPPING OF ECOLOGICAL TRANSPORT INFRASTRUCTURE

At the European Union level, important objectives related to transport infrastructure have led to a series of recommendations for Member States, issued through technical specifications for railway infrastructure (Commission regulation no. 1299, 2014) and detailed requirements for critical structures – tunnels (Commission regulation no. 1303, 2014), with the aim of creating a single European railway area.

Mapping of critical objectives – critical points – railway tunnels (Figure 6) located on Romania's ecological transport infrastructure network from the North – East Development Region of Romania, the analysed region, involves identifying and locating them within the transport network.



Figure 6. Critical points along North - East Development Region

The development and construction of the railway transport network was made before 1990 (Iftime, 2021) along the railway magistral 500 and 600, M500 and M600, crossing mainly areas with plains and hills, which means that critical works on network – railway tunnels, are few, but in the most important points of the routes.

They were imposed mainly by technical constrains in accordance with the existing regulations at the time, resulting in the following art works – railway tunnels:

- Barnova railway tunnel 1 (Figure 7) – CP 3.2.1, located on railway magistral 600, Grajduri – Birnova, 24.5% maximum line gradient (CFR line gradients, 2025), simple track, unelectrified, total length of approximately 237 m, between km 389 + 551 – km 389 + 788, placed in Iasi County;
- Barnova railway tunnel 2 (Figure 7) – CP 3.2.2, located on railway magistral 600, Grajduri – Birnova, 24.5% maximum line gradient (CFR line gradients, 2025), simple track, unelectrified, total length of approximately 241 m, between km 389 + 547 – km 389 + 788, being built between 1979 – 1981, on the project for doubling the railway line between Tecuci – Iasi, placed in Iasi County (Iftime, 2021);



Figure 7. Critical points – Barnova railway tunnels no. 1 and no. 2 (Iftime, 2025) along North - East Development Region

- Movileni railway tunnel – CP 3.2, located on secondary railway line 613, Letcani – Vladeni, 12.3% maximum line gradient (CFR line gradients, 2025), simple track, unelectrified, total length of approximately 965 m, between km 8 + 141 – 9 + 105, placed in Iasi County;
- Cristesti railway tunnel – CP 3.3, located on secondary railway line 519, Pascani – Targu Neamt, 14.3% maximum line gradient (CFR line gradients, 2025), simple track, electrified, total length of approximately 840 m, between km 9 + 530 – 10 + 370, placed in Iasi County;
- Lucacesti tunnel – CP 3.4, located on secondary railway line 517, Suceava V. – G. Humor, 16.5% maximum line gradient (CFR line gradients, 2025), simple track, electrified, total length of approximately 426 m, between km 33 + 698 – km 34 + 124, placed in Suceava County, being built between 1952 – 1962, on the railway line between Suceava - Paltinoasa;
- Mestecanis railway tunnel no. 1 (Figure 8) – CP 3.5.1, located on secondary railway line 511, V. Putnei – Mestecanis, 29.4% maximum line gradient (CFR line gradients, 2025), simple track, electrified, total length of approximately 1666 m, between km 89 + 710 – km 91 + 376, placed in Suceava County, being built between 1976 – 1979 (Iftime, 2021);



Figure 8. Critical points – Mestecanis railway tunnels no. 1 and no. 2 along North - East Development Region

- Mestecanis railway tunnel no. 2 (Figure 8) – CP 3.5.2, located on secondary railway line 502, V. Putnei – Mestecanis, 29.4% maximum line gradient (CFR line gradients, 2025), simple track, electrified, total length of approximately 1623 m, between km 89 + 757 – km 91 + 380, placed in Suceava County, built in 1900 and the rebuild in 1985 (Iftime, 2021);

The research made conducts to the conclusion that the only railway connection between the North – East Development Region and the North - West Development Region, towards European Union is made through the secondary railway line 511, a derivation of the magistral 500 – M500.

The connection has more splitting points from where the railway line can touch the railway cross border points starting from the train station Suceava following the route through: Gura Humorului, Pojorata, Vatra Dornei, Gradinita (border point between regions DRR 2 – DRR 3), Salva, Dej Calatori and Apahida:

- Splitting point Salva (Figure 9) train station to Ukraine railway cross border point - R – CB 7 – Berlibas (UA);
- Splitting point Dej Calatori (Figure 16) train station to Ukraine and Hungary railway cross border points: R – CB 5 – Diacovo (UA) and R – CB 4 – Agerdomajor (HU);
- Splitting point Apahida (Figure 9) train station to Hungary railway cross border point: R – CB 2 – Biharkeresztes (HU);



Figure 9. Development Regions of Romania – North West – Centre – North East

The railway border point between the development regions North - East / North - West is at km 49 + 710, located around Gradinita train station.

The analysis of railway critical points (R - CP) placed on the ecological transport infrastructure network must be extended at least to the first railway splitting point – Salva train station, along where we can find nine critical points that were put into operation in 1938 (Iftime, 2021):

- Larion railway tunnel no. 9 - CP 3.6 – located on secondary railway line 511, Gradinita – Lunca Ilvei, 20.2‰ line gradient (CFR Line gradients, 2025), simple track, electrified, total length of approximately 134 m, between km 47 + 222 – 47 + 356, placed in Bistrita Nasaud County.
- Larion railway tunnel no. 8 - CP 3.7 – located on secondary railway line 511, Gradinita – Lunca Ilvei, 20.2‰ line gradient (CFR Line gradients, 2025), simple track, electrified, total length of approximately 245 m, between km 44 + 546 – 44 + 791, placed in Bistrita Nasaud County.
- Larion railway tunnel no. 7 - CP 3.8 – located on secondary railway line 511, Gradinita – Lunca Ilvei, 20.2‰ line gradient (CFR Line gradients, 2025), simple track, electrified, total length of approximately 857 m,

between km 42 + 781 – 43 + 638, placed in Bistrita Nasaud County.

- Larion railway tunnel no. 6 - CP 3.9 – located on secondary railway line 511, Gradinita – Lunca Ilvei, 20.2‰ line gradient (CFR Line gradients, 2025), simple track, electrified, total length of approximately 238 m, between km 41 + 900 – 42 + 138, placed in Bistrita Nasaud County.
- Larion railway tunnel no. 5 - CP 3.10 – located on secondary railway line 511, Gradinita – Lunca Ilvei, 20.2‰ line gradient (CFR Line gradients, 2025), simple track, electrified, total length of approximately 161 m, between km 40 + 999 – 41 + 160, placed in Bistrita Nasaud County.
- Rachita railway tunnel - CP 3.11 – located on secondary railway line 511, Gradinita – Lunca Ilvei, 20.2‰ line gradient (CFR Line gradients, 2025), simple track, electrified, total length of approximately 150 m, between km 39 + 940 – 40 + 090, placed in Bistrita Nasaud County.
- Rosia railway tunnel - CP 3.12 – located on secondary railway line 511, Gradinita – Lunca Ilvei, 20.2‰ line gradient (CFR Line gradients, 2025), simple track, electrified, total length of approximately 216 m, between km 39 + 326 – 39 + 542, placed in Bistrita Nasaud County.
- Bolovan railway tunnel - CP 3.13 – located on secondary railway line 511, Gradinita – Lunca Ilvei, 20.2‰ line gradient (CFR Line gradients, 2025), simple track, electrified, total length of approximately 166 m, between km 35 + 672 – 35 + 838, placed in Bistrita Nasaud County.
- Poiana Ilvei railway tunnel - CP 3.14 – located on secondary railway line 511, Gradinita – Lunca Ilvei, 20.2‰ line gradient (CFR Line gradients, 2025), simple track, electrified, total length of approximately 216 m, between km 14 + 140 – 14 + 356, placed in Bistrita Nasaud County.

## 5. ANALYSIS OF CRITICAL GREEN TRANSPORT INFRASTRUCTURE POINTS

The analysis of the collected and mapped data indicates that Romania critical ecological transport infrastructure points from the North – East Development Region consists of several critical objectives distributed according to the exposed area as follows:

- Railway secondary line 511 connects two Development Regions of Romania, the North - East Development Region with the North - West Development Region - a unique and only connection, therefore presenting a high vulnerability for the national and international railway system, mainly for the national interest and also, for the European Union, in the event of any type of hazard.

There are plenty (12) of critical points along the route.

- Railway magistral line 600 – M600 connects two Development Regions of Romania, the North - East Development Region with the South - East Development Region, but it is not a single link, as the magistral 500 is being developed almost parallel, so it is not a single link, and the vulnerability for the national and international railway system is reduced in the event of any type of hazard, compared to the secondary railway line 511.

There are only two critical points along the route, and the route connects two types of gauges, normal gauge – 1435 mm with large gauge 1520 mm, in one point – R-CB – 8.

- Railway magistral line 500 – M500 connects two Development Regions of Romania, the North - East Development Region with the South - East Development Region, but it is not a single link, as the magistral 600 is being developed almost parallel, so it is not a single link, and the vulnerability for the national and international railway system is reduced in the event of any type of hazard, compared to the secondary line 511. Also, the M500 connects the Ukrainian border to the European, being one of the most important connections for them.

There are no critical points along the route, but the magistral assures connection for two types of gauges, normal gauge – 1435 mm with large gauge 1520 mm, in two points: R-CB – 9 and R – CB - 10.

The secondary railway lines – 610, 605 and 607 that connect Romania, from the North – East Development Region (DRR3), to the Republic of Moldova does not present critical points.

The critical points (R - CP) on the railway system, consisting of the mapped railway tunnels have the following specific characteristics:

- Railway tunnels: Lucacesti and Mestecanis no. 1 are single track, electrified, with a "basket handle" specific typical cross section (Figure 10).

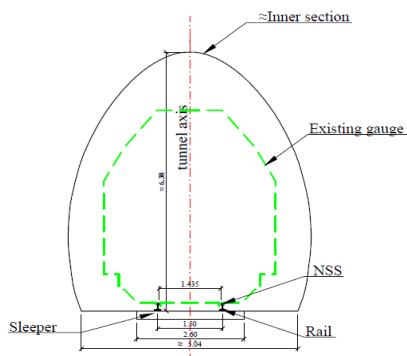


Figure 10. Cross section type "basket handle": inner section for Lucacesti and Mestecanis tunnels

- Railway tunnel: Mestecanis no. 2 is single track, electrified, with a circular cross section type (Figure 11), being executed with mechanized shield (Iftimie, 2021).

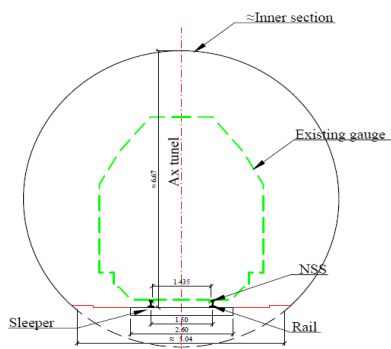


Figure 11. Cross section type circular: mechanized shield inner section for Mestecanis no. 2 tunnel

## 6. DISCUSSIONS

The need to manage European funds, following Romania's accession to the European Union, led to the transposition of European directives into national legislation, so were created the Macro Regions (MR) and Development Regions (DRR) of Romania, based on the administrative-territorial organization existing in Romania at the time, namely the counties of Romania.

The division into macro regions and development regions was based on European principles, resulting in areas with higher population spread over larger or smaller areas. Macro Region Two – MR 2 is the most populated from Romania and Development Region Three - DRR 3 – North - East Development Region is the most populated from Romania's regions, even exceeding urban agglomerations. The distribution of the population in an exposed area leads to major risks and vulnerabilities for our country and for the region.

The choice of the study area in terms of ecological transport infrastructure was based on the population density and its access to quick and high-capacity transport, in the event of a hazard, for means of mass evacuation, as well as the geographical and geopolitical location of the area within the European Union.

The research aims to analyse how state authorities can ensure mass evacuation and by what means of transport for the resident population in the event of a natural or man-made disaster - anthropogenic hazards, so that a large number of people can be evacuated in a short time from a large area of the country, and to identify critical points along the route that provides the evacuation route.

The analysis of critical points in the railway infrastructure network is a measure aligned with current requirements (Commission regulation no. 1299) and challenges (Commission regulation no. 1303). Ensuring means of transport means securing the transport infrastructure, so the analysis of critical points is an activity that will need to be developed over time, transforming what is currently a high risk into a vulnerability with no quick solutions.

The critical points on the railway transport infrastructure network that cannot be replaced in an emergency situation are railway tunnels. Their special characteristics, in terms of design and construction, present major risks.

The research activity carried out for the collection, inventory, creation of a database, location and distribution along the ecological transport infrastructure network in the analysed area – the North - East Development Region led to the need to extend the initial analysis to the neighbouring regions – North West Development Region in order to understand the context in terms of connectivity possibilities and quick evacuation routes.

The expansion of research has conducted to splinting points from where the railway transport infrastructure can reach multiple railway border crossing points. The first splinting point is Salva and the distances to: R – CB 7 is approximately 92 kilometers; R – CB 3 is 268 kilometers passing through Dej Calatori being at approximately 45 kilometers; R – CB 2 is 267 kilometers passing through Apahida being at a distance of approximately 92 kilometers.

Finally, it is obvious that an atlas of the evacuation's routes, completed with the critical points is needed and should be completed with general public information campaigns to promote and to raise awareness are also necessary.

For the Macro Region Two – MR 2, the Development Region Three of Romania – DRR 3 – North – East Development Region, the most populated and the most exposed region, the map of ecological transport infrastructure and the critical points along the emergency route was made and it is presented below (Figure 12), together with the distance to the closest border points of our country.

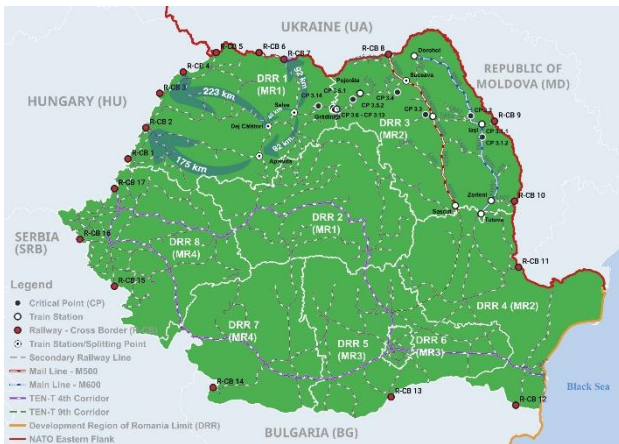


Figure 12. Critical points along North - East Development Region (DRR3)

## 7. CONCLUSION

The national and international context completed with the geographical and geopolitical position of Romania exposes the population to risks that until now have not been evaluated and presented to the general population, the research made being the first of this kind in our country.

The research was conducted for the most exposed region in Romania and was extended to adjacent regions following the routes for environmentally friendly transport infrastructure, correlated with the European policies regarding the access to Trans-European Transport Network (TEN-T), following Comprehensive, extended core and core networks (Maps of the comprehensive, extended core and core networks, 2024).

The research is a base for a possible national risk management asset that can be developed with proper resources and qualified personnel that can ensure general safety of population a predictability on hazardous events.

Based on data from the National Institute of Statistics, analysed at the national level as well as by macro-regions and development regions, the population has been continuously declining since 2012. This downward trend was not significantly influenced by major events during the period, such as the COVID-19 pandemic, the war at the borders, or the opening of borders to the Schengen Area. Macro-Region Two accounts for the largest share of Romania's population, despite experiencing an average annual decrease of approximately 20,000 people between 2012 and 2023.

The density of the analysed Macro Region – MR 2 is the highest among Romania's Macro Regions, approximately 76.79 people/km<sup>2</sup>, except for the Macro Region where the country's capital is located, which is a special case.

The North - East Development Region together with the South - East Development Region represents the Eastern Flank of Romania, part of the Eastern Flank of NATO (NATO, 2025) and at the same time represents the border of Romania, the border of European Union and the border of the Schengen area (Nica, 2023 b).

The Romanian ecologic transport infrastructure network or the railway transport network is one of the densest railway networks from the European continent (Nica, 2023a), so has a great cover of the entire country. The northeast part of the country is well covered by two almost parallel railway magistral – M500 and M600 which connects the north part of the country to the south part and has good connections with our neighbours by the railway cross border points (Nica, 2023b), taking into account the major gap of 85 mm railway gauge (Lousada et al, 2024).

Along the secondary railway line 511 are a number of 12 critical points with a total length of approximately 6.1 kilometres that puts the entire connection under pressure.

Mapping the development region led to worrying conclusions regarding the connections of the most populated region of Romania: is only one railway line connecting the region to the western part of the country and automatically to the European Union; has an important number of critical points, which also have particular and unique design and construction characteristics in terms of section, length, and gradient.

Critical points along the route - railway tunnels, given their year of construction, duration of exploitation, and the standards under which they were built, represent a significant vulnerability, as the possibilities for modernizing them to comply with current standards and TSIs (Commission regulation no. 1299 and 1303, 2014) are very difficult to achieve.

The railway line was designed more than 100 years ago (Teodorescu, 1938), as were the structures that constitute the critical points, so their lifespan has been exceeded and they need to be reconsidered or modernized in line with current standards (NP 109, 2004).

The splitting points which offer alternatives are few and the distances to the railway cross border points are significant, up to 268 kilometres, taking into account the functional railway cross border points and the gauges differences.

The entire research leads to the conclusion that the region poses major risks for passenger and freight transport and that supplies could be interrupted at any time, thus isolating Romania's most populated area.

The country's military, political, and geopolitical exposure should serve as a mobilizing factor for modernization and the creation of environmentally and friendly transport alternatives for the region.

The military factor (European Commission, 2024) and the dual use – civil and military, of railway transport infrastructure is one of the most important issues at present, generous funds being

allocated for the development of the routes for the entire Europe and on the eastern flank (Pierzak, 2024).

The development of the motorway network in the region is in full swing (Nica, 2025b) and has available funds at disposition.

Also, the development of the modern railway network in the country (Nica, 2020a, b) and region (Nica, 2025a, b) is in full swing, as well as in the sights of neighbours (Kurhan, 2024 and Kurhan, 2025) and European authorities, but the funds allocated for the railway are lower compared to the highways.

The research is the first of its kind in Romania, with innovation and originality representing key aspects of the study. Moreover, the development of a map of critical points within a Romanian development region constitutes the first step toward developing an atlas of critical transport infrastructure for the entire country.

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