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ASSESSMENT OF SOCIO-ECONOMIC BENEFITS FROM THE CONSTRUCTION OF BYPASSES OF TRANSPORT INFRASTRUCTURE

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Abstract. The aim of the study is to analyse the feasibility of the second phase of the construction of the Rožaje (Montenegro) bypass project. The objectives of the construction of this bypass are to eliminate or reduce existing problems by redirecting transit flows to the bypass. Based on the observed economic costs of construction and the expected economic benefits from the project in a 20-year period, by applying Cost-Benefit Analysis (CBA), the indicators of the project

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economic feasibility were determined. As part of the socio-economic analysis of the project feasibility, the expected benefits for transport users (savings in travel time and savings in the vehicle exploitation costs), as well as external impacts (impacts on safety and impacts on the environment) were assessed. The analysis showed the dominant savings are in travel time and vehicle exploitation costs. The economic net present value ($ENPV$) of this project is positive and amounts to EUR 55 054 502, the economic internal rate of return ($EIRR$) is 26.88% (with a discount rate of 5%), while the benefit-cost ratio (B/CR) is 4.96. All scenarios developed within the Project Sensitivity Analysis have confirmed that this project has satisfactory economic justification.

Keywords: benefits for transport users, bypass, Cost-Benefit Analysis, external impact, socio-economic benefits, transport infrastructure.

Introduction

Not a small number of studies tried to evaluate the financial, economic, social, ecological and other impacts of transport infrastructure systems on social community (Badassa et al., 2020), as well as the importance of proactive action on changes and challenges which could occur during its construction (Yeh, 1998). For transport infrastructure projects, the most important is the economic analysis of costs and benefits (Margorínová & Trojanová, 2017), which also identifies and quantifies the costs and benefits for society. For transport projects, within the socio-economic evaluation of projects, the key benefits for evaluation are time savings, avoided accidents, operating cost reduction, quality improvements, etc. (de Rus et al., 2022). At the same time, social benefits of these interventions are not in doubt, but the key challenge of the economic evaluation of projects and policies is to determine whether these potential direct and indirect benefits are greater in relation to the opportunity costs of alternative use of resources. In addition, there are two approaches for the economic evaluation of projects (de Rus et al., 2022) the first of which is based on the aggregation of the changes of the economic surpluses of the different groups in the society, while the second concentrates on the change in willingness to pay and the use of resources with the project compared without the project. The use of CBA, which is now a common methodology in the main supranational and national guidelines for economic evaluation, in transport investment projects has long been subject to evaluation and improvement (Barrell & Hills, 1972). Even today this analysis is faced with certain technical challenges related to modelling and appraisal (de Rus, 2021), as well as to the institutional and political context in which this analysis is applied (Mackie et al., 2014). In addition, it is a useful tool for determining priorities in the safety of traffic projects, which in the methodological sense is also continuously being improved (Vecino-Ortiz & Hyder, 2014).

The issue of the feasibility of building bypasses is becoming more and more relevant as some of the latest studies point to the controversial fact that increasing transport capacity is sometimes not the solution to reducing congestion and increasing the average travel speed, which makes it difficult to optimize urban transportation strategies (Bansal & Graham, 2023). Therefore, some studies (Buditiawan et al., 2022) emphasise the need to create a SIA (social impact analysis) which, in some areas, significantly helps the social community, the government and the private sector to anticipate possible changes and social problems brought about by the construction of bypasses in order to provide appropriate solutions in time. Effects of bypasses are numerous and they imply a complex analysis of impacts, such as transportation, non-transportation, demographic, economic, land use effects, etc. During the socio-economic evaluation of the feasibility of the bypass project (Zehawi et al., 2022), construction costs, maintenance costs and road user costs are estimated, which include Vehicle Operating Cost (VOC) and Travel Time Cost (TTC). The redirection of traffic from city centres is done with the aim of multiple socio-economic benefits, such as reducing travel time, traffic accidents, as well as improving the overall flow of traffic and reducing congestion (Sabol, 1996). Furthermore, although the construction of bypasses generally increases the predictability and safety of traffic patterns, Amundsen and Hofset (2000) warn that reducing density increases travel speed that may increase the number and severity of traffic accidents. Thus, Elvic et al. (2009) found a negative correlation between crash severity and traffic density. Interestingly, Srinivasan and Kockelman (2002) concluded that the effects of ring roads mostly depended on the volume of traffic diverted from the city centre. On the other hand, Ahmad et al. (2022) warn that in some developing countries urban traffic congestion is partly caused by the fact that bypass roads are not designed according to bypass standards. Analysing the economic impacts of the construction of bypasses, it can be noted that research results range from those that bypasses have a significant positive impact on local economic activity (Buffington & Burke, 1991), through those that confirm a weak and non-unified impact (Andersen et al., 1993). Guided by market rational economic behavior, studies on the impact of changes in a city road and street structure and the construction of bypass roads on socio-economic activities, the locational pattern of shops and retail areas and the economic vitality of urban centers after the implementation of bypass roads was intensified (van Nes, 2021). Burress (1996) in his study on the economic impact of bypasses around small towns highlights the benefit of generating average time-savings, which is estimated at over a million dollars per year. However, evaluating the impact of bypasses on the local economy, Srinivasan and Kockelman (2002) indicate the potential negative impacts of bypasses and loss in per capita sales of certain industry sectors. Although the overall positive socio-economic benefits of bypasses for communities are indisputable, some studies (Wells & Farnworth, 2001) suggest that smaller communities have a greater potential for the negative economic impact, compared to larger communities.

Babcock and Davalos (2004) point to significant socio-economic benefits of bypasses, in the form of savings in travel time, as well as other positive impacts such as reduction of noise and traffic jams, improved safety, creation of new jobs, increased accessibility of the area, etc. Comer and Finchum (2001) suggest that in order to compare alternative bypass possibilities multiple factors should be cumulatively considered, including total costs, ability to serve traffic, number of residential and commercial displacements, environmental considerations, impact on local businesses, etc. Thompson et al. (2001) showed that the opening of bypasses increased the quality of life, but also had a negative impact on retail sales in the surveyed areas, without a statistically significant impact on total employment growth rate and aggregate retail sales. Volker et al. (2020) warn of the effect of "induced travel" that can lead to overestimation of the benefits of reducing traffic congestion and underestimation of its impact on the environment. Namely, some observations point to the importance of creating additional traffic, which in the long term does not eliminate congestion, nor shorten travel time. Similarly, Boussauw (2023) addressed the problem of methodological recommendations, which mostly followed standardized research methods for quantifying the ecological and economic impacts of different scenarios. They were not up-to-date enough regarding the inclusion of induced trips, which could significantly affect the overestimation of the socio-economic effects of bypasses (e.g., reducing travel time) and underestimating the environmental effects. Chase and Gustavson (2004) suggest the existence of short-term impacts of bypass construction, while long-term economic impacts are small or absent. Namely, the development of bypasses has a short-term effect primarily on traffic-dependent businesses, and a much smaller long-term effect on overall economic effects. Taking into account the fact that the net economic impacts (positive or negative) of bypasses on the wider community are usually relatively small, Collins and Weisbrod (2000) emphasise their impact on the empowerment of certain destinations, as a result of reducing traffic congestion in city centres. In particular, bypassing city centres removes heavy truck traffic, but also generates new industrial locations along new road routes, attracting fresh regional investment. In some studies, the construction of bypasses is associated with the growth of metropolitan areas, the growth of the number of stores and shopping centers, consolidation of distribution channels for gasoline, as well as the decline of rural emigration (Handy et al., 2001). Nevertheless, Tohjiwa (2020) warns of ring road development problems in metropolitan cities, which can become a limitation of urban development and have a devastating impact on regional development. A large number of studies suggest the indisputable positive effects of bypasses refer to less congestion, safer roads for local drivers and pedestrians, reduced truck traffic through city centers, as well as a reduction in the cost of maintaining city centre roads (Wells & Farnworth, 2001; Thompson et al., 2001; Baker & Bellotti, 2002; Mills & Fricker, 2011). Evaluating the social and environmental sustainability of bypasses, studies suggest multiple socio-economic effects of bypasses, such as savings in travel time, reduction of carbon monoxide emissions, reduction of noise, reduction of traffic jams, improvement of accessibility and safety, development of new areas, etc. (Leong et al., 2002). Similarly, Vitkūnas and Meidutė (2011) point to the indisputable advantages of the bypass, such as increasing the average speed, reducing travel time, exhaust gas emissions, noise, etc. Elias et al. (2006) noted that distributional effects of the bypass roads depended on a large number of factors, such as the location of the bypass in relation to the town space, the distance of the bypass from the city center, planning policy, population growth rate, volume of traffic, overall socio-economic condition, etc. Similarly, Fricker and Mills (2009) maintained that the impacts of bypasses varied from county to county and across industry sectors. Furthermore, Gaffney et al. (2017) concluded that bypasses had universal benefits for regional centres and drivers, while Parolin (2017) also confirmed the positive effects of bypasses and the existence of "life after the bypass". Traffic analyses in some studies (Phibbs et al., 2009) indicate a reduced volume of traffic on old roads, and the multiple social effects of bypasses (on the population, schools and students due to the reduction of crowding and noise). Wangzom (2021) concludes that the negative impacts of bypass construction on economic activity are most pronounced in small cities. Regardless of the indisputable positive effects of bypasses (less traffic congestion and less noise), businesses in smaller city centres are "in danger" of falling sales and devaluation of business assets. However, the same study suggests that the results of such and similar research are neither uniform nor final, partly because other factors contribute to the post bypass environment.

Numerous studies evaluated the effect of bypasses on traffic safety. Thus, Elvik et al. (2009) found a statistically significant reduction in the number of injury accidents (of almost 20%), as a result of the construction of bypasses. Similar results were confirmed by many other studies (Jadaan & Nicholson, 1988; Andersson et al., 2001; Egan et al., 2003). Similarly, Cena (2007) points out that the construction of bypasses undeniably increases the safety aspects of traffic and the safety effects are positive for both the bypass and the old road through the city, individually and overall. Namely, on average, the frequency of collisions was reduced by 44% and 66%, on the old and new road networks, respectively (Cena et al., 2011). However, Elias and Shiftan (2011) suggest large variations in the effects of building bypasses on safety, while Goldenbeld and Schermers (2017) conclude that the impact will vary depending on the safety of the old section, as well as whether the bypass creates extra traffic and leads to an increase in speed. Evaluating the environmental sustainability of bypasses, Gawrońska et al. (2019) showed that the bypass construction would not have a negative impact on the environmental element and human health. Possible negative environmental impacts (Ullah et al., 2020) can be mitigated by adopting good construction practices and effective implementation of EMP (Environmental Management Plan).

The aim of the present study is to assess socio-economic feasibility of the second phase of the construction of the Rožaje bypass project in Montenegro, which connects the main road M-2 (Dimiškin Bridge) and the first phase of the bypass (Crnja). The main traffic problems on the existing road are manifested through the appearance of bottlenecks (especially during the peak tourist season), low average vehicle speed (due to bad elements of the existing road, passing through intersections at the same level, conflicts with pedestrian movements, etc.), increased vehicle exploitation and travel time costs, low level of safety and endangering the environment. The objectives of this bypass construction are to eliminate the aforementioned problems by redirecting transit flows to the bypass.

The paper is organised as follows. After the introduction, where a brief overview of the relevant literature is presented, the second section offers basic information about the current traffic state in the municipality of Rožaje. The third section of the paper contains a description of the relevant methodology for the implementation of the socio-economic analysis of the project justification. In the fourth section, results of the socio-economic feasibility analysis of the project are presented. The aim of the socio-economic analysis is to assess whether the project has a positive socio-economic contribution to society and whether it is worth implementing. In the case of road infrastructure projects, the practice is to analyse and evaluate the benefits for transport users and external impacts (wider social impacts). The results of project sensitivity analysis are presented in the fifth section of the paper. In the final section, concluding remarks are made, reviewing the limitations and suggesting opportunities for further research.

1. Current status: The case of the Rožaje bypass project, Montenegro

Road connections with the surroundings of the municipality of Rožaje are made by state, main and regional roads. Connection with the inner zone is also achieved by state roads, as well as by a network of local and uncategorized roads. The national road network in this area is in a rather poor condition, considering its average age, as well as little investment in maintenance and reconstruction, which results in a large number of critical spots, especially at high altitudes. The main road M-5 (Ibar Highway) represents the basis of the road network of the municipality of Rožaje, which connects this municipality in one direction with the municipality of Berane and the whole of Montenegro, and in the other direction with Serbia and Kosovo. Given its location, the area of the municipality of Rožaje represents a transit zone for traffic flows from Serbia towards Podgorica and further to the coast, as well as for flows in the opposite direction. Due to extremely high traffic loads, especially during the summer season, the level of service on the main road in that direction is below required, as is the safety of road traffic. In addition, the main road is also loaded with traffic in the service of the city needs. The road network in the city is adapted to the conditions dictated by the passage of the main road through the centre of the settlement. Thus, when passing through the city, the highway has the character of a transit and city road, with a mixed traffic structure (pedestrians, cyclists, deliveries, etc.).

In order to achieve the planned goals of the city development, it is necessary to completely move transit traffic out of the city. With the construction of the bypass, the existing road would be reconstructed into a road that fully meets the city criteria (pedestrian, bicycle paths, lighting, intersections, etc.). In this way, two types of traffic load would be completely separated: transit and urban.

The Rožaje bypass construction project was preceded by a feasibility study that included a traffic and economic analysis of the project, with the aim of obtaining reliable indicators on which a decision on the justification of the construction should be made. Since the first phase of the bypass was completed, the main goal of the feasibility study was to evaluate the project of the second phase of the bypass construction in Rožaje, which connects the main road M-2 (Dimiškin Bridge) and the first phase of the ring road (Crnja). Figure 1 presents a road network with city bypass on a concrete case.

On the basis of the Traffic Study, which was done for the purpose of developing the spatial urban plan of the municipality of Rožaje, the route of the second phase of the bypass with a length of L = 2.5 km was adopted on the route: Dimiškin Bridge (elevation 1043) → Ibarac → Crnja. The route starts from the Dimishka Bridge, at an intersection with a roundabout. After the intersection, the route enters a tunnel from 1193 m to the Ibarac valley, where it exits at an altitude of approximately 1072 m above sea level. The Ibarac valley is crossed by a viaduct of 154.70 m, then on an open route it enters the Carine tunnel, 692.60 m long and exits in Crnja at an altitude of 1114 m above sea level, where it is connected to the first phase of the bypass by a roundabout. The road will have two traffic lanes with 1.00 m wide banks on both sides. The route of the second phase of the bypass is designed for a calculated speed of

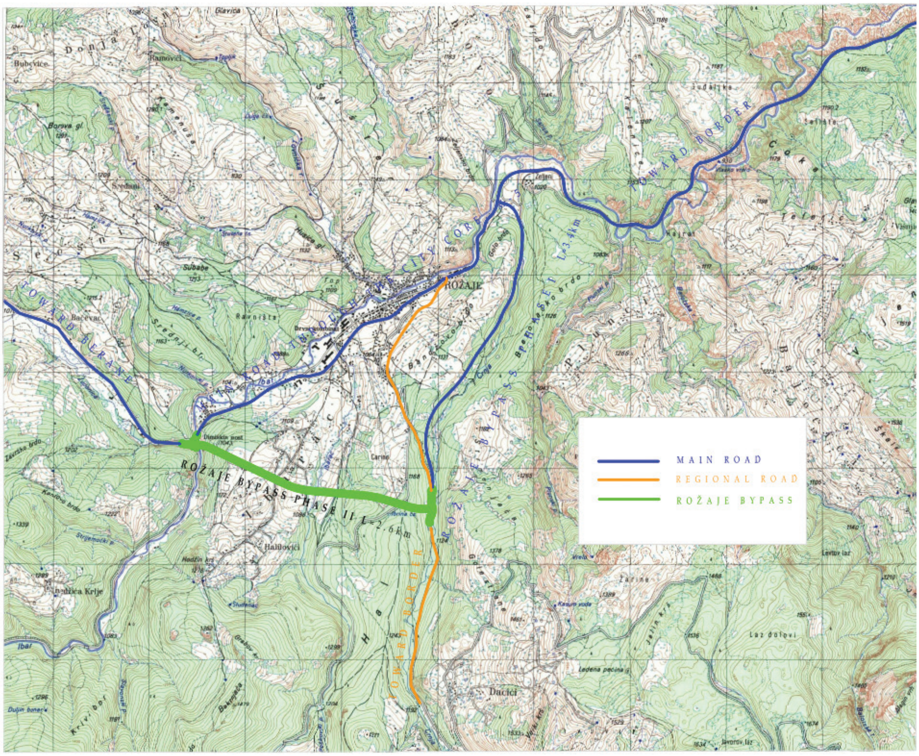

Figure 1. Road network with city bypass

60 km/h, in accordance with the design task and urban planning and technical conditions.

Investment in the construction of the second phase of the Rožaje bypass was determined in the total amount of EUR 19 788 320, of which EUR 14 352 893 were spent so far. The remaining amount needed to complete the investment is EUR 5 435 427.

2. Methodology and data

This section of the paper is divided into two parts. In the first part, an overview of the methodology used for the analysis of the socio-economic justification of the second phase of the Rožaje bypass project construction is presented, while in the second part, the basic parts of the traffic analysis are prepared, which provided the necessary input for the analysis, socio-economic justification of this project.

2.1. Research design

In this paper, as part of the CBA, a comparison of two different scenarios is prepared: "with the project" (which implies the implementation of the planned investment) and "without the project" (which implies the preservation of the existing state). For better monitoring and understanding of the economic evaluation of the Rožaje bypass second phase project, the analysis process is shown in Figure 2.

The basic methodological guidelines for the implementation of the economic analysis of the justification of the second phase of the construction of the Rožaje bypass project were:

- CBA was performed in such a way that the basic principles and rules on which the justification analysis of the second phase of Rožaje bypass project were set in accordance with the principles and rules of the EC and international financial institutions (European Commission, 2015);
- Transformation of market prices into accounting (economic) prices was carried out with the help of conversion factors;
- According to the EC Guidelines for the analysis of costs and benefits, a recommended discount rate was 5% for countries acceding to the EU (European Commission, 2015);
- The volumes of the achieved and forecast traffic on the existing road routes, as well as the distribution of the forecast traffic between the existing road routes and the projected bypass, in a 20-year initial projection period, were given based on data from the traffic part of the justification study;

- The operational procedure applied in the process of analysis and evaluation of project justification consisted of (1) analysis, assuming that there would be no investments in the project that was the subject of evaluation (analysis of the "without the project" scenario), (2) analysis, assuming that the necessary investments would be applied (analysis of the "with the project" scenario) and (3) assessment of the contribution of investments (difference between the "with" and "without the project" scenarios). Detailed forecasts for all sections relevant to the evaluation of this project, for scenarios "with" and "without the project", were taken from the traffic section of the feasibility study;

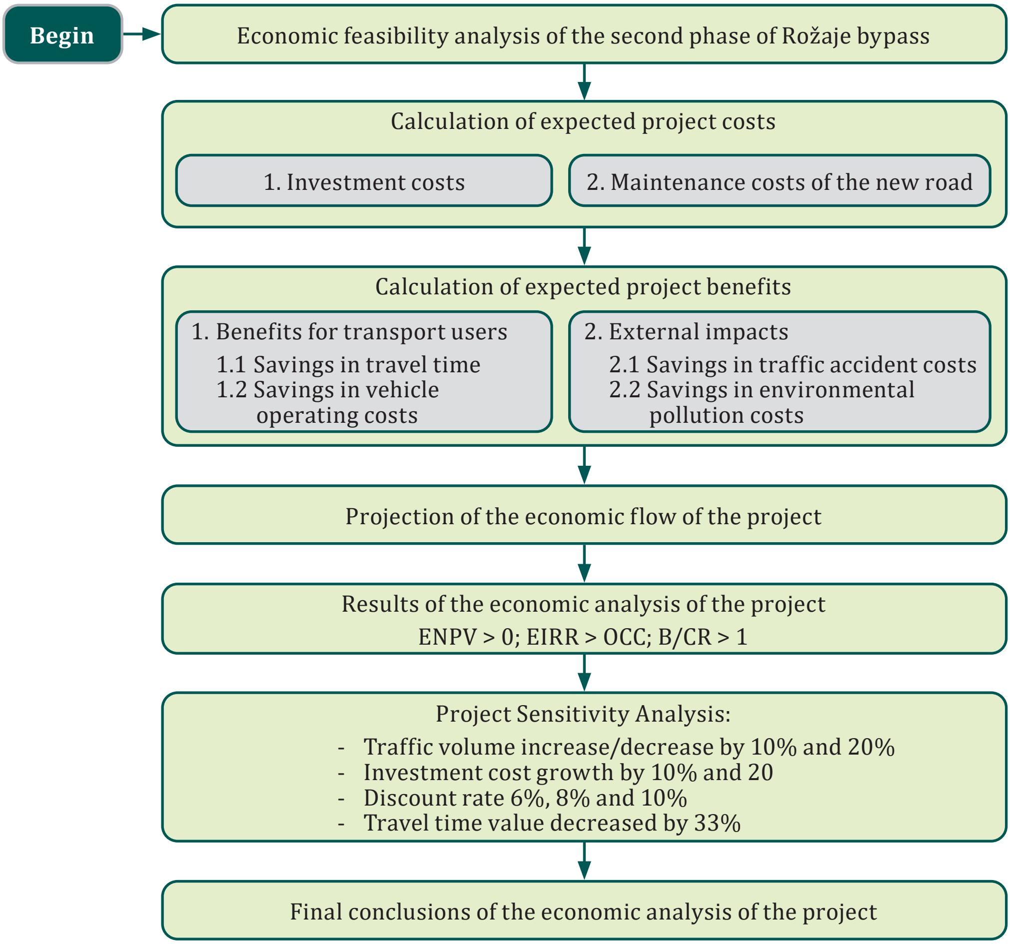

Figure 2. Methodological flowchart

- From the transport users' benefits, savings in travel time and savings in vehicle exploitation costs were calculated, while within the category of external impacts of the project, impacts on traffic safety and impacts on the environment were assessed;
- For the calculation of travel time costs on the network "without the project" and "with the project", as well as for the calculation of the maintenance costs of the considered networks, the classic direct analysis procedure was applied;
- For the calculation of costs from traffic accidents in a 20-year period on the considered network, the corresponding calculated degrees of traffic accidents in relation to vehicle/km were used;
- Based on the difference in vehicle exploitation costs on the network "without the project" and "with the project", in a 20-year projection period, the expected direct economic benefits were calculated on this basis;
- The effects on the environment were calculated as the difference in the costs of environmental pollution on the network "without the project" and the network "with the project", in a 20-year projection period, and the impacts on air pollution and impacts on climate change were considered;
- By applying CBA, the following indicators of project evaluation from the socio-economic aspect: $EIRR$, $ENPV$ and B/CR (European Commission, 2015) were determined. By comparing the value of $EIRR$ with the opportunity cost of capital (OCC) and with the value of $ENPV$ with 0, an evaluation of the justification of the second phase of the Rožaje bypass was made from the socio-economic aspect;
- Within the Project Sensitivity Analysis, the previously mentioned indicators of project justification (EIRR, $ENPV$ and B/CR) were subjected to sensitivity tests, considering possible deviations in the economic costs of construction and economic benefits from construction.

3. Results and discussion

Within this section, we prepared calculation of the expected costs and benefits of the second phase of the Rožaje bypass construction project. After the evaluation of the expected costs and benefits of the project, the economic evaluation of the specific project justification was carried out using standard dynamic indicators. At the end of the section, a sensitivity analysis of the project is provided.

3.1. Expected costs of the second phase of the Rožaje bypass construction project

Project costs calculated within this analysis are defined as investment costs and maintenance costs of the new road (current and investment maintenance). Based on the data obtained from the Transport Administration of Montenegro, the dynamics of the current and remaining implementation of the project is shown in Table 1.

Table 1. Dynamics of investment costs

Year	Planned, EUR	Realized, EUR
2020	7 654 850	7 654 850
2021	4 653 191	4 653 191
2022	7 480 279	2 044 852
Total	19 788 320	14 352 893

Table 2. *SCF* calculation (statistical office of Montenegro and revenue and customs administration)

Description	Amount, million EUR
Total import	2505.1[1]
Total export	437.1[2]
Custom revenues	776.6[3]
SCF	0.79

Notes:

[1] Statistical Office of Montenegro – MONSTAT, External trade, https://www.monstat.org/cg/page.php?id=32&pageid=32

[2] Ibid

[3] Revenue and Customs Administration of Montenegro, Revenue collection, http://www.upravacarina.gov.me/rubrike/aktuelnosti/149759/Pregled-naplate-phrihoda-Upravecarina.htm

Table 3. Regular and investment maintenance costs[4]

Description	Amount
Costs of regular summer road maintenance	4008 EUR/km
Costs of regular winter road maintenance	6400 EUR/km
Investment costs of road maintenance	7.5 EUR/m^2, for 15 years
Costs of regular summer tunnel maintenance	4800 EUR/km
Costs of regular winter tunnel maintenance	6400 EUR/km
Investment costs of road maintenance	5400 EUR/km, for 10 years

Note: [4] Monteput Ltd. Montenegro, 2023

As it can be concluded from Table 1, investments have been determined in the total amount of EUR 19 788 320, of which EUR 14 352 893 have been spent so far (the first phase of project implementation), so the remaining amount needed to complete the second phase of the construction of the Rožaje bypass is EUR 5 435 427.

As sector-specific conversion factors are not available, a standard conversion factor (SCF) has been used, based on the average differences between domestic and international prices due to trade tariffs and restrictions, which can be estimated from foreign trade statistics using the following formula (European Commission, 2020):

$$SCF = \frac{(M + X)}{(M + X + T_m)}, \tag{1}$$

where M – total import, X – total export, T_{m} – value of customs revenues.

Based on the obtained data, SCF was calculated (Table 2).

Construction of the Rožaje bypass will require certain additional costs in the form of ongoing maintenance costs (regular summer and winter maintenance) and investment maintenance. Data on average maintenance costs for roads and tunnels are presented in Table 3.

3.2. Expected benefits of the second phase of the Rožaje bypass construction project

In the case of road infrastructure projects, the practice is to calculate benefits for transport users and external impacts (wider social impacts). The benefits for transport users represent the result of travel that occurs as a result of improved transport conditions. The basic categories of external impacts of road infrastructure projects, which were analysed for a specific project, were impacts on safety and impacts on the environment.

One of the most significant benefits that can arise with the construction of new road infrastructure is travel time savings. During the CBA, a distinction is made between the evaluation of work-related and non-work-related trips. Passenger travel time savings in the specific case were determined as the difference between travel costs “without the project” and “with the project”. The following input data were used for calculation: projected volume of traffic for passenger cars (PC) and buses (BUS), travel times, “without the project” and “with the project”, average vehicle occupancy, average gross earnings in Montenegro and the relationship between business and non-business trips.

Projected volumes of transport for passenger cars and buses, as well as travel times, are taken from the traffic part of the feasibility study. The average vehicle occupancy was determined at the level of 1.7

passengers per PA and 35 passengers per BUS, while the ratio of business and non-business trips was defined as 37% to 63% (Government of Montenegro, 2016). Average gross salary in Montenegro is taken from official statistical sources. Based on the previously mentioned input data, a calculation was made for unit time values (*VOT*) per vehicle (Table 4).

Although it is usual in such analyses, the VOT in the projection are not increased with the GDP growth projection. The reason for this is the situation caused by the epidemic of the Covid-19 virus. Considering the economic principle of prudence, the VOT were taken in the same amount in the projected period. For the purpose of the analysis, the authors calculated the expected total economic costs of passenger travel time on all travel routes affected by the project, in "without the project" and "with the project" scenarios, for the period 2023–2043, considering both driving times on certain sections and the stopping times at the corresponding intersections on those sections. Based on the total driving time per section, travel time costs were calculated according to the previously mentioned parameters.

Table 5 presents total travel time costs for all sections, in "without the project" and "with the project" scenarios, on the basis of which the benefits, i.e. savings in travel time, were calculated.

Table 4. *VOT* **per vehicle (EUR/h)**

Vehicle category	*VOT*
PC	4.99
BUS	102.90

Table 5. Passenger travel time savings for the period 2023–2043

Year	Travel time costs, EUR		Passenger travel time Savings, EUR
	Without the project	With the project	
2023	5 974 746	4 057 564	1 917 183
2024	7 702 082	5 017 318	2 684 765
2025	9 495 701	5 962 364	3 533 338
…[5]			
2041	19 467 642	16 386 740	3 080 902
2042	19 587 218	16 479 044	3 108 174
2043	19 707 319	16 571 639	3 135 680

Note: [5] reducing the size of the tables was done by omitting a certain number of years from the series

According to the relevant internationally recognized methodology (Bickel et al., 2006), *VOC* include fixed costs (which do not change with distance) and operating costs of the vehicle transport (which vary with distance). The following components of vehicle operating costs are recommended: a fixed cost component (depreciation, capital interest, repair and maintenance costs, material costs, insurance, overhead, administration) and a variable cost component (personnel costs, if not included in travel time savings, distance-related depreciation, fuel and lubricant and distance-related maintenance costs). In the road transport sector, vehicle exploitation costs include: costs of fuel, grease, spare parts, maintenance (working hours), tires, depreciation and driver staff. At the same time, the amount of the mentioned costs depends on the vehicle category, driving speed, condition of the road surface, other characteristics of the road, etc.

For the purpose of the specific analysis in the present paper, the savings in the vehicle exploitation costs were determined as the difference between the vehicle exploitation costs “without the project” and “with the project”. The basic input data that were used to calculate the savings in vehicle operation costs were: average annual daily traffic projection for all vehicle categories (PC, LFV, MFV, HFV, TT, BUS), length of road routes (existing roads and future roads), *VOC* for all vehicle categories, in EUR/km. Unit values of *VOC*, by vehicle category, were calculated based on the following quadratic function (Ministry of Infrastructure of Serbia and Roads of Serbia, 2010):

$$VOC = a + b \times V + c \times V^2, \tag{2}$$

where VOC – Vehicle Operating Cost, i.e., cost of vehicle exploitation,
V – driving speed,
a, b, c – predefined parameters which are functions of vehicle type.

The authors prepared VOC calculations by vehicle category and for each section of the road network affected by the construction of the road, in the “without the project” and “with the project” scenario. In addition to calculation of the costs of operating vehicles on the road network “with the project” and “without the project” scenarios, calculation of additional fuel costs due to retention at intersections was performed, i.e., due to the so-called “running the engine in place”. The calculation was made on the basis of predicted volume of traffic by vehicle category, determined average time spent at intersections (Office of Energy Efficiency and Renewable Energy, 2015) and fuel consumption “in place” by vehicle categories and unit prices of fuel in Montenegro (Global Petrol Prices, 2023). Fuel consumption in the city by vehicle category was determined on the basis of conducted research (Table 6).

Official fuel prices in Montenegro used in the calculations are 1.49 EUR/L for diesel, or 1.44 EUR/L for motor gasoline. In the continuation of the analysis, the authors prepared projection of the total costs of vehicle exploitation for the period 2023–2043 on the road network "without the project" and "with the project". Based on the previous projections, savings in vehicle operation costs were calculated as the difference between vehicle operation costs "without the project" and "with the project" and are shown in Table 7.

Costs of traffic accidents, as an important socio-economic cost of transport, in CBA for transport projects are classified into fatal accidents, accidents with severe injuries, accidents with minor injuries and accidents with material damage. The basic categories of accident costs are material damage (costs of vehicle damage, costs of lost or damaged goods), personal loss for victims and medical treatment. Traffic accident cost savings were calculated based on data on average traffic accident costs per vehicle/kilometer, on the road network "without the project" and "with the project". The basic input data used in the calculation of traffic accident savings were traffic volume data – reduced

Table 6. Unit fuel consumption in the city by vehicle category

Vehicle type	Consumption
Passenger car	0.62 L/h
Bus	3.67 L/h
Light freight vehicle	1.67 L/h
Medium freight vehicle	2.23 L/h
Heavy freight vehicle	3.18 L/h
Truck and trailer	3.41 L/h

Table 7. Savings in vehicle exploitation costs for the period 2023–2043

Year	Vehicle exploitation costs, EUR		Vehicle exploitation cost savings, EUR
	Without the project	With the project	
2023	4 584 429	3 538 712	1 045 716
2024	4 980 690	3 807 165	1 173 525
2025	5 151 477	3 923 776	1 227 701
...			
2041	6 168 122	4 624 754	1 543 368
2042	6 207 317	4 650 350	1 556 966
2043	6 246 702	4 675 999	1 570 703

to vehicle/km and unit costs of traffic accidents per vehicle/km (European Commission, 2020). Average unit costs of traffic accidents (per vehicle/km), by vehicle category (Ricardo-AEA, 2014), are shown in Table 8.

For the purpose of the analysis, the authors prepared projection of the total costs of traffic accidents for the period 2023–2043 on the road network "without the project" and "with the project". Based on previously made projections, the savings in the costs of road accidents were calculated as the difference between the costs of road accidents "without the project" and "with the project" (Table 9).

During the CBA, the following environmental impacts of infrastructure transport projects were considered: impacts on air pollution and climate change. The calculation of environmental pollution cost savings is determined as the difference in these costs "without the project" and "with the project". The following input data for calculation were used: predicted volume of traffic by vehicle category, unit costs of air pollution and unit costs of impact on climate change. Average unit costs of air pollution (per vehicle/km) by vehicle category (Ricardo-AEA, 2014) are shown in Table 10.

Table 8. Average unit costs of traffic accidents by vehicle category

Vehicle category	Traffic accident costs, EUR cent/vehicle km
Passenger car	7.2
Bus	18.9
Light freight vehicle	4.1
Medium freight vehicle	
Heavy freight vehicle	15.5
Truck and trailer	

Table 9. Traffic accident savings for the period 2023–2043

Year	Traffic accident costs, EUR		Traffic accident Savings, EUR
	Without the project	With the project	
2023	1 080 412	879 505	200 908
2024	1 174 768	946 195	228 573
2025	1 215 075	975 141	239 934
...			
2041	1 451 328	1 148 428	302 900
2042	1 460 325	1 154 669	305 656
2043	1 469 355	1 160 911	308 445

As an additional input, for the calculation of environmental pollution cost savings, data related to the average unit costs of the impact on climate change were used. Average unit costs of impact on climate change (per vehicle/km), by vehicle category (Ricardo-AEA, 2014), are shown in Table 11.

In terms of the continuation of the analysis, the authors prepared total air pollution costs projection for the period 2023–2043 on the road network in "without the project" and "with the project" scenarios. After the projections, savings in air pollution costs were determined as the difference between air pollution costs "without the project" and "with the project" (Table 12).

In the continuation of the analysis, total costs of climate change for the period 2023–2043 were calculated on the road network in "without the project" and "with the project" scenarios. Savings in climate change

Table 10. Air pollution unit costs

Vehicle category	Air pollution costs, EUR cent/vehicle per km	
	Urban	Suburban
Passenger car – diesel	0.9	0.6
Passenger car – gasoline	0.4	0.1
Bus	10.0	7.9
Light freight vehicle	1.4	0.8
Medium freight vehicle	5.2	3.6
Heavy freight vehicle	7.4	5.6
Truck and trailer	8.5	6.2

Table 11. Unit costs of impact on climate change

Vehicle category	Climate change costs, EUR cent/vehicle per km	
	Urban	Suburban
Passenger car – diesel	2.9	1.9
Passenger car – gasoline	2.9	1.7
Bus	7.4	5.1
Light freight vehicle	3.1	1.9
Medium freight vehicle	5.7	4.3
Heavy freight vehicle	8.9	6.5
Truck and trailer	11.2	8.0

costs are determined as the difference between climate change costs "without the project" and "with the project" (Table 13).

According to the previously performed calculations, residual value of the project was calculated. Residual value of the project was estimated based on the following formula:

$$Y = \left(\frac{A}{X}\right) \times \left(X - V\right), \tag{3}$$

where Y – residual value of project,

A – investment value,

X – real (physical) lifetime of the project and

V – analysis period.

According to the total investment value mentioned above and the estimated lifetime of road infrastructure of 50 years, the residual value is calculated in the amount of EUR 9 067 009 and it is included in the economic cash flow of the project in the last observed year of the projection (Table 14).

Table 12. Savings in air pollution costs for the period 2023–2043

Year	Air pollution costs, EUR		Savings in air pollution costs, EUR
	Without the project	With the project	
2023	172 722	151 683	21 039
2024	187 222	163 184	24 038
2025	193 443	168 177	25 267
...			
2041	230 114	198 062	32 052
2042	231 490	199 139	32 351
2043	232 869	200 215	32 654

Table 13. Savings in climate change costs for the period 2023–2043

Year	Climate change costs, EUR		Savings in climate change costs, EUR
	Without the project	With the project	
2023	487 040	422 412	64 628
2024	529 964	454 443	75 521
2025	548 283	468 345	79 937
...			
2041	655 515	551 572	103 943
2042	659 612	554 570	105 043
2043	663 726	557 567	106 158

3.3. Economic analysis of final results

As stated in Section 3, according to the recommendations of the relevant methodology, the use of a discount rate of 5% is recommended for countries acceding to the EU (European Commission, 2015). Total construction effects – costs and benefits of the project, which were observed by years in the period 2020–2043, were reduced to a common denominator by discounting using the selected discount rate, i.e., they were expressed in the current values of monetary units as shown in Table 14.

In order to increase visibility of the expected socio-economic benefits from the Rožaje bypass project, the relative structure of the project total socio-economic benefits is presented in Figure 3, while the final results of the economic feasibility analysis of the second phase of the Rožaje bypass project are shown in Table 15.

Table 14. Economic cash flow forecast of the second phase of the Rožaje bypass construction project

Year	Investment, EUR	Maintenance costs, EUR	Travel time savings, EUR	Savings in vehicle exploitation costs, EUR	Savings in traffic accidents, EUR	Savings in environmental costs, EUR	Residual value, EUR	Net effects, EUR
2020	6047332							–6047332
2021	3676021							–3676021
2022	5909420							–5909420
…								
2041		38189	3080902	1543368	302900	135995		4722075
2042		38189	3108174	1556966	305656	137394		4764345
2043		46295	3135680	1570703	308445	138813	9067009	13865910

Table 15. Review of project economic feasibility indicators

Feasibility indicators	Value
ENPV	EUR 55 054 502
EIRR	26.88%
B/CR	4.96

We conclude that the results of our research correspond with the results of a large number of studies that assessed the economic, social and other impacts of traffic infrastructure on the social community and users. As shown in Figure 3, the results of our research confirmed significant socio-economic impacts related to the reduction of travel time and environmental benefits (75% and 23% in the total structure, respectively). Vitkūnas and Meidutė (2011) showed that with the construction of bypasses, due to an increase in speed (six times outside peak hours) and a reduction in travel time (eight times during peak hours), there was a significant reduction in carbon monoxide emissions (from 2.7 to 4.57 times). Additionally, our results confirmed the savings in traffic accident costs, from the construction of the bypass. According to our results, a significant number of other studies have indicated that this type of traffic infrastructure leads to a decrease in the number of traffic accidents due to a better traffic flow, greater predictability and safety of traffic patterns due to a reduction in congestion (Yeh, 1998; Sabol, 1996). However, a certain number of studies indicated the problem increased in the severity of traffic accidents due to the increase in travel speed with the construction of bypasses (Amundsen & Hofset, 2000). In the context of increased safety, a large number of studies indicated the effects of bypasses, the construction of which improved the safety dimension of roads for drivers and pedestrians due to the reduction of crowds and the displacement of truck traffic through city centres (Jadaan & Nicholson, 1988; Andersson et al., 2001; Egan et al., 2003; Cena, 2007; Cena et al., 2011). Elvik et al. (2001) estimated a reduction of almost 20% in the number of traffic accidents, while Cena et al. (2011) found a reduction in the frequency of collisions by 44% on the old road network and by 66% on the new road network.

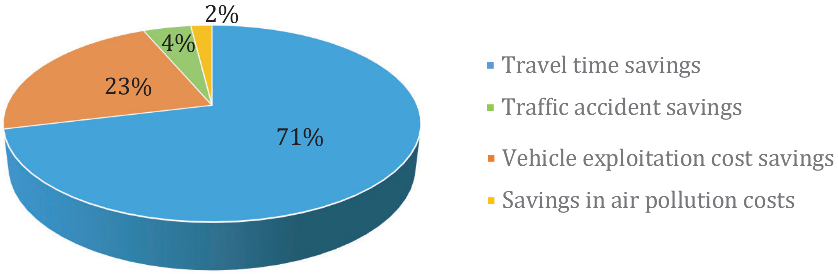

Figure 3. Relative structure of total socio-economic benefits / savings of the project

4. Project sensitivity analysis

Considering that during the evaluation of the efficiency of the project "future" values are used, which cause a certain greater or lesser degree of uncertainty of the obtained results, a project sensitivity analysis was performed, which determined the project profitability threshold by varying the following key parameters: traffic volume, investment costs, discount rates and travel time. Sensitivity analysis results with the assumptions made in the economic analysis are given in Table 16.

Based on the results of the sensitivity analysis of the project presented in Table 16, we concluded that for all "developed" scenarios, which assumed the variation of the key parameters of the analysis, the obtained results were similar to the results obtained in the "base" scenario, which confirmed the conclusion from the "base" scenario that the project had satisfactory socio-economic justification.

Table 16. Sensitivity analysis – economic tests

No.	Type of test	*EIRR* Condition: *EIRR* > *OCC*	*ENPV* Condition: *ENPV* > 0	*B/CR* Condition: *B/CR* > 1
1.	TRAFFIC VOLUME			
	Scenario 1: Base scenario	26.88%	55 054 502	4.96
	Scenario 2: Traffic decreased by 10%	24.91%	48 363 309	4.48
	Scenario 3: Traffic decreased by 20%	22.81%	41 672 116	4.00
	Scenario 4: Traffic increased by 10%	28.75%	61 745 695	5.43
	Scenario 5: Traffic increased by 20%	30.53%	68 436 888	5.91
2.	INVESTMENT COST			
	Scenario 1: Base scenario	26.88%	55 054 502	4.96
	Scenario 2: Investment growth by 10%	26.37%	54 635 679	4.79
	Scenario 3: Investment growth by 20%	25.87%	54 216 855	4.64
3.	DISCOUNT RATE			
	Scenario 1: Base scenario – discount rate 5%	26.88%	55 054 502	4.96
	Scenario 2: Discount rate 6%	26.88%	47 578 550	4.50
	Scenario 3: Discount rate 8%	26.88%	35 654 213	3.74
	Scenario 4: Discount rate 10%	26.88%	26 760 228	3.15
4.	TRAVEL TIME			
	Scenario 1: Base scenario	26.88%	55 054 502	4.96
	Scenario 2: Travel time value decreased by 33%	21.66%	38 250 558	3.81

Conclusions

Investments in the second phase of the Rožaje bypass construction are determined in the total amount of EUR 19 788 320, of which EUR 14 352 893 were spent. The remaining amount needed to complete the project is EUR 5 435 427. Our analysis confirmed the socio-economic sustainability of the project. Namely, results confirmed that the investment in the second phase of the Rožaje bypass construction had a satisfactory socio-economic justification, because the $EIRR$ was higher than the OCC ($EIRR = 26.88\%$), the $ENPV$ was greater than 0 ($ENPV =$ 55 054 502 EUR), and the B/CR was greater than 1 ($B/CR = 4.96$).

Based on the overall analysis, we conclude that, from the point of view of the analysed socio-economic effects, this project has full socio-economic and traffic-technological justification. Considering all the above, it is recommended to continue with all further activities aimed at completing the bypass which would create the conditions for implementation of expected benefits quantified in our paper. The completion and opening of the Rožaje bypass should provide a number of direct effects, such as elimination of bottlenecks, increasing the average speed of vehicles, reducing vehicle exploitation costs and travel time costs, increasing the level of safety, as well as the effects of environmental protection (such as the level of noise, air pollution, etc.).

We believe that the results of our research represent a theoretical and practical contribution in this field. Namely, transport infrastructure projects are expected to have significant socio-economic effects, which primarily determine the investment decision. Therefore, the use of relevant methodology for quantifying and monetizing these benefits is a theoretical contribution of our paper in this field. At the same time, such analyses should provide strong support to policy makers in the decision-making process in order to ensure the optimal allocation of limited resources and satisfy the public interest. These projects improve the traffic infrastructure of municipalities, which is the practical contribution of this paper.

Limitations of our study represent free space for future research. Namely, within the evaluation of the expected socio-economic benefits from the Rožaje bypass construction, not all the benefits that can be achieved by its construction are included. Their quantification, which can improve the results achieved within the framework of economic analysis, opens space for future research.

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