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Evaluation of the cost-benefit method in the feasibility analysis of the Pelješac Bridge construction

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ABSTRACT

In the context of the construction of road infrastructure facilities, there is no doubt that the construction of new roads leads to an increase in the quality of transport services. A new road fosters the development of settlements through which it passes, and indirect benefits are achieved through new investments. Cost-benefit analysis (CBA) as a method involves consideration of a project's financial returns, and most data on project costs and benefits are obtained through a relatively detailed financial analysis. Any independent variable reflected in the change results in a set share in project analysis; it is a critical variable and must be evaluated as reliably as possible. The implementation of a historical capital project in the Republic of Croatia has been highlighted in this paper – the construction of the Pelješac Bridge. Based on the transport criterion, the research has shown significant advantages achieved by bridge construction in the surrounding and wider area. The positive effects of demographic, economic, and social parameters are multiplying. The economic effects of bridge construction are highly favourable since, on the one hand, they are expressed as benefits in terms of savings on the costs of all activities from primary to quintary. On the other hand, they represent multiplications regarding the use and revitalisation of employment and natural resources. In accordance with the expected faster economic growth, the offer structure will cause a change in the relations within service activities in the direction of strengthening investments, intellectual services, tourism with all of its accompanying activities, etc. In the case considered, non-measurable benefits have not been quantified, although, independently from the CBA, their feasibility is fundamental. *Nota bene*, this primarily refers to the political component in strategic decision-making, such as the integration of regions, i.e., the achievement of the state territory integrity.

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1 Introduction

A cost-benefit analysis enables the assessment of the relative cost-effectiveness of investment in a planned project. The analysis is used to calculate the costs, benefits, and risks of the proposed solutions, aiming to determine the most effective way to achieve the objectives. The analysis is a formal technique of seeking the most favourable relationship between the benefits of the project and the costs necessary for their achievement. It is mainly used for public and infrastructure facilities. The government must be prepared to accept certain environmental costs (damages) to the environment and at the expense of the environment for the benefits expressed through growth and development of the economy, employment, resolution of vital problems of the society, i.e., improvement of the standard of living, contributing to the revenues of the state budget of the Republic of Croatia ensured by each project. The impact assessment and selection of the most acceptable project variation aim to reduce these impacts to an acceptable measure. This paper analyses the development of transport and the current transport situation in the Republic of Croatia with emphasis on the large infrastructure project, the construction of the Pelješac Bridge, along with other road infrastructure. It is listed as one of the priority development projects of the Dubrovnik-Neretva County and a project of great strategic importance for connecting Croatia with the European Union. Namely,

high-quality and well-planned infrastructure investments balance economic development; they specifically affect transport development which directly influences economic development through trade; it also supports the tourism industry. They also affect the decrease in transport prices and productivity growth, which ultimately impacts the improvement of the living standard of the whole society.

2 Theoretical approach in the cost-benefit method analysis

Long-term high-quality and balanced transport policy aimed at financing the construction and maintenance of transport infrastructure, the existence of guidelines for its implementation, and understanding of the value of our potential are one of the foundations for the future development of the entire economic system of the Republic of Croatia and the European Union. Infrastructure investments that are poorly planned or not planned at all create developed and underdeveloped regions that, in addition to traffic isolation, struggle with economic and demographic problems, which are closely related to infrastructure issues. Cost-benefit analysis (CBA) is one of the key tools for deterministic and scientifically based evaluation of all relevant parametres in a complex problem. It emerged in the mid-1930s in the United States of America and Western Europe. Cost-benefit analysis is a procedure providing an assessment of social benefits and damages that will occur during the implementation of a particular project. The cost-benefit method provides an assessment of the relative cost-effectiveness of investing in the planned project. The analysis procedures calculate the costs, benefits, and risks of the proposed solutions, aiming to determine the most effective way to achieve the objectives. The analysis is a formal technique of seeking the most favourable relationship between the benefits the project brings and the costs necessary for their achievement. It is mainly used for public and infrastructure facilities and slightly less in other projects where there can be social benefits and damages. The essence of this method is in the so-called "Pareto principle." The Pareto principle is based on the assumption that in today's modern society, it is impossible to implement any project that would not harm anyone. Economists have introduced the concept of potential Pareto's progress for government projects under this principle, according to which it is worthwhile to invest in any project in which the benefactors' benefits outweigh the costs of those incurring the costs generated. Projects that achieve benefits and reimburse the costs may be considered to have made full Pareto progress. Such costs and benefits can be described as the kind of benefits and costs that burden the wider or immediate community, even future generations, which can be considered the first definition of the so-called "sustainable development." In this context, the cost-benefit analysis is an important part of the environmental impact assessment process at the level of individual projects, and it is the necessary support for decision-making in the environmental impact assessment process. The analysis can be used in several phases. It is necessary to determine the value of projects involving social spending. It is also necessary to assess the advantages and disadvantages for the whole society. CBA analysis is a tool for analysing the cost-benefit relationship of a specific project, as well as the comparison of similar projects based on the relationships determining the investment structure. Economists usually advocate using net present value (NPV) in selecting investment projects. Projects should be accepted or rejected depending on whether the net present value is positive or negative. In the circumstances of limited financial resources, a project showing the highest net present value shall be selected among other eligible projects. The cost-benefit analysis aims to calculate the net present value (NPV) of the cost-benefit flow of the project. The net present value is calculated as follows:

$$NPV = \Sigma \left[(B_t - C_t)/(1 + r)_t \right] \quad (1)$$

where:

B_t – expected project benefit (estimated using optimal price) in time unit t,

C_t – expected costs (estimated using optimal price), and

r – discount rate.

In financial terms, the net present value of a project is defined as the value obtained by discounting, separately for each year, future benefits and present costs incurred during the life of the project, using a fixed, predetermined discount rate. Discount rates used should be equal to either the average interest rate on long-term loans in the capital market or the actual interest rate paid by the investor as the borrower. If there is no sustainable labour market (which is often the case in transition economies), the discount rate should reflect the price of capital, i.e., the possible return of the same capital size invested elsewhere. This should be the minimum profit rate under which, in the investor's opinion, it is not worth investing. The discounting period should cover all cost-benefit values in a project life cycle. A project with a positive or zero net present value may be considered eligible. If the net present value is negative, profitability is below the discount rate, and the project should be rejected. Cost-benefit analysis consists of eight parts, which do not necessarily have to be carried out in succession:

a) Project definition

A project must be a clearly defined unit of analysis and not be part of a larger project for a cost-benefit analysis to be defined. Project inputs and outputs should be determined, quantified, and evaluated.

b) Identification of objectives

The main socio-economic objectives that will be affected by the project should be specified in the analysis of objectives. Project objectives should include socio-economic

variables, not just physical indicators. A common mistake in setting objectives involves non-operationalised objectives such as "the project will promote economic development or social welfare" because each investment project affects social welfare in some way. It is not easy to identify and predict all effects of a particular project. It is therefore recommended to focus on key data, which include the project's financial and economic profitability rate and some simple indicators of environmental and employment impact or additional criteria.

c) Cost-effectiveness and option analysis

An investor in a project must prove that the selected project is the best option among other offered projects, which must include detailed documentation. It is common for a cost-effectiveness report to contain information on the economic and institutional environment, estimated demand, available technology, production plan (including the use of some infrastructure), personnel needs, project range, location, physical inputs, time and implementation, project phases (dissemination), financial planning, and environmental aspects.

d) Financial analysis

While a cost-benefit analysis (CBA) exceeds the analysis of projects' financial returns, most data on the costs and benefits of projects are obtained through a relatively detailed financial analysis. The financial planning analysis should demonstrate that there is no risk for a project, i.e., that there are alternative sources of financing.

e) Socio-economic costs and benefits

The above-mentioned parametres are only preparatory steps for estimating social benefits and costs. When calculating the benefits from public projects, the real estimate that should be applied is the price that beneficiaries are willing to pay for the completed project. Social welfare is a multi-dimensional concept with revenue-related components (i.e., spending, investment, and employment) and other parts, which are slightly less connected with them (i.e., long-term investment in tourism, economy, health, and education).

f) Discounting

All future social costs and benefits arising in different years should be discounted according to the initial year using a single social discount rate. Many countries have their social discount rate set for public sector projects. Social discount rates usually range between 3% and 10%. Analysis of the social discount rate is necessary to calculate the project's net present value. The discount rate selection is important because it has a strong (although concealed) influence on the direction of a potential project.

g) Economic rate of return

After collecting the above-mentioned data and making corrections due to price changes and external influences, it is necessary to calculate the economic internal rate of return (EIRR) or the economic net present value (ENPV). This is important because both EIRR and ENPV are calculated to obtain the right to decide whether an investment is profitable.

h) Sensitivity and risk analysis

In the analysis of benefits and costs, the result is usually affected by several factors of uncertainty. Knowing the "sensitivity" of the result to changes in such sensitive situations is important. Carrying out a sensitivity analysis is crucial because it helps those who design the project and make decisions. They should determine whether the project is worth spending money on to obtain more precise data and whether more could be done to reduce or limit uncertainty.

3 Economic valorisation of the Pelješac Bridge

3.1 Geotraffic Position Analysis

It is important to point out that roads of particular importance for the Republic of Croatia, such as Zagreb-Rijeka and Zagreb-Split, are currently not economically viable because they are not a part of international transit. In the long run, the Adriatic-Ionian motorway will include Croatia in international transit, which will impact general transport increase since some transport between the European Union and the Middle East would be taken over. Most parts of the Adriatic-Ionian motorway were built in the Republic of Croatia, while in Bosnia and Herzegovina, parts will be built as a connection to Corridor 5C, connecting the port of Ploče with Budapest via Sarajevo and Osijek. The entire Adriatic-Ionian motorway project could realistically be completed by the end of 2050. Linking the national transport infrastructure with the international transport Corridor 5c and the trans-European corridors, in general, is one of the ways to compete on an equal footing, in terms of transport and economy, with all EU Member States.

The Republic of Croatia has the longest land border with Bosnia and Herzegovina. This border-crossing continuity was interrupted by the narrow corridor through which Bosnia and Herzegovina has access to the sea. The idea of bridging this corridor emerged for the first time in 1997 when the prefect of the Dubrovnik-Neretva County proposed the construction of a bridge that would bridge Mali Ston Bay between Komarna on the mainland and Brijesta on the peninsula of Pelješac. The bridge was added to the county's physical plans in 2000, and the construction works officially started in 2005 and 2007. Three per cent of the original project was implemented by 2010, with HRK 246 million spent and only HRK 71 million gained through construction. When Croatia joined the European Union in 2013, it opened the possibility for the EU to co-finance the construction; in 2015, the EU allocated EUR 330 million from the EU funds to Croatia for financing

Figure 1 View of the construction of the Pelješac bridge

Source: https://cdn.pixabay.com/photo by Filipović/2022/08/02/07/47/peljesac-7359774

85% of the construction costs. The tender launched in 2017 was won in April 2018 by China Road and Bridge Corporation company with a bid of HRK 2 billion and a construction period of 36 months. The last part of the bridge beam was installed in July of 2021. Access roads with several viaducts and tunnels will not be completed until July 2022. Bosnia and Herzegovina's condition was that the bridge be 55 m high so that ships could continue passing smoothly to Neum. Depth continuity around the bridge is 27 m. The bottom is composed of thick deposits of clay and silt, and the whole bridge is based on hundred-meters long steel tubes almost two meters in diameter, which are plunged into the seabed. The bridge is at a place with increased wind activity and in a zone of significant seismic activity. The bridge is, therefore, a precondition for full territorial integration of the Republic of Croatia into the Schengen area, since without it, to reach the area of Dubrovnik through the so-called "Neum Corridor," it would be necessary to cross the Schengen border twice within 10 km. "The Pelješac Bridge is primarily an emotional and political issue, and only subsequently an economic one"; this statement was made during one of many expert and political debates that took place over the past years, which may have best defined all the circumstances related to the bridge construction. The arguments for connecting the south with the rest of Croatia will not be self-evident in the short term. It will be very difficult to pay off the investment as such in the short run, and this is not such a project at all. However, in the long run, it could set a very good basis for the development and economic progress of the region. The regional centre of the Dubrovnik-Neretva County is the City of Dubrovnik, and the county itself can be physically divided into two parts by the existing border with Bosnia and Herzegovina. One part is linked with Donja Neretva with its surrounding area, and the coastal part covers an area with numerous islands such as Mljet, Korčula, Lastovo, and the Elafiti Islands. In addition to the generally poor connectivity within the county, the existing border with Bosnia and Herzegovina is one of the reasons for the poor connection between the Dubrovnik-Neretva County and the rest of Croatia and Europe, which has been a limiting factor in transport and economic development of the Dubrovnik-Neretva County. Except for the motorway connecting the Dubrovnik-Neretva County with the rest of the Republic of Croatia, only as far as Ploče, the Dubrovnik-Neretva County can be

reached through the existing road infrastructure by road DC 8. It is connected with larger cities by air via Dubrovnik Airport, national ferry lines connect the Dubrovnik-Neretva County with Rijeka and Split, and the international ferry line connects Dubrovnik and Bari. The construction of the Pelješac Bridge is significant for the Dubrovnik-Neretva County as an additional incentive for the development of peripheral parts of the corridor: the peninsula of Pelješac and the island archipelago. The cause of the present situation is isolation and dependence on others. If we look into history, we will understand the reasons that were once considered relevant but presently created great problems for the entire county. Dubrovnik's diplomacy, due to the dangers coming from its Venetian surroundings and the possible separation of the Dubrovnik Republic from the hinterland, and threats to its neutrality, gave Turkey a part of its territory. One part is situated between Neum and Klek, and the other in the south, in Sutorina, across the Boka Kotorska Bay. Finally, Pelješac bridge was built and put into traffic on July 26, 2022 and represents a grandiose construction object as can be seen from the following Figure 1.

3.2 Financial Analysis in the Context of the CBA Parametres

The economic evaluation methodology of constructing the primary road network in the Adriatic-Ionian motorway corridor from Ploče to GP Karasovići was fully implemented according to *well-founded research studies*. The basis for an economic assessment is a sequence of costs and benefits over a twenty-year period which includes vehicle exploitation costs, vehicle overheads, passenger time costs, traffic accidents and accident costs, maintenance costs, and construction costs. Modern methods for evaluating investment projects are based on a discounted value calculation, which contributes to the reality of the assessment, i.e., taking into account time preferences. Of the methods based on the discount account, the current value and internal rate of return methods were used to evaluate the construction project of the primary road network in the Adriatic-Ionian motorway corridor from Ploče to GP Karasovići. The present value method evaluates the profitability of investments according to the current investment value. The current investment, considered in the first year of exploitation, is defined as the difference between all benefits and costs during the investment, reduced to the first year of project exploitation. This means that construction costs are compounded, and the benefits are discounted on the first year of exploitation. According to the criterion for making an investment decision, an investment project is considered profitable if the current project value is higher than zero. At the same time, the internal rate of return is defined as the rate that reduces the project's current value to zero, i.e., equals the current investment value to the present value of future benefits. The project is eligible if its internal rate of return is not under the opportunity capital price. The analysis was carried out under the assumption of a constant capital price of 5% to 10% due to substantial investments in capital transport infrastructure. The road users' costs are based on detailed calculations of total user costs on a road network without investment and a road network with investment, construction costs, and maintenance costs. Since the economic analysis includes construction and maintenance costs in addition to user costs, it can be concluded that the conducted economic analysis includes all quantitative and value-determined project costs and benefits. Total road user costs consist of total exploitation costs, passenger time costs, and costs of traffic accidents. Total direct benefits of road users represent the difference between all of the above-mentioned costs on a road network without investment and on a road network with investment, with the addition of the difference between their maintenance costs. This means that the analytical procedure applied in the calculation of road users' costs does not take into account numerous indirect effects of construction on direct users, as well as on a very large number of indirect users

By accepting the Decision on co-financing of the large infrastructure project "Cestovna povezanost s južnom Dalmacijom" [Road Connections with South Dalmatia], the Republic of Croatia received a grant worth EUR **357 million.** The total value of the project is EUR 526 million, including VAT, and EUR 420 million without VAT, of which the EU co-finances 85%. Total eligible costs for bridge construction in HRK are 3,215,559,659.40, while the Republic of Croatia received a grant of EUR 2,733,225,710.49. As mentioned before, the bridge should have been built before, and some construction work had even been initiated. For the Republic of Croatia to apply for the co-financing tender, it first had to terminate the contracts with the companies hired for the construction. Afterwards, it was necessary to research which is the best solution for connecting South Dalmatia with the rest of the country. During this research, it was established that the bridge under consideration was the best solution. Within the Operational Programme Competitiveness and Cohesion 2014-2020, EUR 6.881 billion were made available to the Republic of Croatia, of which EUR 4.321 billion from the European Regional Development Fund (ERDF) and EUR 2,559 billion from the Cohesion Fund (CF). When mandatory co-financing of the implementation of the Operational Programme from the budget of the Republic of Croatia is added to this amount, the total value increased to EUR 8,081 billion. The Republic of Croatia will pay the amount of HRK 482,333,948.91 from its budget, i.e., 15% of the total amount of the construction of the Pelješac Bridge, plus VAT. Also, companies working on the bridge with headquarters in Croatia will pay the VAT in Croatia, i.e., return it to the budget.

Therefore, this project aims to strengthen the integrity of the state territory in the south of the Republic of Croatia by building the Pelješac Bridge with access roads and roads on Pelješac (the so-called "Ston Ring Road").

Strengths	Weaknesses
▪ Favourable geographical and strategic position ▪ Shorter travel time ▪ The shortest connection to Southwest Europe ▪ Increase in the standard of living in the surrounding area ▪ Co-financing from EU funds	▪ Low transport demand in the initial exploitation period ▪ Excessive bridge height due to safe passage ▪ High maintenance cost of the facility
Opportunities	**Threats**
▪ Possibilities for the revitalisation of all economic activities ▪ Facilitated entry to the Schengen Area ▪ Increasing foreign investments	▪ The bridge position is unfavourable due to wind impact ▪ Seismically active area ▪ Long investment repayment period

Figure 2 SWOT Analysis of Construction Feasibility of the Pelješac Bridge

Source: Authors

The plan is to implement the project in the period from 2016 to 2022 and construct a total of 32.53 km of roads with accompanying facilities (viaducts, bridges, tunnels, underpasses, rest stops, water reservoirs, etc.). The construction of the Pelješac Bridge and the road will increase the level of transport system service and traffic safety, provide access to the far south during strong winds, when air and sea transport is unavailable, increase the reliability of supply chains in the region, and reduce travel duration to the far south, which will reduce the impact on the environment. In addition to shorter travel time, which will improve trade between the south and the north and enable safer traffic and easier connections, the Pelješac Bridge will provide the necessary basis for developing southern Dalmatia.

According to the analysis of economic and social impacts, the Pelješac-mainland bridge will not only foster growth but also create the conditions for numerous multiplicative effects that will accompany this growth while simultaneously providing compatibility between the two areas within the immediate area, particularly regarding employment and a more favourable and balanced distribution of income. The bridge will provide a better connection between Pelješac and the rest of Croatia and increase passenger transition to Korčula and other islands. This will undoubtedly be beneficial in the upcoming tourist seasons, which play an important role for residents and businessmen in southern Dalmatia, and the traffic forecast can be seen from the following Figure 3.

According to research conducted at the initiative of the Government of the Republic of Croatia, an increase in employment and productivity growth per employee can be expected. One of this project's main strengths is that it received a grant, i.e., that it is co-financed by EU funds, and the main advantage is traffic integration; thus, the area of southern Dalmatia could make significant progress. In the context of economic and political parametres, it should be pointed out that the Government of the Republic of Croatia passed a Decision granting the company Hrvatske ceste d.o.o. a concession for the special use of the maritime property for the construction and use of the structure "Land – Pelješac Bridge" in the Dubrovnik-Neretva County. The structure "Land – Pelješac Bridge" will be connected to the Croatian road network by access roads D8 and D414, while the proposed scope of the area under concession is in accordance with the location permits issued by the Ministry of Construction and Physical Planning. The same ministry issued a building permit and two of its amendments. Within the scope of the maritime property under concession for the construction and use of the "Land – Pelješac Bridge" structure is a part of the mainland in the Municipality of Slivno and a part of the mainland in the Municipality of Ston, and a part of the seabed at the locations of the bridge columns. The concession shall be granted for a period of 50 years, and the completion deadline was 48 months from the date of the conclusion of the concession contract. The company Hrvatske ceste d.o.o., as concessionaire, will not charge bridge passage, i.e., will not benefit financially; the concession fee is therefore set at a symbolic amount of HRK 0.50 per square metre of the occupied area of the maritime property, i.e., HRK 22,092.50 per year. In the political context, the Pelješac Bridge is undoubtedly the most important project of the current government, for the construction of which many obstacles have been overcome, which secured EU grants worth EUR 357 million, and the expected so-called "sliding scale" has no impact on public opinion. Hrvatske ceste was also awarded a concession for the special use of the maritime property for the construction and use of this bridge on the state road section Sparagovići – Doli in the Municipality of Ston. The concession has been awarded for a period of 50 years, the concession fee per square meter of the occupied area is HRK 0.50 or HRK 246 per year, and the concessionaire will not charge bridge passage.

4 Conclusion

A cost-benefit analysis should be understood and used as an optimisation instrument in assessing the impact of a project on the total economic and social environment. The

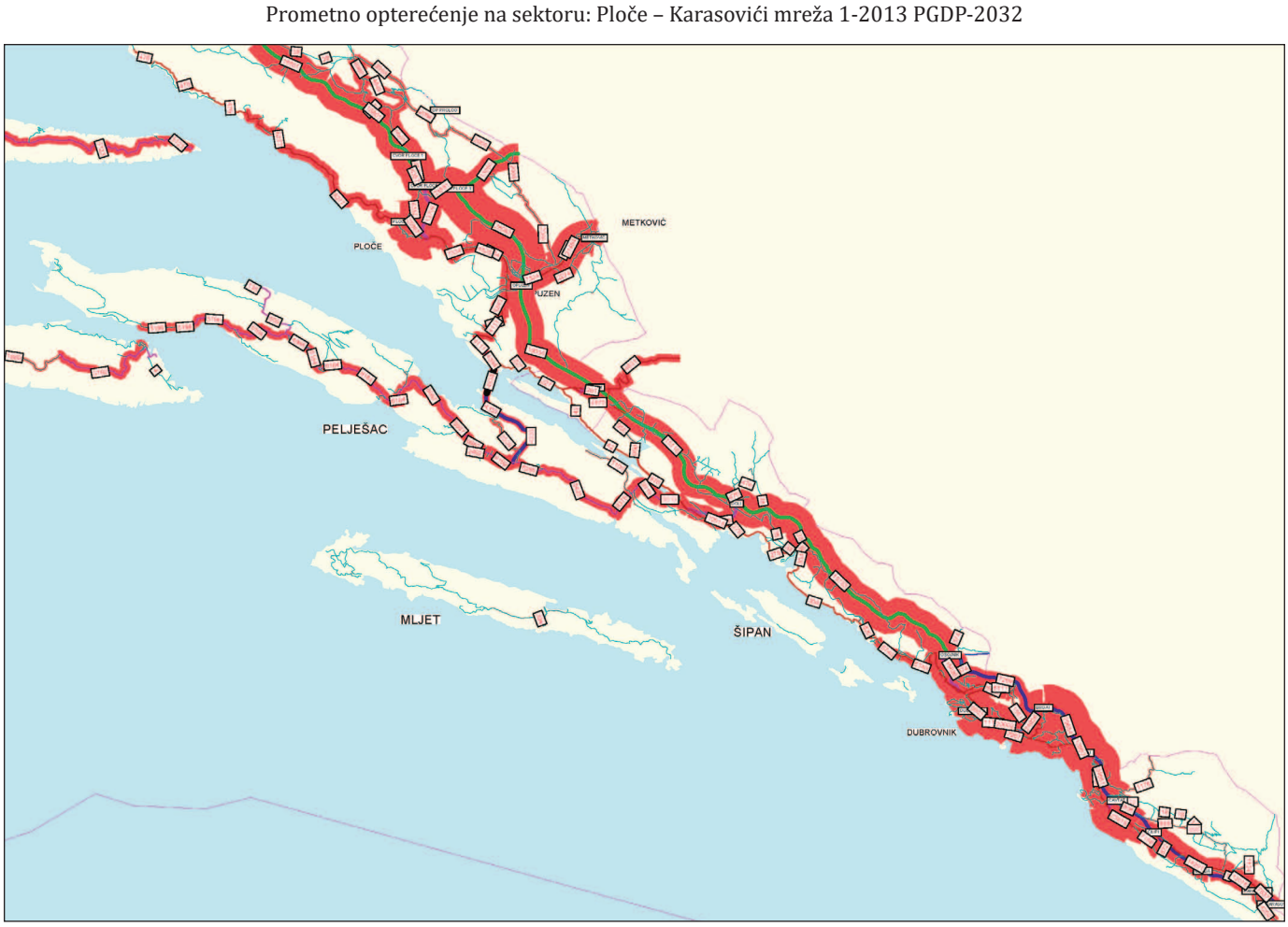

Figure 3 Traffic forecast for the year 2032 (state with expressway and bridge)

Source: Study of justification of the primary road network in the Adriatic-Ionian highway corridor / Ploče - Karasovići sector/, Zagreb, IGH, 2005)

government must be ready to accept certain costs and risks to achieve long-term economic development and employment, solve the vital problems of the society or increase the standard of living. Impact assessment and selection of the most acceptable project version aim to reduce these impacts to an acceptable measure. Cost-benefit analysis provides an assessment of the relative cost-effectiveness of investments in a planned project. The analysis is carried out to calculate the costs, benefits, and risks of the proposed solutions, aiming to determine the most effective way of achieving the objectives. The analysis is a formal technique of seeking the most favourable relationship between the benefits the project brings and the costs necessary for their achievement. It is mainly used for public and infrastructure facilities. This paper analyses transport development and the current transport situation in the Republic of Croatia with emphasis on the large infrastructure project for constructing the Pelješac Bridge, along with other road infrastructure. It is listed as one of the priority development projects of the Dubrovnik-Neretva County and a project of great strategic importance for connecting Croatia with the European Union. Namely, high-quality and well-planned infrastructure investments balance economic development, specifically affecting transport development, which directly affects economic development through trade and support to the tourism industry. They also have an impact on decreasing transport prices and productivity growth, which ultimately has an impact on increasing the living standard of the whole society. Cost-benefit analysis in its original form and methodology has no embedded elements that can unambiguously quantitatively contribute to decision-making in the project selection process. Except for the above-mentioned economic analysis, the traffic safety element is unduly missing in the considered evaluation case. Namely, every newly constructed transport infrastructure facility, in the context of improved safety standards, contributes to increasing traffic safety in terms of material damage and the number of injured and killed persons. The return of invested funds in this part of CBA's usefulness and logic is certainly not negligible. In general, extending the benefit matrix in this context requires an expert approach, which will undoubtedly be one of the future challenges of the scientific evaluation of this relevant economic methodology.

The political importance of the entire project for constructing and exploiting the Pelješac Bridge can ultimately be compared to the period when the Homeland War ended. Thus, the integration and integrity of the state territory fall within the category of unique historical events, making a nation and country a respectable entity in international politics and the global economy regardless of the construction and exploitation cost of a single infrastructure facility.

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