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Road and Rail Infrastructure III

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INVESTMENT PLAN FOR BAR – BOLJARE MOTORWAY

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Abstract

Nowadays the main transport project in Montenegro is Bar-Boljare motorway, the new infrastructure project. The 170km new motorway will connect Serbia to the north of Montenegro, and further south to the Adriatic Coast, and with the Port of Bar, as a major port in the Adriatic. This motorway will be part of Bar-Belgrade-Budapest European Corridor, linking Montenegro to Central Europe, and presenting the transport project with very high national and regional priority. After the main sections of the motorway have been defined the Montenegrin government should make final investment plans for realization in the future. The authors developed the multicriteria model using the Analytic Network Process – ANP, as a solution for analysing and ranking 5 sections of the Bar-Boljare motorway. The network structure of the problem leads to the application of the ANP.

Keywords: investment plan, transport projects, analytic network process

1 Introduction

Project Bar-Boljare motorway is a key element in the strategy of the Montenegro Government of accession to the European Union, as it will allow Montenegro to be fully integrated within Europe. The project is also very important for the unification of the country as it will allow the north-east regions to be connected to the coast through our capital. Finally, the project will allow our key port of Bar to be fully connected to the rest of the European corridors and better serve Serbia and Kosovo, further facilitating the unlocking of this part of the Western Balkans and contributing to economic and political stability in the region.
Motorway toll-road proposed for linking the Adriatic coast at Bar via the capital Podgorica to the Serbian border at Boljare. Planned to connect Montenegro with Republic of Serbia through Požega – Belgrade and further link on the TEN-T corridor X, and hence to Romania and Central Europe. It would also connect with routes to the regional capital cities of Sarajevo in Bosnia and Herzegovina, Tirana in Albania and Skopje in Macedonia, therefore Bar-Boljare motorway has a clear strategic role to play in the region. The approximate length of this link is of about 170 km. Since the size of Montenegrin economy and the estimated total investment value of Bar-Boljare motorway project, which exceeds 2 billion, it's evident that this motorway corridor has to be divided into sections, which all together form an entity, from a technological point of view. After defining the five relevant sections of this motorway corridor, the program of their mutually synchronization in time and space should be set up. In accordance with that, the topic of this paper is defining the final rank of considered sections of the motorway corridor in Montenegro, considering the relevant set of criteria, subcriteria and interest groups.
The authors suggest using the multicriteria decision making approach, the Analytic Network Process, to define the investment plan for Bar-Boljare motorway.
This paper is organized as follows. After the Introduction, the following section is dedicated to the model description. All system's elements: alternatives, criteria, subcriteria and stake-

holders are named. The third section, the brief description of the ANP approach, shows the main steps of the applied multicriteria approach. The next section is Results and discussion, presenting the final obtained results of the model. Finally, the last section contains concluding remarks and future researches.

2 Model description

Following the main concept of the ANP approach, to have different clusters, mutually connected, with or without feedbacks, etc. The developed model has 6 clusters: alternatives, 4 groups of criteria with subcriteria and stakeholders.
All system's elements are presented in the figure 1.

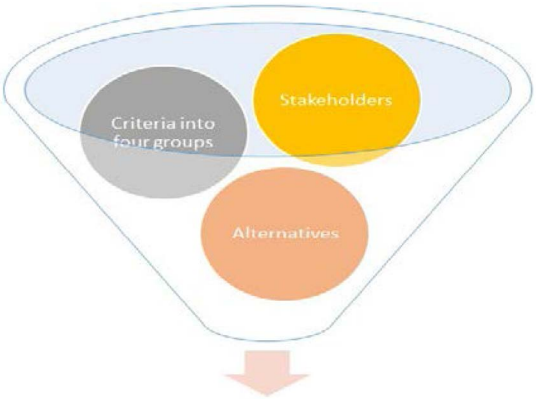

Figure 1 The developed model

2.1 Alternatives

In the existing planning and project documentation, motorway Bar-Boljare corridor is defined as follows: Bar – Djurmani – Sozina tunnel – Virpazar – Tanki Rt – Farmaci (Podgorica) – Smokovac (Podgorica) – Mateševo – Andrijevica – Berane – Boljare (border with Serbia). This was the base for defining the five considered sections, table 1.

Table 1 Sections of the considered motorway

Section		Length
A1	Bar (Djurmani) – Virpazar	11.7 km
A2	Virpazar – Smokovac	38.2 km
A3	Smokovac – Mateševo	43.5 km
A4	Mateševo – Berane	34.3 km
A5	Berane – Boljare	41.3 km
TOTAL:		169 km

In corridor Bar-Boljare motorway, section Djurmani – Sozina tunnel – Virpazar, approximately of 10 km of semi-motorway has been constructed, within 4,2 km of Sozina tunnel, as well as temporary linkages with existing roads in Sutomore and Virpazar. It is proposed that the Bar-Boljare motorway and planned Adriatic-Ionian motorway have a common alignment in zone of capital Podgorica, in the length of approx. 10 km. Proposed motorway sections have been

coded as dual-2 links (2 lane in each direction). Within the model, the motorway has been given the following characteristics:
· lane in each direction;
· design speed of 100 kilometers per hour;
· capacity of 30 000 vehicles per day per direction.

Based on experts' opinion relevant criteria and subcriteria for the model are defined (table 2). Some of them are mutually connected. For instance, the criterion "Increasing the enterprises' competitiveness" is in relation with the criterion "Contribution to the regional development", etc.

Table 2 Criteria and subcriteria of the model

Criteria	Subcriteria	Description
C1 Costs	C11	Construction costs
	C12	Maintenance costs
	C13	Operating vehicle costs
	C14	The economic rate of return EIRR
	C15	Period of construction
C2 Traffic	C21	Number of accidents
	C22	Traffic volume
	C23	Alternative routes
	C24	Forecasted traffic volume
	C25	Changes of traffic flows
	C26	Infrastructure capacity utilization
C3 Environmental impacts	C31	Environmental protection
	C32	External influences
	C33	Demographic changes
C4 Benefits	C41	Travel time savings
	C42	Attractiveness of investment
	C43	Contribution to the regional development
	C44	Increasing of the security
	C45	The impact to the regional significance
	C46	Valorization of the potential
	C47	Tourism development
	C48	Easier access to market
	C49	Area development
	C410	Increasing the enterprises' competitiveness

2.2 Stakeholders

As the relevant stakeholders, following six interest groups are considered:
· S1 – Government;
· S2 – Local authorities;
· S3 – Construction sector;
· S4 – Tourist sector;
· S5 – Private sector;
· S6 – International financial institutions.

Their relative importance is defined, so the final rank among them is: Government, International financial institutions, Construction sector, Tourist sector, Private sector and Local authorities, respectively.

3 Brief description of the ANP approach

The ANP approach has been widely used for developing the model as a support system in the decision making process. The model with network structure is very good for presenting the nature of the problem in practice. The first step in this approach is developing the pairwise comparison matrices, presenting the priority among elements, using the fundamental Saaty scale [7] (table 3).

Table 3 Fundamental Saaty scale

The importance	Definition
1	Equal
2	Intermediate
3	Moderate importance
4	Intermediate
5	Strong importance
6	Intermediate
7	Very strong importance
8	Intermediate
9	Extreme importance

The matrix "A" shows a comparison among elements a_{ij}, representing the experts' priority of one element over the others. The matrix "M" is normalized matrix "A" with elements a'_{ij}.

$$A = \begin{array}{c} \\ A_1 \\ A_2 \\ \\ A_j \\ A_n \end{array} \begin{array}{c} \begin{array}{cccccc} A_1 & A_2 & \cdots & A_i & \cdots & A_n \end{array} \\ \begin{pmatrix} 1 & a_{12} & \cdots & a_{1i} & \cdots & a_{1n} \\ a_{21} & 1 & & & & a_{2n} \\ & & & & & \\ a_{j1} & a_{j2} & & 1 & & a_{jn} \\ a_{n1} & a_{n2} & \cdots & a_{ni} & \cdots & 1 \end{pmatrix} \end{array}, \quad a_{ji} = 1/a_{ij} \tag{1}$$

$$M = \begin{bmatrix} a'_{11} & a'_{12} & \cdots & a'_{1n} \\ a'_{21} & & & \\ & & & \\ \cdots & & a'_{ij} & \cdots \\ a'_{n1} & \cdots & & a'_{nn1} \end{bmatrix}; a'_{ij} = a_{ij} / \sum_{i=1}^{n} a_{ij} \tag{2}$$

The vector of priorities, "W", is an eigenvector of the matrix "A". The factor λ_{max}, where n is a number of criteria, is used for calculation of the consistency index of a matrix of comparisons, CI. This is the main advantage of the eigenvector method.

$$W = \begin{bmatrix} w_1 \\ w_i \\ w_n \end{bmatrix}; \quad w_i = \frac{1}{n}\sum_{j=1}^{n} a_{ij}, \tag{3}$$

$$\lambda_{max} = \sum_{i=1}^{n} \left(w_i \cdot \left(\sum_{i=1}^{n} a_{ij} \right) \right) \tag{4}$$

$$CI = (\lambda_{max} - n)/(n-1) \tag{5}$$

After the consistency index is calculated, the consistency ratio, CR, can be considered as a relation of the consistency index and the random index, RI. For CR › 0.1, the degree of consistency is satisfactory. Otherwise, the judgment of a decision maker should be revised.

$$CR = CI/RI \tag{6}$$

Table 4 The values of RI

n	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

For calculating the final rank of alternatives, the normalized super matrix and the limit matrix should be developed. These calculations can be done in the software Super Decisions (www.superdecisions.com).

4 Results and discussion

After applying the developed model for ranking the sections of the Bar-Boljare motorway, the obtained results are presented in the following table.

Table 5 Final rank of considered projects

Section		Rank
A3	Smokovac – Mateševo	1
A1	Bar (Djurmani) – Virpazar	2
A2	Virpazar – Smokovac	3
A4	Mateševo – Berane	4
A5	Berane – Boljare	5

The section A3, Smokovac-Mateševo, will make better links between the north and south of the country. With a better appreciation of the potential in the field of economy and tourism development in the northern region, it will increase the accessibility to the hardly accessible regions, increase mobility, change market conditions and increase competitiveness of enterprises. Also, this project will increase employment and change the structure of employment, with involvement of local constructions firms, equipment, materials and labor in the construction phase, which will have its multiplier effect on indirect benefits, it will bring significant benefits that go far beyond the economic and financial benefits.

Southern sections A1, Bar-Virpazar, and A2, Virpazar-Smokovac, are highly ranked related to economic and social benefits, especially considering traffic demand. These sections have the highest value of traffic demand.
Section A4, Mateševo-Berane, with constructed section A3, Smokovac-Mateševo, leads to even better valorization of the potential of the northern region, better connection to the main road, regional and local roads, increasing benefits related to the travel time savings, vehicle operating costs, increasing the level of security, etc.
Section A5, Berane-Boljare, is the border section of the Republic of Serbia, which attractiveness could become even higher due to the fact that some sections of the Belgrade-Požega have been already designed and built.

5 Conclusions

The main transport infrastructure project in Montenegro is Bar-Boljare motorway, as a part of Bar-Belgrade-Budapest European Corridor. This road is divided into 5 sections, which should be ranked for investment in the future. This paper presents the model for ranking these sections using the Analytic Network Process, the multi-criteria approach. The model has alternatives, criteria and subcriteria, as well as stakeholders, all together make the network with mutual links and relations. The final obtained rank is as follows: Smokovac-Mateševo, Bar-Virpazar, Virpazar-Smokovac, Mateševo-Berane and Berane-Boljare.

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