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THE EVALUATION OF ALTERNATIVE SOLUTIONS FOR THE HIGHWAY ROUTE E-763 BELGRADE – SOUTH ADRIATIC: A CASE STUDY OF SERBIA

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Preliminary communication
Designing road projects involves a complex decision-making process whose objectives should be the implementation of the road design and its utilization in the narrowest sense, but also the facilitation of mobility, economic development of the area and improvement of the quality of life in a wider sense. All of this requires the consideration and understanding of many problems multi-criterial in nature, and decision making with regard to technical components, environmental constraints and the impact on society. The main goal of this paper is to use a real example to explain the role and significance of multi-criteria evaluation methods. The theoretical postulates of multi-criteria evaluation are presented (VIKOR method). Using multi-criteria evaluation methods ranking was carried out of the alternative solutions offered for the E-763 highway route Belgrade-South Adriatic (Požega-Boljare section). Ranking was carried out on the basis of 12 criteria which form the basis for evaluating each of the alternative solutions. The calculation was performed using the VIKOR program packages and an analysis of the results obtained was carried out.

Keywords: *alternative solutions; criteria; highway route; multi-criteria evaluation; ranking; road design; VIKOR*

Vrednovanje varijantnih rešenja trase autoputa E-763 Beograd - Južni Jadran: studija slučaja u Srbiji

Prethodno priopćenje
Projektiranje putova predstavlja složen proces donošenja odluka čiji osnovni cilj treba biti realizacija projekta puta i njegova eksploatacija u užem smislu, ali i omogućavanje mobilnosti, privrednog razvoja područja i poboljšanje kvaliteta života u širem smislu. Sve ovo zahtjeva sagledavanje i razumijevanje mnogih problema koji su višekriterijske prirode i donošenje odluka u vezi sa tehničkim komponentama, ograničenjima okruženja i utjecajima na društvo. Osnovni cilj rada je da se na realnom primjeru objasni uloga i značaj metoda višekriterijskog vrednovanja. Prezentirane su teorijske postavke višekriterijskog vrednovanja. Primjenom metode višekriterijskog vrednovanja (metoda VIKOR) izvršeno je rangiranje ponuđenih alternativnih rešenja trase autoputa E-763 Beograd-Južni Jadran (dionica Požega-Boljare). Rangiranje je izvršeno na osnovu 12 kriterija koji čine osnovu vrednovanja svakog alternativnog rešenja. Proračun je izveden primjenom programskog paketa VIKOR i izvršena je analiza dobivenih rezultata.

Ključne riječi: *alternativno rješenje; kriteriji; projektiranje putova; rangiranje; trasa autoputa; višekriterijsko vrednovanje; VIKOR*

1 Introduction

Road network is a part of the traffic network which performs a number of important tasks within the complete transport system (accommodating the projected level of traffic, economic and social development, mobility, environmental protection, functioning of the network in exceptional circumstances), aligning at the same time spatially and functionally with other transport subsystems (rail, air, transport, waterways) and complying with the set limits (use of the specified space, financial, technical and technological capabilities).

Designing roads, from identification of the project through choice of the route, implementation of the design and until its evaluation, is a long and complex process. Creating design solutions for roads in line with the functional requirements of traffic, environmental restrictions and maximum economic justification based on the real material potential of society is a multi-criteria task, the realization of which involves a multidisciplinary team of experts on the basis of their knowledge and creative skills (engineers, planners, economists and sociologists). The result of the planning and design process is a set of alternative solutions on the appropriate substrates. In order to choose the most suitable alternative and progress to the next stage of the project, the alternative solutions offered are subjected to the evaluation procedure.

2 Evaluation of road design solutions

Evaluation is the process of assessment that includes procedures for defining criteria (characteristics, i.e. the performance parameters of the alternatives) and indicators (real values for each criterion-monetary units, fuel consumption, levels of service, value assessment) relevant to the evaluation of the alternative solutions offered. A systematic and multidisciplinary approach plays an active role at all stages of a road design project.

Traditional methods of evaluation are based on the analysis of economic (financial) indicators of the project. There are various types of financial analysis, some of which are: Cost-benefit analysis (CBA) and Cost effectiveness analysis (CEA) [1]. CBA is often called socio-economic analysis of costs and benefits. CBA is most commonly used in cases where the funding for the project is provided by international monetary institutions or in the case of concessions. The unit used to measure these impacts is money [2, 3].

However, some impacts that cannot be valued in money (intangible values) can be left out of the quantitative analysis [4]. It is necessary later to qualitatively describe the impacts that cannot be expressed in money in a CBA in the best possible way. When it comes to new building or road reconstruction projects, there are also subjective criteria and objectives which are connected both to the decision-maker and the entire setting. The size of ratings that cannot be measured and which come with individual road project solutions (quality of life, aesthetic value, environmental pollution, emergency situations, etc.) are different for different groups of people. It is impossible to translate them into a common denominator. In their studies, some researchers [5, 6] have indicated the possibility of comparing the quantitative and qualitative aspects of potential alternatives using the multi-criteria evaluation, that is, by using the appropriate methods of multi-criteria analysis. In this way, the possibility was created to analyse multiple and conflicting problems, which is a great advantage of multi-criteria evaluation in the decision-making process [4].

2.1 Multi-criteria evaluation

Multi-criteria evaluation is an inseparable part of the design process. In terms of its role and function in designing roads, multi-criteria evaluation is characterized by the following features:

- multiple criteria - every problem has multiple criteria that may be the objective functions or the attributes;
- the mutual conflict of criteria - multiple criteria often conflict with each other;
- incommensurable units - the criteria are expressed in a variety of qualitative and quantitative units of measurement;
- project design/selection - the solutions for the multi-criteria evaluation of a problem are either the design of the best alternative (there may be more than one of them) or selection of the best final alternative among those previously defined [7].

Within the framework of multi-criteria evaluation there are two different categories: multi-target evaluation (MTE), with its subgroup multi-target programming, and multi-attribute evaluation (MAE). With this in mind, the concept of multi-criteria evaluation in this paper will refer to multi-attribute evaluation (MAE).

2.1.1 Models of multi-criteria evaluation

A typical problem of multi-criteria evaluation can be mathematically presented in the following way:

$$\text{(MAE)}\begin{Bmatrix}\text{Select } A_1, A_2, ..., A_m \\ \text{s.t. } K_1, K_2, ..., K_n\end{Bmatrix}. \quad (1)$$

Selection is based on maximizing the multi-criteria value functions (or benefits) presented by the interested parties. The basic information can be presented with the help of the matrix:

$$K = (K_1, K_2, ..., K_n)$$
$$\boldsymbol{D} = \begin{matrix} A_1 \\ A_2 \\ \vdots \\ A_m \end{matrix} \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix}, \quad (2)$$
$$W = [w_1, w_2, ..., w_n]$$

where: $A = (A_1, A_2, \dots, A_m)$ - m are the alternatives between which the decision makers choose, $K = (K_1, K_2, \dots, K_n)$ - n are the criteria by which the performance is measured, x_{ij}, $i = 1, ..., m;$ $j = 1, ..., n$; - are the ratings of alternative A_i taking into account criterion K_j, w_j - is the weighting factor of criterion K_j.

In multi-criteria evaluation the basic problem is to determine the importance and weights of the criteria. Determining the importance of the criteria is a subjective action in which a system of values is interpreted in a specific task of multi-criteria evaluation. The importance of the criteria is expressed by coefficients of their relative weights: to each criterion $k \in K$ a relative weight w_k, $k = 1, 2, ..., K$ is attached. Different methods are used for determining the weight of the criteria (minimum mean square error method, the Eigenvector method, the entropy method and methods using the collective evaluation of a group of experts: the ranking method, the rating method (evaluation) and the method of pair-wise comparison). In the most simple case, each w_k is a no negative number, and if $\Sigma w_k = 1$, it is said that the relative weights of the criteria are normalized. The different treatment of the weights of the criteria by a variety of methods is most effective when solving multi-criteria problems in which there are only a few alternatives, while differences in the final ranking of the variants when using different methods are characteristic for the problems that include several alternatives. Also, the influence of the distribution of the weights of the criteria differs for different methods of multi-criteria evaluation [8].

Depending on the nature of each specific problem of multi-criteria evaluation, there are three possible basic approaches to its solution:

- the problem of ranking - the set of all alternatives is ranked (action, nodes, project designs) from "the best" to "the worst";
- the problem of choosing one alternative - it is necessary to select the "best" alternative;
- the problem of choosing more alternatives - more alternatives are chosen when:
  – starting with the highest rank, a predefined number of alternatives is adopted,
  – a selection is made of those alternatives which meet certain other conditions that are not incorporated in the initial model of multi-criteria values [9].

2.1.2 Multi-criteria evaluation methods

There are a number of different methods of multi-criteria evaluation present in the relevant literature**.** These methods can be categorized in different ways, e.g. according to the shape of the model (e.g. linear, nonlinear, stochastic), according to the spatial characteristics (e.g. finite or infinite), or the alternatives presented (e.g. pre-specified preferences (possibilities) or interactive) [10]. The Analytic Hierarchy Process (AHP) is one of the most commonly used methods in the field of transportation and it is presented in a study by [11] and in various other papers [4, 12]. In addition, there are also the following methods: PROMETHEE [13], SAW [14], TOPSIS [15] [16, 17], ELECTRE [18], MAVT [19], VIKOR [20].

All of these methods have taken a significant place in the process of evaluating the alternative offered as an aid to decision making. The selection of which method to use for multi-criteria evaluation depends, above all, on the nature of the multi-criteria problem [21], but also on the aspirations of the decision maker, and his/her familiarity with the available methods.

2.1.2.1 The VIKOR method (Multi-criteria Compromise Ranking)

The VIKOR method and its software package (VIKOR) solve optimization tasks which have a number of heterogeneous and conflicting criteria. The resulting solution is a compromise and can be unique or represent a set of close solutions. The compromise solution is the allowable solution which is closest to the ideal. The ideal solution is determined on the basis of the best criteria values and is usually not found in the given set of alternative solutions [22].

The VIKOR method algorithm

It is necessary to carry out ranking of alternative solutions $a_1, a_2, ..., a_J$ with the given values of the criterion functions f_{ij}, $i = 1, n$ and $j = 1, J$, where n is the number of criteria, and J is the number of alternatives. The ranking procedure is as follows [20]:

a) The best f_i^* and the worst f_i^- values for all criterion functions $i = 1, 2, ..., n$ are determined:

$f_i^* = max_j\, f_{ij}, f_i^- = min_j\, f_{ij}$, if the i^{th} function represents the profit, (3)

$f_i^* = min_j\, f_{ij}, f_i^- = max_j\, f_{ij}$, if the i^{th} function represents the cost. (4)

b) On the basis of the measures S_j and R_j ranking of alternative solutions is carried out and the place of alternative a_j is determined on the rank lists $s(a_j)$ and $r(a_j)$, whereas the values of S_j and R_j, $j = 1, 2, ..., J$ are calculated using the relation:

$$S_j = \sum_{i=1}^{n} \omega_i (f_i^* - f_{ij})/(f_i^* - f_j^-) \quad (\text{for } p = 1), \tag{5}$$

$$R_j = max_i\, \omega_i (f_i^* - f_{ij})/(f_i^* - f_j^-) \quad (\text{for } p = \infty), \tag{6}$$

where: n - is the number of criteria, ω_i - is the weight of the i^{th} criterion and it expresses the preference of the decision maker, i.e. the relative importance of the criterion; S_j - is the measure of distance $R(F, 1)$ from the ideal point for alternative j; R_j - is the measure of distance $R(F, \infty)$ from the ideal point for alternative j.

By ranking according to the measures S_j and R_j two rank lists of alternatives are obtained. In order to obtain a unified rank list, compromise programming is used, by means of which S_j and R_j are now criterion functions. The new measure for ranking is:

$$Q_j = vQS_j + (1-v)QR_j = v\frac{S_j - S^*}{S^- - S^*} + (1-v)\frac{R_j - R^*}{R^- - R^*} \tag{7}$$

where: $S^- = max_j\, S_j$ and $R^- = max_j\, R_j$; $v = \frac{n+1}{2n}$ is the weight of the decision-making strategy for the group benefit; $(1-v)$ is the weight of individual dissatisfaction.

QS_j and QR_j represent the normalized values. Alternative a_j is a better multi-criteria alternative than alternative a_k, if $Q_j < Q_k$ and it has a higher position on the rank list.

c) The VIKOR method proposes as the best multi-criteria alternative the one which is in the first place on the compromise rank list for $v = 0.5$ only if it has:

- (C1) – "sufficient advantage" over the alternatives in the next position. For evaluating the "advantages", the difference with measure Q_j is used. Alternative a' has sufficient advantage over the other items on the rank list a'' if:

$$Q(a'') - Q(a') \geq DQ, \tag{8}$$

where DQ is the "advantage threshold". There is a limited threshold at 0.25 for cases with a small number of alternatives

$$DQ = min\left(0{,}25; \frac{1}{(J-1)}\right), \tag{9}$$

- (C2) - a "stable enough" first position with a change of weight v (for $v = 0.25$ and $v = 0.75$). Alternative a' must also be the best ranked using QS and/or QR.

If any of the conditions is not met, a set of compromise solutions is formed in which the first alternative and the one after it are included. If the only condition that the first alternative does not fulfil is (C2), then only the second item on the compromise rank list enters the set of compromise solutions. If it does not meet the condition (C1), then the set of compromise solutions contains the alternatives from the compromise rank list until the one which fulfils the condition that the first alternative does not have sufficient advantage over.

The results of the VIKOR method are:

- a rank list according to measures QR, Q (for $v = 0.5$) and QS;
- a compromise alternative or a set of compromise solutions.

These results are the basis for decision making and adopting the best (multi-criteria optimal) solutions [20].

3 Case Study in Serbia–a presentation of the evaluation of alternative solutions offered

3.1 Case Analysis

Within the General Design of E-763 highway Belgrade-South Adriatic for the part from Požega to the Montenegro border (Boljare), and in accordance with the 1996 Spatial Plan of the Republic of Serbia, four alternative solutions have been designed: West; Centre; East 1 and East 2 (Fig. 1). Realization (construction and exploitation) of each of the analysed alternative solutions has a consequence in a number of direct and indirect as well as positive and negative effects. The purpose of multi-criteria analysis application is to identify the most significant effects for each alternative, to use them as evaluation criteria in order to minimize negative and maximize positive effects, and based on the results of application of a chosen method to rank variants and give a proposal to the investor as to which variant of highway corridor is the most acceptable for further elaboration of the required study-technical documentation.

When evaluating and ranking the variants the results were used of some parts of the General Design and studies as follows: Route design (investment-building and spatial aspect), Traffic study (traffic and economic aspect) and Study of environmental influence [23]. The main technical and exploitation characteristics of the considered design solutions for the highway and the values of predicted traffic flows are shown in Tab. 1 and Tab. 2 respectively.

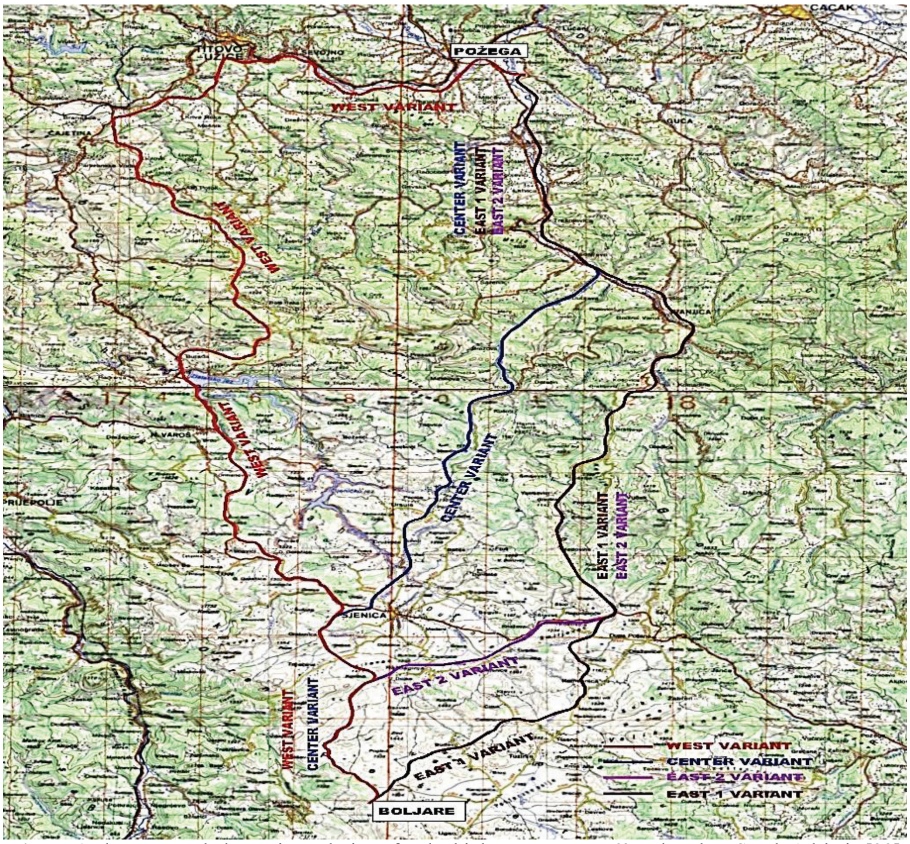

Figure 1 The proposed alternative solutions for the highway route E 763 Belgrade – South Adriatic [23]

Table 1 Technical characteristics of highway route alternative solutions [23]

E 763, Sector III, Požega - Montengro border	Alternative						
	West		Centre		East 1	East 2	
Total route length (km)	141,78		101,36		106,81	111,11	
Design speed (km/h)	120	100	120	100	120	120	100
Length of variant per sections, depending on the design speed(km/h)	26,51	115,27	41,31	60,05	106,81	92,81	18,30
Number of traffic lanes per direction	2	2	2	2	2	2	2
Traffic lane width (m)	3,75	3,5	3,75	3,5	3,75	3,75	3,5
Emergency stopping lane width (m)	2,5	2,5	2,5	2,5	2,5	2,5	2,5
Min. radius of horizontal curve (m)	750	450	750	450	750	750	450
Average gradient along the entire section length (%)	2,51	3,60	2,06	3,13	2,60	2,57	2,81

Table 2 Exploitation characteristics of highway route alternative solutions [23]

E 763, Sector III, Požega - Montenegro border		Alternative				
		Base	West	Centre	East 1	East 2
Average exploitation speed (km/h)		67,95	77,44	78,51	77,52	77,61
Total annual travelling time (h)		12.540.142	8.560.500	4.328.764	4.575.486	4.603.352
Traffic (PGDS)	I year	3.645	6.437	5.032	4.995	4.973
	XX year		12.498	9.769	9.697	9.654
Annual exploitation costs (€)		254.211.451	333.385.201	204.895.959	213.962.676	220.675.256
Annual accident-related costs (€)		431.181	344.945	221.960	232.110	240.707
Fuel consumption (annual)		61.108.840	88.856.893	54.745.814	57.166.720	58.964.572
Investment value (per km of highway) (10^6 €)			20,132	18,073	17,367	18,413
Annual maintenance costs (€)		1% - 2% of investment value	34.960	26.784	28.140	29.464

3.2 Goals, criteria and evaluation indicators

3.2.1 Defining the goals of the evaluation

The most important goals of building the Požega-Boljare highway are:

- increasing the level of service for the projected traffic flows on the road network in the corridor of the planned highway;
- improving the traffic safety level of the projected traffic flows on the road network in the corridor of the planned highway;
- reducing the user exploitation costs for the projected traffic flows on the road network in the corridor of the planned highway;
- facilitating the optimal access of high capacity and quality roads for the existing settlements, functional units and road networks;
- maximum preservation of the environment in the corridor of the planned highway;
- enabling faster development of the catchment area.

Table 3 Selected criteria and relevant indicators

Criteria		Indicators
Construction investment costs	min	Previous and preparatory works; Substructure; Drains and drainage; Superstructure; Multi-level intersections; Facilities for environmental protection; Relocation of roads and other installations; Accompanying contents; Traffic signs and equipment.
Operational cost to the user	min	Fuel costs; Lubricant costs; Cost of pneumatics; Maintenance and repair costs; Additional costs; Time dependent expenses (depreciation, interest, utility costs, salary of driver).
Maintenance costs	min	Length (km). Cost of maintenance (regular, winter and increased due to the condition of the terrain).
Total cost of traffic accidents	min	The number of accidents (number of fatalities, number of casualties, material damage). The consequences of accidents (number of fatalities, number of casualties, material damage).
Travel time	min	Length (km); Longitudinal gradient (%); Speed (km/h).
Clash of the highway alternatives with settlements	min	Arable land; Forest; Urbanized areas; Meadows and pastures; Orchards and vineyards.
Spatial conflict with the existing land use	min	Relationship between the HW corridor and residential areas - the corridor passes at 100-300m from a settlement; the corridor passes at a distance of up to 100m and touches a settlement; the corridor passes through most of a settlement; Relationship between the HW corridor and industrial zones - the corridor passes at 100-300m from an industrial zone; the corridor passes at a distance of up to 100m from an industrial zone; the corridor passes through most of an industrial zone; Relationship between the HW route and the existing structure of land use - the corridor passes through meadows and pastures; the corridor passes through forest, orchards, vineyards and arable land; the corridor passes through a settlement.
Degradation of future possibilities for spatial planning	min	The corridor restricts further development and cuts through a settlement; the corridor passes at a distance of less than 500m from a settlement and partially restricts its further development; the corridor passes at a distance greater than 500m and does not restrict further development.
Functionality of connecting spatial units and the activation of development potential	max	Functional connectivity of settlements: the corridor connects 6 or more settlements (municipal centres); the corridor connects up to 5 settlements (municipal centres). The possibility of activating the potential for tourism: the corridor connects a greater number of zones and localities; the corridor connects a smaller number of zones and localities; the corridor does not connect any tourist zones and localities.
The risk of destruction or degradation of cultural and natural heritage	min	Monuments and archaeological sites in the impact zone. Protected natural areas in the impact zone.
Relationship with environmental consequences	min	Noise - the length of the route through a settlement (km), the route touches a settlement and the settlement is in the impact zone (km), the length of the route where there are settlements outside the impact zone and the route goes through a tunnel (km). Air pollution - the length of the route through settlements and forest (km), the length of the route through agricultural land (km), other (km). Water courses in the impact zone, water power facilities in the impact zone. Soil pollution - length of the route through orchards, vineyards and agricultural land (km), length of the route through forest (km), length of the route through settlements and other (km); Flora and fauna - length of the route through forest (km), length of the route through meadows, pastures and agricultural land (km), length of the route through settlements and other (km); Vibration - monuments and archaeological sites in the impact zone, length of the route through settlements (km), other (km).
Impact on the development of society and indirect economic effects	max	Development of tourism; Development of agriculture; Changes in the structure of employment; Increase in the renting potential of the land; Changes in property value Stop the outflow of the population; Increase in the quality of life.

3.2.2 Selection of criteria and evaluation indicators

Multi-criteria evaluation of the alternative project solutions involves consideration from various aspects: investment and construction, traffic and exploitation (operation), spatial and urban, environmental and socio-economic. On the basis of this, criteria were chosen on which multi-criteria evaluation and ranking of the offered alternatives were based. The chosen criteria were developed through appropriate indicators. Tab. 3 shows the chosen criteria and the relevant indicators.

In Tab. 4, based on [23], for the given criteria the values have been calculated for all evaluation indicators and they are shown in the form suitable to carry out the predicted procedures of multi-criteria evaluation.

Table 4 Comparative presentation of the indicators for each route

Indicator			Highway Route			
			West	Centre	East 1	East2
			The calculated indicator values			
(1)	€	min.	2 854 412 000	1 830 858 000	1 854 867 000	2 045 642 000
(2)		min.	333 853 201	204 859 959	213 962 676	220 675 256
(3)		min.	2 796 815	2 142 738	2 251 236	2 357 113
(4)		min.	344 945	221 960	232 110	240 707
(5)	h	min.	8 560 501	4 328 764	4 515 483	4 603 952
(6)	km	min.	9.36	1.33	3.43	2.46
(7)	points	min.	8.46	2.73	4.07	3.77
(8)		min.	0.32	0.41	4.76	4.76
(9)		max.	0.54	1.56	1.14	1.14
(10)		min.	22	15	15	19
(11)		min.	177.455	116.043	133.792	138.474
(12)		max.	35	45	52	53

3.3 Determining the relative weights of the criteria (w_i)

The relative weights of the defined criteria of multi-criteria evaluation were established by means of expert assessment. A simplified Delphi method was applied. A total of 56 participants (24 experts and 32 representatives from 7 municipalities in the catchment area) were surveyed. The surveys were conducted using questionnaires. On the basis of the results of a statistical analysis carried out on the participant's responses to the survey [23] the final results, that is, the relative weights of individual criteria (seen in Tab. 5) were presented.

Table 5 The relative weights of individual criteria

CRITERION	Weight of criterion	*W* Professionals (experts)	*W* Residents from the area	*W* MEDIAN VALUE
Construction investment costs	W_1	0.12	0.11	**0.11**
Operational cost to the user	W_2	0.09	0.08	**0.08**
Maintenance costs	W_3	0.08	0.08	**0.08**
Total cost of traffic accidents	W_4	0.14	0.10	**0.11**
Travel time	W_5	0.11	0.09	**0.10**
Clash of the highway alternatives with settlements	W_6	0.05	0.07	**0.06**
Spatial conflict with the existing land use	W_7	0.05	0.06	**0.06**
Degradation of future possibilities for spatial planning	W_8	0.06	0.11	**0.09**
Functionality of connecting spatial units and the activation of development potential	W_9	0.04	0.05	**0.04**
The risk of destruction or degradation of cultural and natural heritage	W_{10}	0.07	0.07	**0.07**
Relationship with environmental consequences	W_{11}	0.10	0.11	**0.11**
Impact on the development of society and indirect economic effects	W_{12}	0.08	0.07	**0.08**

3.4 Results of ranking–selection of the best alternative route solution using the VIKOR method

Based on the established methodology of a comparative presentation of the criteria and their indicators with their corresponding relative weights using the VIKOR method the following results were obtained: - a rank list of the alternative solutions according to individual criteria (Tab. 6) and a rank list according to *QR* - minimax strategy; *Q* - compromise and *QS* - majority benefit (Tab. 7).

Based on the results of the evaluation using the VIKOR method based on the presented criteria (Tab. 6) and the rank list according to measures *QR, Q* and *QS* (Tab. 7), we can conclude that the Centre alternative route solution is the most favourable and it has a sufficiently stable first position. The advantage of this alternative solution in relation to the one that follows it (East 1) is 0.442 (44.2 %).

Table 6 Results of multi-criteria ranking: Rank list according to individual criteria

	Criteria		W_i	Highway route			
				West	Centre	East 1	East 2
1	Construction investment costs	min	0.11	4	1	2	3
2	Operational cost to the user	min	0.08	4	1	2	3
3	Maintenance costs	min	0.08	4	1	2	3
4	Total cost of traffic accidents	min	0.11	4	1	2	3
5	Travel time	min	0.10	4	1	2	3
6	Clash of the highway alternatives with settlements	min	0.06	4	1	3	2
7	Spatial conflict with the existing land use	min	0.06	4	1	3	2
8	Degradation of future possibilities for spatial planning	min	0.09	1	2	3	4
9	Functionality of connecting spatial units and the activation of development potential	max	0.04	4	1	2	3
10	The risk of destruction or degradation of cultural and natural heritage	min	0.07	4	1	2	3
11	Relationship with environmental consequences	min	0.11	4	1	2	3
12	Impact on the development of society and indirect economic effects	max	0.08	4	3	2	1

Table 7 Results of multi-criteria ranking: Rank list by measures

	Highway route	Rank list by measures		
		QR	Q	QS
1	CENTER	0.036	0.000	0.038
2	EAST 1	0.091	0.442	0.210
3	EAST 2	0.091	0.493	0.291
4	WEST	0.111	1.000	0.909

4 Conclusion

Key steps in the process of road design projects are creating alternative solutions, their evaluation and making a decision regarding the best solution, that is, a decision on the elements which are a prerequisite for transition to the next phase of the project. An effective approach to the process of evaluation is essential to improving the quality of decision-making.

In this paper the problem of determining the best alternative solution for the route for the General plan for the E 763 highway Belgrade-South Adriatic was analysed using a multi-criteria evaluation method (VIKOR method). In multi-criteria evaluation methods the goals are defined, and the criteria, their indicators and their weights are determined. Evaluation of the proposed alternative solutions was carried out by the VIKOR method. The results showed that the alternative Centre was the most favourable solution for the corridor route for the E763 Belgrade-South Adriatic highway.

Despite their indisputable quality, it should be noted that the effectiveness of that method, in the process of decision making depends to a great extent on the abilities and experience of the decision maker. The decision maker must be able to determine the importance of each criterion. This highlights in particular the significance of unbiased definition of the weight coefficients for individual criteria, since the chosen solution most often is not equally acceptable to the investors, the local community and other interested parties. A potential shortcoming of this approach is manifested in the fact that the interested parties can have different attitudes regarding the relative relationship between the chosen criteria, therefore the application of different methods makes it possible to have insight into the quality of the chosen alternative.

If the previous conditions are fulfilled, the VIKOR method becomes a powerful tool in the hands of decision makers that provides strong support to the process of solving complex problems of multi-criteria decision making.

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