THE 10th ANNIVERSARY INTERNATIONAL SCIENTIFIC
PROFESSIONAL CONFERENCE
SECURITY AND CRISIS MANAGEMENT – THEORY AND PRACTICE (SeCMan)
- THE 10th ANNIVERSARY INTERNATIONAL FORUM
„SAFETY FOR THE FUTURE 2024" -
27th and 28th September 2024, Belgrade, Republic of Serbia

APPLICATION OF MULTI-CRITERIA METHODS IN THE PROCUREMENT OF FIREFIGHTING HELICOPTERS FOR THE NEEDS OF THE EMERGENCY MANAGEMENT SECTOR OF THE MINISTRY OF INTERNAL AFFAIRS OF THE REPUBLIC OF SERBIA

Goran Bozic[1]
[1] Ministry of Defense of the Republic of Serbia, Crnotravska 17, Belgrade, Republic of Serbia, goranbozic998@gmail.com

Received: 17th July 2024
Accepted: 13th September 2024

Professional paper

Abstract: *This paper presents the application of the MABAC method for ranking the best alternative, as well as the application of multi-criteria boundary approximation value comparison (GAO) using methods SAW and TOPSIS. The procedure is illustrated through seven areas of applying multi-criteria methods in the procurement process of firefighting helicopters for the needs of the Emergency Management Sector of the Ministry of Internal Affairs of the Republic of Serbia. The criteria and their weight coefficients were defined using existing research literature and statistics.*

Key words: *Decision-making, Public procurement, AHP, MABAC, SAW, TOPSIS, fire, EMS*

1. INTRODUCTION

National strategies of major organizations, such as states, confederations, or international alliances, encompass the use of various resources, including economic, military, informational, police, and diplomatic resources, as well as those of the Emergency Management Sector. Changes in the modern world, particularly rapid technological advancements, have also impacted the tactics employed by emergency management sectors. It is evident that the procurement of helicopters for the needs of the Emergency Management Sector (EMS) of the Ministry of Internal Affairs (MoIA) of the Republic of Serbia represents a tactical decision aligned with the long-term strategic goals of the Republic of Serbia, and this decision falls under the jurisdiction of the MoIA. Given that these helicopters are primarily used in natural disasters caused by fires, they are part of the ecological sphere that includes fire management, particularly forest fires which are closely related to the basic question of this paper that forms the basis for developing criteria and alternatives for deciding on the purchase of helicopters for firefighting purposes, specifically targeting forest fires, for the needs of the MoIA whose fundamental misson is also assisting in the protection of civilian structures. As threats to national security pose risks to society on a global, regional, and local level, the Republic of

Serbia, like other states, has faced these challenges and their subsequent consequences in recent years. Natural disasters as such have a destructive impact on critical infrastructure and society, creating a need to establish general objectives, which the social community strives for, aimed at preventive response and enhancing the security of people, animals, as well as their material and cultural assets. The nature of the problem concerning the procurement of helicopters for the needs of the EMS of the MoIA determines the limited availability of relevant technical, technological, and operational data. The criteria related to these types of data are thoroughly defined in the study. The purpose of this study is also to demonstrate the use of multi-criteria methods in optimization processes. The study illustrates the application of a relatively newer method and compares the obtained results with those derived from another method. The obtained results complement the presentation of individual methods and enable their use in comparative analyses of multi-criteria optimization. The aim of this study is to develop a decision-support model that will be used when purchasing helicopters intended primarily for the suppression of forest fires at various locations, including regional and urban areas, where conditions involving natural or artificial fortification obstacles may restrict access. The application of a specific model would significantly facilitate the process of selecting and purchasing one of the offered types of helicopters and their manufacturers.

The paper is structured into seven sections, in addition to the introduction, conclusion, and references it also includes: a description of the problem with a focus on its specificities; a literature review; a description of the applied methods including AHP, MABAC, SAW, and TOPSIS methods; an overview of the model with the calculation of weight coefficients for criteria and alternatives; the application of SAW and TOPSIS methods; and sensitivity analysis with variations in weight coefficients and comparison of results with other methods.

2. PROBLEM DESCRIPTION

The procurement of helicopters for firefighting, as a crucial and quantitatively significant component of the technical resources for the EMS, necessitates clear, comprehensive, and precisely defined criteria. The multitude of conditions that helicopters must meet is defined by a diverse set of technical and technological requirements. To assess these conditions, as well as other critical aspects, a comprehensive expert evaluation is necessary, encompassing both the overall system and all components of the given task. Given the Republic of Serbia's long-term military neutrality, special attention must be paid to the importance of utilizing equipment in peacetime conditions i.e for the performance of non-combat tasks and providing assistance to the civilian population. Experience and statistical data and analysis from credible expert agencies and other countries experience indicate that, in peacetime conditions, helicopters play a dominant role in fire protection, therefore, it is essential to give special attention to this aspect of the problem. Due to climate changes in recent years, the geographical area of the Republic of Serbia, as well as the broader Balkan region, frequently experiences forest fires. Without delving into the merits of whether they are caused by natural processes or human factors, forest fires undoubtedly act as disruptive elements to social organization and are an unavoidable aspect of the daily lives of citizens. Consequently, there is a need for preventive measures against such natural disasters including the acquisition of a specified number of helicopters for forest fire suppression.

Various definitions by scientists and philosophers addressing this phenomenon converge on the same conclusion, so one definition of a forest fire is: "A forest fire is an uncontrolled, spontaneous spread of fire across a forested area, and when it covers a large expanse, it takes on the character of a natural disaster." (Jakovljevic, Cvetkovic, Gacic, 2015).

Actually, a forest fire is an intense spread of fire across an area that absorbs it, thereby taking on the characteristics of a destructive force. As such, it requires the urgent deployment of helicopters specifically designed for fire suppression to prevent, in the shortest possible time, a catastrophe manifested in the form of large-scale land degradation, economic losses, human and animal casualties, and ecological disaster. The essence of the problem lies in the range of available options, specifically the types of helicopters, and the selection of a variant that the decision-maker will choose based on a comparative method of developed alternatives, all for the purpose of possible preventive action against potential occurrences. Actually the problem that has emerged is the development of a model for a single-criterion function driven by real-world challenges, where the decision-maker must simultaneously consider multiple objectives so that the optimal solution is considered the best by all criteria, which may be expressed in different units of measurement, have varying probabilities of occurrence, are mutually conflicting etc. Historically and chronologically, forest fires cause immense ecological and economic damage, human and animal casualties, and the degradation of large forested areas and agricultural lands. According to data from the year 2000, a total of 53% of forested areas in the Republic of Serbia are owned by Srbijasume and Vojvodina Sume, while the remaining 47% of forests are owned by private forest owners. Forest fires have become increasingly frequent in Serbia over the past decade, with a notable peak in 2007, which saw 500 forest fires, and an even higher in 2012, with 700 fires. This highlights the need for preventive measures against such natural disasters and the acquisition of helicopters. In public procurement, the criteria of significance can vary between organizers and purchasers. Some consider the offered price of goods or services to be the most important criterion, while others believe that a higher-priced product or service is then of a better quality and thus prefer quality and technological superiority. On the other hand, there are cases where the purchaser considers the delivery time as the primary criterion, while price and quality are classified as secondary.

3. LITERATURE REVIEW

According to Bozanic, the selection of alternatives involves identifying the best option by comparing all developed variants (alternatives) and the evaluation of these alternatives also depends on the individuals participating in the decision-making process. Guided by the economic principle that every institution, including the Emergency Management Sector, strives for a more organized public procurement process. In conclusion, decisions cannot be made without prior knowledge, i.e. a purposeful decision cannot be made without knowledge and the process of business intelligence. ,,Knowledge management and business intelligence are new concepts for systematically achieving goals within a business system." (Radivojevic, Tepsis, Dumonjic, 2011), while "Decision-making is the process of choosing among a set number of alternatives." (Bozanic, 2018). "Therefore, every problem has its own characteristics and carries certain constraints”. (Suknovic, Delibasic, Jovanovic, Vukicevic, Radovanovic, 2021). The fundamental principle of the MABAC method in decision-making, as demonstrated by Pamucar (2015), involves defining the distance of the criterion function of each observed alternative from the GAO in the context of selecting the optimal transportation manipulative equipment.

Given that the EMS as an institution is demanding on the matter of diverse range of products, standards, quality, and continuity in supply, it is essential to consider the system of economy and efficiency in procurement, the rational expenditure of resources, and the selection of solutions.

4. DESCRIPTION OF APPLIED METHODS

The study employs two types of methods: AHP and MABAC. The first method was used to determine the weight coefficients, while the MABAC method was employed to define the distances of the criterion functions for each of the observed alternatives. In the specific example presented, the selection will be determined for one of the three possible alternatives, denoted as A1, A2, and A3, based on the criteria designated as K1 through K6, derived from the technical and technological data provided by the manufacturers.. In the comparative sensitivity analysis, the SAW and TOPSIS methods will be applied. The choice of method for solving a multi-criteria analysis depends on the specific problem at hand, the information available, the alternatives, and the preferences of the decision-maker.

4.1. AHP method (The Analytic Hierarchy Process)

Table 1: General Hierarchical Model in AHP

			GOAL			
Criterion			Criterion		Level 1	Criterion
Sub-criterion			Sub-criterion		Level 2	Sub-criterion
Alternative			Alternative			Alternative

The selection of helicopters will be conducted based on the hierarchy of criteria presented in Table 1. While Table 3 represents the decision table based on which the helicopter selection analysis will be conducted. To solve the task and obtain the eigenvector, we will select from the table the prioritization method, additive normalization method, using the following expression: A) $a_{ij} = \frac{a_{ij}}{\sum_{i=1}^{n} a_{ij}}$; B) $w_{ij} = \frac{\sum_{i=1}^{n} w_{ij}}{n}$ we determine the values of the eigenvector for the criteria and the degree of consistency *(CR)*, И) $CR = \frac{CI}{RI}$

4.2. MABAC method (Multi-Attributive Border Approximation area Comparison MABAC)

Table 2: Sketch of the Conceptual Approach to the Problem

Generating Alternative Solutions	Selection of Criteria
Defining Relative Weights of Criteria	Evaluation of Alternative Solutions
Ranking and Selection of a Single Solution	

The MABAC method is considered one of the more recent decision-making methods. It was developed by Dragan Pamucar at the Center for Defense Logistics Research at the University of Belgrade and was first introduced to the scientific community in 2015. "Each criterion in the decision matrix belongs to either the 'benefit' or 'cost' group (subjective or objective) and consists of six steps." (Pamucar, 2017).

After the known weight vectors, the ranking of alternatives is performed that is determining the best alternative where the steps will be applied i.e the calculation of the elements of the weighted matrix *(V)* and the normalization of the elements of the initial matrix *(N).*

4.3. SAW method (Simple Additive Weighting)

The fundamental hypothesis of the SAW method is that each criterion in the decision matrix belongs to either the 'benefit' or 'cost' group of criteria. The weights of the criteria are determined using one of the known methods, while the quantification of qualitative criteria is performed using techniques such as fuzzy, logic, linguistic, scales etc.. (Bozanic, 2018).

In this case, the quantification of qualitative criteria was carried out using the VIKOR method so that after problem generation and quantification of qualitative criteria, the next step was to normalize the values. The values of the normalized matrix are calculated based on the formulas for the max and (min) criteria P) $n_{ij} = \frac{f_{ij}}{\sqrt{\sum_{i=j}^{m} f_{ij}^2}}$; C) $n_{ij} = 1 - \frac{f_{ij}}{\sqrt{\sum_{i=1}^{m} f_{ij}^2}}$. The results obtained using the formula *T)* $V_{ij}=X_{ij} * W_j$ represent the calculation of the weighted normalized matrix.

The next step is to summarize the normalized values according to the criteria using the formula С) $S_j = \sum_{j=1}^{m} w_j x_{ij}$,$j=1,2,...m$

4.4. TOPSIS method (Technique for Order Preference by Similarity to Ideal Solution)

The TOPSIS method was developed in 1991 by researchers Hwang and Yoon. It involves ranking alternatives based on a comparison of the ideal and anti-ideal values, specifically distances between these values. (Pamucar, 2017). The solution that minimizes cost criteria while maximizing benefit criteria represents the ideal solution, whereas the solution that minimizes benefit criteria and maximizes cost criteria is referred to as the anti-ideal solution. The solution obtained in this manner represents the closest optimal alternative to the ideal solution, while also being the farthest alternative from the ideal anti-negative solution.

„The TOPSIS method consists of six steps: 1) Normalization of the values in the decision matrix; 2) Weight normalization of the matrix: 3) Determination of ideal solutions; 4) Calculation of the distances of alternatives from the ideal solutions; 5) Determination of the relative closeness of alternatives to the ideal solution; 6) Ranking of alternatives ” (Pamucar, D. *Operations Research—Deterministic Methods and Models*, Rabek, Belgrade, 2017).

1. step represents the normalized matrix.

In this method, vector normalization is applied using formulas for criteria types

У) $,,benefit"\ r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{n} x_{ij}^2}}$; Ф) „$cost$” $r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} r_{ij}^2}}$; Х) $V_{ij} = X_{ij} * \omega_j$

Ideal solution **A*** ; Negative ideal solution **A⁻** · Euclidean distances are determined using formulas for "benefit" and "cost": Ц) $S_i^+ = \sqrt{\sum_{i=1}^{6} (Vij - Vj^+)^2}$; Ч) $S_i^- = \sqrt{\sum_{j=1}^{6} (Vij - Vj)^2}$; The alternatives are closest to the ideal solution, and each alternative is assigned a relative distance.

5. MODEL PRESENTATION

5.1. Calculation of Weight Coefficients for Criteria

Before applying the method, the criteria, on which the evaluation will be based, are defined. The primary issue is certainly determining the weights of the criteria, which arises in multi-criteria analysis models and certainly mentioned criteria weights influence the final result in the decision-making process. Determining the weights of criteria can be achieved using various methods. In the study, the AHP method was used to determine the weight coefficients. Given that decision-maker often relies on recommendations from an expert team, the number of criteria must also be carefully selected. The selection of criteria was influenced by the purpose, way of usage and to a large extent the characteristics and complexity of the tasks performed by the equipment. It is also necessary to consider the overall picture of helicopter usage, its compliance with the use of other equipment, and all aspects of the assumed tasks. The criteria were also determined based on statistical data, including the number of annual fires in the Republic of Serbia, the areas they affected, as well as methods and deficiencies encountered during firefighting. A significant factor in the selection was the bucket capacity, cost, as well as mobility, including the speed of vertical ascent, movement radius, and maintenance. An excessive number of criteria significantly complicates the task and, due to their diversity, importance, mutual opposition, or overlap, does not guarantee the selection of the best solution. Similarly, selecting too few criteria does not ensure the best solution. Therefore, the role and expertise of the decision-maker and the expert team are crucial and largely determine the best solution. The decision-maker, in accordance with the previous, selected the alternatives and criteria for the helicopter selection shown in Table 3.

Table 3: Alternatives and criteria

	К/А	К1	К2	К3	К4	К5	К6
		Price/$	**Crew member**	**Carrying capacity buckets/L**	**Vertical ascent m/s**	**Range km**	**Mainten. Delivery**
KAMOW КА-32 A1 115-RUSSIA	**A1**	15800000	3	5000	15	800	
AERBAS H215 SUPER PUMA-FRANC.	**A2**	17820000	2	4500	7,4	866	
SIKORSKY S64 ERIKSON AK-USA	**A3**	16000000	3	9840	6,75	370	

Real-world problems often do not have criteria of equal significance so the decision-maker must define the importance factors of each criterion using appropriate weight coefficients or so-called weights. Weight coefficients in some methods have a decisive impact on the solution, so it is necessary to analyze how the solution behaves depending on the possible real variations in criterion weights. It is essential to compare the significance of the criteria according to Saaty's scale of evaluation in order to form the pairwise comparison matrix of criteria, as shown in Table 4.

Table 4: Pairwise comparison

К/А	К1	К2	К3	К4	К5	К6
A1	1	7	3	4	2	2
A2	(7)	1	(2)	(3)	(5)	(6)
A3	(3)	2	1	2	(4)	(6)
A4	(4)	3	(2)	1	(5)	(6)
A5	(2)	5	4	5	1	(6)
A6	(2)	6	6	6	6	1

The values in parentheses are reciprocal values of preferences, while the other values represent the preference of one criterion over another.

The consistency ratio (CR) represents the ratio of **the consistency index.**

Table 5: Calculation of Consistency

		Calculation of Consistency – CR		
B	**b/w**	**λ max**	**CI**	**CR**
2,069	6,78	6,62	0,12	0,09
0,23	6,53			
0,4727	6,26			
0,374	6,06			
1,176	6,53			
2,609	7,61			

Since the consistency ratio (CR) value is 0.10 or less, which matches the acceptable threshold of 0.10, the result is considered sufficiently accurate, and no adjustments are necessary.

5.2. Selection of the Optimal Alternative

The decision regarding the alternatives was based on the delivery time, the supply of spare parts, the existing maintenance equipment, the training period for piloting and maintenance, as well as the geopolitical relations with the countries of the equipment manufacturers. The evaluation of alternatives based on criteria K1, K2, K3, K4, and K5 was conducted using the technical characteristics provided by the helicopter manufacturers, while the evaluation of alternatives based on criterion K6 was performed by the decision maker using the Likert scale for evaluating alternatives.

Step 1. Forming the initial decision matrix (X). "As the first step, the evaluation of 'm' alternatives is carried out according to 'n' specified criteria" (Pamucar, 2017).

Table 6: Initial decision matrix

K/A	**K1**	**K2**	**K3**	**K4**	**K5**	**K6**
	price	**Crew m.**	**Carr. capp.**	**V.a. m/s**	**Range/km**	**Ext. influe.**
	min	min	Max	max	Max	min
	Wi=0,3048	Wi=0,0352	Wi=0,0754	Wi=0,0617	Wi=0,18	Wi=0,3424
A1	15800000	3	5000	15	800	3
A2	17820000	2	4500	7,4	866	5
A3	16000000	3	9840	6,75	370	1
charac.crit.	min	min	Max	max	Max	min
X+	17820000	2	9840	15	866	5
X-	15800000	3	4500	6,75	370	1

C=K where the label 'K' in the presented tables replaces the label 'C,' i.e the criterion.

Step 2. Normalization of the elements in the evaluation matrix (X). The elements of the normalized matrix (N) are determined by applying the formulas for "benefit" and "cost" criteria. **Step 3.** The calculation of the elements of the weighted matrix (V)**. Step 4.** The determination of the GAO matrix *(G).* In this step, the geometric averaging of the values of alternatives based on the criteria is performed, and the mentioned matrix is obtained. After calculating the values of g_1, the GAO matrix is formed (*G*). **Step 5.** The calculation of the distance of alternatives from GAO *(* q_{ij} *)* is determined as the difference between the elements of the weighted matrix *(V)* and GAO *(G).*

Table 7: ***Matrix of Alternatives Distance from GAO***

G	**0,474**	**0,044**	**0,097**	**0,0793**	**0,275**	**0,493**

	C_1	C_2	C_3	C_4	C_5	C_6
	min	min	max	Max	max	min
A1	**0,135**	-0,0088	-0,015	0,043	**0,06**	0,0206
A2	**-0,16**	0,0264	-0,022	-0,013	**0,085**	-0,151
A3	**0,104**	-0,0088	**0,0538**	-0,017	**-0,095**	**0,191**

Matrix for Calculating the Distance of Alternatives from GAO

Step 6. Ranking of alternatives**.** Calculation of criteria function values for alternatives.

Table 8: Rank of alternatives

	S_{123}	**Rank**
A1	0,2348	1
A2	-0,2346	3
A3	0,228	2

Based on the obtained results, we can conclude that alternative A1 is the highest ranked, meaning that the ranking of alternatives is structured according to the presented hierarchy.

MABAC $\Rightarrow$ $A_1f \rightarrow A_3f \rightarrow A_2f$

6. APPLICATION OF THE SAW METHOD

The method is directly applied to the decision matrix. Primarily, the quantification of qualitative criteria is performed, as illustrated in Table 9.

Table 9: The Quantification of Qualitative Criteria

K/A	**K1**	**K2**	**K3**	**K4**	**K5**	**K6**
	ω=0,2	**ω=0,1**	**ω=0,1**	**ω=0,1**	**ω=0,2**	**ω=0,3**
A1	15800000	3	5000	15	800	very low
A2	17820000	2	4500	7,4	866	high
A3	16000000	3	9840	6,75	370	very high
charac.crit.	max	min	max	max	max	max

Since the indices for criteria K1-K6 are known, the indices for criterion K6 are determined according to the scale for quantifying qualitative criteria. While the characteristics of criteria K1-K5 are determined based on objective elements, criterion K6 is based on subjective elements. The next step is the normalization of the matrix values. After obtaining the normalized values, the weighted normalized decision matrix is calculated, and the summation of normalized values by criteria is performed.

Table 10: Rank of Alternatives

	Q_{123}	**Rank**
A1	110,42	3
A2	124,65	1
A3	111,73	2

Table 10 shows the alternatives according to their rankings. It should be noted that the obtained solution does not necessarily represent the optimal solution, therefore solving the problem will also be examined using other MCDM methods. To derive a high-quality solution from the final result, it is necessary to involve a certain number of experts, which would ensure that the approach meets the decision-maker's criteria.

7. APPLICATION OF THE TOPSIS METHOD

After defining the concepts, the decision matrix *R* is used here, where each row in the matrix corresponds to a particular alternative, and each column corresponds to a specific criterion.

Table 11: Initial Decision Matrix

A/K	**K1**	**K2**	**K3**	**K4**	**K5**	**K6**
A1	15800000	3	5000	15	800	1
A2	17820000	2	4500	7,4	866	7
A3	16000000	3	9840	6,75	370	9
Σx^2	8231924^{14}	22	142,075	352,322	1526856	131
$\sqrt{\Sigma x^2}$	28,691	4,69	11,919	18,03	1235,66	11,44
charac.crit.	max	min	max	Max	max	Max

The essence lies in transforming criterion values into values that enable mutual comparison..

Table 12: Normalized Matrix

A/K	**K1**	**K2**	**K3**	**K4**	**K5**	**K6**
A1	550,695	0,36	0,419	0,831	0,647	0,087
A2	621,1	0.537	0,377	0,41	0,7	0,611
A3	557,666	0,36	0,825	0,374	0,299	0,786
Wi	**0,2**	**0,1**	**0,1**	**0,1**	**0,2**	**0,3**

In this method, vector normalization is applied using the formulas for both "benefit" and "cost" type criteria:

Step 2. represents the construction of the weighted normalized matrix by multiplying with the criteria weights.

Table 13: Weighted Matrix

	K1	**K2**	**K3**	**K4**	**K5**	**K6**
A1	110,13	0,036	0,0419	0,0831	0,129	0,0261
A2	124,22	0,0573	0,0377	0,041	0,14	0,1833
A3	111,53	0,036	0,0825	0,0374	0,059	0,235

Step 3. involves determining the ideal and anti-ideal solutions. Table 15.

Table 14: Matrix of Ideal and Anti-Ideal Values

	K1	**K2**	**K3**	**K4**	**K5**	**K6**
S^*	124,22	0,0573	0,0825	0,0831	0,14	0,235
S^-	110,13	0,036	0,0377	0,0374	0,059	0,0261

The table presents the selection of the ideal solution and the negative ideal solution. The ideal solution **A***{124,22; 0,0573; 0,0825; 0,0831; 0,14; 0,235};

The negative ideal solution $\mathbf{A}^-$ {110,13; 0,036; 0,037;0,0374; 0,059; 0,0261}

Step 4. The determination of the distances of alternatives from the ideal solutions is presented in Table 15.

Table 15: Euclidean distances of alternatives

Alternatives	S_i^+	S_i^-
A1	14,09	0,083
A2	0,0802	14,09
A3	12,69	1,41

Euclidean distances are determined for both "benefit" and "cost" types.

The alternatives are closest to the ideal solution, and each has a determined relative distance.

Step 5. determines the relative closeness of the alternatives.

Table 16: Relative closeness of the alternatives Q_i* or C_i*

Alternatives	$Q*_i$	Rank
A1	0,0058	3
A2	0,994	2
A3	0,1	1

Step 6. Ranking of alternatives.

TOPSIS A3 A2 A1

Ranking is done based on descending values, so the best alternative is the one with the highest value, as shown in Table 16.

8. SENSITIVITY ANALYSIS

Sensitivity analysis represents a tool for testing the stability of results and is implemented by varying the initial weight coefficients of criteria and comparing the results obtained from the proposed method with the results from other methods.

8.1. Sensitivity analysis by varying the weight coefficients of criteria

Sensitivity analysis of the output results is used to check the stability of the results by modifying the initial weight coefficients of the criteria and comparing the results of the given method with those of other methods. Table 17.

Table 17: Scenarios for Changing the Weight Coefficients of Criteria

	S_1	S_2	S_3	S_4	S_5	S_6
K_1	0,166	0,3	0,14	0,14	0,14	0,14
K_2	0,166	0,14	0,3	0,14	0,14	0,14
K_3	0,166	0,14	0,14	0,3	0,14	0,14
K_4	0,166	0,14	0,14	0,14	0,3	0,14
K_5	0,166	0,14	0,14	0,14	0,14	0,3
K_6	0,166	0,14	0,14	0,14	0,14	0,14

Table 18: Ranking of Alternatives Using Different Scenarios

	S_1	S_2	S_3	S_4	S_5	S_6
A_1	1	2	3	2	3	3
A_2	3	3	2	2	2	2
A_3	2	1	1	2	1	1

Table 18 shows the alignment of alternative rankings with the rankings of actual criterion weights, leading to the conclusion that, in most scenarios, there is stability in the higher significance.

8.2. Comparison of The Results with Other Methods

By comparing the results of the analyzed method with the results of other methods, the following outcomes were obtained::

Table 19: Comparison results

MABAC	**A1 A3 A2**
SAW	**A2 A3 A1**
TOPSIS	**A3 A2 A1**

The obtained results, using the actual criteria weights, indicate that even after sensitivity analysis, alternative A3 predominantly occupies the second and first positions, while alternative A1 predominantly occupies the third and first positions.

9. CONCLUSION

The selection of helicopters for the needs of the Emergency Management Sector of the Ministry of Internal Affairs of the Republic of Serbia was carried out using the AHP method to determine the weighting coefficients, while the MABAC method was used for ranking alternatives and additionally, the methods SAW and TOPSIS were applied in the comparative analysis. By comparing the weighting coefficients of the ranking tables of alternatives, a noticeable relative proximity between the second-ranked and the first-ranked alternatives is observed. The set of alternatives and criteria is sufficient and relevant for determining the best solution. The methodological difference lies in the selection of the weight coefficients for individual criteria. In the AHP method, the decision-maker defines the mutual relationship of individual criteria and compares alternatives based on given single criteria by using Saaty's scale of values. In the MABAC method, the individual weight coefficients are defined (determined) by the decision-maker and so according to this method, the top-ranked alternative is A1, which corresponds to the Kamov helicopter model.

The scientific contribution of this work is the result of analyzing existing literature and our operational research through comparative methods that is solutions obtained by applying four types of multi-criteria decision-making methods to bridge the gap between literature analysis and results based on multi-criteria decision-making models. Additionally, as a contribution, it can be noted that the application of a specific model fills the gap, or rather the vacuum, between the initial visual result of the decision, which was obtained solely through visual means or aesthetics, and the result derived from relevant parameters. The development of the model and the obtained results, along with its application, facilitate a more straightforward and efficient evaluation of the state of each proposed solution, thereby aiding the decision-maker in selecting one of the offered types of helicopters and their manufacturers. Since the Republic of Serbia only possesses fire trucks and backpack sprayers intended for individual use by personnel, there is an inherent limitation in extinguishing fires, particularly forest fires that cover larger areas. This issue highlights the need for an alternative solution, such as the acquisition of helicopters, which would bridge the gap between basic tools (backpack sprayers) and fire trucks. By introducing helicopter units that effectively address the aforementioned problem in terms of quantity, another gap is filled: the reduction of human resource usage, which mitigates the quantitative risk of accidents and, more importantly, reduces the risk of fatalities. Essentially, the decision-maker determines the individual weights of the criteria through this process. In the outlined procedures, the varying weights of individual criteria lead to different results for the top-ranked alternative. The decision-maker's discretionary right is to choose the method of Multi-Criteria Optimization, and consequently, the preferred alternative is selected accordingly. Given that public procurement of helicopters is a costly and complex process, as well as the equipment itself, the challenge of selection and decision-making is significantly greater and more responsible. In this regard, it is essential to adhere to all legal provisions, regulations, and standards. Building on the aforementioned, it is necessary to apply an appropriate method to achieve approximate objectivity in selecting the specific equipment, based on already objective and concrete technical and tactical data. From what is shown it can be concluded that, in addition to its practical and theoretical contributions, the paper serves as support and a helpful tool for the decision-maker to make the most accurate decision in the shortest possible time, thereby minimizing potential errors or eliminating them through the presented results. Similarly, it facilitates the prompt resolution of crisis situations. Moreover, the research represents a continuity towards finding more precise decision-making methods, their modification using existing coefficients and criteria, as well as the development of new definitions for the concept of decision-making.

REFERENCES

Bozanic, D. (2018). Odlucivanje, Visekriterijumsko odlucivanje.

Bozanic, D., Pamucar, D., (2014, 2016, 2018). Visekriterijumsko odlucivanje metoda Simple Additive Weighting).

Bozanic, D., Pamucar, D., Karovic, S., (2015). Primene metode MABAC u podrsci odlucivanju upotrebe snaga u odbrambenoj operaciji.

Goztepe, K. i Kahraman C., A New Approach to Military Decision Making Process: Suggestions from MCDM Point of Viev, (2015). Zbornik radova, International Conference on Military and Security Studies.

Jakovljevic, V., Cvetkovic, M.V., Gacic. J. (2015). Prirodne katastrofe i obrazovanje.

MUP RS, (2010-2020). Zakon o Prostornom planu Republike Srbije.

Pamucar, D. (2017). Operaciona istrazivanja, Deterministicke metode i modeli.

Radivojevic, M., Tepsic, M., Dumonjic, B. (2011). Poslovna inteligencija.

Saati, T. L., Mc-Grav-Hill, Njujork, (1980). The analytic hichrarchy process.

Sluzbeni glasnik, (2015). Zakon o ministarstvima, RS-br 44/14.

Sluzbeni glasnik, (2020). Zakon o javnim nabavkama.

Suknovic, M., Delibasic, B., Jovanovic, M., Vukicevic, M., Radovanovic, S. (2021). Odlucivanje, sedmo prerađeno i dopunjeno izdanje.

Saranovic, J. (2009). Kvalitet popune jedinica cz kao preduslov efikasnijeg angazovanja u vanrednim situacijama.

Strbac, K. (2009). Kako upravljati, Vanredne situacije