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SELECTION OF LANDING SITE FOR INFANTRY RIVER CROSSING USING ALUMINUM BOAT M70: APPLICATION OF DIBR AND TOPSIS METHOD

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Abstract: *This research analyzes the problem of choosing a location for conducting infantry river crossing using the aluminum boat M70, applying the multicriteria decision-making method. It has been found that the use of these models significantly accelerates and simplifies the decision-making process, contributing to efficiency and speed in the process itself. At the same time, a comparison was made between the results obtained using multicriteria decision-making methods and the opinions of experts in the field of overcoming water obstacles. The research conclusions emphasize that multicriteria decision-making methods are highly reliable for decision-making, especially in the context of military operations. The focus of the research is on the significance of applying multicriteria methods, which opens up new perspectives for analyzing and improving the application of such models in real conditions. The applied multicriteria decision-making model consists of two phases. The first phase involves defining the weighting coefficients of criteria using the DIBR (Defining Interrelationships Between Ranked criteria) method. In the second phase, the best alternative is chosen using the TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) method. This research not only supports efficient and comprehensive planning in military operations but also further confirms the relevance and usability of multicriteria decision-making methods in wartime conditions.*

Keywords: Decision, multi-criteria decision making, DIBR, TOPSIS

1. Introduction

The Serbian Armed Forces actively participate in various operations within assigned missions and tasks, including overcoming water obstacles. This type of activity is considered one of the most critical in a wide spectrum of operations. Regardless of the nature of the operation - whether offensive or defensive - every river represents a significant obstacle.

For this reason, the decisive aspect in overcoming water obstacles is making the right decision. The military attaches great importance to the decision-making process. Unit commanders, during combat operations, often face challenges in making more or less significant decisions. In this context, the use of multicriteria decision-making methods provides necessary support to this process.

The choice of this topic highlights the importance and significance of operational planning when overcoming water obstacles, especially in the context of military operations. The goal of every military unit is to efficiently overcome such obstacles in the shortest possible time and at the highest level of safety. The success of the operation

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often depends on the commander's decision. Therefore, the application of multicriteria decision-making models aims to assist the commander in making the most appropriate decision.

These models provide an analysis of various criteria and alternatives, providing a detailed mathematical representation. However, the commander retains the right to ultimately accept or reject the proposed solution. In any case, these models can significantly facilitate and expedite the process.

2. Literature Review

To address various problems using multi-criteria decision-making, different methods are employed. This section presents literature focusing on the use of the DIBR and TOPSIS methods.

The DIBR method was first introduced by Pamučar et al. in their paper "Circular economy concepts in urban mobility alternatives using integrated DIBR method and fuzzy Dombi CoCoSo model" [1], Tešić and Marinković [2] utilize the DIBR method for selecting complex combat systems based on efficiency criteria, Radovanović et al. [3] in their paper perform the selection of unmanned aerial vehicles for various purposes using the DIBR method, Božanić et al. [4] use this method for ranking methods and techniques in managing Lean organization systems in the maintenance of special-purpose technical systems, while Lukić [5] applies it to analyze the dynamics of the economic performance of the BiH economy in the period 2013 - 2022; for earthquake risk assessment, Tešić et al. [6] also used the DIBR method.

On the other hand, the TOPSIS method first appears in the paper "Systems selection by multiple attribute decision making" [7], Hajiaghaei-Keshteli [8] aims to provide a new decision-making approach for food packaging business using the mentioned method, Singh et al. [9] aim to explore the context, reasons, and specific advantages of using TOPSIS in the field of materials science and engineering to achieve the goals of competitive supply chains, in order to alleviate flood and water scarcity problems, the construction of dams at appropriate locations is a key water management strategy addressed by Rane et al. [10] in their paper.

3. Description of Applied Methods

This research will address the issue of selecting a location for infantry river crossing using the aluminum boat M70, applying a hybrid model based on the DIBR (Defining Interrelationships Between Ranked Criteria) method and the TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) method.

3.1. Description of the DIBR Method

The DIBR method is a relatively new method for determining the weighting coefficients of criteria. It is based on defining relationships between ranked criteria. The following are the 5 steps of the DIBR method: 1) Ranking criteria according to significance; 2) Comparing criteria and defining mutual relationships; 3) Defining relationships for calculating weighting coefficients; 4) Calculating the weighting coefficient of the most influential criterion; 5) Defining the degree of satisfaction of subjective relationships between criteria [1].

To ensure that the calculation of the weighting coefficients of criteria, using the DIBR method, is at an appropriate level, 5 experts were surveyed. When comparing criteria, the opinions of experts for the same criteria were different. To give each criterion a unique value, the aggregation of weighting coefficients of criteria was performed. Aggregation was performed using the Bonferroni Mean operator, according to the expression:

$$BM^{p,q}(K_1,K_2,\dots,K_n) = \left[\frac{1}{n(n-1)}\sum_{\substack{i,j=1\\ i\neq j}}^{n} K_i^p K_j^q\right]^{\frac{1}{p+q}}$$

where $BM^{p,q}(K_1,K_2,\dots,K_n)$ represents the averaged values obtained by applying the Bonferroni Mean operator; $p,q \geq 0$ represent the stabilization parameters of the Bonferroni operator; and K_i^p и K_j^q represent the values of criteria being aggregated.

3.2. Description of the TOPSIS Method

The TOPSIS method was first introduced in the paper “Systems selection by multiple attribute decision making” [7]. This method evaluates and ranks alternatives based on multiple criteria. This is achieved by comparing the distance of each alternative from ideal solutions. Ideal solutions represent the most desirable values for each criterion. The goal is to select an alternative that is closest to the ideal solution, i.e., one that most closely approaches the desired values for all criteria. At the same time, the selected alternative should be furthest from the negative-ideal solution. The method allows for the systematic analysis of complex decision-making problems, considering multiple factors and enabling clear comparison of alternatives.

The applied method uses a decision matrix (D), where m represents the number of alternatives and n represents the number of criteria:

$$D = \begin{array}{c} \\ A_1 \\ A_2 \\ A_3 \\ \vdots \\ A_m \end{array} \begin{array}{c} \begin{array}{ccccc} x_1 & x_2 & x_3 & \cdots & x_n \end{array} \\ \begin{bmatrix} x_{11} & x_{12} & x_{13} & \cdots & x_{1n} \\ x_{21} & x_{22} & x_{23} & \cdots & x_{2n} \\ x_{31} & x_{32} & x_{33} & \cdots & x_{3n} \\ \vdots & \vdots & \vdots & & \vdots \\ x_{m1} & x_{m2} & x_{m3} & \cdots & x_{mn} \end{bmatrix} \end{array}$$

The basic framework of the TOPSIS method is directly applied to the presented decision matrix and is defined through the following steps:

1) Normalization of ratings;
2) Multiplication of normalized values of the matrix by criterion weighting coefficients;
3) Determination of ideal solutions;
4) Determination of the distances of alternatives from ideal solutions;
5) Determination of the relative closeness of alternatives to the ideal solution;
6) Ranking of alternatives.

4. Implementation of the Multicriteria Decision-Making Model

In March 2024, a survey was conducted with experts in overcoming water obstacles. After conducting the survey and processing the expert opinions, six criteria significant for selecting a location for infantry river crossing using the aluminum boat M70 were defined:

- Criterion 1 (K1) – Water obstacle speed: represents the speed of water movement per unit of time [m/s].

• Criterion 2 (K2) – Water obstacle width: represents the distance between the shores, measured across the surface of the water obstacle.
• Criterion 3 (K3) – Extent of works on enemy shore development: encompasses works such as the adjustment of shore height, shore slope, removal of various natural and artificial obstacles on the shore, etc.
• Criterion 4 (K4) – Extent of works on own shore development: involves similar works as for the enemy shore. In this case, it is preferable for the shore to be low. There should be no mine or explosive barriers on the own shore, which greatly facilitates its development.

Criteria K3 and K4 are of a linguistic nature and require assigning numerical values to them. The scale for translating linguistic expressions into numerical values is shown in Table 1.

Table 1 Scale for translating linguistic into numerical values for K3 and K4

Rating	Very small scope of work	Small scope of work	Medium scope of work	Large scope of work	Very large scope of work
Score	1	3	5	7	9

• Criterion 5 (K5) – Exposure to enemy action: the crossing point should provide the highest level of protection against attacks from the air, land, or water obstacles by the enemy.

Criterion K5 is also linguistic in nature. To translate it into numerical values, Table 2 is used.

Table 2 Scale for translating linguistic into numerical values for K5

Assessment	Very High Exposure	High Exposure	Medium Exposure	Low Exposure	Not Exposed
Rating	5	4	3	2	1

• Criterion 6 (K6) – Access roads: represent the pathways that lead to and from the water obstacle.

Criterion K6 is also of a linguistic nature. To translate it into numerical values, Table 3 is used.

Table 3 Scale for translating linguistic into numerical values for K6

Assessment	**Very Good**	**Good**	**Medium**	**Poor**	**Very Poor**
Rating	5	4	3	2	1

Through the implementation of the DIBR method steps and the incorporation of expert opinions, the values of criterion weighting coefficients (τ) have been calculated.

The first step of the DIBR method is criterion ranking. In this specific example, the experts ranked the criteria as shown in Table 4.

Table 4 Criteria Ranking

Rang	E1	E2	E3	E4	E5
1.	K1	K1	K1	K2	K1
2.	K3	K2	K2	K1	K2
3.	K2	K4	K3	K3	K3
4.	K4	K3	K4	K4	K4
5.	K6	K5	K5	K6	K5
6.	K5	K6	K6	K5	K6

When all steps of the DIBR method were conducted, the values of criterion weighting coefficients were obtained (see Table 5).

Table 5 Criterion Weighting Coefficients

	E1	E2	E3	E4	E5
K1	0,334783	0,375834	0,257525	0,211055	0,270151
K2	0,182609	0,250556	0,257525	0,316583	0,270151
K3	0,273913	0,134915	0,210702	0,211055	0,180101
K4	0,121739	0,134915	0,140468	0,140704	0,147355
K5	0,034783	0,072646	0,093645	0,060302	0,079345
K6	0,052174	0,031134	0,040134	0,060302	0,052897

By applying the Bonferroni Mean operator, the aggregated values of the criterion weighting coefficients were obtained, as shown in Table 6.

Table 6 Aggregated Values of Criterion Weighting Coefficients

	Bonferoni
K1	0,288395
K2	0,254574
K3	0,200858
K4	0,136969
K5	0,067417
K6	0,047044

Once the calculation of criterion weighting coefficients was completed, the selection of the best alternative was pursued. Initially, a decision matrix was created, to which the described method was directly applied. Table 7 displays the criterion values for 10 alternatives for each criterion.

Table 7 Initial Decision Matrix

Initial Decision Matrix						
Criteria Alternatives	K1	K2	K3	K4	K5	K6
A1	1,2	248	5	7	3	4
A2	1,8	137	3	9	3	4
A3	0,9	269	7	9	2	3
A4	1	200	5	1	4	2
A5	1,5	189	7	5	2	3
A6	0,4	311	9	7	4	5
A7	0,8	283	9	3	5	1
A8	1,3	145	3	5	1	5
A9	2,1	86	1	5	3	4
A10	1,6	193	3	7	4	2
Criterion characteristic	cost	cost	cost	cost	cost	benefit

By applying the defined steps of the TOPSIS method to the initial decision matrix, the following results were obtained (see Table 8).

Table 8 Ranking of Alternatives

Alternative	Rank
A1	7
A2	5
A3	9
A4	2
A5	10
A6	4
A7	8
A8	1
A9	3
A10	6

Results from Table 8 indicate that in this specific scenario, the best alternative for underwater tank crossing is alternative A8. Alternatives A4 and A9 ranked second and third, respectively, and can also be considered as optimal solutions. Alternative A5 ranks last and is not recommended as a solution for this problem, given that it does not provide favorable opportunities for infantry river crossing using the aluminum boat M70 across most criteria.

5. Conclusion

In military operations, where water obstacles are exceptionally critical, the assumption is that performance will be directly proportional to the speed and efficiency of decision-making. Therefore, the application of multicriteria decision-

making methods is necessary to overcome challenges and minimize risks in task execution. These methods provide a structured and systematic approach to considering numerous aspects, contributing to the quality and speed of decision-making.
In contemporary military environments, where operations require challenging approaches to territories with water obstacles, the ability to react quickly is of paramount importance. Multicriteria decision-making methods not only facilitate the decision-making process but also provide an additional level of depth and analysis, enabling commanders to gain rapid and comprehensive insights into the complexity of the situation.
From this research, it can be concluded that a combined approach using multicriteria decision-making models and expert opinions represents the best path towards efficiently overcoming water obstacles. This ensures a comprehensive and focused approach to decision-making, reducing the risk of errors and facilitating operational processes.

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