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Optimising Assault Boat Selection for Military Operations: An Application of the DIBR II-BM-CoCoSo MCDM Model

Duško Tešić[1*], Darko Božanić[1*], Marko Radovanović[1], Aleksandar Petrovski[2]

[1] Military Academy, University of Defence, 11042 Belgrade, Serbia
[2] Military Academy “General Mihailo Apostolski”, Skopje - Associated Member of University “Goce Delcev” - Shtip, 1000 Skopje, North Macedonia

[*] Correspondence: Duško Tešić (dusko.tesic@va.mod.gov.rs); Darko Božanić (darko.bozanic@va.mod.gov.rs)

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Abstract: In the pivotal task of selecting an assault boat conducive for military operations, especially amidst the challenges posed by water obstacles, the utilisation of Multi-Criteria Decision-Making (MCDM) methods surfaces as vital. In this investigation, a meticulous application of the DIBR II (Defining Interrelationships Between Ranked criteria II) - BM (Bonfferoni Mean) – CoCoSo (COmbined COmpromise SOlution) multi-criteria decision-making model is performed. Initially, the weight coefficients of the criteria were determined via the DIBR II method, with expert opinions being cohesively aggregated using BM operators. Subsequently, the CoCoSo method was employed to discern the optimal alternative among various assault boats. A comprehensive analysis, entailing the examination of the sensitivity of the output results to alterations in the weight coefficients of the criteria, was conducted post-final ranking of alternatives. Noteworthy is the finding that negligible deviations in defining the weight coefficients by experts do not impose a significant impact on the ultimate selection of the optimal alternative. Furthermore, a comparative analysis alongside other MCDM methods corroborated not only the efficacy but also the superiority of the implemented model. The insights derived underscore the practical applicability, stability, and accuracy of the proposed model in choosing assault boats for military operations. This exploration fortifies the decision-making process in military contexts related to overcoming water obstacles and portends potential applicability in domains necessitating intricate multi-criteria decision-making.

Keywords: Assault boat; Selection; Multi-Criteria Decision-Making (MCDM); Defining Interrelationships Between Ranked criteria II (DIBR II); Bonfferoni Mean (BM); COmbined COmpromise SOlution (CoCoSo)

1 Introduction

In the contemporary context of intricate and dynamically evolving security landscapes, global armed forces are confronted with myriad challenges and threats, necessitating the deployment of highly effective and adaptable weaponry and equipment. Paramount among such considerations is the selection of assault boats, essential for the rapid, covert deployment of military personnel. Utilized during offensives, particularly in landings on enemy-defended coasts, assault boats prove pivotal for special forces and primary infantry units alike [1]. The complexity inherent in ensuring the selection of an optimal naval assault vehicle renders decision-making a meticulous process. Herein, the employment of Multi-Criteria Decision-Making (MCDM) methods emerges as a vital strategy for optimising the selection process by enabling systematic evaluations of various vessel characteristics, performance metrics, and usage scenarios.

MCDM, an interdisciplinary domain, involves analysing and evaluating alternatives amidst the presence of multifaceted criteria or decision factors [2–5]. When orchestrated towards the selection of an assault boat for military utilisation, MCDM allows Decision Makers (DMs) to evaluate, both quantitatively and qualitatively, vital aspects such as speed, manoeuvrability, carrying capacity, tactical features, and cost, among others. A notable advantage of integrating MCDM methods into assault boat selection for military forces lies in the capability to accommodate all pertinent criteria and decision factors, frequently encountering conflict or interdependence [6, 7]. The flexibility afforded to DMs to modulate the weight of each criterion according to organisational needs and priorities ensures that the chosen vessel aligns seamlessly with the specific demands and strategic direction of military operations. Furthermore, MCDM methods facilitate sensitivity analysis, enabling DMs to ascertain how variations in criteria definition or weights might impact the final decision-making [8–13], a capacity that is indispensable in the fast-paced, ever-shifting military environments.

Table 1 provides an overview of the application of MCDM methods and theories for defining weight coefficients of criteria, ranking, and selecting different alternatives in the military context.

Table 1. MCDM applications and theoretical frameworks in military context – A concise literature review

Research Subject and Reference	Applied Methods
Addressing the Dump Truck Selection Dilemma [12]	Fuzzy LMAW-Grey MARCOS
Formulating Strategy within Defence Systems [13]	DIBR, DOMBI, Fuzzy MAIRCA
Identifying Pivotal Factors for Implementing Chatbots in Military Mental Health Services [14]	Fuzzy Delphi, DEMATEL, influential-network-relation map (INRM), DANP
Selecting the Optimal Resilience Training Programme [15]	Fuzzy TOPSIS, Fuzzy AHP
The Anti-Tank Guided Missiles (ATGMs) Selection Conundrum [16]	Fuzzy Entropy, Fuzzy CoCoSo with Bonferroni
Navigating Decision-Making Processes in the Serbian Armed Forces [17]	Fuzzy logic
Overseeing Military Human Resource Management [18]	SAPEVO-M, ELECTRE-MOr
Evaluating International High-Performance Aircraft for Defence Applications [19]	Fuzzy AHP, Fuzzy TOPSIS
Identifying Optimal Locations for Landing Operation Points [20]	Fuzzy LMAW, Fuzzy SAW, Fuzzy MABAC, Fuzzy VIKOR, Fuzzy COPRAS, Fuzzy MAIRCA
Facilitating Decision-Making within the Engineering Units of the Serbian Army [21]	Fuzzy logic
A Systematic Approach to Warship Selection [22]	AHP
Optimal Military Aircraft Selection Strategies [23]	Interval Type-2 Fuzzy AHP, Interval Type-2 Fuzzy TOPSIS
Strategic Military Camp Selection [24]	LBWA, Z-MAIRCA
Criteria for Selecting Fighter Aircraft [25]	ARAS, FUCOM
Unmanned Aerial Vehicle (UAV) Selection Criteria and Challenges [26]	AHP, TOPSIS
Evaluation of River Crossing Location Strategies [27]	Fuzzy logic

In the ensuing sections, the application of MCDM methods for selecting an assault boat tailored to the exigencies of armed forces will be meticulously explored. The key steps under scrutiny will encompass the defining of criteria using the DIBR II method, data collection, alternative evaluations, and culminating in decision-making, facilitated through the CoCoSo method. Moreover, the BM operator was employed for aggregating the perspectives of six experts, under the assumption that each expert's competencies were deemed equivalent, and therefore, each opinion was afforded equal significance. Complementary to this, a sensitivity analysis of the output results derived from the proposed methodology, as well as a comparative analysis with other MCDM methodologies, was executed to validate the model. Subsequent segments will provide a detailed exposition of the proposed model and the methodologies employed for assault boat selection within military operational contexts.

2 Methodology

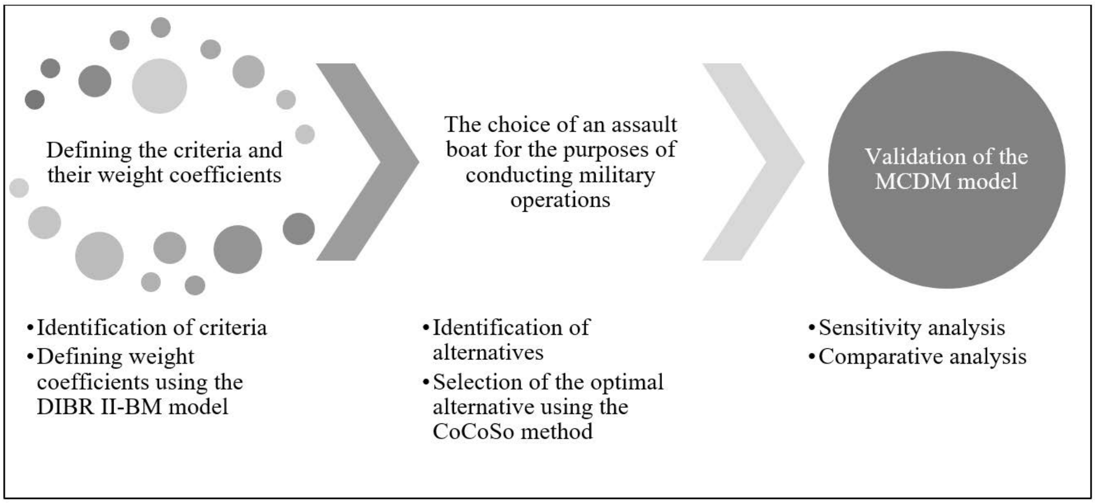

Figure 1. MCDM model DIBR II-BM-CoCoSo

Note: This figure has been prepared by the authors

Addressing such intricacy in problem-solving necessitates the structuring of an MCDM model, encompassing several phases and inclusive of distinct, consequential steps. Exhibited in Figure 1 is the devised DIBR II-BM-CoCoSo model.

Subsequent sections provide a delineation of each method incorporated into the MCDM model, as portrayed in Figure 1, alongside a succinct analysis of relevant literature pertinent to the utilised methods.

2.1 Bonfferoni Mean Operator

To synthesise the expert opinions from six specialists, the BM operator [28, 29] was employed, with its mathematical formulation being articulated by Eq. (1). Given that expert values of competence are deemed equivalent, conferring equal influence upon all contributors, this operator emerges as apt since it eschews consideration for the weight coefficients of the competences.

$$BM^{p,q}\left(x_1, x_2, \ldots, x_n\right) = \left(\frac{1}{n(n-1)} \sum_{\substack{i,j=1 \\ i \neq j}}^{n} x_i^p x_j^q\right)^{\frac{1}{p+q}} \tag{1}$$

Herein, values of p and q denote the stabilization parameters of the function, x_{ij} signifies the data set under aggregation, and n is indicative of the total expert count.

2.2 DIBR II Method

The DIBR II method has been developed for the determination of weight coefficients of criteria (w_n), utilising a limited set of mutual comparisons amongst neighbouring criteria [26]. To date, its application is noted in only two studies [30, 31]. Despite its nascent introduction to the literature, its potential is pronounced, largely attributed to its simplistic mathematical underpinning, delineated in subsequent steps [30, 31].

Steps 1 and 2: Identification and evaluation of the criteria $C = \{C_1, C_2, \ldots, C_n\}$ and their respective importance $C_1 > C_2 > \ldots > C_n$.

Step 3: Relationships amongst contiguous criteria ($\eta_{n-1,\mathrm{n}}$) are established as:

$$w_1 : w_2 = \eta_{1,2} : 1 \mapsto \frac{w_1}{w_2} = \eta_{1,2} \tag{2}$$

$$w_2 : w_3 = \eta_{2,3} : 1 \quad \mapsto \frac{w_2}{w_3} = \eta_{2,3} \tag{3}$$

$$\ldots$$

$$w_{n-1} : w_n = \eta_{n-1,\mathrm{n}} : 1 \mapsto \frac{w_{n-1}}{w_n} = \eta_{n-1,\mathrm{n}} \tag{4}$$

Simultaneously, a discernment between the foremost ranked criterion and the least ranked one is made as:

$$w_1 : w_n = \eta_{1,\mathrm{n}} : 1 \quad \mapsto \frac{w_1}{w_n} = \eta_{1,\mathrm{n}} \tag{5}$$

Steps 4 and 5: Comparative analyses between the premier-ranked and other criteria are conducted, indicated in Eqs. (6) to (8). The weight coefficient of the pre-eminent criterion is further specified in Eq. (9).

$$w_2 = \frac{w_1}{\eta_{1,2}} \tag{6}$$

$$w_3 = \frac{\omega_1}{\eta_{1,2} \cdot \eta_{2,3}} \tag{7}$$

$$\ldots$$

$$w_n = \frac{w_1}{\eta_{1,2} \cdot \eta_{2,3} \cdot \dots \cdot \eta_{n-1,\mathrm{n}}} \tag{8}$$

$$w_1 = \frac{1}{1 + \frac{1}{\eta_{1,2}} + \frac{1}{\eta_{1,2} \cdot \eta_{2,3}} + \dots + \frac{1}{\eta_{1,2} \cdot \eta_{2,3} \cdot \dots \cdot \eta_{n-1,\mathrm{n}}}} \tag{9}$$

Step 6: Weight coefficients of the residual criteria are established using Eqs. (6) to (8).

Step 7: A scrutiny of the quality of relationships amongst the criteria is undertaken. Specifically, a correlation between deviation values S_n (Eq. (10)) and the control value w_n^c (Eq. (11)) is sought. An approximate equivalence (a permissible variation up to 10%) is anticipated between these, contingent upon the fulfilment of $0 \leq S_n \leq 0.1$.

$$S_n = \left| 1 - \frac{w_n}{w_n^c} \right| \tag{10}$$

$$w_n^c = \frac{w_1}{\eta_{1,n}} \tag{11}$$

2.3 CoCoSo Method Application

The CoCoSo method, substantiated upon the SAW (Simple Additive Weighting) and WPM (Weighted Product Model) methods [32], has been utilised diversely across various domains, serving to rank and optimise alternative selections in conjunction with a myriad of other MCDM methods (refer to Table 2).

Table 2. Applicational domains of the CoCoSo method [33]

Subject Area	Number of Documents
Engineering	109
Computer Science	89
Mathematics	51
Business, Management and Accounting	40
Environmental Science	37
Energy	34
Decision Sciences	32
Social Sciences	28
Materials Science	19
Physics and Astronomy	12
Economics, Econometrics and Finance	10
Chemistry	8
Chemical Engineering	8
Psychology	5
Arts and Humanities	5
Medicine	4
Agricultural and Biological Sciences	4
Earth and Planetary Sciences	2
Multidisciplinary	1
Health Professions	1
Biochemistry, Genetics and Molecular Biology	1

In the ensuing text, the steps embodying the CoCoSo method are delineated [32, 34].

Step 1: Initial Decision Matrix X_{ij} Formulation.

Step 2: Normalisation of the Initial Decision Matrix Subjected to Criterion Type – Either Benefit (Eq. (12)) or Cost (Eq. (13)).

$$r_{ij} = \frac{x_{ij} - x_i^-}{x_i^+ - x_i^-} \tag{12}$$

$$r_{ij} = \frac{x_i^+ - x_{ij}}{x_i^+ - x_i^-} \tag{13}$$

Here, x_{ij} symbolises the analysed alternative per the scrutinised criterion, x_i^+ and x_i^- designate the maximum and minimum values of the scrutinised criterion across alternatives respectively.

Step 3: Calculation of the Weighted Sum S_i (Eq. (14)) and Power Weight of Comparability Sequences for Alternatives P_i (Eq. (15)).

$$S_i = \sum_{j=1}^{n} (w_j r_{ij}) \tag{14}$$

$$P_i = \sum_{j=1}^{n} (r_{ij})^{w_j} \tag{15}$$

Step 4: Ascertainment of the Relative Weights of Alternatives K_i (Eqs. (16)-(18)).

$$K_{ia} = \frac{P_i + S_i}{\sum_{j=1}^{m} (P_i + S_i)} \tag{16}$$

$$K_{ib} = \frac{S_i}{S_i^-} + \frac{P_i}{P_i^-} \tag{17}$$

$$K_{ic} = \frac{\mu (S_i) + (1-\mu)(P_i)}{\mu S_i^+ + (1-\mu) P_i^+} \tag{18}$$

Step 5: Alternatives' Ranking, Effected Through the Application of Eq. (19); Thus, an Alternative, Signified as K_i, Attaining a Higher Value Shall Garner a Superior Rank.

$$K_i = \sqrt[3]{(K_{ia} K_{ib} K_{ic})} + \frac{1}{3} (K_{ia} + K_{ib} + K_{ic}) \tag{19}$$

Subsequently, the aforementioned methodologies were deployed within the MCDM model, as depicted in Figure 1, catering to the predicament of assault boat selection for the enactment of military operations.

3 Results

Initially, criteria conditioning the selection of the subject were identified, facilitated through consultation with six field experts, and are sequentially listed according to significance in Table 3.

Subsequently, a comparison of criteria was conducted by the aforementioned experts, employing the DIBR II method, Eqs. (2)-(11), culminating in the determination of the weight coefficients for each expert, delineated in Table 4.

An aggregation of the criteria weights proffered by the experts, achieved using the BM operator (Eq. (1)), yielded the final values of the weight coefficients pertinent to the selection of an assault boat for military application, as illustrated in Table 5.

Ensuing the established methodology, identification of alternatives was pursued, comprising ten distinct assault boats commercially available, each possessing unique characteristics $A = \{A_1, A_2, \ldots, A_{10}\}$. To quantify the linguistic criteria, the construction of a linguistic evaluation scale was necessitated, depicted in Table 6.

Upon the identification of alternatives and the delineation of the linguistic scale, the Decision Maker (DM) constructed an initial decision matrix, also representative of Step 1 in the CoCoSo method application, detailed in Table 7. Considering the notable difficulty in obtaining specific pricing for individual military-use boats and available information indicating a price range of $1,300,000 to $2,600,000, prices within this range were arbitrarily selected for model testing purposes.

In Step 2, utilising the linguistic scale for evaluation (Table 6) and Eqs. (11) and (12), values from the initial decision-making matrix were normalized, contingent upon the type of criteria, showcased in Table 8.

Table 3. Criteria for assault boat selection

Criterion	Description of Criteria	The Type of Criteria
K_1 - Draft	It represents the minimum draft depth, that is, the depth to which the boat is immersed in water. It is expressed in meters.	Numeric, Cost
K_2 - Capacity	The total number of troops it can transport in one round (troops and crew).	Numeric, Benefit
K_3 - Price	It represents the cost price of the boat on the market, expressed in dollars.	Numeric, Cost
K_4 - Speed	Speed of movement of the boat on the water, expressed in km/h. The speed depends on the technical construction of the boat and the propulsion engines installed in it.	Numeric, Benefit
K_5 – Armor	It indicates the degree of armor protection of the boat in terms of protection from the effects of the enemy, both the vessel itself and the protection of the soldiers transported by it.	Linguistic, Benefit
K_6 - Range	It represents the maximum number of kilometers that the boat can travel on a single tank fill.	Numeric, Benefit
K_7 - Armament	The armament with which the boat is equipped, i.e., its firepower.	Linguistic, Benefit

Table 4. Criteria weight coefficients per expert

	C_1	C_2	C_3	C_4	C_5	C_6	C_7
E_1	0.2710	0.1807	0.1506	0.1369	0.0912	0.0869	0.0828
E_2	0.2564	0.1768	0.1538	0.1398	0.0999	0.0908	0.0825
E_3	0.2660	0.1773	0.1478	0.1407	0.0938	0.0893	0.0851
E_4	0.2724	0.1702	0.1419	0.1290	0.1075	0.0977	0.0814
E_5	0.2688	0.1734	0.1445	0.1257	0.1005	0.0958	0.0912
E_6	0.2721	0.1701	0.1479	0.1286	0.1029	0.0935	0.0850

Table 5. Final values of criteria weight coefficients

	C_1	C_2	C_3	C_4	C_5	C_6	C_7
w	0.2678	0.1748	0.1477	0.1334	0.0993	0.0923	0.0847

Table 6. Linguistic evaluation scale

Scale	Crisp Value
Apsolutly satisfies (AS)	5
Satisfies (S)	4
Partially satisfying (PS)	3
Partially unsatisfactory (PU)	2
Not satisfy (NS)	1

Table 7. Initial decision matrix

	C_1	C_2	C_3	C_4	C_5	C_6	C_7
A_1	0.61	12	1400000	74	S	232	AS
A_2	0.85	10	1500000	100	PS	321	S
A_3	0.85	14	1600000	93	PS	242	S
A_4	0.75	12	2500000	102	AS	463	AS
A_5	0.60	14	2000000	102	S	463	S
A_6	0.85	11	1700000	74	S	321	AS
A_7	0.65	6	1300000	60	PS	500	AS
A_8	0.85	12	1300000	93	AS	463	S
A_9	0.66	14	2000000	74	S	407	S
A_{10}	0.60	12	1800000	74	S	740	PS

Table 8. Normalized matrix

	$\mathbf{C_1}$	$\mathbf{C_2}$	$\mathbf{C_3}$	$\mathbf{C_4}$	$\mathbf{C_5}$	$\mathbf{C_6}$	$\mathbf{C_7}$
A_1	0.9600	0.7500	0.9167	0.3333	0.5000	0.0000	1.0000
A_2	0.0000	0.5000	0.8333	0.9524	0.0000	0.1752	0.5000
A_3	0.0000	1.0000	0.7500	0.7857	0.0000	0.0197	0.5000
A_4	0.4000	0.7500	0.0000	1.0000	1.0000	0.4547	1.0000
A_5	1.0000	1.0000	0.4167	1.0000	0.5000	0.4547	0.5000
A_6	0.0000	0.6250	0.6667	0.3333	0.5000	0.1752	1.0000
A_7	0.8000	0.0000	1.0000	0.0000	0.0000	0.5276	1.0000
A_8	0.0000	0.7500	1.0000	0.7857	1.0000	0.4547	0.5000
A_9	0.7600	1.0000	0.4167	0.3333	0.5000	0.3445	0.5000
A_{10}	1.0000	0.7500	0.5833	0.3333	0.5000	1.0000	0.0000

Table 9. Sum of weighted comparability sequences for alternatives (S_i)

	$\mathbf{C_1}$	$\mathbf{C_2}$	$\mathbf{C_3}$	$\mathbf{C_4}$	$\mathbf{C_5}$	$\mathbf{C_6}$	$\mathbf{C_7}$
A_1	0.2571	0.1311	0.1354	0.0445	0.0497	0.0000	0.0847
A_2	0.0000	0.0874	0.1231	0.1270	0.0000	0.0162	0.0424
A_3	0.0000	0.1748	0.1108	0.1048	0.0000	0.0018	0.0424
A_4	0.1071	0.1311	0.0000	0.1334	0.0993	0.0420	0.0847
A_5	0.2678	0.1748	0.0615	0.1334	0.0497	0.0420	0.0424
A_6	0.0000	0.1093	0.0985	0.0445	0.0497	0.0162	0.0847
A_7	0.2142	0.0000	0.1477	0.0000	0.0000	0.0487	0.0847
A_8	0.0000	0.1311	0.1477	0.1048	0.0993	0.0420	0.0424
A_9	0.2035	0.1748	0.0615	0.0445	0.0497	0.0318	0.0424
A_{10}	0.2678	0.1311	0.0862	0.0445	0.0497	0.0923	0.0000

Table 10. Power weight values of comparability sequences for alternatives (P_i)

	$\mathbf{C_1}$	$\mathbf{C_2}$	$\mathbf{C_3}$	$\mathbf{C_4}$	$\mathbf{C_5}$	$\mathbf{C_6}$	$\mathbf{C_7}$
A_1	0.9891	0.9510	0.9872	0.8637	0.9335	0.0000	1.0000
A_2	0.0000	0.8859	0.9734	0.9935	0.0000	0.8515	0.9430
A_3	0.0000	1.0000	0.9584	0.9683	0.0000	0.6959	0.9430
A_4	0.7824	0.9510	0.0000	1.0000	1.0000	0.9298	1.0000
A_5	1.0000	1.0000	0.8787	1.0000	0.9335	0.9298	0.9430
A_6	0.0000	0.9211	0.9419	0.8637	0.9335	0.8515	1.0000
A_7	0.9420	0.0000	1.0000	0.0000	0.0000	0.9427	1.0000
A_8	0.0000	0.9510	1.0000	0.9683	1.0000	0.9298	0.9430
A_9	0.9291	1.0000	0.8787	0.8637	0.9335	0.9063	0.9430
A_{10}	1.0000	0.9510	0.9235	0.8637	0.9335	1.0000	0.0000

Table 11. Relative weights of alternatives

	$\mathbf{K}_{ia}$	$\mathbf{K}_{ib}$	$\mathbf{K}_{ic}$
A_1	0.1067	3.2471	0.8619
A_2	0.0837	2.1963	0.6764
A_3	0.0830	2.2725	0.6706
A_4	0.1039	2.9667	0.8396
A_5	0.1238	3.6689	1.0000
A_6	0.0982	2.4356	0.7932
A_7	0.0727	2.2507	0.5874
A_8	0.1056	2.9232	0.8529
A_9	0.1172	3.1970	0.9471
A_{10}	0.1053	3.1554	0.8507

During Step 3, application of Eq. (14) facilitated the derivation of values for the sum of the weighted comparability sequences for alternatives (S_i), demonstrated in Table 9, while employment of Eq. (15) yielded the power weight values of comparability sequences for alternatives (P_i), revealed in Table 10.

In Step 4, through the application of Eqs. (16)-(18), relative weights of alternatives were ascertained, with corresponding values presented in Table 11. The adopted value for μ was set at 0.5.

During Step 5, calculation of the real weight of each alternative (K_i), facilitated through utilization of Eq. (19) and values from Table 11, enabled the final ranking of alternatives, portrayed in Table 12.

Table 12. Final ranking of alternatives

	K_i	Rank
A_1	2.0736	3
A_2	1.4846	9
A_3	1.5107	8
A_4	1.9407	5
A_5	2.3662	1
A_6	1.6835	7
A_7	1.4283	10
A_8	1.9347	6
A_9	2.1285	2
A_{10}	2.0267	4

Insight gleaned from Table 12 indicates that alternative A_5 is emblematic of the optimal solution to the research problem (assault boat selection), while alternative A_7 is precluded from optimal consideration under any circumstance. Subsequent sections proffer an analysis of the model's sensitivity to alterations in the weight coefficients of the criteria, in addition to a juxtaposition of the attained results with outcomes derived through alternative methods, intending to validate the model.

4 Validation of the MCDM Model

The validation of the proposed methodology was pursued via a twofold approach, encompassing a preliminary sensitivity analysis of the output results and subsequent comparative analysis of the results derived from the MCDM model against those from alternative MCDM methods. Analyses were aimed at elucidating the stability and accuracy of the model relative to sensitivity to variations in the weight coefficients of the criteria and ranks of alternatives, thereby influencing the selection of the optimal alternative.

4.1 Sensitivity Analysis

Sensitivity analysis was conducted, focusing on alterations in the weight coefficients of the criteria. Thus, 20 scenarios were devised, encapsulating various weight changes and their subsequent application in the model. Scenario S1 was indicative of a context where all weight coefficients were held equal, whilst remaining scenarios were obtained through the subtraction of a specified value from the most consequential criterion and equal distribution of it amongst other criteria (Figure 2).

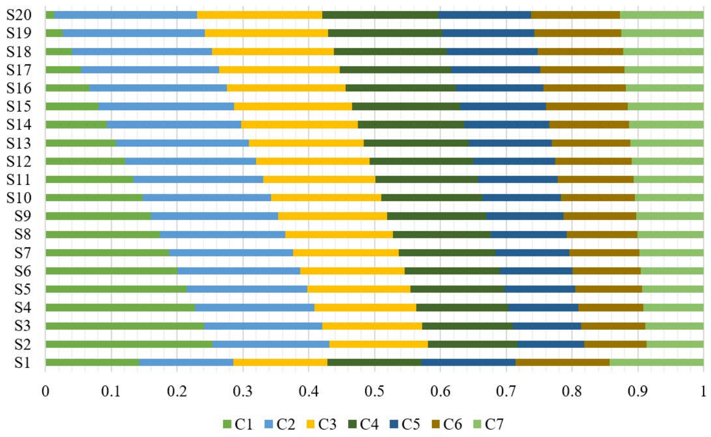

Figure 2. Scenarios of variations in weight coefficients of criteria

Note: The authors prepared this figure

The application of the scenarios depicted in Figure 2 yielded the ensuing ranks of alternatives (Figure 3):

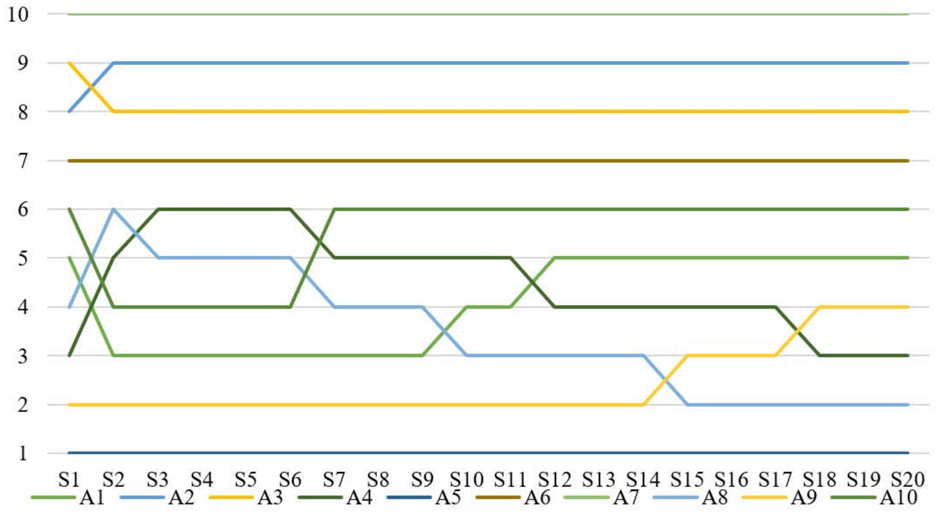

Figure 3. Ranks of alternatives following application of scenario variations in weight coefficients of criteria

Note: The authors prepared this figure

Post sensitivity analysis, it was inferred that the foremost ranked alternative, with its inherent characteristics, retained its rank robustly, and that the lowest-ranked alternative remained consigned to the final position across all scenarios. Additionally, it was concluded that rank alterations manifested amongst other alternatives, barring alternative A_7, which also persisted as the lowest-ranked alternative. Ultimately, the overarching inference highlighted that whilst the model exhibited sensitivity to modifications in criterion coefficients, it did not do so excessively, thus attesting to its stability. Minor inaccuracies in the expert-defined criteria weights were deemed inconsequential to the selection of the optimal alternative. Following this, a comparison of the obtained results with those from alternative methods was performed.

4.2 Comparative Analysis

A juxtaposition of results, derived utilising the CoCoSo method, was conducted against those obtained through several MCDM methods (Figure 4): MAIRCA (Multi-Attributive Ideal-Real Comparative Analysis) [35], MABAC (Multi-Attributive Border Approximation area Comparison) [36], MARCOS (Measurement of Alternatives and Ranking according to the Compromise Solution) [37], WASPAS (Weighted Aggregated Sum Product ASsessment) [38], EDAS (Evaluation based on Distance from Average Solution) [39], COPRAS (COmplex PRoportional ASsessment) [40], and ARAS (Additive Ratio ASsessment) [41].

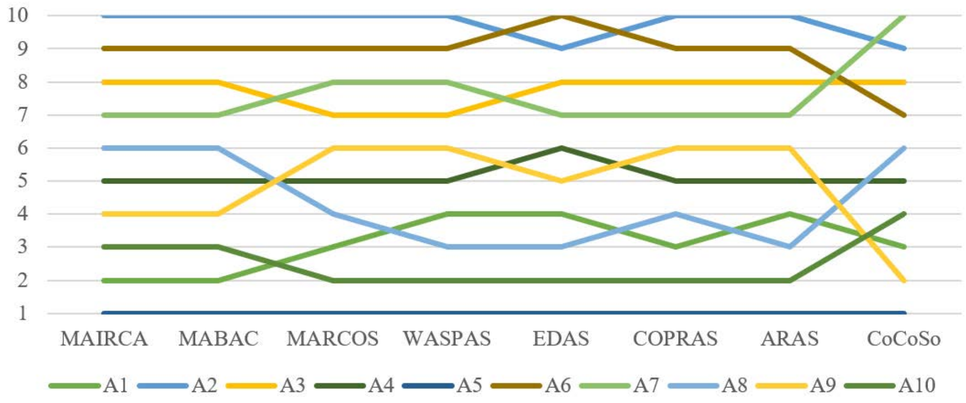

Figure 4. Ranks of alternatives using various methods in relation to the CoCoSo method

Note: The authors prepared this figure

Inspection of Figure 4 revealed that alternative A_5 consistently secured the premier rank across all cases, while alternative A_7 predominantly languished at the terminus of the ranking list, substantiating the stability and precision of the proposed methodology, and thereby verifying the MCDM model.

5 Conclusions

A pivotal stride towards enhancing the proficiency of military organisations in overcoming water obstacles an intricate and volatile environment has been elucidated through the employment of MCDM methods in the selection of an assault boat tailored for the requisites of the armed forces. Engendered through a systematic scrutiny of criteria, evaluation of divergent alternatives, and data-driven decision-making, MCDM methods pave the way for more insightful and optimised decisional outcomes, thereby amplifying operational capability and congruence with the strategic objectives of the military entities.

The DIBR II method, recognised for its nascent potential and distinctive characteristics, was utilised for delineating the weight coefficients of the criteria. Definition of the interrelation between the criteria within this method was accomplished by six specialists in overcoming water obstacles, with the agglomeration of their insights achieved using the BM operator, culminating in the final valuations of the weight coefficients of the criteria. The resultant criteria weights not only elucidate the significance of each criterion but also shed light on their respective influence upon the conclusive decision.

Through the incorporation of the ascertained criteria weights into the CoCoSo method and subsequent application thereof, selection of the optimal alternative namely, an assault boat apt for military operations was actualised. In the ensuing phase of the investigation, validation of the MCDM model was executed, involving an analysis of the output results' sensitivity to variations in the weight coefficients of the criteria and a comparative analysis of the findings yielded using the propounded methodology with those deriving from alternative MCDM methods. It was substantiated that the illustrated MCDM model remains stable amid alterations in criteria weights and that inconsequential discrepancies during their determination will not impinge upon the ultimate choice. The comparative analysis authenticated that each MCDM method, against which the proposed methodology was benchmarked, yielded the same optimal alternative, thereby affirming the model's correctness and stability.

Future investigations will be channelled towards the development of alternative MCDM models, amalgamated with operators for the aggregation of expert opinions, taking into account their weight coefficients of competencies, identified as the principal limitation of the present research. Despite the demonstrable validity of the exhibited methodology and the integration of domain experts, it must be underscored that such models serve merely to assist the Decision Maker (DM), with the final decision resting intrinsically with the DM.

Data Availability

The data used to support the research findings are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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