Multicriteria Algorithms with Applications

Journal Homepage: sciencesforce.com/mawa

Multicriteria Algo. Appl. Vol. 6 (2025) 34–56

Paper Type: Original Article

Selection of Military UAV using LMAW and TOPKOR Methods in Neutrosophic Environment

Amira Salam [1,*] and Mai Mohamed [1]

[1] Faculty of Computers and Informatics, Zagazig University, Zagazig 44519, Sharqiyah, Egypt.
Emails:sallam18@fci.zu.edu.eg; mmgaafar@zu.edu.eg.

Received: 23 Aug 2024 **Revised:** 30 Nov 2024 **Accepted:** 28 Dec 2024 **Published:** 01 Jan 2025

Abstract

Unmanned aerial vehicles (UAVs) are becoming more and more popular as a means of targeting terrorist and insurgent groups across the world due to a rise in terror threats, unconventional military threats, and geopolitical conflicts. The advantages are evident: lower risk to defense personnel's lives, targeted strikes to destroy hostile units, and cost-effectiveness. UAVs may now carry out a wider range of military and homeland security (HLS) missions, including combat strategies, surveillance, and reconnaissance, thanks to technological advancements in the field. UAVs have come a long way from being simple surveillance devices to becoming highly advanced military and peacekeeping equipment. There are various types of military drones, and it is important to have an effective method for selecting the best option for a given situation. In this study, we have introduced the LMAW and TOPKOR methods, which are integrated with the neutrosophic environment to efficiently handle uncertainty and ambiguity in choosing the best military UAV. An empirical analysis of a real-world scenario involving four initial military UAVs, evaluated by four specialists against five criteria, was conducted. The case study demonstrates the effectiveness and feasibility of the proposed evaluation process. We also performed sensitivity analysis and weighted analysis of the alternatives. Additionally, we used CRITIC, ENTROPY, MEREC, RAWEC, VIKOR and ARAS techniques for comparisons.

Keywords: Military UAVs; Trapezoidal Neutrosophic Number; MCDM; LMAW.

1 | Introduction

With the advancements in technology and the widespread adoption of the Internet of Things (IoT), unmanned aerial vehicles (UAVs) are being used in various applications such as air surveillance, crisis and disaster management, monitoring, reconnaissance, and other vital applications [1, 2]. These vehicles are controlled remotely and can fly either fully or partially autonomously [3]. With the advancement of UAV technology, their use has grown in military and defense applications, as well as in geopolitical conflicts, due to their abilities for continuous surveillance and reconnaissance, and their capability to locate and strike the enemy[4, 5]. The rapid development and use of UAV technology in military and HLS (Homeland Security) applications are reshaping the future of security and combat. UAVs have become essential tools for military operations, reconnaissance, and surveillance due to the integration of advanced AI, high-resolution photography, real-time data transmission, and enhanced endurance capabilities. The trends toward increased autonomy, coordinated swarm operations, stealth, and 5G integration also highlight the growing strategic importance and technological advancement of these UAVs. Equipped with advanced sensors and cameras,

Corresponding Author: sallam18@fci.zu.edu.eg
https://doi.org/10.61356/j.mawa.2025.6452

these military UAVs can gather valuable intelligence in hostile territory without risking the lives of soldiers. For instance, UAVs with AI technology can monitor the surroundings and identify potential threats while soldiers are resting, thus reducing the need for large human surveillance teams and their associated costs. Additionally, UAVs can overcome line-of-sight constraints and provide a wider field of view from their elevated vantage point, which is particularly important in challenging terrains.

Given the wide range of UAVs used in military operations, it's important to have efficient technology to help in selecting the right one. The decisions made by planners will determine how effectively and in what manner drones can carry out military and defense tasks. As a result, our study frames the issue as a decision-making challenge, where a multi-criteria selection method is needed to choose the best UAV with cutting-edge technology.

The process of making decisions when considering multiple criteria simultaneously to rank or select alternatives is known as multi-criteria decision analysis (MCDA), sometimes referred to as multi-criteria decision-making (MCDM). MCDM can be applied to most decisions made by individuals or groups that entail ranking or selecting among alternatives (including people). The main aim of MCDM is to define and solve decision problems formally. Most MCDM techniques involve balancing criteria and openly evaluating trade-offs between them. By minimizing decision-makers reliance on intuition alone and their vulnerability to collective decision-making errors such as "groupthink," MCDM aims to reduce biases. MCDA aids in better decision-making by systematically establishing the weights and trade-offs between the criteria, Figure 1 shows the outline of the MCDM Procedure.

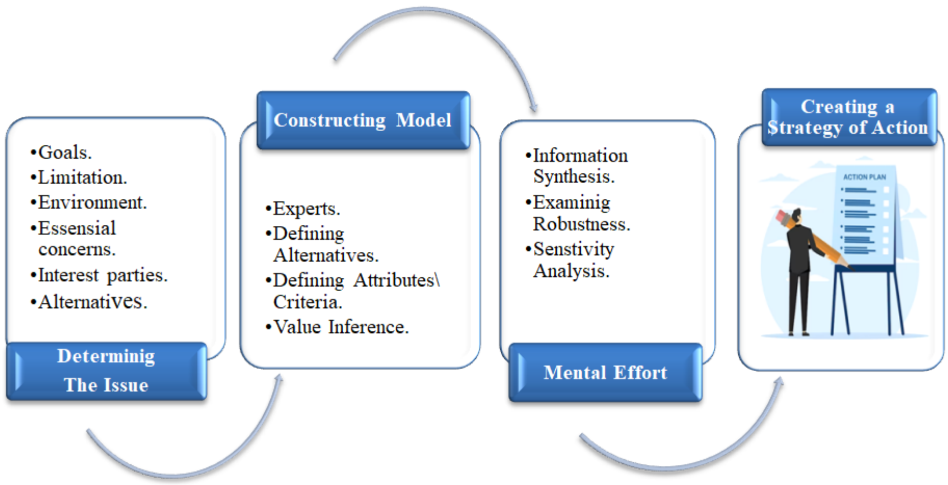

Figure 1. The outline of the MCDM procedure.

MCDM has been used in many different domains, and it has been discovered that the TOPSIS, AHP, PROMETHEE, and GP approaches are the most often used techniques for resolving multi-criteria problems [6]. MCDM proved to be a useful instrument in choosing the right UAV for important military operations, the available alternatives were ranked using the TOPSIS approach, and the criteria weights were determined using the AHP method [7]. In [8] the PROMETHEE approach was used to categorize the alternatives and the AHP method was used to determine the weights of the criteria to choose the best-armed UAV employed in the defense industry. The AHP method was utilized to establish the criteria weights, and the TOPSIS method was employed to rank alternatives in a fuzzy environment this was carried out to choose military robots that could carry out duties such as weapon destruction, detection, and surveillance [9]. The AHP method and the TOPSIS method were used to evaluate the aerial warfare effectiveness of military airplanes and select the best option among them [10]. Also in [11] the AHP and TOPSIS methods in a fuzzy environment for weapon selection. The VIKOR method is one of the MCDM methods introduced in 1998. It is characterized by being one of the compensatory methods. The features must be independent and finally, it provides a compromise that balances the conflicting criteria, the VIKOR method has been utilized in the military and defense sectors [12-14]. In 2019, the TOPKOR method was integrated with the fuzzy set, which combines the advantages of the TOPSIS and VIKOR methods, and it was used to establish the order of importance for the building of renewable power plants [15]. But the fuzzy set can only deal with truth and falsity; it cannot cope with the ambiguity and inconsistency that are part of reality. The LMAW method is one of the MCDM approaches for determining the weight coefficients of the criterion that manages the rank reversal issue that arises in the TOPSIS method and demonstrates stability in a dynamic setting [16]. To make decisions, the researchers in [17] used the LMAW approach in a fuzzy environment. However, the fuzzy set solely deals with truth and falsity and is unable to handle the ambiguity and inconsistency that exist in reality. Therefore, we are the first to utilize the TOPKOR and LMAW methods in neutrosophic environment using single valued trapezoidal neutrosophic numbers (SVTN-LMAW-TOKOR) for selecting suitable unmanned aerial vehicles (UAVs) in the defense and military sectors. With the help of specialists, we evaluated four alternatives against five criteria.

1.1 | Research Contributions

Appling the MCDM technique to select the optimal UAV suitable for military and defense fields through:

- The SVTN-TOPKOR method was developed to rank options in a neutrosophic environment and select the best UAV for military use in a specific scenario. Neutrosophic sets are more precise than fuzzy sets and are better at representing uncertainty and ambiguity in information.
- Established the SVTN-LMAW, a newly updated version of the LMAW approach to determine criteria weight in a trapezoidal neutrosophic environment.
- Our methodology tackles the imprecision in the actual decision-making process, assisting in the creation of an accurate decision matrix.
- Designed a new single-valued trapezoidal neutrosophic scale.
- To evaluate and ascertain the stability of the suggested method under different sets of criteria weights, a sensitivity analysis was carried out.
- A comparative analysis was conducted between our proposed approach and RAWEC, VIKOR, and ARAS methods. The results demonstrated the effectiveness of our approach.

The structure for the remaining portion of the article is as follows: Section 2, "existing work", Section 3 "techniques", Section 4 "case study", Section 5 "sensitivity analysis", Section 6 "comparative analysis", Section 7 "managerial implications", Section 8 "challenges and future directions", Section 9 "conclusion" and, Section 10 "study restrictions".

2 | Existing Work

2.1 | UAVs in Military and Defense Applications

The world is increasingly dependent on information technology, leading to collaboration between information technology and aviation technology to introduce various types of UAVs. These UAVs are integrated with technologies such as cloud computing and artificial intelligence to enhance their capabilities, which are used in many applications, including military and defense operations [18]. The use of UAVs in the military has proven to be effective. An analysis was conducted on a group of UAV swarms, focusing on how to maintain awareness on the battlefield, avoid collisions and obstacles, and make decisions via the Internet [19].UAVs have demonstrated their effectiveness in military and security operations, they excel in reconnaissance and security exploration by simulating a war area to spy on the adversary and determine their location using the Pinhole algorithm [20]. Not only are UAVs capable of performing surveillance and reconnaissance, but they are also invaluable in military communications, serving as a multifunctional point of contact. This makes UAV usage essential for the success of military operations [21].

2.2 | UAVs Military Features

UAVs today are marvels of technology, combining durability, edge computing, and advanced AI for enhanced surveillance, crucial for HLS and military applications [22]. Among the advanced features is: High-Resolution Image: UAVs today have access to exceptionally high-resolution image equipment, which makes it possible to analyze topography, buildings, and even individual faces in detail from considerable elevations. Using its high-resolution cameras, a UAV may take comprehensive pictures of a metropolis while conducting urban surveillance. This makes it feasible to distinguish distinct faces in a crowd, thoroughly examine the structural stability of buildings after a natural disaster, or even identify suspicious activity from great heights that are invisible to the naked eye. Decision Making: AI systems enable UAVs to make important judgments quickly. For example, a UAV requires very little human input to identify targets, assess hazards, and even decide on flying routes. UAVs with AI algorithms installed in them can quickly scan overhead footage during a military operation to find possible risks, such as enemy troops or unsafe areas. Then, with the least amount of input from human operators, it may choose the safest flight path to avoid being detected or confronted, and rank targets for surveillance according to the degree of threat they pose. Extended Air Time: UAVs can now stay in the air for longer because of developments in battery and propulsion technologies. Some versions can fly for days without having to land. A military UAV with improved battery and propulsion technologies can stay in the air for several days during a border surveillance mission. This UAV continuously scans a wide, possibly hostile border region for enemy invasions, smuggling operations, and unauthorized crossings. Its prolonged flight duration guarantees ongoing monitoring, giving border security personnel a steady supply of intelligence and empowering them to act quickly in the event of any dangers identified. Autonomous Navigation: Modern UAVs can navigate challenging areas on their own, thanks to advanced edge computing and artificial intelligence (AI) [23]. This includes analyzing terrain, avoiding obstacles, and adapting mission plans based on real-time data. For example, if a UAV is on a search and rescue mission in a dense forest, it can use AI edge computing to maneuver through the terrain. It can identify and avoid obstacles like trees and cliffs assess the terrain to find the safest paths, and adjust its flight plan in response to changes like weather patterns or new information about the missing person's whereabouts. Real-time Data Transmission: UAVs can transmit data in real-time, providing instant situational awareness and intelligence to command centers. This is essential for operations and decision-making that requires quick responses. In rapidly changing crises such as natural disasters or security breaches, UAVs can send real-time video and sensor data to command centers. This allows commanders to conduct intelligent video analysis and make well-informed decisions promptly. For example, they can allocate resources to specific locations or modify plans in response to current events [24]. Wide Area Coverage: Thanks to these endurance enhancements, UAVs are now able to monitor and collect data over prolonged distances, a crucial capability for large-scale operations. A large-scale disaster response scenario could involve the use of an HLS UAV with wide-area coverage capabilities to survey the impacted area, such as after a significant earthquake or hurricane. In a short amount of time, the UAV locates survivors, assesses damage, and pinpoints regions that require immediate assistance over a wide geographic area. To effectively allocate disaster response efforts and resources and guarantee that relief reaches the most impacted areas in a timely way, this broad area coverage is essential.

The market for military UAVs with AI capabilities is expected to grow as the use of UAVs in security and defense increases. These UAVs are used for tasks such as combat operations and surveillance, and their development is supported by rising defense budgets. Advanced UAVs designed for military use are equipped with internal weaponry and advanced AI capabilities [25-27].

3 | Techniques

This research introduces a new approach called SVTN-TOPKOR, which combines the VIKOR and TOPSIS methods in a neutrosophic environment using a single-valued trapezoidal neutrosophic set to evaluate and select the best military UAV. The process begins with identifying the necessary criteria and assigning weights to them using the SVTN-LMAW method. Subsequently, we rank the most suitable UAVs using the SVTN-TOPKOR technique and ultimately select the best one; Figure 2 shows the flowchart of the methodology.

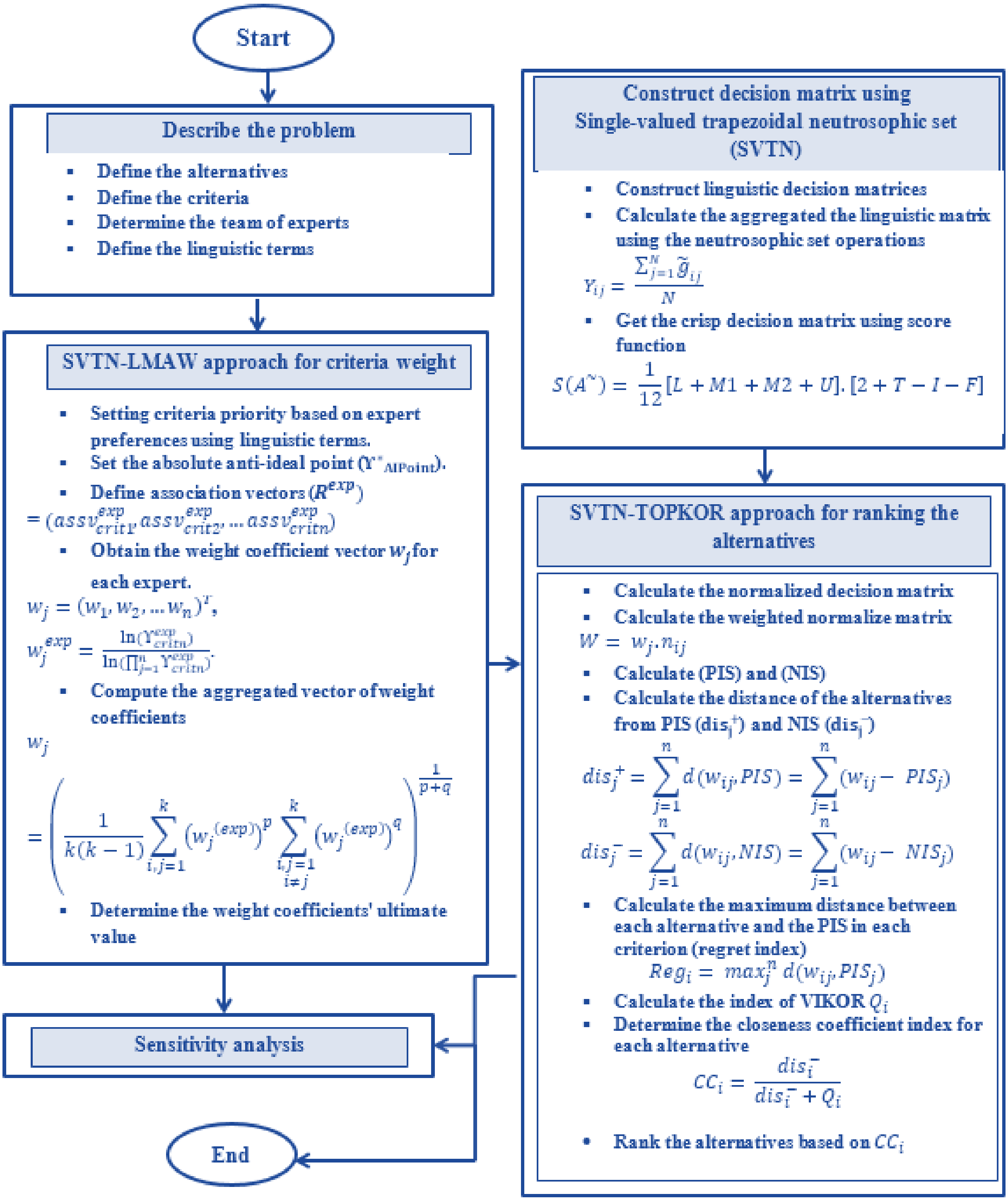

Figure 2. Flowchart of the methodology.

The steps in our approach are as follows:

Step 1: Describe the problem.

In a multi-criteria decision-making problem, there are multiple alternatives $Alter = \{Alter1, Alter2, \dots \dots Alter_m\}$ that need to be evaluated based on various criteria. To determine the best option among a set of alternatives for an MCDM process, a group of experts in the problem domain, denoted as $Expert = \{exp1, exp2 \dots exp_k\}$, should produce a set of linguistic decision matrices $LDM =$

$\{LDM1, LDM2 \dots \dots LDM_k\}$ based on a preset linguistic scale. This evaluation is done under the set of criteria $crit = \{crit1, crit2, \dots\dots crit_n\}$.

Step 2: Determine the weight of criteria by the LMAW method [16]:

The SVTN-LMAW approach is reliable in dynamic situations and works well with large volumes of data. Moreover, changing the quantity of options and standards does not affect the coherence of the LMAW approach's mathematical structure. The steps for creating SVTN-LMAW are as follows:

Step 2.1: Setting criterion priorities

The expert group $Expert = \{exp1, exp2 \dots exp_k\}$ ranks the criteria $crit = \{crit1, crit2, \dots\dots crit_n\}$ based on priority. The experts use linguistic values like "excellent" or "bad" to indicate the importance of each criterion. However, these values are vague and don't provide the level of certainty needed for evaluation. To address this, we use the trapezoidal neutrosophic number scale to prioritize the criteria, as it allows for imprecise information to be taken into account.

To overcome vagueness and uncertainty, the experts' preferences are represented by the trapezoidal neutrosophic number scale in Table 1, which uses the scoring function in Eq. (11) to turn linguistic concepts into explicit numbers that reflect the degree of confirmation of the expert's judgment. Consequently, we derive the priority vector. $prio^{exp} = \{\Upsilon_{c1}^{exp}, \Upsilon_{c2}^{exp}, \dots \Upsilon_{cn}^{exp}\}$, in which the value of Υ_{critn}^{exp} is the linguistic scale assigned to the criterion $crit_i (1 < i < n)$.

Step 2.2: Set the absolute anti-ideal point ($\Upsilon^*_{AIPoint}$), a value that represents the least important value in the collection of all priority vectors.

$$\Upsilon^*_{AIPoint} = \frac{\Upsilon_{min}^{exp}}{s} = \frac{\min\{\Upsilon_{crit1}^{exp}, \Upsilon_{crit2}^{exp}, \dots \Upsilon_{critn}^{exp}\}}{s} \tag{1}$$

Where s is the number greater than the base of the (ln) logarithm function.

Step 2.3: Define association vectors (R^{exp}). To reduce the value of the criteria scores, the association between each element of the priority vector and the absolute anti-ideal point $\Upsilon^*_{AIPoint}$ is ascertained as follows:

$$assv_{critn}^{exp} = \frac{\Upsilon_{critn}^{exp}}{\Upsilon^*_{AIPoint}} \tag{2}$$

$$R^{exp} = (assv_{crit1}^{exp}, assv_{crit2}^{exp}, \dots assv_{critn}^{exp}) \tag{3}$$

Where $assv_{critn}^{exp}$ is the value from the association vector obtained by Eq. (2), and R^{exp} is the association vector of expert $exp\ (1 < exp < k)$.

Step2.4: Ascertain each expert's weight coefficients vector (w_j) as follows:

$$w_j^{exp} = \frac{\ln(\Upsilon_{critn}^{exp})}{\ln(\prod_{j=1}^{n} \Upsilon_{critn}^{exp})} \tag{4}$$

$$w_j = (w_1, w_2, \dots w_n)^T \tag{5}$$

Step 2.5: Utilize the Bonferroni aggregator to compute the aggregated vector of weight coefficients. This can be done as follows:

$$w_j = \left(\frac{1}{k(k-1)} \sum_{i,j=1}^{k} \left(w_j^{(exp)}\right)^p \sum_{\substack{i,j=1 \\ i \neq j}}^{k} \left(w_j^{(exp)}\right)^q \right)^{\frac{1}{p+q}} \tag{6}$$

Where $p, q \geq 0$ present stabilization parameters of the Bonferroni aggregator, while w_j^{exp} Presents the weight coefficients obtained based on the evaluations of the experts.

Step 2.6: Determine the weight coefficients' ultimate value.

Table 1: SVTN - Scale for the evaluation process.

Terms	L,M1,M2,U	Validation Degree (VD) = (T,I,F)
Completely insignificant (CIS)	<(0,0,0,0)>	Completely Not sure (CNS) <(0,1,1)>
Not Significant (NS)	<(0,0,0,1)>	Not sure (NS) <(0.25 , 0.75, 0.75)>
Very Minor Significant (VMS)	<(1,1.5,2,3)>	Very Minor sure (VMS) <(0.45,0.60,0.60>)
Median Significant (MS)	<(2,2.5,3,4)>	Median sure (MS) <(0.5,0.5,0.5)>
Significant (S)	<(3,3.5,4,5)>	Sure (S) <(0.75,0.20,0.20)>
Firmly Significant (FS)	<(5,5.5,6,7)>	Firmly sure (FS) <(0.85,0.15,0.15)>
Very Firmly Significant (VFS)	<(6,6.5,7,8)>	Very Firmly sure (VFS) <(0.90,0.10,0.10)>
Definitely Significant (DS)	<(7,7.5,8,9)>	Definitely sure (DS) <(1.00,0.00,0.00)>

Step 3: Single-Valued Trapezoidal neutrosophic TOPKOR (SVTN-TOPKOR)

Step 3.1: Construct decision matrix: A multi-criteria decision problem is represented by a matrix known as the decision matrix $(m\ x\ n)$. In this matrix, each row represents a different option and each column represents a specific criterion. The matrix is a valuable tool for evaluating and selecting the best choice when considering multiple criteria simultaneously for making the decision. Some individuals base their decisions solely on linguistic terms, which may not provide enough information to make an informed decision due to ambiguity and uncertainty. To address this issue, we introduced our model in a neutrosophic environment capable of handling linguistic uncertainty and ambiguity. We introduced a new single-valued trapezoidal neutrosophic scale (SVTN) to convert linguistic terms into a numerical scale, enabling experts to create a decision matrix, as illustrated in Table 1.

Step 3.1.1: Construct linguistic decision matrix:

The single-valued trapezoidal neutrosophic decision matrix is represented as follows:

$$G = [\tilde{g}_{ij}]_{m,n} =$$

$$\begin{bmatrix} < [(L_{11}, M1_{11}, M2_{11}, U_{11}; VD)] > & \cdots & < [(L_{1j}, M1_{1j}, M2_{1j}, U_{1j}; VD)] > \\ \vdots & \ddots & \vdots \\ < [(L_{i1}, M1_{i1}, M2_{i1}, U_{i1}; VD)] > & \cdots & < [(L_{mn}, M1_{mn}, M2_{mn}, U_{mn}; VD)] > \end{bmatrix} \quad (7)$$

Where m is the number of alternatives$(Alter)$, n is the number of criteria $(Crit)$, and $(\tilde{g}_{ij})$ is the SVTN value of the ith alternative concerning the jth criterion.

Step 3.1.2: Aggregated SVTN decision matrix.

Each expert will have their own SVTN decision matrix because there are several experts involved. The SVTN-aggregation decision matrix ($SVTN - ag_{ij}$), construct by utilizing Eq. (8). Eqs. (9) and (10), used to combine these individual matrices into a single comprehensive matrix.

$$Y_{ij} = \frac{\sum_{j=1}^{N} \tilde{g}_{ij}}{N} \quad (8)$$

Let, $A_1^{\sim}$ and $B_1^{\sim}$ Are two single-valued trapezoidal neutrosophic numbers, then the operations for SVTN – numbers are defined as follows:

$$A_1^{\sim} + B_1^{\sim} = < (a_1 + b_1,\ a_2 + b_2, a_3 + b_3, a_4 + b_4\ ); \min(T_1, T_2), \max(I_1, I_2), \max(F_1, F_2) > \quad (9)$$

$$A_1^{\sim} \otimes B_1^{\sim} = < (a_1 b_1,\ a_2\, b_2, a_3\, b_3, a_4\, b_4\ ); \min(T_1, T_2), \max(I_1, I_2), \max(F_1, F_2) > \quad (10)$$

Step 3.1.3: Convert the SVTN decision matrix into a crisp decision matrix.

After that, convert the single-valued trapezoidal neutrosophic number $\tilde{g}_{ij}$ to crisp number g_{ij} by applying the score function in Eq. (11) to the SVTN-aggregation decision matrix.

$$S(A^{\sim}) = \frac{1}{12}[L + M1 + M2 + U].[2 + T - I - F] \quad (11)$$

Step3.2: Calculate the normalized decision matrix$N = [n_{ij}]_{mxn}$, as follows:

$$n_{ij} = \begin{cases} \frac{x_{ij}}{\max x_{ij}} & , j = 1,2 \dots n\ , \ for\ benefit\ criteria \\ \frac{\min x_{ij}}{x_{ij}} & , j = 1,2 \dots n\ , \ for\ non-benefit\ criteria \end{cases} \quad (12)$$

Step 3.3: Calculate the weighted normalized $W = [w_{ij}]_{mxn}$ The matrix depends on the criteria weight that was calculated before.

$$W = w_j . n_{ij} \quad (13)$$

Step 3.4: Determine the positive ideal solution (PIS) and negative ideal solution (NIS), C_{ij} refers to the value of ith alternatives in the jth criteria, $c_j^*$is the bestC_{ij}, and c_j^- is the worstC_{ij}.

For positive criteria:

$$\begin{cases} PIS = c_j^* = \max w_{ij}\ ; i = 1, \dots m\ and\ j = 1, \dots n \\ NIS = c_j^- = \min w_{ij}\ ; i = 1, \dots m\ and\ j = 1, \dots n \end{cases} \quad (14)$$

For negative criteria:

$$\begin{cases} PIS = c_j^* = \min w_{ij}\ ; i = 1, \dots m\ and\ j = 1, \dots n \\ NIS = c_j^- = \max w_{ij}\ ; i = 1, \dots m\ and\ j = 1, \dots n \end{cases} \quad (15)$$

Step 3.5: Calculate the distance of the alternatives from PIS (dis_j^+) and NIS (dis_j^-), as follows:

$$dis_j^+ = \sum_{j=1}^{n} d(w_{ij}, PIS) = \sum_{j=1}^{n}(w_{ij} - PIS_j) \quad (16)$$

$$dis_j^- = \sum_{j=1}^{n} d(w_{ij}, NIS) = \sum_{j=1}^{n}(w_{ij} - NIS_j) \quad (17)$$

Step 3.6: Calculate the maximum distance between each alternative and the PIS in each criterion (regret index), as follows:

$$Reg_i = max_j^n\ d(w_{ij}, PIS_j) \quad (18)$$

Step 3.7: Calculate the index of VIKOR, as follows:

$$Q_i = v\left[\frac{dis_i^+ - disP_i^+}{disN_i^+ - disP_i^+}\right] + (1 - v)\left[\frac{Reg_i - Reg_i^+}{Reg_i^- - Reg_i^+}\right] \quad (19)$$

Where, $disP_i^+ = min_i dis^+$,$disN_i^+ = max_i dis^+$,$Reg_i^+ = min_i Reg_i$,$Reg_i^- = max_i Reg_i$ and $v \in [0,1]$.

Step 3.8: Determine the closeness coefficient index for each alternative, as follows:

$$CC_i = \frac{dis_i^-}{dis_i^- + Q_i} \quad (20)$$

Step 3.9: Rank the alternatives: The alternative that has the highest CC_i Represents the optimal one.

4 | Case Study (Result and Analysis)

In 2022, in southern Ukraine near the Dnieper River, specifically in the Russian-occupied city of Kherson, Ukrainian forces needed to gather intelligence and take pictures of the armor, missiles, and heavy weapons that Russia was amassing for war against Ukraine. This was essential to determine their numbers and types and accurately locate the enemy. Therefore, an effective and accurate method was needed to collect information and determine the location. Drones could be utilized to perform these tasks. Our approach was employed to choose the most suitable drone for these situations. In our case study, we will be examining and evaluating four types of military UAVs that are described as candidate alternatives in Table 3. A team of four experts with high knowledge and experience in the fields of military, mechanical engineering, and artificial intelligence (as represented in Table 2) will evaluate the alternatives based on five criteria (as represented in Table 4).

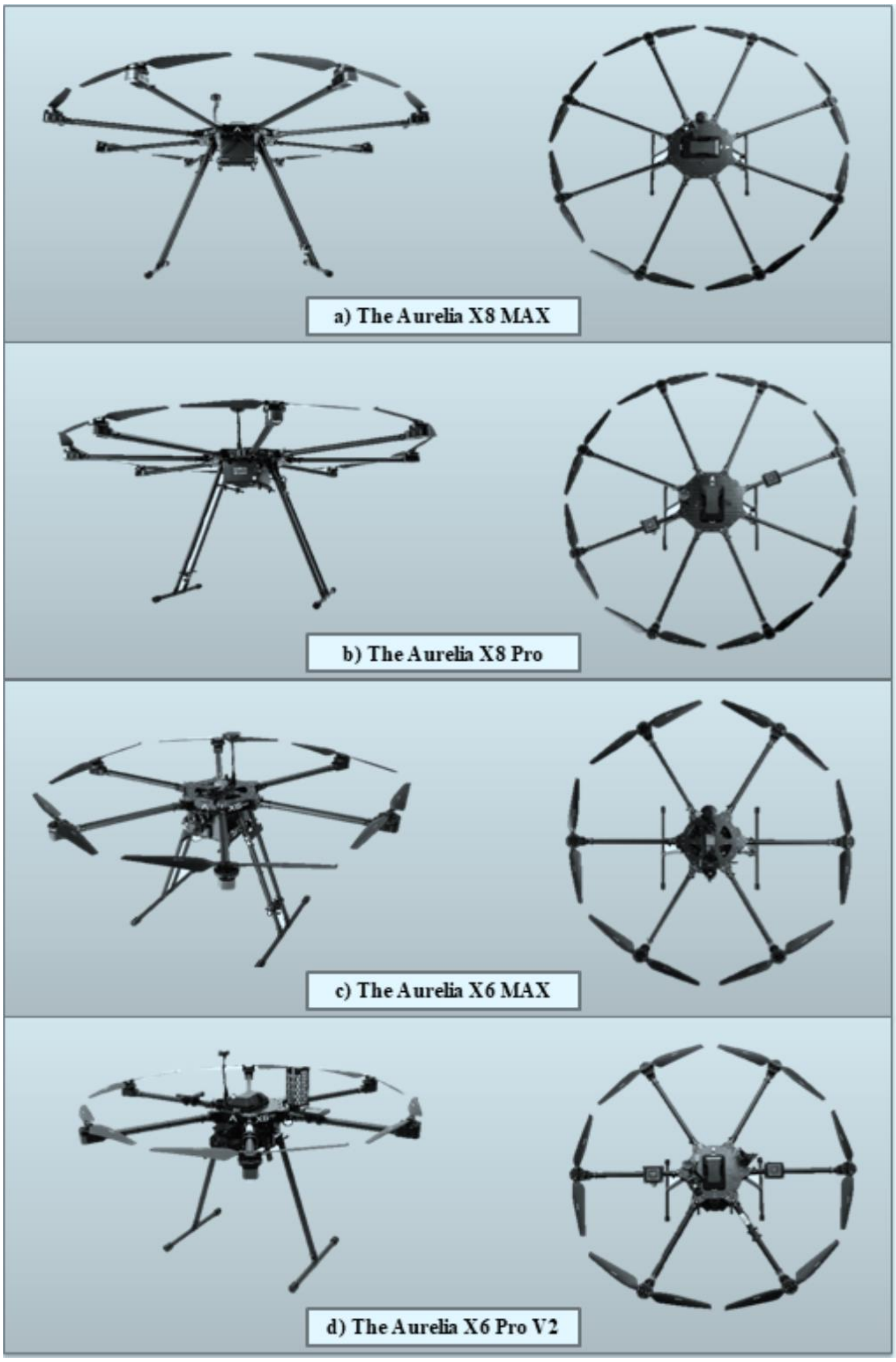

Figure 3. Types of UAVs used in the military field.

Table 2. Expert information.

Expert	Degree	Field
$\boldsymbol{Exp1}$	PhD	Aeronautical Engineering
$\boldsymbol{Exp2}$	PhD	Mechanical engineering
$\boldsymbol{Exp3}$	PhD	Artificial intelligence
$\boldsymbol{Exp4}$	PhD	Military Aeronautical Engineering

Table 3. Alternatives and their description.

Alternatives	Name	Features
Alter 1	The Aurelia X8 MAX	Carry up to 11 kg (24 lb.) payload. Up to 50 minutes of flight time 5 km (3 mi) range Octocopter 8-rotor design for further redundancy and reliability Single GPS Setup Fixed landing gear setup It costs about 9.718,95€
Alter2	The Aurelia X8 Pro	Carry up to 10 kg (22 lb) Up to 50 minutes of flight time 5 km (3 mi) range Octocopter 8-rotor design for further redundancy and reliability Dual GPS Setup for high-precision accuracy Custom-built retracting landing gear. It costs about 15.885,95€
Alter 3	The Aurelia X6 MAX	Premium parts are used in the X6 MAX to provide longer flying times, greater payload weight, improved performance, and increased precision. Carry up to 6 kg (13 lb) Up to 70 minutes of flight time 5 km (3 mi) range Hexacopter 6-rotor design for redundancy and reliability Can be fully customized to any need It costs about 7.849,95 €
Alter 4	The Aurelia X6 Pro V2	Carry up to 6 kg (13 lb) payload Up to 70 minutes of flight time 5 km (3 mi) range Drone Rescue System (Parachute) Dual U.S.-Made F9P GPS Modules 6x Obstacle Avoidance Sensors Garmin LiDAR for Terrain Following ADS-B Aircraft Detect and Avoid Modules Hexacopter 6-rotor design for redundancy and reliability It costs about 13.082,95€

Table 4. The criteria definition.

ID	Criteria	Type
$\boldsymbol{Crit1}$	Operating range	Max
$\boldsymbol{Crit2}$	Real-time Data Transmission	Max
$\boldsymbol{Crit3}$	Flight Time	Max
$\boldsymbol{Crit4}$	Payload mass	Max
$\boldsymbol{Crit5}$	Cost	Min

SVTN-LMAW approach for criteria weight: Four experts used the trapezoidal neutrosophic number scale in Table 1 and Eq. (11) to rank the criteria based on their significance. The computation of the trapezoidal neutrosophic for criteria priority is shown in Table 5. Table 6 indicates that four professionals conducted the examination, resulting in the establishment of four priority vectors.

For instance: the first expert $Exp1$ assesses $Crit2$ as Definitely Significant (DS) to rank it. Single-valued trapezoidal neutrosophic numbers (SVTN) have lower, median1, median2, and upper values of 7, 7.5, 8, and 9, respectively. With a truthiness degree = 0.90, an indeterminacy degree of 0.10, and a falsity degree of 0.10,, the expert's judgment has a very firmly significant (VFS) validation degree. Equation 11's scoring function allows us to compute the clear value in the following way:

$$S(A^{\sim}) = \frac{1}{12}[7 + 7.5 + 8 + 9].[2 + 0.9 - 0.1 - 0.1] = 7.0875$$

The third expert $Exp1$ assesses $Crit2$ as Definitely Significant (DS) as well, but his opinion's validation degree is firmly significant (FS), with values of $(T, I, F) = (0.85, 0.15, 0.15)$, thus the clear value is computed as: 6.69375.

This demonstrates the significance of the neutrosophic scale because the criteria cannot be evaluated solely by language information. Then, the association vectors R^{exp} is determined, which were computed using Eqs. (2) and (3) based on the absolute anti-ideal point $\Upsilon^*_{AIPoint}$and the priority vectors $prio^{exp}$.

Table 7 illustrates how the weight coefficient values for each expert are determined using Eqs. (4) and (5).

To find the final weight of the criteria, we calculate the combined vector of the weighted coefficients using Eq. (6), where the first element of the aggregated vector denotes the final weight of $Crit1$, as indicated in Table 8. Here's a tip: we set p and q to 1. Figure 4 illustrates this: The highest criterion,$Crit2$, has a value of 0.248287, while the lowest, $Crit3$, has a value of 0.082097.

Table 5. Single-valued trapezoidal neutrosophic calculation for criteria priority in the LMAW method.

Exp_k	$Crit1$	**SVTN–Number Scale ((L,M1,M2,U); T,I,F)**	**Clear Value**
$Exp1$	VFS;VFS	((6,6.5,7,8); 0.90,0.10,0.10)	6.1875
$Exp2$	FS;S	((5,5.5,6,7); 0.75,0.20,0.20)	4.6020
$Exp3$	FS;FS	((5,5.5,6,7); 0.85,0.15,0.15)	4.9937
$Exp4$	VFS;FS	((6,6.5,7,8); 0.90,0.10,0.10)	5.8437
	$Crit2$	SVTN–Number Scale ((L,M1,M2,U); T,I,F)	Clear Value
$Exp1$	DS;VFS	((7,7.5,8,9); 0.90,0.10,0.10)	7.0875
$Exp2$	VFS;S	((6,6.5,7,8); 0.75,0.20,0.20)	5.3854
$Exp3$	DS;FS	((7,7.5,8,9); 0.85,0.15,0.15)	6.69375
$Exp4$	DS;FS	((7,7.5,8,9); 0.85,0.15,0.15)	6.69375
	$Crit3$	SVTN–Number Scale ((L,M1,M2,U); T,I,F)	Clear Value
$Exp1$	MS;VFS	((2,2.5,3,4); 0.90,0.10,0.10)	2.5875
$Exp2$	VMS;S	((1,1.5,2,3); 0.75,0.20,0.20)	1.4687
$Exp3$	FS;FS	((5,5.5,6,7); 0.85,0.15,0.15)	4.9937
$Exp4$	FS;S	((5,5.5,6,7); 0.75,0.20,0.20)	4.6020
	$Crit4$	SVTN–Number Scale ((L,M1,M2,U); T,I,F)	Clear Value
$Exp1$	VFS;VFS	((6,6.5,7,8); 0.90,0.10,0.10)	6.1875
$Exp2$	FS;S	((5,5.5,6,7); 0.75,0.20,0.20)	4.6020
$Exp3$	FS;FS	((5,5.5,6,7); 0.85,0.15,0.15)	4.9937
$Exp4$	FS;S	((5,5.5,6,7); 0.75,0.20,0.20)	4.6020
	$Crit5$	SVTN–Number Scale	Clear Value

		((L,M1,M2,U); T,I,F)	
$Exp1$	FS;FS	((5,5.5,6,7); 0.85,0.15,0.15)	4.9937
$Exp2$	S;FS	((3,3.5,4,5); 0.85,0.15,0.15)	3.2300
$Exp3$	MS;FS	((2,2.5,3,4); 0.85,0.15,0.15)	2.4437
$Exp4$	S;FS	((3,3.5,4,5); 0.85,0.15,0.15)	3.2300

Table 6. The calculation of $prio^{exp}$ and R^{exp}.

$prio^{exp} = \{\Upsilon_{c1}^{exp}, \Upsilon_{c2}^{exp}, .. \Upsilon_{cn}^{exp}\}$	Value		$R^{exp} = (assv_{crit1}^{exp}, assv_{crit2}^{exp}, \dots assv_{critn}^{exp})$
$prio^1 = (VFS, DS, MS, VFS, FS)$	(6.1875, 7.0875, 2.5875, 6.1875, 4.9937)	R^1	(12.375, 14.175, 5.175, 12.375, 9.987)
$prio^2 = (FS, VFS, VMS, FS, S)$	(4.6020, 5.3854, 1.4687, 4.6020, 3.2937)	R^2	(9. 204, 10.770, 2.937,9.204, 6.587)
$prio^3 = (FS, DS, FS, FS, MS)$	(4.9937, 6.6937, 4.9937, 4.9937, 2.4437)	R^3	(9.987, 13.387, 9.987, 9.987, 4.887)
$prio^4 = (VFS, DS, FS, FS, S)$	(5.8430, 6.6937, 4.6020, 4.6020, 3.2937)	R^4	(11.687, 13.387, 9.204, 9. 204, 6.587

Table 7. Four experts' weight coefficient vectors (w_j).

w_j	w_1^e	w_2^e	w_3^e	w_4^e	w_5^e
w_1	0.216346	0.228025	0.141369	0.216346	0.197913
w_2	0.226985	0.243059	0.110192	0.226985	0.19278
w_3	0.207608	0.234039	0.207608	0.207608	0.143138
w_4	0.216089	0.228026	0.195095	0.195095	0.165696

Table 8. The Final Weight of criteria by LMAW method.

Criteria	$Crit1$	$Crit2$	$Crit3$	$Crit4$	$Crit5$
Final weight	0.230874	0.248287	0.082097	0.225429	0.185823

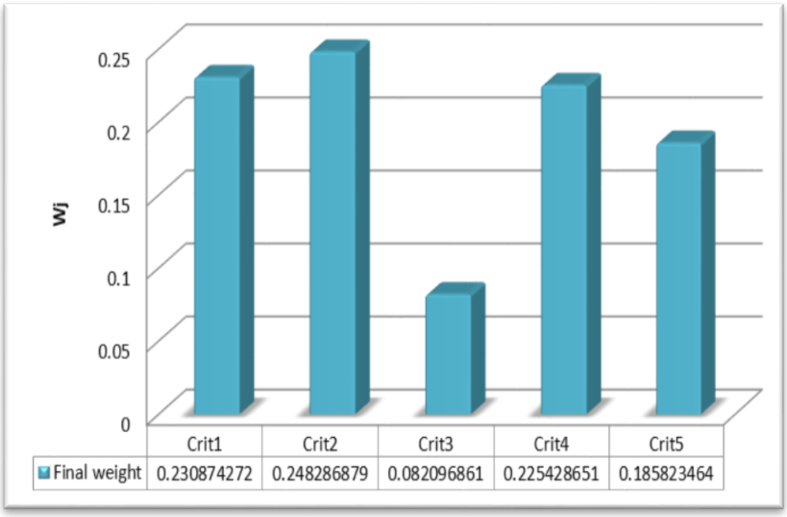

Figure 4. The rank of the criteria is based on the final weight.

SVTN-TOPKOR: To create a final decision matrix requires some steps: The team of experts, represented in Table 2, started evaluating the criteria listed in Table 4. They used the SVTN number scale in Table 1 and applied the score function in Eq. (11) to obtain the precise values of the four decision matrices. The linguistic decision matrices are created based on the expert's opinions as shown in Table 9. Then convert linguistic decision matrices into trapezoidal neutrosophic matrices utilizing the SVTN number scale in Table 1, as shown in Tables (10-13) respectively.

As there are more than SVTN matrices, thus, all SVTN matrices are collected into one aggregated SVTN matrix by utilizing the aggregation function in Eq. (8) and utilizing the SVTN operations in Eqs. (9) and (10). Table 14 shows the aggregated SVTN matrix. By utilizing the score function in Eq. (11) the aggregated SVTN matrix converts into the crisp matrix (final decision matrix) as shown in Table 15. After obtaining the final decision matrix, we calculate the normalized decision matrix by utilizing Eq. (12), as shown in Table 16. After that, the weighted normalized decision matrix is determined utilizing the weights of the criteria we derived from the previous SVTN-LMAW method and Eq. (13), as shown in Table 17, then the PIS and NIS are determined by utilizing Eqs. (14) and (15). Table 18 shows the computations for the SVTN-TOPKOR approach. Note that $v = 0.5$, indicating that the normalized utility index's weight and the normalized regret index's weight are equal. Figure 5 shows the ranking of the alternatives based on the SVTN-TOPKOR approach, where the order of alternatives is as follows: $Alter_2 > Alter_4 > Alter_3 > Alter_1$

Table 9. The linguistic decision matrices by 4 experts.

Expert	$Alter_m$	$Crit1$	$Crit2$	$Crit3$	$Crit4$	$Crit5$
Exp1	Alter 1	MS;FS	FS;FS	S;S	VFS;S	FS;VFS
	Alter2	FS;S	VFS;VFS	FS;VFS	VFS;VFS	FS;VFS
	Alter 3	S;FS	VFS;FS	S;FS	VFS;FS	VFS;VFS
	Alter 4	FS;FS	DS;FS	VFS;VFS	VFS;DS	S;VFS
Expert	Alternatives	$Crit1$	$Crit2$	$Crit3$	$Crit4$	$Crit5$
Exp2	Alter 1	S;MS	S;S	S;FS	FS;S	FS;FS
	Alter2	S;FS	S;VFS	FS;FS	VFS;VFS	FS;FS
	Alter 3	S;S	S;FS	S;VFS	FS;FS	FS;VFS
	Alter 4	S;VFS	FS;VFS	FS;VFS	VFS;DS	MS;VFS
Expert	Alternatives	$Crit1$	$Crit2$	$Crit3$	$Crit4$	$Crit5$
Exp3	Alter 1	FS;S	FS;S	FS;S	S;VFS	S;FS
	Alter2	VFS;S	VFS;FS	FS;FS	FS;S	VFS;FS
	Alter 3	FS;FS	FS;FS	VFS;FS	FS;S	FS;VFS
	Alter 4	VFS;FS	FS;VFS	FS;FS	VFS;VFS	FS;FS
Expert	Alternatives	$Crit1$	$Crit2$	$Crit3$	$Crit4$	$Crit5$
Exp4	Alter 1	FS;MS	S;S	S;FS	VFS;FS	FS;FS
	Alter2	FS;FS	S;VFS	FS;FS	VFS;VFS	FS;FS
	Alter 3	FS;S	S;FS	S;VFS	VFS;VFS	FS;VFS
	Alter 4	FS;VFS	FS;VFS	FS;VFS	VFS;DS	MS;VFS

Table 10. First expert's SVTN decision matrix.

$Alter_m$	$Crit1$
	((L,M1,M2,U); T,I,F)
Alter 1	((2,2.5,3,4); 0.85,0.15,0.15)
Alter2	((5,5.5,6,7); 0.75,0.20,0.20)
Alter 3	((3,3.5,4,5); 0.85,0.15,0.15)
Alter 4	((5,5.5,6,7); 0.85,0.15,0.15)
Al	$Crit2$
$Alter_m$	((L,M1,M2,U); T,I,F)
	((5,5.5,6,7); 0.85,0.15,0.15)
Alter 1	((6,6.5,7,8); 0.90,0.10,0.10)
Alter2	((6,6.5,7,8); 0.85,0.15,0.15)
Alter 3	((7,7.5,8,9); 0.90,0.10,0.10)
$Alter_m$	$Crit3$
	((L,M1,M2,U); T,I,F)
Alter 1	((3,3.5,4,5); 0.75,0.20,0.20)
Alter2	((5,5.5,6,7); 0.90,0.10,0.10)

Alter 3	((3,3.5,4,5); 0.85,0.15,0.15)
Alter 4	((6,6.5,7,8); 0.90,0.10,0.10)
$\boldsymbol{Alter_m}$	$Crit4$
	((L,M1,M2,U); T,I,F)
Alter 1	((6,6.5,7,8); 0.75,0.20,0.20)
Alter2	((6,6.5,7,8); 0.90,0.10,0.10)
Alter 3	((6,6.5,7,8); 0.85,0.15,0.15)
Alter 4	((6,6.5,7,8); 1,00,00)
$\boldsymbol{Alter_m}$	$Crit5$
	((L,M1,M2,U); T,I,F)
Alter 1	((5,5.5,6,7); 0.90,0.10,0.10)
Alter2	((5,5.5,6,7); 0.90,0.10,0.10)
Alter 3	((6,6.5,7,8); 0.90,0.10,0.10)
Alter 4	((3,3.5,4,5); 0.90,0.10,0.10)

Table 11. Second expert's SVTN decision matrix.

$\boldsymbol{Alter_m}$	$\boldsymbol{Crit1}$
	((L,M1,M2,U); T,I,F)
Alter 1	((3,3.5,4,5); 0.50,0.50,0.50)
Alter2	((3,3.5,4,5); 0.85.0.15,0.15)
Alter 3	((3,3.5,4,5); 0.75,0.20,0.20)
Alter 4	((3,3.5,4,5); 0.90,0.10,0.10)
$\boldsymbol{Al}$	$Crit2$
$\boldsymbol{Alter_m}$	((L,M1,M2,U); T,I,F)
Alter 1	((3,3.5,4,5); 0.50,0.50,0.50)
Alter2	((3,3.5,4,5); 0.90,0.10,0.10)
Alter 3	((3,3.5,4,5); 0.85,0.15,0.15)
Alter 4	((5,5.5,6,7); 0.90,0.10,0.10)
$\boldsymbol{Alter_m}$	$Crit3$
	((L,M1,M2,U); T,I,F)
Alter 1	((3,3.5,4,5); 0.85,0.15,0.15)
Alter2	((5,5.5,6,7); 0.85,0.15,0.15)
Alter 3	((3,3.5,4,5); 0.90,0.10,0.10)
Alter 4	((5,5.5,6,7); 0.90,0.10,0.10)
$\boldsymbol{Alter_m}$	$Crit4$
	((L,M1,M2,U); T,I,F)
Alter 1	((5,5.5,6,7); 0.75,0.20,0.20)
Alter2	((6,6.5,7,8); 0.90,0.10,0.10)
Alter 3	((5,5.5,6,7);0.85,0.15,0.15)
Alter 4	((6,6.5,7,8); 1,00,00)
$\boldsymbol{Alter_m}$	$Crit5$
	((L,M1,M2,U); T,I,F)
Alter 1	((5,5.5,6,7); 0.85,0.15,0.15)
Alter2	((5,5.5,6,7); 0.85,0.15,0.15)
Alter 3	((5,5.5,6,7); 0.90,0.10,0.10)
Alter 4	((2,2.5,3,4); 0.90,0.10,0.10)

Table 12. Third expert's SVTN decision matrix.

$\boldsymbol{Alter_m}$	$\boldsymbol{Crit1}$
	((L,M1,M2,U); T,I,F)
Alter 1	((5,5.5,6,7); 0.75,0.20,0.20)

Alter2	((6,6.5,7,8); 0.75,0.20,0.20)
Alter 3	((5,5.5,6,7); 0.85,0.15,0.15)
Alter 4	((6,6.5,7,8); 0.85,0.15,0.15)
Al	$Crit2$
$Alter_m$	((L,M1,M2,U); T,I,F)
	((5,5.5,6,7); 0.75,0.20,0.20)
Alter 1	((6,6.5,7,8); 0.85,0.15,0.15)
Alter2	((5,5.5,6,7); 0.85,0.15,0.15)
Alter 3	((5,5.5,6,7); 0.90,0.10,0.10)
$Alter_m$	$Crit3$
	((L,M1,M2,U); T,I,F)
Alter 1	((5,5.5,6,7); 0.75,0.20,0.20)
Alter2	((5,5.5,6,7); 0.85,0.15,0.15)
Alter 3	((6,6.5,7,8); 0.85,0.15,0.15)
Alter 4	((5,5.5,6,7); 0.85,0.15,0.15)
$Alter_m$	$Crit4$
	((L,M1,M2,U); T,I,F)
Alter 1	((3,3.5,4,5); 0.90,0.10,0.10)
Alter2	((5,5.5,6,7); 0.75,0.20,0.20)
Alter 3	((5,5.5,6,7);0.75,0.20,0.20)
Alter 4	((6,6.5,7,8); 0.90,0.10,0.10)
$Alter_m$	$Crit5$
	((L,M1,M2,U); T,I,F)
Alter 1	((3,3.5,4,5); 0.85,0.15,0.15)
Alter2	((6,6.5,7,8); 0.85,0.15,0.15)
Alter 3	((5,5.5,6,7); 0.90,0.10,0.10)
Alter 4	((5,5.5,6,7); 0.85,0.15,0.15)

Table 13. Fourth expert's SVTN decision matrix.

$Alter_m$	$Crit1$
	((L,M1,M2,U); T,I,F)
Alter 1	((5,5.5,6,7); 0.50,0.50,0.50)
Alter2	((5,5.5,6,7); 0.85,0.15,0.15)
Alter 3	((5,5.5,6,7); 0.75,0.20,0.20)
Alter 4	((5,5.5,6,7); 0.90,0.10,0.10)
Al	$Crit2$
$Alter_m$	((L,M1,M2,U); T,I,F)
	((3,3.5,4,5); 0.50,0.50,0.50)
Alter 1	((3,3.5,4,5); 0.90,0.10,0.10)
Alter2	((3,3.5,4,5); 0.85,0.15,0.15)
Alter 3	((5,5.5,6,7); 0.90,0.10,0.10)
$Alter_m$	$Crit3$
	((L,M1,M2,U); T,I,F)
Alter 1	((3,3.5,4,5); 0.85,0.15,0.15)
Alter2	((5,5.5,6,7); 0.85,0.15,0.15)
Alter 3	((3,3.5,4,5); 0.90,0.10,0.10)
Alter 4	((5,5.5,6,7); 0.90,0.10,0.10)
$Alter_m$	$Crit4$
	((L,M1,M2,U); T,I,F)
Alter 1	((6,6.5,7,8); 0.85,0.15,0.15)
Alter2	((6,6.5,7,8); 0.90,0.10,0.10)

Alter 3	((6,6.5,7,8); 0.90,0.10,0.10)
Alter 4	((6,6.5,7,8); 1,00,00)
$Alter_m$	$Crit5$
	((L,M1,M2,U); T,I,F)
Alter 1	((5,5.5,6,7); 0.85,0.15,0.15)
Alter2	((5,5.5,6,7); 0.85,0.15,0.15)
Alter 3	((5,5.5,6,7); 0.90,0.10,0.10)
Alter 4	((2,2.2,3,4); 0.90,0.10,0.10)

Table 14. The aggregated SVTN matrix.

$Alter_m$	$Crit1$
	((L,M1,M2,U); T,I,F)
Alter 1	((15,17,19,23); 0.50,0.50,0.50)
Alter2	((19,21,23,27); 0.75,0.20,0.20)
Alter 3	((16,18,20,24); 0.75,0.20,0.20)
Alter 4	((19,21,23,27); 0.85.0.15,0.15)
Al	$Crit2$
$Alter_m$	((L,M1,M2,U); T,I,F)
Alter 1	((16,18,20,24); 0.50,0.50,0.50)
Alter2	((18,20,22,26); 0.85,0.15,0.15)
Alter 3	((17,19,21,25); 0.85,0.15,0.15)
Alter 4	((22,24,26,30); 0.90,0.10,0.10)
$Alter_m$	$Crit3$
	((L,M1,M2,U); T,I,F)
Alter 1	((14,16,18,22); 0.75,0.20,0.20)
Alter2	((20,22,24,28); 0.85,0.15,0.15)
Alter 3	((15,17,19,23); 0.85,0.15,0.15)
Alter 4	((21,23,25,29); 0.85,0.15,0.15)
$Alter_m$	$Crit4$
	((L,M1,M2,U); T,I,F)
Alter 1	((20,22,24,28); 0.75,0.20,0.20)
Alter2	((23,25,27,31); 0.75,0.20,0.20)
Alter 3	((22,24,26,30); 0.75,0.20,0.20)
Alter 4	((24,26,28,32); 0.90,0.10,0.10)
$Alter_m$	$Crit5$
	((L,M1,M2,U); T,I,F)
Alter 1	((18,20,22,26); 0.85,0.15,0.15)
Alter2	((21,23,25,29); 0.85,0.15,0.15)
Alter 3	((21,23,25,29); 0.90,0.10,0.10)
Alter 4	((12,14,16,20); 0.85,0.15,0.15)

Table 15. The crisp matrix.

$Alter_m$	$Crit1$	$Crit2$	$Crit3$	$Crit4$	$Crit5$
Alter 1	9.25	9.75	13.70833	18.40833	18.275
Alter2	17.625	18.275	19.975	20.75833	20.825
Alter 3	15.275	17.425	15.725	19.975	22.05
Alter 4	19.125	22.95	20.825	24.75	13.175

Table 16. The normalized decision matrix.

$Alter_m$	$Crit1$	$Crit2$	$Crit3$	$Crit4$	$Crit5$

Alter 1	0.48366	0.424837	0.658263	0.743771	0.72093
Alter2	0.921569	0.796296	0.959184	0.838721	0.632653
Alter 3	0.798693	0.759259	0.755102	0.807071	0.597506
Alter 4	1	1	1	1	1

Table 17. The weighted normalized decision matrix.

$Alter_m$	$Crit1$	$Crit2$	$Crit3$	$Crit4$	$Crit5$
Alter 1	0.111665	0.105481	0.054041	0.167667	0.133966
Alter2	0.212766	0.19771	0.078746	0.189072	0.117562
Alter 3	0.184398	0.188514	0.061992	0.181937	0.111031
Alter 4	0.230874	0.248287	0.082097	0.225429	0.185823

Table 18. The computations for the SVTN-TOPKOR approach.

$Alter_m$	dis_j^+	dis_j^-	Reg_i	Q_i	CC_i	Rank
Alter 1	0.370767	0.051858	0.142805525	1	0.04930107	4
Alter2	0.114924	0.307701	0.050576957	0.067795	0.819452822	1
Alter 3	0.169847	0.252778	0.059772767	0.210431	0.545710802	3
Alter 4	0.074793	0.347832	0.074792891	0.131282	0.725989778	2

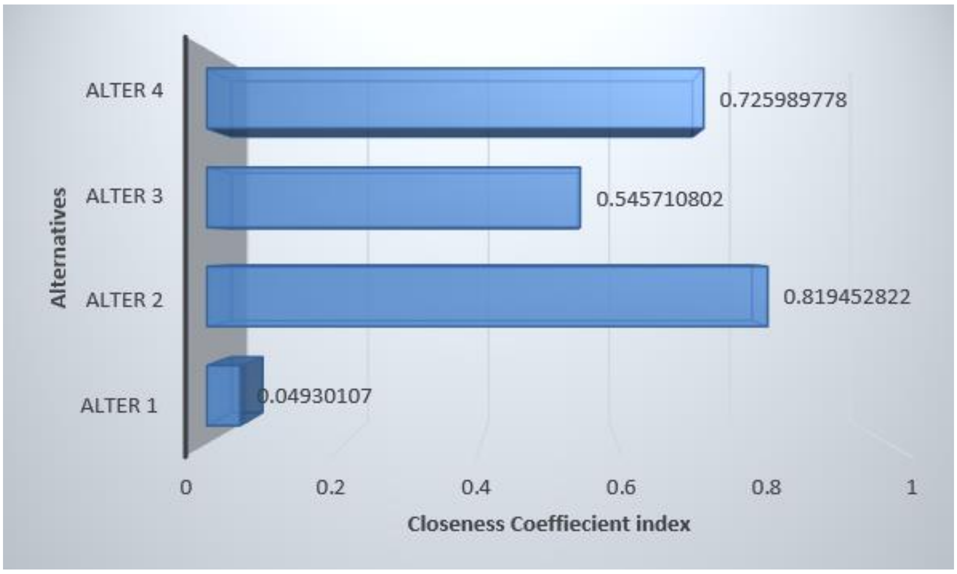

Figure 5. Ranking the alternatives according to the SVTN-TOPKOR approach.

5 | Sensitivity Analysis

A sensitivity analysis of the SVTN–LMAW–TOPKOR data is required to determine the efficacy and efficiency of the recommended approach. This analysis will show how the final ranking of alternatives will be affected by various criteria weights. Seven examples are examined, as depicted in Figure 6. Table 19 shows the Closeness coefficient index values for examples 1 to 7. As a result, the alternatives are ordered. Example 1: To meet the condition$\sum_{i=1}^{n} w_j = 1$, we set the weight of the first criterion, w_1, to 0.5, and the weights of the following criteria, w_2: w_5, to the same value of 0.125. As a result, we found that the alternatives are listed in the following order:$Alter_4 > Alter_2 > Alter_3 > Alter_1$.

Example 2: We assume that the weight of the second criterion,w_2 is equal to 0.5, and that the weights of the other criteria, w_1 and w_3: w_5, have the same value, 0.125. It was discovered that the alternatives are listed in the following order: $Alter_4 > Alter_2 > Alter_3 > Alter_1$.

Example 3: We assume that the third criterion's weight, w_3 is equal to 0.5 and that the weights of the other two criteria, $w_1{:}\,w_2$ and $w_4{:}\,w_5$, are also equal, at 0.125. Consequently, it was discovered that the options are listed in the following order: $Alter_2 > Alter_4 > Alter_3 > Alter_1$

Example 4: To satisfy the condition $\sum_{i=1}^{n} w_j = 1$, we take the weight of the fourth criterion, w_4, to be equal to 0.5, and the weights of the remaining criteria, $w_1{:}\,w_3$ and w_5 are equal in value, which is 0.125. Consequently, it was discovered that the options are listed in the following order: $Alter_4 > Alter_2 > Alter_3 > Alter_1$

Example 5: We assigned a weight of 0.5 to the fifth criterion, w_5, whose type is cost and weights of 0.125 to the other four criteria $w_1{:}\,w_4$. Based on this, the order of the alternatives is as follows: $Alter_2 > Alter_3 > Alter_4 > Alter_1$

We will show how the ultimate ranking of the alternatives is affected when the value of variable v changes.with $v = 0.25$ the order of the alternatives is the same but with$v = 1$, the "The Aurelia X6 Pro V2" is the highest. Stated differently, the SVTN-TOPKOR approach is influenced by the value of v.

Example 6: We will assume that the value of variable v is 0.25 instead of 0.5, using the weight values obtained from the SVTN-LMAW method. Therefore, we have determined the order of the alternatives as follows: $Alter_2 > Alter_4 > Alter_3 > Alter_1$

Example 7: We will assume that the value of variable v is 1 instead of 0.5, using the weight values obtained from the SVTN-LMAW method. Therefore, we have determined the order of the alternatives as follows: $Alter_4 > Alter_2 > Alter_3 > Alter_1$

This study's suggested SVTN-LMAW-TOPKOR strategy shows enough stability for the criterion at different set weights. Also, highlights its influence as the value of variable v changes.

Table 19. Ranking of the alternatives under the sensitivity analysis.

Method	**SVTN -LMAW-TOPKOR**		**Example 1**		**Example 2**		**Example 3**	
$Alter_m$	CC_i	Rank	CC_i	Rank	CC_i	Rank	CC_i	Rank
Alter 1	0.04930107	4	0.033708	4	0.034884	4	0.033708	4
Alter2	0.819452822	1	0.858428	2	0.335871	2	0.86297	1
Alter 3	0.545710802	3	0.454999	3	0.27692	3	0.243881	3
Alter 4	0.725989778	2	0.941093	1	0.42687	1	0.798846	2
Method	Example 4		Example 5		Example 6		Example 7	
$Alter_m$	CC_i	Rank	CC_i	Rank	CC_i	Rank	CC_i	Rank
Alter 1	0.033708	4	0.180837	4	0.049301	4	0.049301	4
Alter2	0.410995	2	1	1	0.900768	1	0.69413	2
Alter 3	0.24538	3	0.758148	2	0.619787	3	0.440431	3
Alter 4	1	1	0.205577	3	0.638511	2	1	1

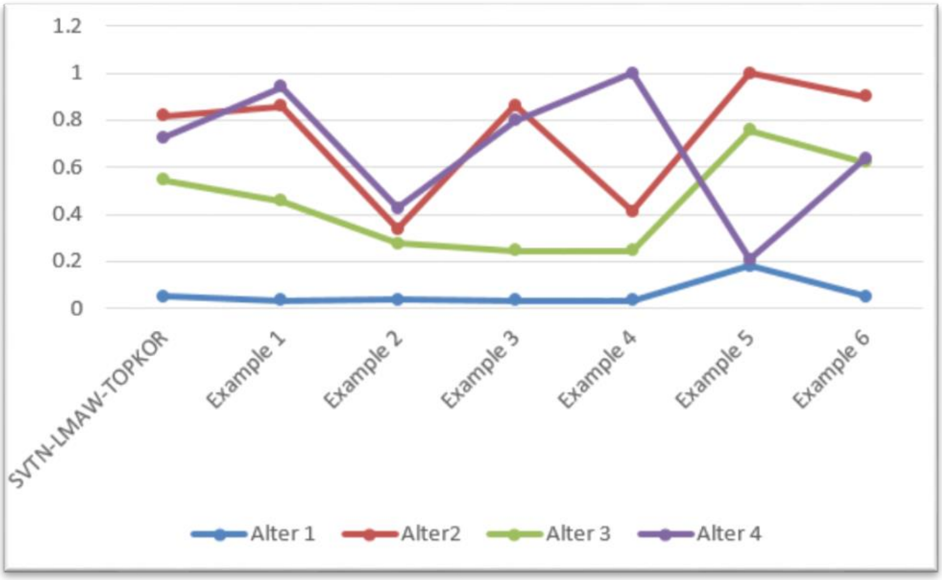

Figure 6. Sensitivity analysis from examples 1 to 7.

6 | Comparative Analysis

The results of many commonly used MCDM approaches for determining criteria weights have been compared with the results of the suggested SVTN-LMAW method. MEREC [28], Entropy [29] and CRITIC [30]. Table 20 displays the criteria weight according to those methods. Figure 7 displays the ranking of the criteria based on those methods, where $Crit5$ represents the highest weight by the CRITIC method, and $Crit4$ represents the highest weight by both the MEREC and Entropy methods.

We compared the result of our proposed SVTN-TOPKOR approach with RAWEC [31], VIKOR [32] and ARAS [33] methods. RAWEC, VIKOR, and ARAS results indicated that $Alter4$ is the best option. Additionally, RAWEC and VIKOR ranked Alter 1 as the worst, while $Alter3$ was ranked lowest by the ARAS method, as displayed in Figure 8. One of the best methods for figuring out whether two ordinal variables are connected or not is to use Spearman's correlation, which we apply to compare the ranks obtained from the two approaches that compute as follows [34]:

$$SpCorrel = 1 - \left[\frac{6.\sum_{m=1}^{A}(diff)^2}{A.(A^2-1)}\right] \quad (14)$$

The value of $SpCorrel$ between SVTN-TOPKOR and ARAS equal to zero meaning the weak correlations while the value of $SpCorrel$ between the SVTN-TOPKOR and both RAWEC and VIKOR is equal to 0.8 which meaning strong correlations. The value of $SpCorrel$ between SVTN-TOPKOR and ARAS equal to zero, meaning weak correlations, while the value of $SpCorrel$ between the SVTN-TOPKOR and both RAWEC and VIKOR is equal to 0.8, meaning strong correlations, as displayed in Table 21.

Table 20. Criterion weights using different methods.

Method / Criteria	SVTN-LMAW	Rank	CRITIC	Rank	MEREC	Rank	Entropy	Rank
$Crit1$	0.230874	2	0.17768502	2	0.13804824	4	0.233654	3
$Crit2$	0.248287	1	0.140470028	4	0.1292957	5	0.10987	5
$Crit3$	0.082097	5	0.173939684	3	0.22140811	3	0.137683	4
$Crit4$	0.225429	3	0.114947349	5	0.2606397	1	0.260273	1
$Crit5$	0.185823	4	0.392957919	1	0.25060825	2	0.25852	2

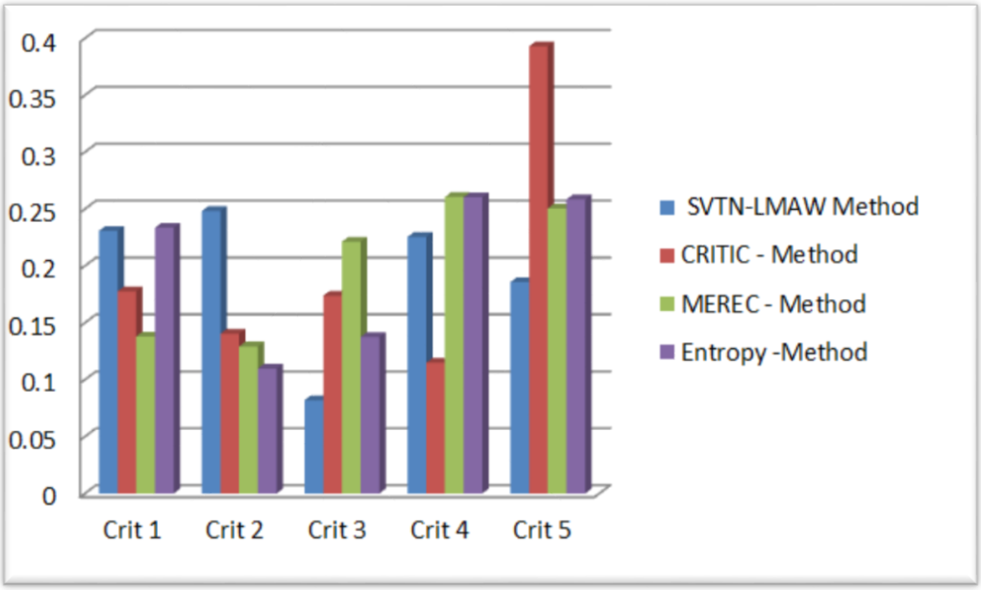

Figure 7. Ranking of the criteria according to different MCDM methods.

Table 21. The value of Spearman correlation coefficient between SVTN-TOPKOR and other methods.

Method	SVTN-TOPKOR		ARAS		RAWEC		VIKOR	
Alternatives	CC_i	Rank	K_i	Rank	Q_i	Rank	Q_i	Rank
Alter 1	0.0493010	4	1.088202	2	-0.852546498	4	1	4
Alter2	0.8194528	1	1.068183	3	0.049104285	2	0.565924	2
Alter 3	0.5457108	3	1	4	-0.033817619	3	0.714642	3
Alter 4	0.7259897	2	1.580167	1	1	1	0	1
Value of $SpCorrel$			0		0.8		0.8	

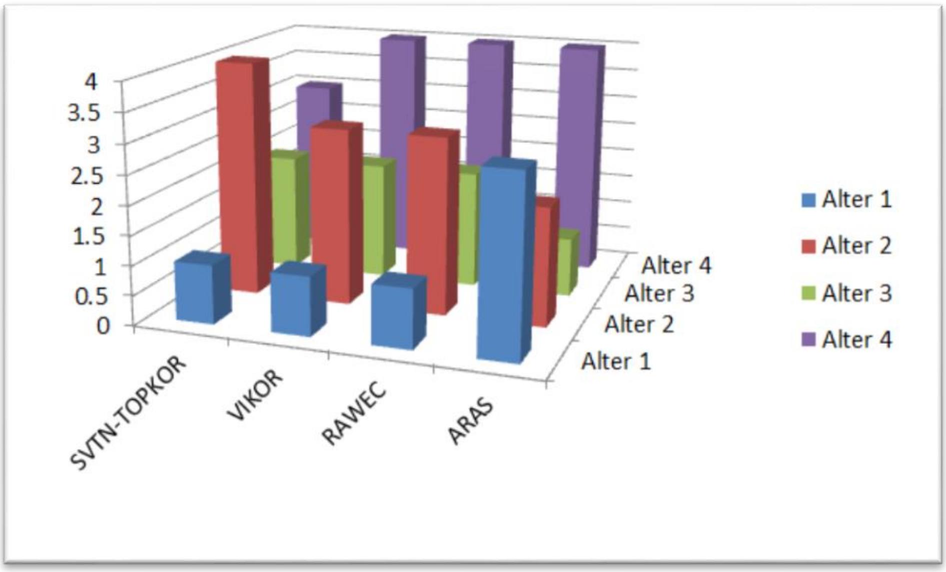

Figure 8. Ranking the alternatives according to various MCDM methods.

7 | Managerial Implications

In recent years, UAVs have made significant and rapid advancements worldwide. Enthusiasts closely monitor these developments. UAVs have diverse applications in civil and military domains, providing a wide range of services to individuals and organizations. These capabilities are contingent upon technological and aviation industry progress. UAVs will become increasingly important in determining the course of international security and defense policies as the market for military UAVs grows due to rising government funding and technological advancements. With technological advancement, experts have realized that UAVs are not just amateur games, but rather are necessary in many vital branches of life, such as modern military wars and defense. They help armies, governments, and defense ministries discover the enemy, defend the homeland, provide real-time information, surveillance, and reconnaissance, and carry out operations on the battlefield. It is also useful for infantry units. The safety and operational strategy of military forces worldwide will undoubtedly continue to improve as military drone technology advances and becomes integrated into various aspects of military logistics and combat.

8 | Challenges and Future Directions

There are several challenges to consider when deploying UAVs for military and defense purposes. The first challenge is ensuring the accuracy and reliability of the data collected. Factors such as sensor quality, picture resolution, and image processing algorithms can affect the consistency and quality of the data obtained by UAVs. It is crucial to ensure the integrity and reliability of the data collected by UAVs to make well-informed military and security decisions. The second challenge is the limited UAV flight time, which is often due to battery life. This constraint can impact the effectiveness of UAV operations. The third challenge is the real-time transmission of intelligence gathered by drones to military commanders through communication channels that are vulnerable to disruption. In the event of a communication breakdown, critical decisions based on the data may not be promptly relayed. Lastly, there is a possibility of adverse effects if UAVs are not operated accurately.

To tackle these challenges, it's crucial to have a comprehensive approach that involves close collaboration among technology developers, governing authorities, and military leadership to ensure the safe, proper, and effective integration of UAVs into military and defense systems.

As a future work, we suggest combining another MCDM method for calculating the weight of criteria with the SVTN-TOPKOR method for ranking the alternatives. In addition, we will focus on developing additional criteria and sub-criteria for decision-making.

9 | Conclusion

The inclusion of drone technology in military tactics can lead to significant improvements in situational awareness, real-time information provision, soldier safety, and battlefield medical care. Therefore, drones are essential for upgrading military operations. However, selecting military drones can be challenging due to the wide array of varieties and technologies available. Therefore, in our research, we have proposed a new method that combines the Single-Valued Trapezoidal Neutrosophic set with the LMAW and TOPKOR approaches for the selection and assessment of UAVs in the military and defense domains. This combination has been effective in reducing decision-making uncertainty. To accurately determine the weight of each criterion based on the decision maker's preferences and eliminate inconsistencies, we have introduced SVTN-LMAW for calculating the weights of criteria. Additionally, to further rank the options and select the optimal one, we have presented SVTN-TOPKOR, which is known for its computational simplicity. The SVTN-TOPKOR method aims to address uncertainty in decision-making in addition to combining the strengths of both the TOPSIS and VIKOR methods. Where, it focuses on the distance between the PIS and the NIS, as well as the total distance of each alternative from the PIS and its maximum distance in each criterion. The selected method was used for an experiment case in which four highly qualified experts assessed four options based on five criteria: operating range, real-time data transmission, flight time, payload mass, and cost. According to the findings, the second alternative is the most suitable for solving the problem.

The results indicate that "The Aurelia X8 Pro" is the top priority. This is because it can carry up to 10 kg (22 lb.), has a flight time of up to 50 minutes, a range of 5 km (3 mi), an octocopter 8-rotor design for extra redundancy and reliability, a dual GPS setup for high-precision accuracy, custom-built retracting landing gear. Also, its cost is acceptable.

10 | Study Restrictions

Although the criteria and the presented decision-making technique may be applied in other nations, the resulting weights for the criteria and alternatives are restricted to the current case study, as is the case with many MCDM problems.

Acknowledgments

The author is grateful to the editorial and reviewers, as well as the correspondent author, who offered assistance in the form of advice, assessment, and checking during the study period.

Author Contributions

All authors contributed equally to this work.

Funding

This research has no funding source.

Data Availability

The datasets generated during and/or analyzed during the current study are not publicly available due to the privacy-preserving nature of the data but are available from the corresponding author upon reasonable request.

Conflicts of Interest

The authors declare that there is no conflict of interest in the research.

Ethical Approval

This article does not contain any studies with human participants or animals performed by any of the authors.

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