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*Research article*

# Location selection criteria for a military base in border region using N-AHP method

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**Abstract:** The existence of natural gas and rare mineral reserves, energy transmission lines, and sacred places within its borders makes that geography a target for other countries, whether neighboring or not. These countries spend most of their budgets on war technologies and good defense. There are many factors to consider when choosing the location of a military base, which is vital in terms of both defense and logistic support. This study aimed to determine the criteria that should be taken into account in determining the borderline security and selecting the location of military bases of great strategic importance by getting rid of the disadvantages of classical decision-making processes. For this purpose, a solution to the problem was sought with the method obtained by combining the AHP method, one of the latest approaches in the decision-making process, with neutrosophic logic. In order to enable the experts to cope with uncertain information and to prevent errors in preference values due to differences in individual approaches, three expert opinions were obtained and the Delphi method was used to increase the advantages of the neutrosophic analytic hierarchy process (N-AHP) method by utilizing the degree of consensus. Expert opinions were received to determine, prioritize, and group the criteria using the Delphi method, and after these criteria were analyzed, their importance levels were determined by weighting the criteria using the N-AHP method. Thus, an important study in which these two compatible methods were used together for the establishment of a military base was presented to researchers. When the criteria weights of the 12 sub-criteria are analyzed, it was concluded that ease of logistics access is the most important criterion for base location selection.

**Keywords:** neutrosophic set theory; triangular neutrosophic numbers; delphi technique; analytic neutrosophic hierarchy process (AHP); decision process
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## 1. Introduction

Since the beginning of human history, the concept of security has been a very important concept to maintain its existence. With the transition from cities to the concept of country, security has turned into a structure that needs to be carried out more systematically. The concept of security actually represents the power of a country [1]. Although the concept of security implies defense, the security of many countries is based on the idea that the best defense is offense, and that countries will ensure their security by attacking with appropriate strategies in proportion to their power [2]. The presence of security forces with superior equipment and technology is interpreted as the country having a strong defense system, as it creates a deterrent against hostile approaches [3]. In addition, countries resort to different additional methods to ensure security. For example, many countries are involved in agreements and alliances in different ways in line with their own interests and security needs, and sometimes they leave these alliances [4]. Country administrators take steps by considering the need to establish a global balance of power and ensure regional security to ensure national security, and for this, they go beyond the land borders and participate in agreements to protect the seas around their countries [5]. The most realistic way to ensure national security is to follow a policy that takes into account the regional and global balances as well as the ethnic issues of the countries [6]. These sensitive decisions and policies are also directly related to military action steps.

Today, while many countries are calling for disarmament and peace, they also create attack systems with advanced technologies, including nuclear weapons, and argue that they have established defense systems. In other words, the policies of the countries regarding the desire to be stronger take place before the peace efforts. With these thoughts, the European Commission started the European Defense Action Plan in 2016 to ensure the development of a competitive and innovative defense industry and strong defense technology [7]. Therefore, it was proposed that the military facilities and technologies that are a part of the defense system could be developed and inspected by a control mechanism.

Armed conflicts are one of the primary methods of winning the struggle for power. It is a known fact that some countries use terrorist groups in attacks. Terrorist organizations are part of plans to take over strategically located countries, and this is the biggest reason for the compulsory development of the defense industry of many countries [8]. In addition, the fight against terrorism is among the reasons for the disintegration or extinction of countries that could not overcome the economic crisis in this century. It is clear that in an attack on any country, infrastructure and communication networks will be targeted along with military facilities [9]. From the opposite side, the enemy forces must have good intelligence and use advanced surveillance technologies to reach their targets. In addition, the collapse of the information system in the region that is to be captured by cyber-attacks and the subsequent rapid destruction of people with weapons of mass destruction before they even realize what is happening are shameful events for humanity.

Considering that the period of military threat and the beginning of wars cannot be known and that the first periods of wars are the most intense, governments should deploy their forces before the war to achieve their war aims [10]. It should be noted here that the choice of location where countries will position their military facilities is of critical importance in terms of cross-border operations and defense of strategically located places. The effect of environmental degradation, epidemics, and natural events such as earthquakes play a decisive role in the positioning of military facilities. For this, countries in geographies that are especially under threat need to gain military facilities and technologies that can adapt to the rapidly developing conditions of their armies. One of the technologies developed for the protection of established facilities is the unmanned aerial vehicle (UAV). UAV defense systems are deployed to guard from threats, unfriendly missions, or intrusions into a confined space [11]. Fixed-wing UAVs, which can take off and land vertically with an electric motor with an increased capacity, provide a great advantage in terms of border defense and operability thanks to their ability to stay in the air for much longer. With UAVs capable of performing intelligence gathering, reconnaissance, and surveillance missions, a great advantage is gained against the enemy [12]. In addition to a dynamic army, modern and advanced equipment that will ensure the safety of the facilities, the army, and the people should be available at all times. Modern and robust facilities and the presence of an army equipped with the latest technology are extremely important in terms of maintaining the confidence of the people. With the good use of artificial intelligence and machine learning methods and the strong information technology infrastructure of the army, superiority can be achieved in both defense and war [13].

A country planning a cross-border operation for whatever purpose must have the means to transport troops and equipment to the bases from the air and ground in case of any conflict and have the necessary stock for a long-term struggle. Here, it is important to create a defense mechanism that should be established by anticipating the actions of the enemy. While the army is dealing with any cross-border operation, attacks from other borders and internal turmoil are among the possible possibilities. In addition, both cyber and physical attacks on the electrical grid pose serious problems [14]. For this reason, the need of critical examination of security issues is revealed to prevent possible threats or failures [15]. In other words, military facilities must have a structure established with the latest technology and their continuity must be ensured by constantly updating them.

In the United nations (UN) Charter, which aims to ensure justice in the international system after World War II and to resolve all kinds of conflicts by resorting to more peaceful means, the expression “use of force” was included instead of the expression “war”, and thus it was aimed to prevent armed interventions that do not involve war in [16]. According to the article, the state that wants to exercise its right of self-defense must notify the United Nations Security Council (UNSC) about the content of the operation before using its right arising from international law. On the other hand, to protect border security, countries are trying to ensure border management by establishing a “National Coordination and Joint Risk Analysis Center”, as well as electro-optical watchtowers and reconnaissance surveillance vehicles at the border [17]. In addition, the establishment of “community centers” for the economic and social integration of people forced to migrate into the country is also important in terms of border management [18]. Example: Turkey-Syria border. The existence of a state of the art military facility, which is of great importance in terms of ensuring border security in such geographies, is necessary not only in times of war but also in times of peace.

Countries taking precautions against threats outside their borders affects the issue of “international relations” in [19]. Since there is no clear legal procedure determined by the UNSC regarding the trial and extradition of foreign terrorist fighters, the trial and extradition situation is based on each country's domestic law and bilateral agreements with other countries [16]. However countries' efforts towards border security disturb other countries and various sanctions are imposed to prevent these efforts. On the other hand, countries that provide weapons and economic support to terrorist groups due to conflicts of interest will see that these groups pose a threat to their own countries after a certain period. Some countries have chosen to act together against these and similar external threats. For example, agreements determining maritime jurisdiction areas have been signed between some countries that want to own hydrocarbon fields and act in line with their common interests [20]. While some coastal countries had not previously felt the need to declare maritime authority over the regions, which is the continuation of their territorial lands, they later had to declare their continental shelves, due to conflicts of interest and violations of rights. One of the important issues to be considered while establishing a base for the army is the protection of wildlife and ecosystem. Because it is not fully know what countries can do with the secretly developed war technologies and harmful substances. It is extremely worrying that civil unrest occurs in strategically important regions in coastal countries where bilateral agreements have been signed and that natural disasters are said to be the result of climate change. In addition, unfavorable conditions in the country, such as internal wars, a worsening financial system, and a drastic reduction in water riches, have also resulted in susceptibility to various soil-transmitted diseases [21]. For this reason, military forces, which play a major role both during epidemic periods and in preventing internal unrest, need to be deployed taking into account the strategic location of the region.

After giving information about the requirements, difficulties, and characteristics of establishing a military base and the reasons for choosing the subject of the study, the theoretical background of the methodology to be applied will now be discussed.

Decision-making is defined as the choice made by individuals, groups, or organizations among possible actions [22]. Moreover, the decision-making process is “the process of choosing the most optimal alternative by weighing the relevant alternatives in terms of their advantages and disadvantages, after thinking analytically about how a person should act in the face of any situation or problem” [23]. Rationality in the decision-making process is characterized by examining the alternatives in detail with their quantities and values and evaluating them reasonably [24–27]. Decision makers widely employ these methods they are supple enough to be used for almost any decision problem. Some of the multi-criteria decision-making methodologies are the analytical hierarchy process (AHP), analytical network process (ANP) and preference ranking methods based on similarity (TOPSIS).

The first goal in multi-criteria decision-making (MCDM) problems is to determine the weight or superiority situations to choose among various alternatives by taking into account more than one criterion. In 1968, The AHP was first studied by Myers and Alpert, and then Saaty, in 1977 developed it as a model and made available for use in solving decision-making problems [28,29]. The AHP method is considered a ratio-scale measure theory with the principle of obtaining comparison scale weights by making “pairwise comparisons” between elements in a hierarchical structure consisting of criteria and choices. The inclusion of decision makers' opinions in the decision process in AHP is the superiority of this method over other decision-making methods. Among the different types of MCDM procedures, the AHP method is one of the most popular ways for investigators. The AHP method has a wide application area in the literature due to its ability to collectively model abstract and concrete judgments in studies. Illustrative samples of decision problems where AHP is used are healthcare quality assessment [30], gun selection [31], assessment of quality prizes [32], etc.

The AHP model aims to help decision makers analyze various location situations, evaluate, and select alternatives. However, this concept has followed a process of evolution in parallel with the change and development in decision-making processes. The classical AHP model was evaluated first with fuzzy and then with intuitionistic fuzzy concepts in line with the needs, and since these were inadequate, it was moved to neutrosophic structures. Examples of the first studies on fuzzy extensions of AHP include Van Laarhoven and Pedrycz's studies in 1983 [33] and Buckley's studies in 1985 [34]. In the late 90s, Chang offered a scope analysis of the fuzzy AHP in [35] and Xu and Liao expanded AHP to intuitionistic fuzzy theory in [36]. AHP and neutrosophic structures are merged into an integrative pattern called neutrosophic AHP (N-AHP) in [37]. Neutrosophic structures put forward by Smarandache in [38] as a generalization of the fuzzy set are expressed with three parameters called truth, falsity, and uncertainty. Since there are many situations of uncertainty and instability in life, real-life applications of neutrosophic structures are very useful and necessary. For some daily life applications of neutrosophic numbers, see [39–41].

The location selection of a civil or military facility has strategic importance, and in fact, this situation is a multi-criteria decision problem. The main objective of this paper is to give a neutrosophic extension of AHP to select a military base location in the border region. Since linguistic evaluations regarding facility location selection include uncertain concepts and uncertainties, it is aimed to solve the problem with the N-AHP method, taking into account the above-mentioned development in decision-making processes.

After briefly introducing the N-AHP method, let us return to the rationale for the selection of our study topic.

Looking at recent wars, it can easily be thought that crowded armies alone are not sufficient. As in the war between Ukraine and Russia, using electromagnetic waves to track smart weapons in recent years has become an important move that will change the course of the war. When the navigation systems that connect aircraft with satellites to detect enemy tanks and troops are disabled using electromagnetic waves, the vehicles become unusable. Communication links with troops are blocked by signals to avoid being targeted by deceptive guided weapons. Using this technology, Israel mixed global positioning system (GPS) signals in its air space with electronic warfare systems to prevent possible missile attacks from nearby or distant countries. Electronic weapons, such as satellite dishes that can be installed in buildings, emit electromagnetic waves to monitor and block communication links and change the course of wars by directing critical weapons. The war between two armies (Russia and Ukraine) with good electronic warfare capabilities, where techniques are developed in real-time, gives important ideas about the location of military bases and the advanced technology they should have during the peace period. It is clear that the military facilities established in the border region play a major role, especially in the success of the military struggle between nearby geographies.

When the literature on establishing a military base is examined, it is seen that some of the studies are related to the physical conditions that the facility must have, while some of them include evaluations only from air, sea or land perspectives. For example, in [42] location selection for a military airport is discussed. In another study, a case study was prepared regarding military forces establishing camps in enemy regions in [43]. In [44] they used the AHP method with geographic information system (GIS) support to position the military.

In the event of the slightest conflict with a country's border neighbors, the presence of a military base close to the border is extremely important for the return of air and ground vehicles, no matter how advanced the technology, and for making the necessary modifications immediately. Timely delivery of the needed materials to the soldiers and the robustness of the communication network between the center and the soldiers are important reasons that bring the army closer to winning the war. When evaluated from this perspective, the decisions made by experts gain importance in determining the location where the military facility will be established.

The main purpose of the Delphi method, which we used to complement the N-AHP method in our study, is to reveal and refine group judgments [45]. For explanations on how to use the Delphi method, see [46]. The Delphi method is a method used to assist decision-makers, which enables the most appropriate decision to emerge as a result of the consensus of experts.

Now, studies in the literature where different approaches are applied regarding the establishment of military facilities will be mentioned. In [47], they aimed to choose the most appropriate place to establish a disaster management and support base necessary to combat natural disasters and non-natural threats in a selected region close to the border. For this purpose, they used the Fuzzy AHP method. Bojer et al. used an intuitionistic fuzzy decision matrix for military strategic location selection with the help of AHP, GIS, and machine learning algorithms in their study in which they conducted a case study in [48]. In [49], ANP and TOPSIS methods were applied to obtain the location criteria for establishing a UAV Base on land to ensure security and defense at sea. In another naval base study, it is aimed to evaluate the alternatives for determining the locations of the docks and offices of naval bases in a selected region with both qualitative and quantitative factors in [50]. In [51], DEMATEL-ANP and MAIRCA method were used to select the location where military ammunition depots would be established. As can be seen, there are studies that benefit from the ease of use of the AHP method in military facility construction, as well as studies that apply one or more of other multiple decision-making methods. Our opinion here is that researchers trying to overcome the limitations of the classical method do not follow the process that starts with fuzzy logic but try methods they reach with different perspectives.

This study, prepared with approaches known in the literature as N-AHP and Delphi method, is an original study for the location selection of a military facility to be established to protect the border lines that have strategic importance for the security of the regions. It is aimed to conduct a study to determine the necessary criteria for location selection when it is desired to establish a military base in the border region. For this purpose, the opinions of 3 experts were taken and analyzed with the Delphi method and it was decided what the main criteria and sub-criteria should be. Delphi technique in three stages has been realized. All criteria were then weighted utilization N-AHP steps and the global weighting was used to determine which of these criteria was the most important based on expert opinions.

The main contributions of the article to the literature are as follows:

- Our study is an original study in which N-AHP and Delphi methods are applied using triangular single-valued neutrosophic numbers regarding the establishment of military facilities on the border line.
- In order to eliminate the disadvantages of the traditional AHP method and include the opinions of decision makers in the applications, we applied the steps of the current N-AHP and Delphi approach, which Abdel-Basset et al introduced to the literature in 2017 with the use of trapezoidal numbers, with an approach that also includes the single-valued triangular neutrosophic concept.
- We applied the methods used by Abdel-Basset et al. for the decision-making process regarding search engines by using different neutrosophic numbers on a current problem, taking into account the endless wars in different geographies.
- In decision-making research on neutrosophic sets, when solutions to daily life problems are sought by taking into account all issues such as accuracy, inaccuracy and uncertainty, neutrosophic

sets develop a more valid solution than fuzzy and intuitionistic fuzzy sets. For this reason, the N-AHP method was preferred instead of the classical AHP model.

The design of the study is as follows. In Section 2, a brief summary of some basic definitions of neutrosophic set theory are given. In Section 3, the methodology of the decision-making model using the N-AHP method is mentioned. In Section 4, the numerical data of the research conducted by applying the Delphi and N-AHP methods together are explained. Finally, in Section 5, the comparison of the research with previous studies and future studies are given.

## 2. Preliminaries

In this part, the basic definitions containing neutrosophic set, triangular neutrosophic numbers, and operations on triangular neutrosophic numbers are defined.

**Definition 2.1.** [52,53] *Let $\psi$ be a space of points and $x \in \psi$. A neutrosophic set $\tilde{B}$ in $\psi$ is definite by a truth-membership function $t_{\tilde{B}}(x)$, an indeterminacy-membership function $i_{\tilde{B}}(x)$, and a falsity-membership function $f_{\tilde{B}}(x)$. $t_{\tilde{B}}(x), i_{\tilde{B}}(x)$, and $f_{\tilde{B}}(x)$ are real standard or real nonstandard subsets of $\left]-0,1^+\right[$. That is $t_{\tilde{B}}(x):\psi \to \left]-0,1^+\right[$, $i_{\tilde{B}}(x):\psi \to \left]-0,1^+\right[$, and $f_{\tilde{B}}(x):\psi \to \left]-0,1^+\right[$. There is no restriction on the sum of $t_{\tilde{B}}(x), i_{\tilde{B}}(x)$ and $f_{\tilde{B}}(x)$ so $-0 \le \sup t_{\tilde{B}}(x) + \sup i_{\tilde{B}}(x) + \sup f_{\tilde{B}}(x) \le 3^+$.*

**Definition 2.2.** [52–54] *Let $\psi$ be a universe of discourse. A neutrosophic set $\tilde{B}$ over $\psi$ is an object taking the form $\tilde{B} = \{\langle x, t_{\tilde{B}}(x), i_{\tilde{B}}(x), f_{\tilde{B}}(x)\rangle : x \in \psi\}$, where $t_{\tilde{B}}(x):\psi \to [0,1], i_{\tilde{B}}(x):\psi \to [0,1]$ and $f_{\tilde{B}}(x):\psi \to [0,1]$ with $t_{\tilde{B}}(x) + i_{\tilde{B}}(x) + f_{\tilde{B}}(x) \in [0^-,3]$ for every $x \in \psi$. The intervals $t_{\tilde{B}}(x), i_{\tilde{B}}(x)$ and $f_{\tilde{B}}(x)$ symbolize the truth-membership degree, the indeterminacy-membership degree, and the falsity membership degree of $x$ to $\tilde{B}$, respectively. For simplicity, a neutrosophic number is symbolized by $\tilde{B} = (\tilde{a}, \tilde{b}, \tilde{c})$, where $\tilde{a}, \tilde{b}, \tilde{c} \in [0,1]$ and $\tilde{a} + \tilde{b} + \tilde{c} \le 3$.*

**Definition 2.3.** [55,56] Suppose that $t_{\tilde{a}}, i_{\tilde{a}}, f_{\tilde{a}} \in [0,1]$ and $a_1, a_2, a_3 \in \Re$ where $a_3 \ge a_2 \ge a_1$. Then, a triangular neutrosophic number, $\tilde{a} = \langle (a_1, a_2, a_3); t_{\tilde{a}}, i_{\tilde{a}}, f_{\tilde{a}} \rangle$ is a special neutrosophic set on $\Re$, whose truth, indeterminacy, and falsity-membership functions are defined as:

$$T_{\tilde{a}}(x) = \begin{cases} t_{\tilde{a}}\left(\dfrac{x - a_1}{a_2 - a_1}\right), & x \in [a_1, a_2] \\ t_{\tilde{a}}, & x = a_2 \\ t_{\tilde{a}}\left(\dfrac{a_3 - x}{a_3 - a_2}\right), & x \in (a_2, a_3] \\ 0, & otherwise \end{cases}, \tag{1}$$

$$I_{\tilde{a}}(x) = \begin{cases} \dfrac{a_2 - x + i_{\tilde{a}}(x - a_1)}{a_2 - a_1}, & x \in [a_1, a_2] \\ i_{\tilde{a}}, & x = a_2 \\ \dfrac{x - a_2 + i_{\tilde{a}}(a_3 - x)}{a_3 - a_2}, & x \in (a_2, a_3] \\ 1, & otherwise \end{cases}, \tag{2}$$

$$F_{\tilde{a}}(x)=\begin{cases}\dfrac{a_2-x+f_{\tilde{a}}(x-a_1)}{a_2-a_1}, & x\in[a_1,a_2]\\ f_{\tilde{a}}, & x=a_2\\ \dfrac{x-a_2+f_{\tilde{a}}(a_3-x)}{a_3-a_2}, & x\in(a_2,a_3]\\ 1, & otherwise\end{cases}, \tag{3}$$

where $t_{\tilde{a}}, i_{\tilde{a}}$ , and $f_{\tilde{a}}$ arethe maximum truth, minimum indeterminacy, and minimum falsity-membership degrees respectively.

**Definition 2.4.** [55–57] *Let* $\tilde{k}=\langle(k_1,k_2,k_3);t_{\tilde{k}},i_{\tilde{k}},f_{\tilde{k}}\rangle$ *and* $\tilde{l}=\langle(l_1,l_2,l_3);t_{\tilde{l}},i_{\tilde{l}},f_{\tilde{l}}\rangle$ *be two triangular neutrosophic numbers and* $\gamma\neq 0$ *be any real number. So,*

*(1) Addition of two triangular neutrosophic numbers*

$$\tilde{k}+\tilde{l}=\langle(k_1+l_1,k_2+l_2,k_3+l_3);t_{\tilde{k}}\wedge t_{\tilde{l}},i_{\tilde{k}}\vee i_{\tilde{l}},f_{\tilde{k}}\vee f_{\tilde{l}}\rangle,$$

*where "* $\wedge$ *" and "* $\vee$ *" show min and max operators, respectively.*

*(2) Subtraction of two triangular neutrosophic numbers*

$$\tilde{k}-\tilde{l}=\langle(k_1-l_3,k_2-l_2,k_3+l_1);t_{\tilde{k}}\wedge t_{\tilde{l}},i_{\tilde{k}}\vee i_{\tilde{l}},f_{\tilde{k}}\vee f_{\tilde{l}}\rangle.$$

*(3) Inverse of triangular neutrosophic number*

$$\tilde{k}^{-1}=\left\langle\left(\frac{1}{k_3},\frac{1}{k_2},\frac{1}{k_1}\right);t_{\tilde{k}},i_{\tilde{k}},f_{\tilde{k}}\right\rangle,$$

*where* $\tilde{k}\neq 0$.

*(4) Multiplication of triangular neutrosophic number by the constant value*

$$\gamma\tilde{k}=\begin{cases}\langle(\gamma k_1,\gamma k_2,\gamma k_3);t_{\tilde{k}},i_{\tilde{k}},f_{\tilde{k}}\rangle, & if \quad \gamma\rangle 0\\ \langle(\gamma k_3,\gamma k_2,\gamma k_1);t_{\tilde{k}},i_{\tilde{k}},f_{\tilde{k}}\rangle, & if \quad \gamma\langle 0\end{cases}.$$

*(5) Division of two triangular neutrosophic numbers*

$$\frac{\tilde{k}}{\tilde{l}}=\begin{cases}\left\langle\left(\frac{k_1}{l_3},\frac{k_2}{l_2},\frac{k_3}{l_1}\right);t_{\tilde{k}}\wedge t_{\tilde{l}},i_{\tilde{k}}\vee i_{\tilde{l}},f_{\tilde{k}}\vee f_{\tilde{l}}\right\rangle, & if \quad k_3\rangle 0,l_3\rangle 0\\ \left\langle\left(\frac{k_3}{l_3},\frac{k_2}{l_2},\frac{k_1}{l_1}\right);t_{\tilde{k}}\wedge t_{\tilde{l}},i_{\tilde{k}}\vee i_{\tilde{l}},f_{\tilde{k}}\vee f_{\tilde{l}}\right\rangle, & if \quad k_3\langle 0,l_3\rangle 0\\ \left\langle\left(\frac{k_3}{l_1},\frac{k_2}{l_2},\frac{k_1}{l_3}\right);t_{\tilde{k}}\wedge t_{\tilde{l}},i_{\tilde{k}}\vee i_{\tilde{l}},f_{\tilde{k}}\vee f_{\tilde{l}}\right\rangle, & if \quad k_3\langle 0,l_3\langle 0\end{cases}.$$

*(6) Multiplication of a triangular neutrosophic number*

$$\tilde{k}\tilde{l} = \begin{cases} \left\langle (k_1 l_1, k_2 l_2, k_3 l_3); t_{\tilde{k}} \wedge t_{\tilde{l}}, i_{\tilde{k}} \vee i_{\tilde{l}}, f_{\tilde{k}} \vee f_{\tilde{l}} \right\rangle, & if \quad k_3 \rangle 0, l_3 \rangle 0 \\ \left\langle (k_1 l_3, k_2 l_2, k_3 l_1); t_{\tilde{k}} \wedge t_{\tilde{l}}, i_{\tilde{k}} \vee i_{\tilde{l}}, f_{\tilde{k}} \vee f_{\tilde{l}} \right\rangle, & if \quad k_3 \langle 0, l_3 \rangle 0 \\ \left\langle (k_3 l_3, k_2 l_2, k_1 l_1); t_{\tilde{k}} \wedge t_{\tilde{l}}, i_{\tilde{k}} \vee i_{\tilde{l}}, f_{\tilde{k}} \vee f_{\tilde{l}} \right\rangle, & if \quad k_3 \langle 0, l_3 \langle 0 \end{cases}.$$

*(7) Power of triangular neutrosophic number*

$$\tilde{k}^{\gamma} = \left\langle \left(\tilde{k}_1^{\gamma}, \tilde{k}_2^{\gamma}, \tilde{k}_3^{\gamma}\right); t_{\tilde{k}}^{\gamma}, 1-\left(1-i_{\tilde{k}}\right)^{\gamma}, 1-\left(1-f_{\tilde{k}}\right)^{\gamma} \right\rangle.$$

## 3. Neutrosophic analytic hierarchy process

The method was formed by using Saaty's AHP technique and neutrosophic sets together. Since classical AHP does not contain the concept of uncertainty and fuzzy AHP does not reflect the thoughts of decision-makers accurately and correctly, the N-AHP method was used to reflect the thoughts of the decision maker accurately and efficiently in [58]. N-AHP can handle qualitative and quantitative criteria. In classical AHP, the scale used to evaluate the criteria is named the nine-point scale and consists of net numbers. In real life, the decision maker cannot determine the net values with different criteria due to a lack of any information or data [36]. Therefore, the neutrosophic AHP scale was found.

The steps of the proposed methodology are theoretically elaborated in the subsections below. The linguistic scale and identical triangular neutrosophic numbers are given in Table 1 below.

Saaty invented the AHP method, which deals with the importance of criteria and sub-criteria according to the degree of importance of the criteria and their sub-criteria between each other with mutual binary matrices. N-AHP is shaped by the evolution of the AHP method. In this method, the pairwise comparison matrices of the criteria are determined using the neutrosophic score scale. According to the N-AHP approach developed by [55], the steps of N-AHP are as follows.

**Table 1.** Neutrosophic triangular scale version of Saaty's scale.

| Saaty scale | Definition | Neutrosophic triangular scale |
|---|---|---|
| 1 | Equally influential | $\tilde{1} = \langle(1,1,1);0.50,0.50,0.50\rangle$ |
| 3 | Slightly influential | $\tilde{3} = \langle(2,3,4);0.30,0.75,0.70\rangle$ |
| 5 | Strongly influential | $\tilde{5} = \langle(4,5,6);0.80,0.15,0.20\rangle$ |
| 7 | Very strongly influential | $\tilde{7} = \langle(6,7,8);0.90,0.10,0.10\rangle$ |
| 9 | Absolutely influential | $\tilde{9} = \langle(9,9,9);1.00,0.00,0.00\rangle$ |
| 2,4,6,8 | Sporadic values between two close scales | $\tilde{2} = \langle(1,2,3);0.40,0.65,0.60\rangle$ |
| | | $\tilde{4} = \langle(3,4,5);0.60,0.35,0.40\rangle$ |
| | | $\tilde{6} = \langle(5,6,7);0.70,0.25,0.30\rangle$ |
| | | $\tilde{8} = \langle(7,8,9);0.85,0.10,0.15\rangle$ |

**Step 1.** Pairwise comparison matrices of the main and sub-factors are created according to the above-mentioned linguistic scale values of the decision makers selected according to their areas of expertise and duration. The neutrosophic pairwise comparison matrix of the main factors and sub-factors is as follows;

$$\tilde{B} = \begin{bmatrix} 1 & \tilde{b}_{12} & \cdots & \tilde{b}_{1n} \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{b}_{n1} & \tilde{b}_{n2} & \cdots & 1 \end{bmatrix}, \tag{4}$$

$\tilde{B}$ satisfies the situation $\tilde{b}_{ji} = \tilde{b}_{ij}^{-1}$ based on the inversion operator defined in Definition 2.4.

**Step 2.** Assessments performed by more than one expert are aggregated by geometric mean. The unified neutrosophic decision matrix equation is calculated according to the following equation:

$$\tilde{k}\tilde{l} = \begin{cases} \left\langle (k_1 l_1, k_2 l_2, k_3 l_3); t_{\tilde{k}} \wedge t_{\tilde{l}}, i_{\tilde{k}} \vee i_{\tilde{l}}, f_{\tilde{k}} \vee f_{\tilde{l}} \right\rangle, & if \quad k_3 \rangle 0, l_3 \rangle 0 \\ \left\langle (k_1 l_3, k_2 l_2, k_3 l_1); t_{\tilde{k}} \wedge t_{\tilde{l}}, i_{\tilde{k}} \vee i_{\tilde{l}}, f_{\tilde{k}} \vee f_{\tilde{l}} \right\rangle, & if \quad k_3 \langle 0, l_3 \rangle 0 \\ \left\langle (k_3 l_3, k_2 l_2, k_1 l_1); t_{\tilde{k}} \wedge t_{\tilde{l}}, i_{\tilde{k}} \vee i_{\tilde{l}}, f_{\tilde{k}} \vee f_{\tilde{l}} \right\rangle, & if \quad k_3 \langle 0, l_3 \langle 0 \end{cases}.$$

Also, N-AHP can be applied in group evaluation [59]. In this situation, the final value is computed with the weighted geometric mean, see Eqs (5) and (6). Weights are used to quantify the importance of every expert criterion, taking into account certain criteria such as expert opinion, knowledge, and effort, among others.

$$\bar{x} = \left( \prod_{i=1}^{n} x_i^{w_i} \right)^{1 / \sum_{i=1}^{n} w_i}. \tag{5}$$

If the weights of the experts get together, that is $\sum_{i=1}^{n} w_i = 1$, Eq (5) converts to Eq (6),

$$\bar{x} = \prod_{i=1}^{n} x_i^{w_i}. \tag{6}$$

**Step 3.** For a matrix whose consistency ratio is at the desired level, the crispy values are found in the following equation:

$$S(\tilde{a}) = \frac{1}{8}[a_3 + a_2 + a_1] \times [2 + t_{\tilde{a}} - f_{\tilde{a}} - i_{\tilde{a}}].$$

**Step 4.** After finding the crispy values, the sum value of every column is computed and each matrix element is divided by the sum of the matrix elements column in which it is found. This is continued up to the last matrix element.

**Step 5.** In the matrix produced after dividing by the sum of the columns, each row is averaged and then the neutrosophic criteria weights are found.

**Step 6.** The consistency of the evaluation matrices between the criteria is calculated. If the consistency ratio $(CR) \leq 0.1$, this means that the comparison matrix is coherent. For this calculation we need the RTI value. This index is varied by Saaty according to the number of criteria in the matrix.

Another detail to take into consideration when using this method is the calculation of the consistency index (CI), as in [59] which is functions according to $\lambda_{\max}$, the maximum eigenvalue of the matrix. Saaty suggests that the coherence of assessments can be identified by equation $CI = \frac{\lambda_{\max} - n}{n-1}$, here $n$ is the order of the matrix. Furthermore, the CR is defined by the equation $(CR) = \frac{CI}{RTI}$, where RTI is determined in Table 2.

**Table 2.** RTI related to every order.

| n | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| RTI | 0.00 | 0.00 | 0.58 | 0.90 | 1.12 | 1.24 | 1.32 | 1.41 | 1.45 | 1.49 |

If $(CR) \leq 0.1$, we can that we can assume that the expert assessment is sufficiently accurate and hence we continue to utilize the AHP.

**Step 7.** After the weights of the main and sub-criteria are computed according to the neutrosophic AHP steps, global criteria weights are determined. Global criteria weights are obtained by multiplying the main criteria weights with the sub-criteria weights. Among these values, the one closest to 1 indicates the most appropriate criterion for us to choose.

## 4. Process

### *4.1. Steps of delphi technique*

Now, we are presenting the stages of the recommended model. The Delphi technique is a method of making predictions or making decisions on a certain subject by taking the opinions of experts in the field. There are several ways to implement the Delphi method. Even though the purpose of the Delphi method is to ask a team of experts for their opinion on a specific subject to build consensus and opinion, it also It was also embraced in the development of the benchmarks [56,60,61]. Delphi survey, containing suggestions from experts on design, improvement and optimization of the survey collecting response. In the presented model, we utilized the Delphi technique to determine and evaluate the criteria and to assess the opinions of the experts. The intent of Delphi methods differs between the assorted disciplines. According to previous research, many disadvantages arise when shown in the range (1–9) of the N-AHP scale by [62]; also, we used a scale from 0 to 1 in our model. Furthermore, N-AHP is used to select priority alternatives.

The steps of our suggested model can be accomplished in the following steps:

To organize the Delphi questionnaire, we should do the following:

***(1) Selection of experts:***

Three experts with a potent background in the field in which the survey was conducted were invoked as participants in the Delphi questionnaire.

***(2) Design the survey:***

We will follow a procedure like in [58]. The survey rounds ranged from five to three, according as to the degree of consensus of the experts. Here, we used only three stages to achieve the maximum degree of consensus of experts.

- The first survey was conceived from the literature comment on the problem area because, according to Kerlinger's view [63], the revised Delphi method is suitable if fundamental information on the objective topic is practicable. The first questionnaire will be asked of each expert in writing. In the first round of the survey, each expert will be asked the following questions: "What are the criteria and sub-criteria of the issue according to the literature comment", "What are the criteria and sub-criteria of the issue according to the literature comment", "What is the order of the gauge in your idea", "Work on the criteria and write your opinion", "Please compose the pecking order of the problem in your idea", and "Send the answer sheet to the research team".

- In the third round of the survey, all experts will be given the criteria from the previous survey and will be invited to reconsider their views and reconstruct the problem hierarchy according to the revised criteria. If there is no change in the expert's previous opinion, we will ask the rationale for this. In the third tour questionnaire, each expert will receive the information and judgments from the previous questionnaire and will be asked to revise their judgments and make a reconstruction of the problem hierarchy according to updated criteria. In the case of keeping an expert on their old opinion, they should give reasons for staying on their opinion. In the final survey, the list of criteria, their order, and final opinions are collected, and experts who do not agree are asked to reconsider their opinions for the last time.

In summary, the opinions of 3 experts on the criteria were collected in writing. Then, their opinions on the criteria were tried to be combined and presented to all three experts in a single list. The experts were then invited to express their comments again. Their opinions were collected again and combined again. This process continued in 3 cycles. In each cycle, the criteria became closer to the final decision list. As a result of the experts' unchanged opinions, the cycle was ended. The final decision list is as follows in Table 3.

**Table 3.** Experts' opinions on the criteria in the first three rounds.

| | 1st round | | 2nd round | | 3rd round | |
|---|---|---|---|---|---|---|
| | Main criteria | Sub-criteria | Main criteria | Sub-criteria | Main criteria | Sub-criteria |
| 1st expert | 5 | 15 | 4 | 13 | 4 | 12 |
| 2nd expert | 5 | 14 | 4 | 14 | 4 | 13 |
| 3rd expert | 4 | 14 | 3 | 13 | 3 | 12 |

In the last round, all experts agreed on 4 main criteria and 12 sub-criteria as in Figure 1.

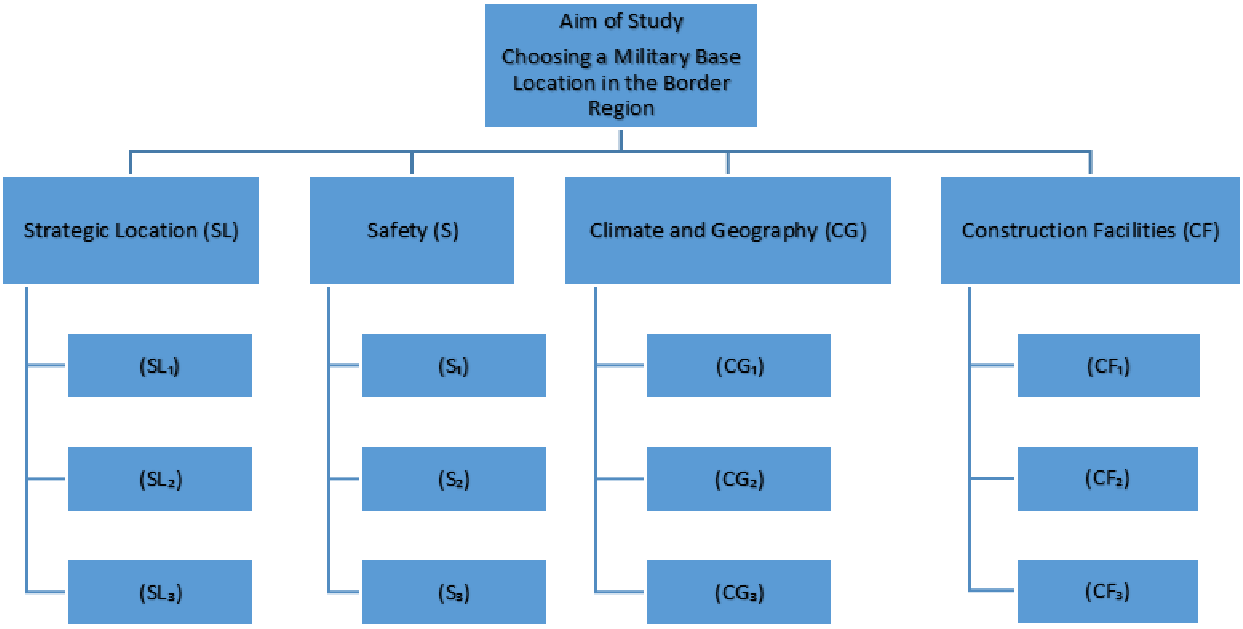


**Figure 1.** Military base location selection model in the border region.

*4.2. Findings*

In this study, the problem of site selection for a military base to be established in the border region is addressed. While addressing the problem, N-AHP, one of the MCDM techniques, which is considered to be suitable for the research topic and provides an evaluation closer to the logic of human thought, was used. The data obtained as a consequence of the implementation of the N-AHP method are given below. The research model required to obtain the data is shown in Figure 1. Within the scope of the aforementioned research design, an entire of 4 criteria were determined. The criteria are shown in Table 4. In this study, the aforementioned methods and calculations related to the model were made through the Microsoft Excel package program. The pairwise comparison matrices required for the N-AHP method were created by taking the comments of three decision-makers. A combined decision matrix was created by taking the geometric mean of the pairwise comparison matrices obtained. The aforementioned geometric averaging process was also used to find the local weights of the main criteria, sub-criteria, and global weights of sub-criteria. Then, the synthetic degree value calculation matrix (S) was obtained for the main criteria, sub-criteria, and global weights. As an example of this calculation, Table 9 shows the synthetic degree value calculation matrix of the main criteria.

The main criteria and sub-criteria for the site selection of a military base to be established in the border region can be determined as in Table 4.

**Table 4.** Table showing sub-criteria and main criteria.

| Main criterion | Sub-criterion |
|---|---|
| Strategic location (SL) | Proximity to the border line ($SL_1$)<br>Lack of geographical barriers ($SL_2$)<br>Ease of logistics access ($SL_3$) |
| Safety (S) | Proximity to threats ($S_1$)<br>Presence of natural barricades ($S_2$)<br>Effectiveness of the intelligence network ($S_3$) |
| Climate and geography (CG) | Weather conditions ($CG_1$)<br>Topography ($CG_2$)<br>Distance from archaeological and settlement areas ($CG_3$) |
| Construction facilities (CF) | Land structure ($CF_1$)<br>Infrastructure facilities ($CF_2$)<br>Availability of natural resources ($CF_3$) |

Below are the pairwise matrices corresponding to the criteria given by the experts in Tables 5–7.

**Table 5.** Pair-wise matrix that meets the criteria set by Expert 1.

| Main criterions | (SL) | (S) | (CG) | (CF) |
|---|---|---|---|---|
| (SL) | ⟨(1,1,1);0.50,0.50,0.50⟩ | ⟨(1,1,1);0.50,0.50,0.50⟩ | ⟨(4,5,6);0.80,0.15,0.20⟩ | ⟨(6,7,8);0.90,0.10,0.10⟩ |
| (S) | ⟨(1,1,1);0.50,0.50,0.50⟩ | ⟨(1,1,1);0.50,0.50,0.50⟩ | ⟨(4,5,6);0.80,0.15,0.20⟩ | ⟨(6,7,8);0.90,0.10,0.10⟩ |
| (CG) | ⟨(1/6,1/5,1/4);0.80,0.15,0.20⟩ | ⟨(1/6,1/5,1/4);0.80,0.15,0.20⟩ | ⟨(1,1,1);0.50,0.50,0.50⟩ | ⟨(1/4,1/3,1/2);0.30,0.75,0.70⟩ |
| (CF) | ⟨(1/8,1/7,1/6);0.90,0.10,0.10⟩ | ⟨(1/8,1/7,1/6);0.90,0.10,0.10⟩ | ⟨(2,3,4);0.30,0.75,0.70⟩ | ⟨(1,1,1);0.50,0.50,0.50⟩ |

**Table 6.** Pair-wise matrix that meets the criteria set by Expert 2.

| Main criterions | (SL) | (S) | (CG) | (CF) |
|---|---|---|---|---|
| (SL) | ⟨(1,1,1);0.50,0.50,0.50⟩ | ⟨(9,9,9);1.00,0.00,0.00⟩ | ⟨(2,3,4);0.30,0.75,0.70⟩ | ⟨(7,8,9);0.85,0.10,0.15⟩ |
| (S) | ⟨(1/9,1/9,1/9);1.00,0.00,0.00⟩ | ⟨(1,1,1);0.50,0.50,0.50⟩ | ⟨(1/6,1/5,1/4);0.80,0.15,0.20⟩ | ⟨(7,8,9);0.85,0.10,0.15⟩ |
| (CG) | ⟨(1/4,1/3,1/2);0.30,0.75,0.70⟩ | ⟨(4,5,6);0.80,0.15,0.20⟩ | ⟨(1,1,1);0.50,0.50,0.50⟩ | ⟨(2,3,4);0.30,0.75,0.70⟩ |
| (CF) | ⟨(1/9,1/8,1/7);0.85,0.10,0.15⟩ | ⟨(1/9,1/8,1/7);0.85,0.10,0.15⟩ | ⟨(1/4,1/3,1/2);0.30,0.75,0.70⟩ | ⟨(1,1,1);0.50,0.50,0.50⟩ |

**Table 7.** Pair-wise matrix that meets the criteria set by Expert 3.

| Main criterions | (SL) | (S) | (CG) | (CF) |
|---|---|---|---|---|
| (SL) | ⟨(1,1,1);0.50,0.50,0.50⟩ | ⟨(9,9,9);1.00,0.00,0.00⟩ | ⟨(6,7,8);0.90,0.10,0.10⟩ | ⟨(6,7,8);0.90,0.10,0.10⟩ |
| (S) | ⟨(1/9,1/9,1/9);1.00,0.00,0.00⟩ | ⟨(1,1,1);0.50,0.50,0.50⟩ | ⟨(9,9,9);1.00,0.00,0.00⟩ | ⟨(7,8,9);0.85,0.10,0.15⟩ |
| (CG) | ⟨(1/8,1/7,1/6);0.90,0.10,0.10⟩ | ⟨(1/9,1/9,1/9);1.00,0.00,0.00⟩ | ⟨(1,1,1);0.50,0.50,0.50⟩ | ⟨(1,1,1);0.50,0.50,0.50⟩ |
| (CF) | ⟨(1/8,1/7,1/6);0.90,0.10,0.10⟩ | ⟨(1/9,1/8,1/7);0.85,0.10,0.15⟩ | ⟨(1,1,1);0.50,0.50,0.50⟩ | ⟨(1,1,1);0.50,0.50,0.50⟩ |

Above are the statements of pairwise comparisons of the main criteria according to the experts. The details of the calculation according to the N-AHP method are explained through this example.

Here, the neutrosophic numbers corresponding to each linguistic expression are geometrically averaged to form a combined matrix in Table 8.

**Table 8.** Geometric averaged combined matrix.

| Main criterions | (SL) | (S) | (CG) | (CF) |
|---|---|---|---|---|
| (SL) | ⟨(1,1,1);0.79,0.21,0.21⟩ | ⟨(4.33,4.33,4.33);0.79,0.21,0.21⟩ | ⟨(3.63,4.72,5.77);0.67,0.37,0.33⟩ | ⟨(6.32,7.32,8.32);0.95,0.03,0.05⟩ |
| (S) | ⟨(0.23,0.23,0.23);0.79,0.21,0.21⟩ | ⟨(1,1,1);0.79,0.21,0.21⟩ | ⟨(1.82,2.08,2.38);0.93,0.05,0.07⟩ | ⟨(6.65,7.65,8.65);0.95,0.03,0.05⟩ |
| (CG) | ⟨(0.17,0.21,0.28);0.67,0.37,0.33⟩ | ⟨(0.42,0.48,0.55);0.93,0.05,0.07⟩ | ⟨(1,1,1);0.79,0.21,0.21⟩ | ⟨(0.79,1.00,1.26);0.67,0.37,0.33⟩ |
| (CF) | ⟨(0.12,0.14,0.16);0.95,0.03,0.05⟩ | ⟨(0.12,0.13,0.15);0.95,0.03,0.05⟩ | ⟨(0.79,1.00,1.26);0.67,0.37,0.33⟩ | ⟨(1,1,1);0.79,0.21,0.21⟩ |

**Table 9.** Synthetic degree value calculation matrix for main criteria (S).

| Main criterions | (SL) | (S) | (CG) | (CF) |
|---|---|---|---|---|
| (SL) | 0.89 | 3.86 | 3.48 | 7.85 |
| (S) | 0.21 | 0.89 | 2.20 | 8.21 |
| (CG) | 0.16 | 0.51 | 0.89 | 0.75 |
| (CF) | 0.15 | 0.14 | 0.75 | 0.89 |
| Sum of column values | 1.41 | 5.41 | 7.32 | 17.70 |

Chang's synthetic degree value calculation method for the nth object is then calculated according to the following equation:

$$\text{Snak: } \frac{1}{8} \times (1+1+1) \times (2+0.79-0.21-0.21) = 0.89.$$

According to the column total value, every member in the matrix is divided by with the total value of the columns in which it is located, and the following Table 10 is obtained.

**Table 10.** Table obtained by dividing each member by the total value of the columns.

| | (SL) | (S) | (CG) | (CF) |
|---|---|---|---|---|
| (SL) | 0.63 | 0.71 | 0.47 | 0.44 |
| (S) | 0.15 | 0.17 | 0.30 | 0.46 |
| (CG) | 0.12 | 0.09 | 0.12 | 0.04 |
| (CF) | 0.11 | 0.03 | 0.10 | 0.05 |

According to the table above, the row average of each row is found, so the criteria weights are calculated and the below Table 11 is obtained.

**Table 11.** Criteria weights.

| | (SL) | (S) | (CG) | (CF) |
|---|---|---|---|---|
| Weights | 0.57 | 0.27 | 0.09 | 0.07 |

When the practical steps shown above as an example are applied to all main and sub-criteria and evaluated in the opinion of experts respectively, the weights in the Table 12 below are obtained.

**Table 12.** The details of the coherent calculation for the quality sub-criterion.

| Main criterions | (SL) | (S) | (CG) | (CF) | Weights | S×W | (S×W)/W |
|---|---|---|---|---|---|---|---|
| (SL) | 0.89 | 3.86 | 3.48 | 7.85 | 0.57 | 2.427964 | 4,286041989 |
| (S) | 0.21 | 0.89 | 2.20 | 8.21 | 0.27 | 1,14649 | 4,26310668 |
| (CG) | 0.16 | 0.51 | 0.89 | 0.75 | 0.09 | 0,36575 | 3,914255005 |
| (CF) | 0.15 | 0.14 | 0.75 | 0.89 | 0.07 | 0,255956 | 3,597690555 |

The coherency ratio of the pairwise comparison matrices between the criteria is one of the important factors affecting the result. Therefore, consistency should be analyzed and calculated in detail. In the consistency formula developed by Saaty, if the CR is less than 0.10, it might be stated that the pairwise comparison matrix is coherent. The details of the coherent calculation for the quality sub-criterion are given below.

First, the synthetic degree value matrix is multiplied by the matrix product of criteria weights $(S \times W)$. Then, the resulting values are divided by the weight values respectively $[(S \times W)/W]$. Here, while finding the $\lambda_{max}$ value, the average value of (S×W)/W is taken.

$$\lambda_{\max} = (4,286041989 + 4,26310668 + 3,914255005 + 3,597690555)/4 = 4,01527356 ,$$

$$CI = \frac{\lambda_{\max} - n}{n-1} = \frac{4,01527356 - 4}{4-1} = 0,005091 ,$$

$$CR = \frac{CI}{RTI} = \frac{0,005091}{0,9} = 0,005657 .$$

According to this result, the CR for the main criteria is 0,005657. Since it is less than 0.10, the comparison matrix prepared for these criteria is also coherent. With this calculation method, it was measured whether the matrices of other sub-criteria were consistent or not, and according to all these calculated values, all matrices were found to be consistent.

In the selection of the most appropriate criterion, the table created for the criteria weightings was utilized. In the table below, the weight values of the main and sub-criteria are found in the synthetic degree value matrix (S). In the most appropriate criteria selection step, global weight values are needed. When calculating this value, the weight value of the main criterion and the weight values of the sub-criteria belonging to the relevant main criterion are needed. The global weight is obtained by multiplying these two values.

In the light of all these calculations, the value closest to 1 among the global weight values we have found with the N-AHP technique directs us toward the selection of the most appropriate criterion in Table 13. As a result of the study, when the values are analyzed, Ease of logistics access is the critical criterion for choosing a military base location in the border region with the N-AHP method (Ease of logistics access global weight value is 0,32567747202).

**Table 13.** Weight values of main and sub-criteria in the synthetic degree value matrix (S).

| Main criterion | Main criteria weights | Sub-criterion | Local weights | Global weights |
|---|---|---|---|---|
| (SL) | 0.57 | $(SL_1)$ | 0,244394836 | 0,13930505652 |
| | | $(SL_2)$ | 0,184241178 | 0,10501747146 |
| | | $(SL_3)$ | 0,571363986 | 0,32567747202 |
| (S) | 0.27 | $(S_1)$ | 0,073468434 | 0,01983647718 |
| | | $(S_2)$ | 0,22719471 | 0,0613425717 |
| | | $(S_3)$ | 0,699336856 | 0,18882095112 |
| (CG) | 0.09 | $(CG_1)$ | 0,202830181 | 0,01825471629 |
| | | $(CG_2)$ | 0,289108811 | 0,02601979299 |
| | | $(CG_3)$ | 0,508061008 | 0,04572549072 |
| (CF) | 0.07 | $(CF_1)$ | 0,421685069 | 0,02951795483 |
| | | $(CF_2)$ | 0,145563179 | 0,01018942253 |
| | | $(CF_3)$ | 0,432751752 | 0,03029262264 |

## 5. Conclusions

Military bases are generally established to be used as command centers, military supply points, intelligence centers, and training areas. These military bases can sometimes be located in cross-border places to protect border integrity. In this context, modern moves to strengthen the intelligence network are inevitable for the existence, continuity, and functionality of the military base. By housing new system weapons in these facilities and having departments that enable the development of these weapons, a good intelligence network is provided and air attack systems can be actively used. The fact that the technology departments of the base close to the border produce electronic warfare products, test them in peacetime, and send them to the front in case of war is a great advantage in terms of overcoming location and geographical challenges at the appropriate time.

Location selection in the military sense is one of the favorite topics that researchers study using different methods. Here is a brief overview of some of these studies. They discuss the problem of place choice for a military airfield using some multi-criteria decision-making methods [42]. In [51], they applied a multi-criteria decision-making model, especially the DEMATEL-ANP method, in location selection for ammunition depots. Also, in [64] they applied the AHP method for the location selection of the spaceport to be established in Indonesia.

The most important approach that this study brings to the literature is that it is the first study in which the single-valued N-AHP method, which is constructed based on triangular neutrosophic numbers, is used together with the Delphi method in the location selection of military facilities on the border. Apart from the problem we studied, the most important study in the literature, in which N-AHP and Delphi method were used together, examined a decision-making problem regarding international search engines using trapezoidal numbers [58]. The reason why we use neutrosophic triangular numbers in our study is that membership functions for triangular numbers can be constructed more easily and are useful.

Since the AHP technique is a useful method where reliable results can be obtained with the opinions of expert participants, the neutrosophic version of this method was preferred in the study. Considering that this method will be used in ordering the importance of the criteria, a hierarchical structure has been established. A pairwise comparison of the criteria was made through the decision criterion matrix, and then pairwise comparison decision matrices were created. N-AHP was used for military base location selection in the border region within the scope of 4 main criteria and 12 sub-criteria determined by the Delphi method. The N-AHP method, which helps simplify complex problems that are difficult to solve and contributes to the decision-making process by bringing together numerical and subjective information, has been simplified and made consistent by analyzing expert opinions with the Delphi method in order to prevent the uncontrolled increase in the number of pairwise comparisons with the increase in the number of criteria. Otherwise, applying the N-AHP method alone, as applied in the literature, will cause a lot of time to be lost in the solution process of complex problems.

Looking at the obtained criteria weights, it is revealed that the 5 most important criteria for the military base location examined within the scope of the study are "Ease of logistics access ($SL_3$)", "Effectiveness of the intelligence network ($S_3$)", "Proximity to the borderline ($SL_1$)", "Lack of geographical barriers ($SL_2$)", and "Presence of natural barricades ($S_2$)" respectively. The results show that ease of logistics access is the most important criterion for base location selection. Therefore, it is thought that providing the soldiers who will go to war with all the equipment and technologies that will be useful during the conflict, with professional methods, is an important step towards winning the war.

We can summarize the results we obtained from the numerical data of the study as follows.

- We found that N-AHP and Delphi methods were compatible with each other and gave consistent usable results for our problem.
- Considering the ease of expression of triangular neutrosophic numbers and the fact that the functions to be constructed with the help of these numbers will be more useful, it is thought that the study will be taken as a reference by researchers for different daily life problems.
- It is thought that studying using a mathematical approach on location selection, which military units use in different ways, will give the authorities an idea.
- Although it may seem like a preparation for war periods, we have demonstrated the applicability of our method for a more peaceful world, considering that military facilities are also necessary for the establishment of peace.

New studies can be carried out to increase the quality in the fields of economy, health, and technology through different techniques that can be integrated into the N-AHP method, among the methods applied in this study. Additionally, solutions to important daily life problems can be sought by expanding single-value studies to interval-value studies using compatible N-AHP and Delphi methods. In addition, the TOPSIS method (e.g., [65] can be examined for details of the method), which is compatible with the methods we apply, can be applied in addition to the two methods. Thus, the methods in the study can be applied as solutions to many more daily life problems. Furthermore, the methods we have applied can also be applied to other daily life problem solution researches prepared in the field of neutrosophic, including N-AHP or prepared with other methods. For example [66–68].

## Use of AI tools declaration

The authors declare they have not used Artificial Intelligence (AI) tools in the creation of this article.

## Conflict of interest

There is no conflict of interest between the authors.

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