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NSS

Neutrosophic Sets and Systems, Vol. 73, 2024

University of New Mexico

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Abstract. Special economic zones (SEZs) are essential if a developing country is to boost economic growth. The selection of an SEZ site might be viewed as a multi-criteria decision-making (MCDM) difficulty because of the many conflicting aspects connected to different locations. This work presents a flexible neutrosophic MCDM approach for optimal SEZ site search. The single-valued neutrosophic sets transform the qualitative evaluation of the criteria for SEZ alternatives into a quantitative evaluation. The method based on removal effect on criteria (MEREC) approach is improved in a neutrosophic environment to ascertain the relevance of every characteristic of SEZ alternatives. We suggested a three-tuple neutrosophic combined compromised solution (N-CoCoSo) to evaluate the choice of expert to solve the SEZ site ranking problem. According to the planned N-CoCoSo, coastal forest regions are the worst location for SEZ sites; agricultural land near coastal areas is ideal. The sensitivity and comparability study helps establish the suggested method's consistency and resilience.

Keywords: Special economic zone; MCDM; Single-valued neutrosophic set; CoCoSo; MEREC.)

1. **Introduction**

A Special Economic Zone (SEZ) refers to a specifically designated geographic region inside a nation subjected to distinct economic rules compared to the remaining areas of the country [1]. These policies frequently adopt a more permissive approach, intending to entice foreign investment, stimulate commerce, increase exports, create jobs, develop regional and national infrastructure, and foster economic expansion [2]. The SEZ commonly provides various advantages, including tax exemptions, exemptions from customs duties, and lenient labor regulations, to promote the establishment of firms within the designated zone [3]. The implementation of SEZ has emerged as a prominent issue in pursuing higher economic objectives at the governmental and policymaker levels, intending to attain sustainable development goals shortly [4]. Numerous nations across the globe have implemented SEZs as integral components of their economic growth strategies [5–7].

The crucial points of SEZ location selection depend on qualitative considerations like community backing and environmental effects against quantitative ones like land cost and transportation accessibility [8]. The complexity of decision-making in this situation can be addressed using multi-criteria decision-making (MCDM) methodologies enabling a structured study of numerous aspects pertinent to SEZ location selection [9]. Establishing meaningful criteria is an essential first step in applying MCDM to selecting SEZ locations [10]. These criteria are typically established by researchers drawing on prior research to reflect the unique requirements and goals associated with the SEZ's intended purpose. The selection of SEZ locations is being carried out using Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) [10] and Analytic Hierarchy Process (AHP) [11, 12]. Fuzzy MCDM's aggregation method provides a more thorough understanding of these trade-offs, allowing for more educated decision-making [13]. Crisp approaches can drastically change the ranking of alternatives since they are susceptible to even little changes in the criteria weights. This sensitivity can pose a concern in decisions like SEZ selection, where criterion weights are frequently subject to expert opinion. Because stakeholder input and new information might cause criterion weights to vary in SEZ selection, fuzzy MCDM offers a more flexible decision-making framework that can adjust to these changes without significantly impacting the results.

Considering these objectives, this article contributes the following advantages:

- □ A framework for location selection for SEZs is formulated, identifying different geographic locations with their crucial criteria.
- □ Criteria like public perception, environmental restoration, climate regulation, transport proximity, and risk assessment are quantified using single-valued neutrosophic sets (SVNSs).

- ☐ The method based on removal effect on criteria (MEREC) [14] is applied to determine the criteria weight to avoid subjective assessment.
- ☐ An integrated MCDM methodology is developed using neutrosophic rating of the criteria, MEREC, and the neutrosophic extension of combined compromise solution (CoCoSo) [15] approach to counter hesitant and uncertain MCDM issues.
- ☐ The proposed combined approach is applied to identify a suitable prospective SEZ location.
- ☐ The reliability and consistency of the proposed approach are evaluated by comparing it to several prominent MCDM approaches.
- ☐ The sensitivity analysis evaluates the influence of internal parameter modification and criteria weight variation on the ranking of the choices.

The description of the remaining portion of the paper is as follows: The relevant literature review is located in Section 2. The preliminary mathematics of SVNSs is the subject of Section 3. According to Section 4, the geographic context serves as the foundation for the SEZ's location. The proposed integrated neutrosophic methodology is described in Section 5. Figure 6 illustrates the proposed methodology through numerical examples. Section 7 comprises the findings of this article.

2. **Literature review**

Yazdani et al. [15] presented the CoCoSo method as a novel MCDM strategy for determining the best option by merging exponentially weighted product models with simple additive weighting. The benefits of the CoCoSo strategy are as follows: (i) it uses three separate compromise aggregation techniques [16, 17]; (ii) it offers optimum choices devoid of paradoxical events [18, 19], and (iii) it is mostly unaffected by the addition or deletion of options [20]. The CoCoSo method, in contrast to other MCDM strategies, improves the precision of the deciding mechanism and has a greater degree of resolution in discriminating the choices that are being considered [21–23]. Scholars were inspired by the advantages of the CoCoSo method and applied it to their research for various applications. Yazdani et al. [24] developed a grey interval-based CoCoSo technique to assess the efficiency of construction vendors. Ecer et al. [25] suggested an integrated BWM-CoCoSo framework for supplier selection. Peng and Huang [26] extended the CoCoSo approach in the q-rung ortho-pair fuzzy set and combined it with CRITIC for financial risk assessment. Peng and Smarandache [27] formulated a combined CRITIC-CoCoSo approach for the security evaluation of the earth industry. Liao et al. [28] suggested a pythagorean expansion of the CoCoSo technique to determine the optimal logistic distribution centre. Peng et al. [29] proposed a Pythagorean CRITIC-CoCoSo framework for evaluating 5G industries. Ulutacs et al. [30] developed a GIS-based SWARA-CoCoSo technique for selecting logistic center locations. Rani and Mishra [31] developed a similarity measure-based CoCoSo approach to determine the best way to recycle electrical and electronic equipment waste. Yazdani et al. [32] developed a neutrosophic CRITIC-CoCoSo method for supplier selection. Mishra and Rani [33] extended the CoCoSo approach in a neutrosophic context for performance evaluation of logistic suppliers. Peng and Luo [16] assessed the bubble in the China stock market through a picture fuzzy extension of the CoCoSo approach. Rani et al. [34] developed a combined SWARA-CoCoSo methodology to determine the optimal source of renewable energies. Alrasheedi et al. [19] suggested an interval-valued intuitionistic CoCoSo framework to identify factors in green growth in manufacturing sectors. Peng et al. [23] improved the CRITIC-CoCoSo technique in an interval-valued fuzzy soft context for assessing healthcare management through AI. Torkayesh et al. [20] developed a hybrid weighting method using BWM and LBWA with CoCoSo to rank the healthcare facilities in European countries. Demir et al. [35] extended FUCOM and CoCoSo in fuzzy environments to choose the best plan for sustainable urban transportation. A decision-making model using picture fuzzy-based CoCoSo was developed by Qiyas et al. [36] for choosing the best drug. Chen et al. [37] developed a fermatean CoCoSo method for risk evaluation in professional hazards related to health issues. Pamucar and Gorcun [38] proposed a combined fuzzy LBWA-CoCoSo approach to reduce transportation costs in shipping industries. Wei [39] assessed the quality of English courses for college standards through a neutrosophic CoCoSo approach. Peng et al. [40] proposed a neutrosophic CRITIC-CoCoSo model for assessing project-driven immersion teaching. Wei and Pan [41] assessed the teaching quality in sport management through the neutrosophic extension of the CoCoSo approach. Li and Qin [42] suggested a triangular neutrosophic CoCoSo method for college content assurance of innovation and entrepreneurship projects. Mohamed et al. [43] developed a triangular neutrosophic expansion of the AHP-CoCoSo method to identify the risk in the food supply chain. Nabeeh and Sallam [44] proposed a neutrosophic CoCoSo approach to choosing the best bearing ring in the medical field. Aytekin et al. [45] identified the barriers to blockchain technology implementation through the neutrosophic CoCoSo approach.

2.1. *MCDM approaches for location selection of SEZ*

SEZ location selection is based on several objectives: transportation proximity, land cost, local govt.'s rules and regulations, climate, environment, availability of labor, foreign investment, public perception, and many more. Several case studies are conducted in different countries or states using MCDM approaches [46]. Table 1 provides case studies conducted through MCDM for location selection of SEZ-related issues.

Table 1. Case studies of location selection issues using MCDM.

Contributor	Benchmark	Country	Application
Mohon and Naseer [47]	AHP	India	Port locations
Ahmed et al. [10]	AHP-VIKOR	Pakistan	SEZ location
Komchornrit [48]	AHP-PROMETHEE	Thailand	SEZ location
Asaad M. A. et al. [49]	AHP-RSW-SRS	Egypt	Landfill site selection
Tercan et al. [50]	AHP-WLC	Turkey	Solar power system location
Mulusew et al. [12]	AHP	Ethiopia	Waste disposal site selection
Saatsaz et al. [51]	AHP-GIS	Iran	Landfill selection
Zak et al. [46]	ELECTRE	Poland	Logistic center location selection
Nguyen et al. [52]	BWM-ELECTR	Vietnam	Dry port location selection
Rajput et al. [53]	AHP-LAM	India	Business climate

Table 1 shows that the AHP method has been applied primarily to conduct the case studies on location selection. The locations considered for prospective sites for constructing SEZ include only one location. On these points, the prospective research areas can include:

- There is a need for a more fuzzy MCDM approach in location selection problems. However, describing the nature of the essential factors of location selection issues through fuzzy sets is more acceptable.
- Regional geographic advantage is a crucial factor in SEZ location selection. The demographic characteristics, local weather, food habits, and available facilities are critical factors in searching for a suitable SEZ location. These crucial issues still need to be addressed in the literature.
- Determining the criteria weight is always an important factor in ranking the alternatives. Researchers often need to pay more attention since either they use subjective assessment or minimal objective procedure to determine the same.
- There is a need for more MCDM methods that consider uncertainty and hesitation in the computation process. The computation process should include a complete absorption of uncertainty to reflect the decision expert's opinions.

3. Preliminaries on neutrosophic set

Definition 3.1. An SVNS [54] on a fixed set X is defined by $A = (x,\ \varphi_A(x),\ \varpi_A(x),\ \varrho_A(x)|x \in X)$, where $\varphi_A(x),\ \varpi_A(x),\ \varrho_A(x) \in [0,\ 1]$ are sets of membership, non-membership, and indeterminacy degrees of the element $x \in X$ to the set A, respectively, with $0 \leq \varphi_A(x) + \varpi_A(x)+\varrho_A(x) \leq 3$. In general, $0 \leq (\varphi_A(x))^q+(\varpi_A(x))^q+(\varrho_A(x))^q \leq 3$, $\forall x \in X$. For simplicity, we use $A = (\varphi_A(x),\ \varpi_A(x),\ \varrho_A(x))$ as a single valued neutrosophic number (SVNE).

Definition 3.2. [55] Let $A_1 = (\varphi_1,\ \varpi_1,\ \varrho_1)$ and $A_2 = (\varphi_2,\ \varpi_2,\ \varrho_2)$ be two SVNEs and $\lambda \geq 0$ then the basic arithmetic operations are defined as follows:

$$A_1 \bigoplus A_2 = (\varphi_1 + \varphi_2 - \varphi_1.\varphi_2,\ \varpi_1\varpi_2,\ \varrho_1\varrho_1)$$
$$A_1 \bigotimes A_2 = (\varphi_1.\varphi_2,\ \varpi_1 + \varpi_2 - \varpi_1\varpi_2,\ \varrho_1\varrho_1)$$
$$\lambda A = (1 - (1 - \varphi)^{\lambda},\ \varpi^{\lambda},\ \varrho^{\lambda})$$

Definition 3.3. Score function of SVNS: [56] Let $A = (\varphi_A(x),\ \varpi_A(x),\ \varrho_A(x)|x \in X)$ be a SVNE and $\varphi_A(x),\ \varpi_A(x),\ \varrho_A(x) \in [0,\ 1]$ are sets of membership, non-membership degree, and indeterminacy of the element $x \in X$ to the set A, respectively. Then the score function of A is defined as:

$$\text{SC}(A) = \frac{3 + 3 * (\varrho_A(x))^q - 2 * (\varpi_A(x))^q - (\varphi_A(x))^q}{6} \tag{1}$$

Where $q \geq 1$ is the exponents and if $q = 1$, the score function represents for SVNE.

4. An MCDM framework of SEZ's location selection

The first step in formulating an MCDM issue is identifying available alternatives and their critical criteria. In this section, we have identified five prospective areas for SEZ and nine criteria that significantly impact SEZ location selection.

4.1. *Identification of SEZ location*

Identifying the appropriate site for a SEZ entails thoroughly assessing infrastructure, workforce availability, governmental regulations, market entry opportunities, and environmental and social considerations. A thorough evaluation should be conducted to choose sustainable solutions for long-term viability. Taking this into consideration, we have examined the following geographical locations as alternatives to encompass all potential areas:

Forestry coastal (O_1)**:** The coastal forestry region is valuable because it has raw materials that reduce logistics challenges, transit infrastructure that saves time, and precise regulations and environmental standards for managing the ecosystem. However, most coastal settlements are near cities, making marketplaces easier to reach.

Forestry hill (O_2)**:** Establishing a SEZ in a hilly region is feasible; however, it necessitates a meticulous assessment of the distinctive opportunities and challenges presented by the local communities, environment, and terrain. Strategic planning, targeted economic incentives, and environmental safeguards will be essential for the sustainability and viability of this endeavor.

Barren and fallow plane (O_3)**:** Developing supporting infrastructure and constructing networks that facilitate access to local and international markets may use the extensive land in Barren and fallow plains. The interconnections of these locations enable the conveyance of products and services between domestic and international markets without jeopardizing any environmental strategies. Consequently, it is imperative to engage in meticulous preparation to minimize adverse effects and optimize potential economic benefits.

Agricultural land coastal (O_4)**:** Coastal agricultural fields generally provide expansive areas of level or slightly inclined ground well-suited for industrial and commercial development. The presence of available land facilitates the establishment of manufacturing facilities, warehouses, residential complexes, and the essential supporting infrastructure for the activities of SEZs. In addition to this, it possesses the preexisting infrastructure for a comprehensive transportation network encompassing roadways, trains, and ports. The area would have an ample local workforce, decreasing recruiting expenses and promoting long-term job prospects for neighboring areas.

Agricultural land plane (O_5)**:** Agricultural plains are ideal for establishing large-scale industries because of the abundance of necessary resources such as infrastructure, transportation, labor, and easy access to raw materials. The industry also took advantage of local agricultural resources in many aspects. They are assessing the condition of natural resources, identifying threats, and assessing the efficacy of conservation strategies through scientific research and monitoring programs.

4.2. *Defining Criteria*

The literature assessment and experts' opinions in the relevant field are the sources from which the requirements for developing a special economic zone (SEZ) are gathered [10], [**?**] toward. The following are the primary factors to consider when surveying a location for a SEZ building:

Public Perception (Y_1)**:** Considering the local people's willingness to allow the establishment of industry on agricultural land, the impact on public health caused by pollution, and the long-term sustainability of the social and economic equilibrium defines this criterion.

Environmental restoration (Y_2)**:** Continuous monitoring is necessary to restore the environment damaged by deforestation, pollution, and carbon sequestration to promote the development of a healthy society organized by the region's policies.

Climate regulative (Y_3)**:** Ensuring environmental resilience that promotes human well-being requires understanding and protecting the climate regulator. The function of natural ecosystems in controlling the pattern at regional and international levels is being discussed.

Presence of labour and their settlement (Y_4)**:** To satisfy the operational requirement of industrialization, which drives economic success, this specifies the education and training for developing skilled laborers.

Foreign resources (Y_5)**:** This criteria investigates the knowledge, skills, intellectual property, technological advancement, transfer of consumer products, and collaboration that enhance local capital about global resources.

Transport facility (Y_6)**:** The success of a SEZ is contingent upon the presence of an efficient transportation infrastructure. It must be meticulously planned and integrated with the SEZ's overall infrastructure to ensure seamless connectivity to national and international markets, reduce costs, and support efficient logistics.

Installation cost (Y_7)**:** These cost parameters pertain to the system's installation, machinery relocation, and transportation, all of which benefit the organization.

Risk and uncertainty (Y_8)**:** The remainder of this piece elucidates the strategies for attaining enduring objectives about societal and economic advancement through adopting secure and salubrious regulations and using more environmentally friendly industrial technology.

The aforementioned criteria for identifying SEZ locations are the most effective for selecting alternatives. The beneficiary criteria are $Y_1,\ Y_2,\ Y_3,\ Y_4,\ Y_5$, and Y_6, while the cost criteria are Y_7 to Y_8.

5. The proposed Methodology: Neutrosophic MEREC-CoCoSo Approach

The primary aim of this section is to create a decision-making method that employs the MEREC and CoCoSo approaches to address ambiguous MCDM problems. The proposed method is detailed below, with each phase delineated.

Step 1: Formulation of MCDM problem: Encourage a decision-maker (DM) to be accessible to evaluate the criteria of each option using the SVNE rating. Create a MCDM challenge considering 'p' alternatives $O = \{O_1,\ O_2,\ ...,\ O_p\}$ and 'q' criteria $Y = \{Y_1,\ Y_2,\ ...,\ Y_q\}$, where beneficiary and non-beneficiary criteria are denoted by Y_b and Y_{nb} respectively, such that $Y_b \cup Y_{nb} = Y$ and $Y_b \cap Y_{nb} = \emptyset$.

Step 2: Neutrosophic decision matrix: Gather DM's opinions to form a neutrosophic decision matrix $\daleth = (a_{ij})_{p\times q}$, such that $a_{ij} = (\varphi_{ij},\ \varpi_{ij},\ \varrho_{ij}),\ i = 1(1)p;\ j = 1(1)q$. The rating of the i^{th} alternative and j^{th} criterion is a_{ij}, determined by the neutrosophic linguistic scale provided in Table 2.

TABLE 2. Criteria assessment scale.

Linguistic terms	SVNE (φ, ϖ, ϱ)
Worst Case Acceptable (EL)	(0.261, 0.813, 0.701)
Very Poorly Acceptable (TL)	(0.346, 0.728, 0.643)
Poorly Acceptable(AL)	(0.463, 0.651, 0.586)
Acceptable (N)	(0.558, 0.533, 0.551)
Fairly Acceptable (AH)	(0.646, 0.422, 0.386)
Moderately Acceptable (TH)	(0.753, 0.317, 0.215)
Highly Acceptable (EH)	(0.831, 0.262, 0.113)
Exceptionally Acceptable (NH)	(0.982, 0.142, 0.097)

Step 3: Preference of the alternative: Determine the primary preference based on the alternate choice $\mathrm{P}_{\mathrm{O}_i}$. Since the DM views the options as having an equal chance of occurring:

$$\mathrm{P}_{\mathrm{O}_i} = \frac{1}{p} \text{ such that } \sum_{i=1}^{p} \mathrm{P}_{\mathrm{O_i}} = 1.$$

Step 4: Neutrosophic MEREC approach to determine the criteria weight: Follow these procedures for establishing the criteria weight using the MEREC method:

Step 4.1: Use the decision matrix $\beth$ from Table 2 to evaluate the neutrosophic criteria weights.

Step 4.2: Compute the normalized neutrosophic decision matrix $\beth_N = (\eta_{ij})_{p\times q}$ using equation (2).

$$\eta_{ij} = \begin{cases} \frac{\min_k x_{kj}}{x_{ij}} \text{ for } j \in \mathrm{Y}_b \\ \frac{x_{ij}}{\max_k x_{kj}} \text{ for } j \in \mathrm{Y}_{nb} \end{cases} \tag{2}$$

Step 4.3: Compute the overall performance S_i of the options O_i using equation (3).

$$S_i = \ln(1 + (\frac{1}{p}\sum_j |\ln(\eta_{ij})|)) \tag{3}$$

Step 4.4: Determine the performance of each alternative, irrespective of the criteria S_{ij} using equation (4).

$$S_{ij} = \ln(1 + (\frac{1}{p}\sum_{k\neq j} |\ln(\eta_{ij})|)) \tag{4}$$

Step 4.5: To determine the removal effect of the j^{th} criteria, compute the sum of absolute deviation using equation (5).

$$E_j = \sum_j |S_{ij} - S_i| \ j = 1(1)q \tag{5}$$

Step 4.6: Establish the neutrosophic weights of the criteria using equation (6).

$$\omega_j = \frac{E_j}{\sum_j E_j},\ j = 1(1)q \tag{6}$$

Step 5: Normalization of neutrosophic decision matrix: Normalize the neutrosophic decision matrix ($\beth$) using equation (7).

$$r_{ij} = \begin{cases} \frac{x_{ij} - \min_j x_{ij}}{\max_j x_{ij} - \min_j x_{ij}} \text{ for } j \in \mathrm{Y}_b \\ \frac{\max_j x_{ij} - x_{ij}}{\max_j x_{ij} - \min_j x_{ij}} \text{ for } j \in \mathrm{Y}_{nb} \end{cases} \tag{7}$$

Step 6: Real evaluation of the alternatives: Determine the real evaluation of neutrosophic weighted sum measure (WSM) (L_i) and weighted product measure (WPM) (M_i) corresponding performance indexes using equation (8).

$$\mathrm{L}_i = \sum_{j=1}^{q} \omega_j \bigotimes r_{ij} \text{ and } \mathrm{M}_i = \sum_{j=1}^{q} {r_{ij}}^{\omega_j} \tag{8}$$

Step 7: Neutrosophic appraisal score: Calculate the neutrosophic appraisal scores for the alternatives using equation (9).

$$\begin{cases} \kappa_{i\alpha} = \frac{\mathrm{L}_i + \mathrm{M}_i}{\sum_{i=1}^{m} (\mathrm{L}_i + \mathrm{M}_i)} \\ \kappa_{i\beta} = \frac{\mathrm{L}_i}{\min_i(\mathrm{L}_i)} + \frac{\mathrm{M}_i}{\min_i(\mathrm{M}_i)} \\ \kappa_{i\gamma} = \frac{\lambda \mathrm{L}_i + (1-\lambda)\mathrm{M}_i}{\lambda \max_i(\mathrm{L}_i) + (1-\lambda)\max_i(\mathrm{M}_i)},\ \lambda \in (0,\ 1) \end{cases} \tag{9}$$

Step 8: Overall appraisal score: Compute overall appraisal score κ_i of each alternatives using equation (10)

$$\kappa_i = (\kappa_{i\alpha}\kappa_{i\beta}\kappa_{i\gamma})^{1/3} + \frac{1}{3}(\kappa_{i\alpha} + \kappa_{i\beta} + \kappa_{i\gamma}),\ i = 1(1)p \tag{10}$$

Step 9: Ranking order: Determine the ranking of each choice in decreasing order depending on the κ_i values.

Figure 1 shows the description of the SEZ selection problem by a sequential structure.

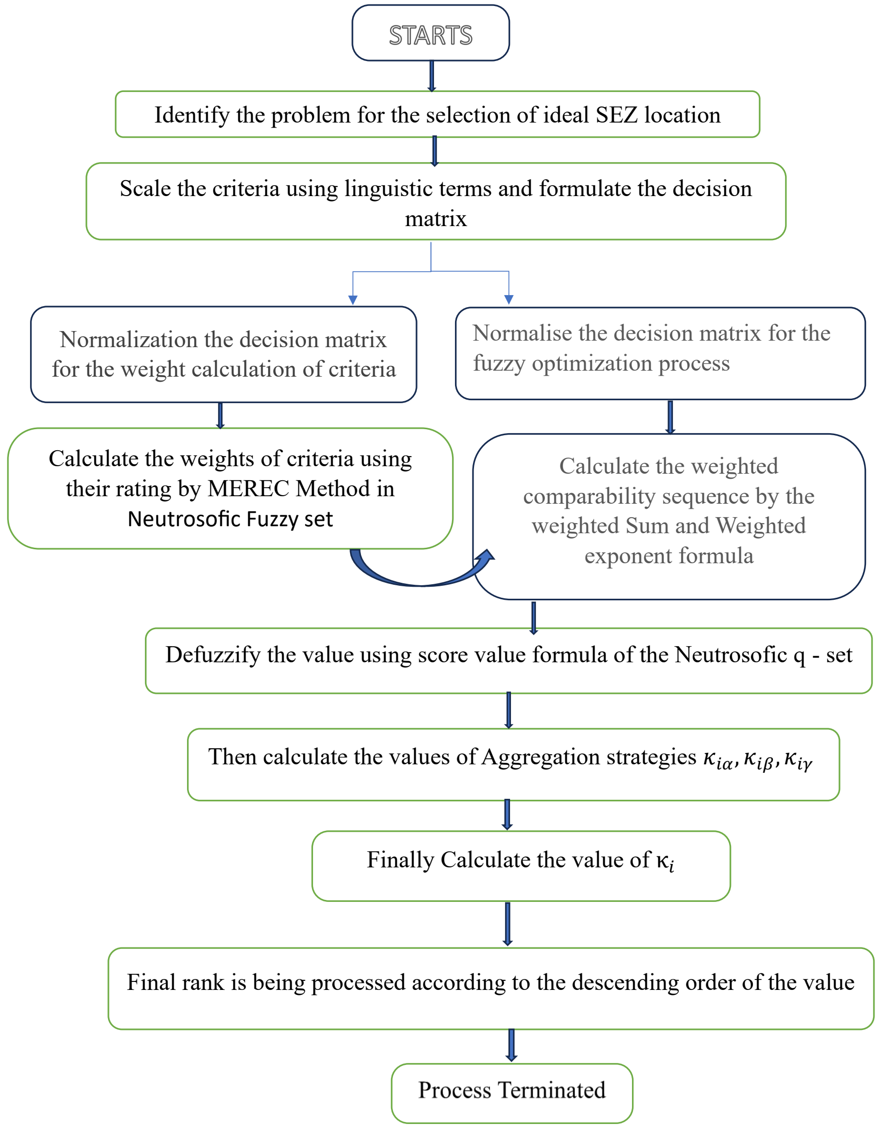

FIGURE 1. Description of SEZ selection problem by a sequential three-level structure.

6. Numerical illustration of proposed neutrosophic MEREC-CoCoSo approach

Step 1: The MCDM framework of the SEZ location selection has five options $O = \{O_1, O_2, O_3, O_4, O_5\}$ and eight criteria $Y = \{Y_1, Y_2, Y_3, Y_4, Y_5, Y_6, Y_7, Y_8\}$ such that $Y_b = \{Y_1, Y_2, Y_3, Y_4, Y_5, Y_6\}$ and $Y_{nb} = \{Y_7, Y_8\}$.

Step 2: Table 3 provides the construction of the neutrosophic decision matrix $(\beth)_{5\times 8}$ in accordance with the SVN rating from Table 2.

TABLE 3. Linguistic neutrosophic decision matrix.

Alt./Cr.	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6	Y_7	Y_8
O_1	EH	AN	AL	TL	TH	AN	AN	TL
O_2	AL	AH	EH	AL	AN	TL	AL	EL
O_3	TH	EH	AN	AN	AL	AH	EL	TH
O_4	AN	NH	TH	AH	TH	EH	TL	AL
O_5	NH	TH	AN	EH	AH	TH	AH	AH

Step 3: Since this MCDM issue of location selection for SEZ have five alternatives, $P_{O_i} = \frac{1}{5}$ such that $sum_{i=1}^{5} \mathrm{P}_{\mathrm{O_i}} = 1$.

Step 4: Proposed neutrosophic MEREC method for criteria weight computation:

Step 4.1: The neutrosophic decision matrix of Table 3 is generated using the criteria rating from Table 2.

Step 4.2: The normalized decision matrix $\beth_N$ is provided in Table 4 using equation (2).

TABLE 4. Normalised neutrosophic decision matrix

Zone	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6	Y_7	Y_8
O_1	(0.557,0.542,0.858)	(1,0.266,0.176)	(1, 0.402,0.193)	(1,0.360,0.176)	(0.615,1,1)	(0.620,0.492,0.205)	(0.864,0.656,0.786)	(0.459,0.895,0.917)
O_2	(1,0.218,0.165)	(0.864,0.336,0.251)	(0.557,1,1)	(0.747,0.402,0.193)	(0.829,0.595,0.390)	(1,0.359,0.176)	(0.717,0.801,0.836)	(0.858,0.519,0.551)
O_3	(0.615,0.448,0.451)	(0.672,0.542,0.858)	(0.829,0.492,0.205)	(0.620,0.492,0.205)	(1,0.487,0.367)	(0.536,0.621,0.293)	(0.404,1,1)	(1,0.390,0.307)
O_4	(0.829,0.266,0.176)	(0.568,1,1)	(0.615, 0.826,0.526)	(0.536,0.621, 0.293)	(0.615,1,1)	(0.416,1,1)	0.536,0.895,0.917)	(0.615,0.801,0.836)
O_5	(0.472,1,1)	(0.741,0.448,0.451)	(0.829,0.492,0.205)	(0.416,1,1)	(0.717,0.751,0.557)	(0.459,0.826,0.526)	(1.000,0.519,0.551)	(0.347,1,1)

Step 4.3: The equation (4) is employed to ascertain the aggregate performance of the alternatives S_i, which is detailed in Table 5.

TABLE 5. Overall performance of the alternatives.

Cr./Alt.	O_1	O_2	O_3	O_4	O_5
$(S_i, SN(i), SH(i))$	(0.269, 0.494, 0.641)	(0.192, 0.555, 0.710)	(0.326, 0.484, 0.663)	(0.433, 0.255, 0.395)	(0.429, 0.286, 0.422)

Step 4.4: Table 6 provides the efficacy of each alternative, which is determined by equation (4).

Step 4.5: The sum of the absolute deviations is calculated using equation (9) and is presented in Table 6.

Step 4.6: Using equation (6), the neutrosophic criteria weights are computed and are displayed in Table 6.

Table 6. Absolute deviation and neutrosophic criteria weights.

Alt./Cr.	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6	Y_7	Y_8
O_1	(0.057,0.048,0.010)	(0,0.106,0.121)	(0,0.072,0.115)	(0,0.081,0.122)	(0.048,0,0)	(0.047,0.168,0.110)	(0.014,0.107,0.016)	(0.077,0.207,0.128)
O_2	(0.000,0.116,0.117)	(0.015,0.081,0.089)	(0.062,0,0)	(0.031,0.068,0.107)	(0.019,0.038,0.060)	(0.000,0.152,0.113)	(0.035,0.026,0.011)	(0.031,0.186,0.130)
O_3	(0.045,0.064,0.053)	(0.037,0.048,0.010)	(0.017,0.056,0.108)	(0.044,0.056,0.108)	(0.000,0.057,0.067)	(0.058,0.055,0.082)	(0.085,0.041,0.000)	(0.037,0.148,0.090)
O_4	(0.015,0.137,0.158)	(0.047,0,0)	(0.040,0.019,0.056)	(0.052,0.047,0.109)	(0.040,0,0)	(0.074,0.053,0)	(0.052,0.018,0.007)	(0.089,0.007,0.015)
O_5	(0.063,0,0)	(0.025,0.078,0.067)	(0.015,0.069,0.139)	(0.074,0,0)	(0.027,0.027,0.049)	(0.065,0.067,0.054)	(0.000,0.117,0.050)	(0.117,0.007,0.067)
SUM	(0.181,0.365,0.338)	(0.123,0.314,0.287)	(0.135,0.216,0.417)	(0.201,0.252,0.445)	(0.135,0.122,0.175)	(0.244,0.496,0.360)	(0.186,0.309,0.084)	(0.352,0.555,0.430)
W_i	(0.116,0.139,0.133)	(0.079,0.120,0.113)	(0.087,0.082,0.164)	(0.129,0.096,0.175)	(0.087,0.046,0.069)	(0.157,0.189,0.142)	(0.120,0.118,0.033)	(0.226,0.211,0.169)

Step 5: The normalized decision matrix of the neutrosophic decision matrix (Table 3 using equation (7) is displayed in Table 7.

Table 7. Normalized decision matrix according to proposed N-CoCoSo method

Alt./Cr.	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6	Y_7	Y_8
O_1	(0.317,0.105,0.015)	(0.000,0.447,0.447)	(0.000,0.447,0.447)	(0.000,0.447,0.447)	(0.447,0.000,0.000)	(0.195,0.260,0.370)	(0.213,0.680,0.102)	(0.053,0.923,0.370)
O_2	(0.000,0.447,0.447)	(0.093,0.320,0.285)	(0.447,0.000,0.000)	(0.108,0.373,0.399)	(0.147,0.289,0.405)	(0.000,0.447,0.447)	(0.163,0.815,0.213)	(0.290,0.647,0.097)
O_3	(0.250,0.154,0.108)	(0.288,0.137,0.016)	(0.115,0.312,0.414)	(0.195,0.260,0.370)	(0.000,0.447,0.447)	(0.277,0.154,0.230)	(0.000,1.000,0.447)	(0.447,0.553,0.000)
O_4	(0.082,0.344,0.415)	(0.447,0.000,0.000)	(0.352,0.063,0.096)	(0.277,0.154,0.230)	(0.447,0.000,0.000)	(0.447,0.000,0.000)	(0.082,0.903,0.348)	(0.106,0.854,0.264)
O_5	(0.447,0.000,0.000)	(0.206,0.200,0.116)	(0.115,0.312,0.414)	(0.447,0.000,0.000)	(0.282,0.141,0.206)	(0.375,0.053,0.086)	(0.447,0.553,0.000)	(0.000,1.000,0.447)

Step 6: The neutrosophic WSM and WPM are computed using equation (8). Table 8 provides neutrosophic WSM, and Table 9 provides neutrosophic WPM.

Table 8. Neutrosophic weighted sum measure.

Alt./Cr.	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6	Y_7	Y_8
O_1	(0.037,0.230,0.146)	(0,0.513,0.510)	(0,0.493,0.538)	(0,0.501,0.544)	(0.039,0.046,0.069)	(0.031,0.400,0.459)	(0.026,0.717,0.132)	(0.012,0.940,0.477)
O_2	(0,0.524,0.521)	(0.007,0.402,0.366)	(0.039,0.082,0.164)	(0.014,0.433,0.504)	(0.013,0.322,0.446)	(0,0.551,0.526)	(0.020,0.836,0.239)	(0.066,0.722,0.251)
O_3	(0.029,0.271,0.227)	(0.023, 0.240,0.127)	(0.010,0.368,0.510)	(0.025,0.331,0.480)	(0,0.472,0.485)	(0.043,0.313,0.340)	(0.0000,1.0000,0.466)	(0.101,0.647,0.170)
O_4	(0.010,0.434,0.493)	(0.036,0.120,0.113)	(0.030,0.140,0.245)	(0.036,0.235,0.365)	(0.039,0.046,0.069)	(0.070,0.188, 0.142)	(0.010,0.914,0.370)	(0.024,0.885,0.388)
O_5	(0.052,0.139,0.133)	(0.016,0.296,0.216)	(0.010,0.368,0.510)	(0.058,0.096,0.175)	(0.024,0.181,0.261)	(0.059,0.231,0.216)	(0.054,0.605,0.033)	(0,1,0.541)

Table 9. Neutrosophic weighted product measures

Cr./Alt.	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6	Y_7	Y_8
C_1	(0.869,0.014,0.002)	(0,0.069,0.070)	(0,0.070,0.070)	(0,0.072,0.070)	(0.901,0,0)	(0.818,0.036,0.055)	(0.819,0.136,0.013)	(0.686,0.281,0.055)
C_2	(0,0.070,0.070)	(0.751,0.045,0.040)	(0.906,0.000,0)	(0.756,0.057,0.060)	(0.780,0.043,0.062)	(0,0.070,0.070)	(0.792,0.195,0.029)	(0.853,0.125,0.012)
C_3	(0.844,0.020,0.014)	(0.861,0.018,0.002)	(0.768,0.045,0.063)	(0.814,0.037,0.055)	(0,0.074,0.070)	(0.854,0.020,0.032)	(0,1,0.070)	(0.902,0.098,0)
C_4	(0.736,0.050,0.064)	(0.908,0,0)	(0.880,0.008,0.012)	(0.851,0.021,0.032)	(0.901,0,0)	(0.906,0,0)	(0.725,0.259,0.051)	(0.749,0.219,0.037)
C_5	(0.906,0,0)	(0.827,0.026,0.015)	(0.768,0.045,0.063)	(0.904,0,0)	(0.849,0.019,0.028)	(0.886,0.007,0.011)	(0.902,0.098,0)	(0,1,0.070)

Step 7: The relative significance of the alternatives is determined by calculating the appraisal score using equation (1), which is presented in Table 10.

Step 8: The overall appraisal scores of the options are computed using equation (9) and is provided in Table 10.

TABLE 10. Overall appraisal scores of the alternatives.

Alt.	WS_i	WP_i	$\kappa_{i\alpha}$	$\kappa_{i\beta}$	$\kappa_{i\gamma}(\lambda = 0.5)$	κ_i
O_1	-1.187	2.265	0.116	1.977	-0.250	1.260
O_2	-1.215	2.660	0.156	2.174	-0.087	1.492
O_3	-1.066	2.533	0.158	1.996	0.022	1.426
O_4	-0.725	3.610	0.311	2.191	0.952	2.038
O_5	-0.683	3.092	0.260	1.927	0.743	1.747

For standardization, the coefficient of the compromise decision system indicated by $\lambda \in (0,\ 1)$ and is set to 0.5 to assign identical preference.

Step 9: The decreasing order of the overall appraisal scores determines the ranking order of the SEZ locations, which is $\mathscr{O}_4 \succ \mathscr{O}_5 \succ \mathscr{O}_2 \succ \mathscr{O}_3 \succ \mathscr{O}_1$.

The computation of the proposed N-CoCoSo method is carried out for $q = 2$ in equation (1) and the outcome is displayed in Table 11.

TABLE 11. Overall appraisal scores of the SEZ locations for $q = 2$ in equation (1).

Alt.	WS_i	WP_i	$\kappa_{i\alpha}$	$\kappa_{i\beta}$	$\kappa_{i\gamma}(\lambda = 0.5)$	κ_i
O_1	-4.664	8.180	0.066	1.972	0.177	1.022
O_2	-4.797	11.548	0.126	2.412	0.340	1.428
O_3	-4.020	12.068	0.150	2.313	0.405	1.477
O_4	-2.625	22.284	0.367	3.272	0.990	2.602
O_5	-2.418	17.978	0.291	2.702	0.783	2.109

Hence the ranking order of the alternatives is $\mathscr{O}_4 \succ \mathscr{O}_5 \succ \mathscr{O}_3 \succ \mathscr{O}_2 \succ \mathscr{O}_1$. The parameter q is not significantly affected by the ranking of the SEZ locations, despite the fact that the overall performance scores are sensitive to variations in q.

6.1. *Sensitivity Analysis*

To evaluate the influence of internal parameter variation and criteria weight variation on the sorting order of the proposed approach, this section implements two distinct categories of sensitivity analysis.

6.1.1. *Internal parameter variation*

The alteration in internal parameters has a major impact on the sorting sequence of the options. This impact plays an important role in checking the robustness of the proposed approach. The impact of variation in parameter λ to determine the neutrosophic appraisal score at Step 7 is depicted in Table 12.

TABLE 12. Impact of λ variation on ranking orders of SEZ locations.

Alt.	Ranking order
$\lambda = 0.1$	$\mathscr{O}_4 \succ \mathscr{O}_5 \succ \mathscr{O}_2 \succ \mathscr{O}_3 \succ \mathscr{O}_1$
$\lambda = 0.2$	$\mathscr{O}_4 \succ \mathscr{O}_5 \succ \mathscr{O}_2 \succ \mathscr{O}_3 \succ \mathscr{O}_1$
$\lambda = 0.3$	$\mathscr{O}_4 \succ \mathscr{O}_5 \succ \mathscr{O}_2 \succ \mathscr{O}_3 \succ \mathscr{O}_1$
$\lambda = 0.4$	$\mathscr{O}_4 \succ \mathscr{O}_5 \succ \mathscr{O}_2 \succ \mathscr{O}_3 \succ \mathscr{O}_1$
$\lambda = 0.5$	$\mathscr{O}_4 \succ \mathscr{O}_5 \succ \mathscr{O}_2 \succ \mathscr{O}_3 \succ \mathscr{O}_1$
$\lambda = 0.6$	$\mathscr{O}_4 \succ \mathscr{O}_5 \succ \mathscr{O}_2 \succ \mathscr{O}_3 \succ \mathscr{O}_1$
$\lambda = 0.7$	$\mathscr{O}_4 \succ \mathscr{O}_5 \succ \mathscr{O}_3 \succ \mathscr{O}_2 \succ \mathscr{O}_1$
$\lambda = 0.8$	$\mathscr{O}_4 \succ \mathscr{O}_5 \succ \mathscr{O}_3 \succ \mathscr{O}_2 \succ \mathscr{O}_1$
$\lambda = 0.9$	$\mathscr{O}_2 \succ \mathscr{O}_1 \succ \mathscr{O}_3 \succ \mathscr{O}_4 \succ \mathscr{O}_5$

Table 12 shows that the λ alteration has marginally modified the ranking order of the choices. The rankings obtained for $\lambda = 0.1$ to $\lambda = 0.6$ are identical, whereas those for $\lambda = 0.7$ and $\lambda = 0.8$ deviate a bit. However, the ranking order produced for $\lambda = 0.9$ differs entirely from the others. In conclusion, ranking orders have little impact on λ variation since they only alter the value of a single component in the performance score. Figure 2 illustrates the influence of λ change on ranking order.

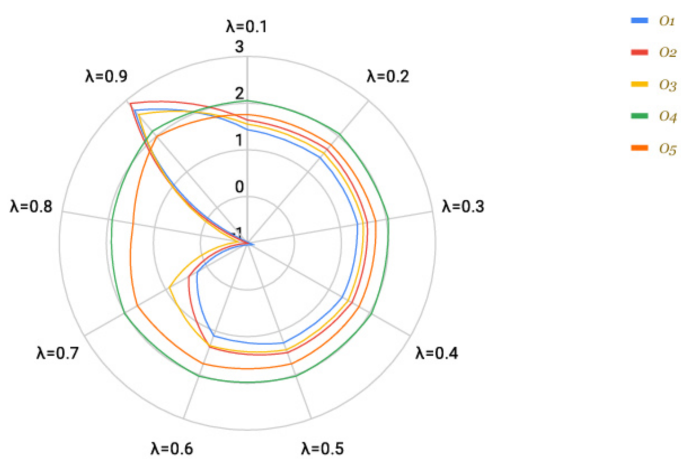

FIGURE 2. Impact of λ variation on performance scores of SEZ locations.

The performance scores of SEZ locations $\mathscr{O}_4$ and $\mathscr{O}_5$ are not affected by the λ variation, as illustrated in figure 2. Nevertheless, the performance values of $\mathscr{O}_1$, $\mathscr{O}_2$, and $\mathscr{O}_3$ have been substantial affected for $\lambda \in (0.7,\ 0.9)$. In summary, the performance values of the alternatives exhibit minimal fluctuation in response to variations in λ. This is because it can modify only one of the three parameters comprising the performance score.

6.1.2. *Criteria weight variation*

The relevance of the criterion may vary depending on the viewpoint of the decision expert. In this context, it is significant to examine the influence of criterion variation on the ordering of the choices. The rank-exponent approach [57] for criteria weight determination is described as follows:

Suppose that k_j and w_j represent the rank and preference degree of the j^{th} criterion, respectively, then $w_j = \frac{(n-k_j+1)^p}{\sum_{j=1}^{n}(n-k_j+1)^p},\ p \geq 0$. When $p = 1$, it is called the rank-sum approach and assigns equal weights (holistic) when $p = 0$.

This article uses entropy, holistic, rank-sum, and rank-exponent ($p = 2$) methods to determine the criteria weight. To apply these approaches, the neutrosophic decision matrix (Table 6) is transformed into a crisp decision matrix using equation (1), regardless of the proposed N-CoCoSo approach in determining the ranking orders. Table 13 provides the computed criteria weights using these approaches.

Table 13. Weights of each criteria determined by various methods.

Methods	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6	Y_7	Y_8
Entropy [58]	0.138	0.131	0.124	0.123	0.119	0.126	0.116	0.123
Holistic	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125
Rank-Sum	0.167	0.111	0.056	0.139	0.028	0.194	0.083	0.222
Rank-Exponent ($p = 2$)	0.078	0.044	0.240	0.314	0.123	0.176	0.020	0.005
MEREC [14]	0.122	0.120	0.122	0.126	0.130	0.123	0.129	0.129

Table 13 shows that the entropy and MEREC approaches assign almost identical weights to the criteria, consistent with the holistic preference. However, rank-sum and rank-exponent for $p = 2$ approaches assign specific preferences. According to rank-sum approach, criteria Y_1, Y_6, and Y_8 have much higher importance than the criteria average weighted criteria. The rank-sum approach assign significantly lower importance to the criteria Y_3, Y_5, and Y_7. The rank-exponent approach for ($p = 2$) assigns too high preference to the criteria Y_3, Y_4, and Y_6 than the remaining criteria. The reason for the difference in weight allocation in rank-sum and rank-exponent approaches may lie in the subjective assessment compared to objective assessment in entropy and MEREC approaches. Figure 3 shows the variation in criteria weight allocation through these approaches.

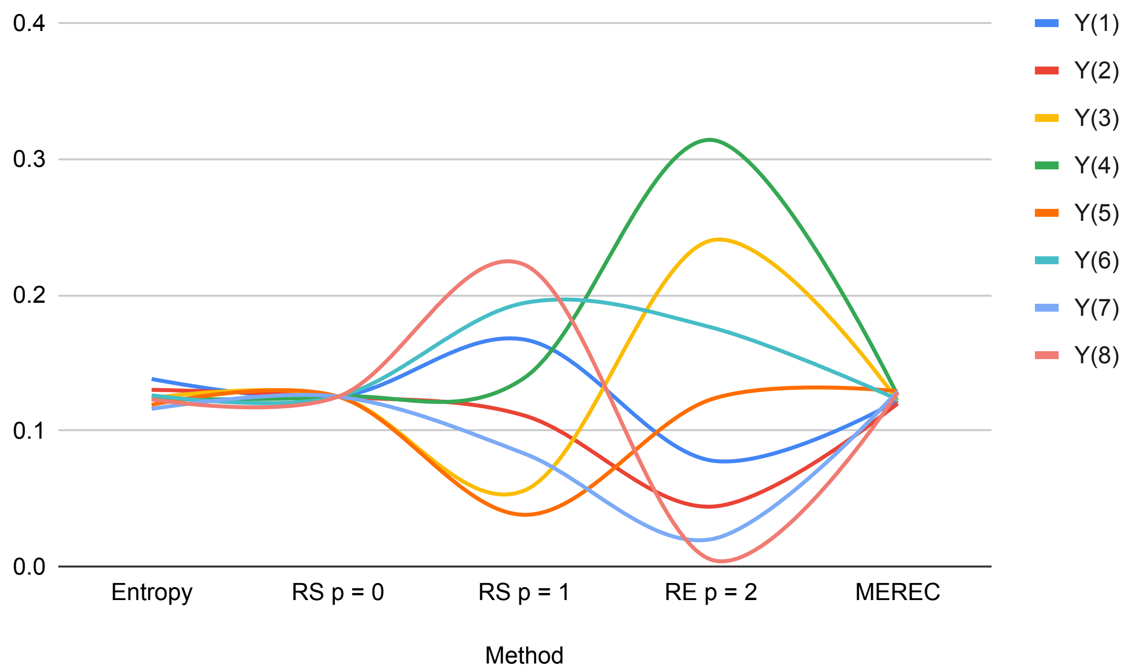

FIGURE 3. Criteria weight variation in different approaches.

The beginning and ending portions of the curves in figure 3 show that the criteria weight allotted to all the criteria is almost equal in entropy, rank-sum, and MEREC approaches. The maximum variation is seen in the weight allocation of the rank-exponent approach for $p = 2$. The most crucial criterion is Y_8 in the rank-sum approach, while Y_4 receives the highest preference in the rank-exponent approach for $p = 2$. The variation is observed for almost all criteria in their weight allocation in rank-sum and rank-exponent approaches; still, this variation is eye-catching in the criteria weight of Y_3 and Y_8. Table 14 illustrates the influence of criteria weight scheduling on the ranking sequence of the options.

TABLE 14. Ranking orders for criteria weight alteration.

Methods	Ranking order
Entropy	$\mathcal{O}_4 \succ \mathcal{O}_5 \succ \mathcal{O}_3 \succ \mathcal{O}_1 \succ \mathcal{O}_2$
Holistic	$\mathcal{O}_4 \succ \mathcal{O}_5 \succ \mathcal{O}_3 \succ \mathcal{O}_1 \succ \mathcal{O}_2$
Rank-Sum	$\mathcal{O}_4 \succ \mathcal{O}_5 \succ \mathcal{O}_3 \succ \mathcal{O}_1 \succ \mathcal{O}_2$
Rank-exponent ($p = 2$)	$\mathcal{O}_3 \succ \mathcal{O}_4 \succ \mathcal{O}_2 \succ \mathcal{O}_1 \succ \mathcal{O}_5$
MEREC	$\mathcal{O}_4 \succ \mathcal{O}_5 \succ \mathcal{O}_2 \succ \mathcal{O}_3 \succ \mathcal{O}_1$

The ranking sequence of the options in entropy and holistic criteria weight determination are identical, as expected from their criteria weight allocation, as depicted in Table 14. Surprisingly, the ranking sequence obtained from the rank-sum approach also coincides with the entropy and holistic approaches, though their criteria weight allocations are entirely different. The ranking order obtained in the MEREC approach has a slight variation between $\mathscr{O}_4$ and $\mathscr{O}_5$ compared to the ranking orders obtained from entropy and holistic approaches. The ranking order obtained through criteria weight determined by the rank-exponent approach for $p = 0$ is entirely different from those of the remaining approaches. However, the alternative $\mathscr{O}_4$ scores second in the ranking order, proving its superiority among the remaining alternatives. The influence of criteria weight alteration on the performance of the alternatives is depicted in figure 4.

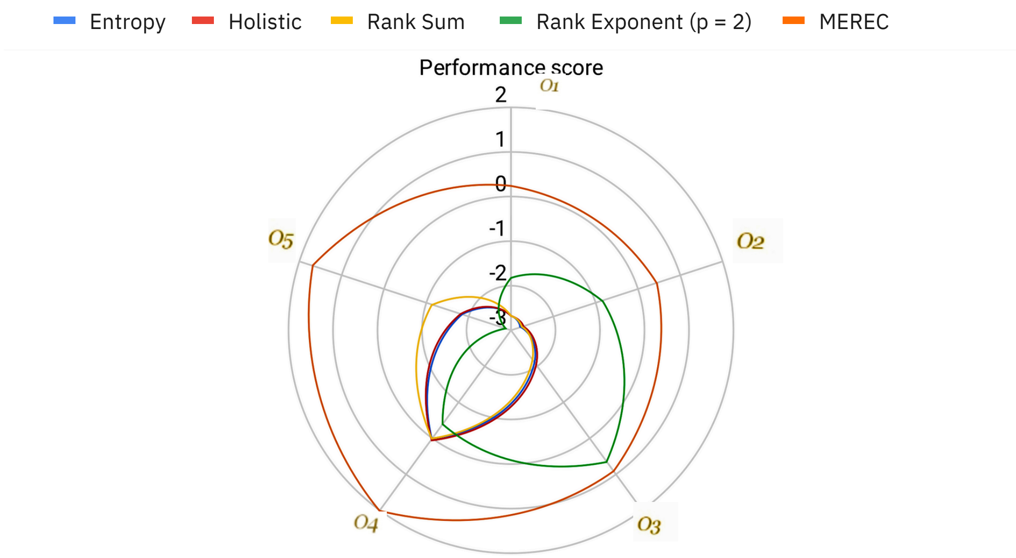

Figure 4. Variation of alternative's performance scores due to criteria weight alteration.

The performance scores of the locations for SEZ are significantly influenced by the criteria weight variation, as illustrated in Figure 4. Compared to the remaining locations, the SEZ location $\mathscr{O}_1$ only outperforms them regarding holistic criteria weight. The $\mathscr{O}_2$ and $\mathscr{O}_3$ options exhibit appalling performance in the entropy, rank-sum, and MEREC approaches, while they perform exceptionally well in the remaining two approaches. The $\mathscr{O}_4$ and $\mathscr{O}_5$ options exhibit comparable performance across all criteria weight determination procedures. Consequently, it is verifiable that these two alternatives are viable to select the location of a SEZ.

6.2. *Comparison analysis*

To establish the proposed neutrosophic MEREC-CoCoSo approach, it is imperative to check the outcomes of the suggested technique with some popular existing MCDM techniques like

MAIRCA [59], EDAS [60], CODAS [61], and MABAC [62] approaches. Here, we have determined the criteria weights through the MEREC approach to maintain logical similarity, and these approaches are applied to a crisp decision matrix obtained from neutrosophic decision matrix (Table 3) using equation (1). Table 15 displays the obtained outcomes of this comparison analysis.

TABLE 15. Comparison analysis of proposed approach.

Approach	MAIRCA		EDAS		CODAS		MABAC		SVN-CoCoSo	
Options	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank
$\mathscr{O}_1$	0.567	5	0.630	3	14.898	3	0.0356	3	1.259	5
$\mathscr{O}_2$	0.531	4	0.846	1	26.637	1	0.046	2	1.492	3
$\mathscr{O}_3$	0.827	3	0.672	2	11.492	4	0.0730	1	1.425	4
$\mathscr{O}_4$	0.857	2	0.138	5	15.457	2	-0.061	4	2.037	1
$\mathscr{O}_5$	1.057	1	0.199	4	10.120	5	-0.078	5	1.746	2

The proposed neutrosophic MEREC-CoCoSo approach shares significant similarities with the MAIRCA approach, while the outcomes in the EDAS, CODAS, and MABAC approaches are significantly different. The first two positions obtained by the alternatives $\mathscr{O}_4$ and $\mathscr{O}_5$ in SVN-CoCoSo and MAIRCA approaches are identical, while the remaining positions are identical. Hence, the alternative $\mathscr{O}_4$ has significant credibility than the remaining alternatives. The alternative $\mathscr{O}_1$ fails to prove its credibility as it is almost at the end of the ranking orders in all approaches. The performance score comparison of the alternatives is shown in figure 5.

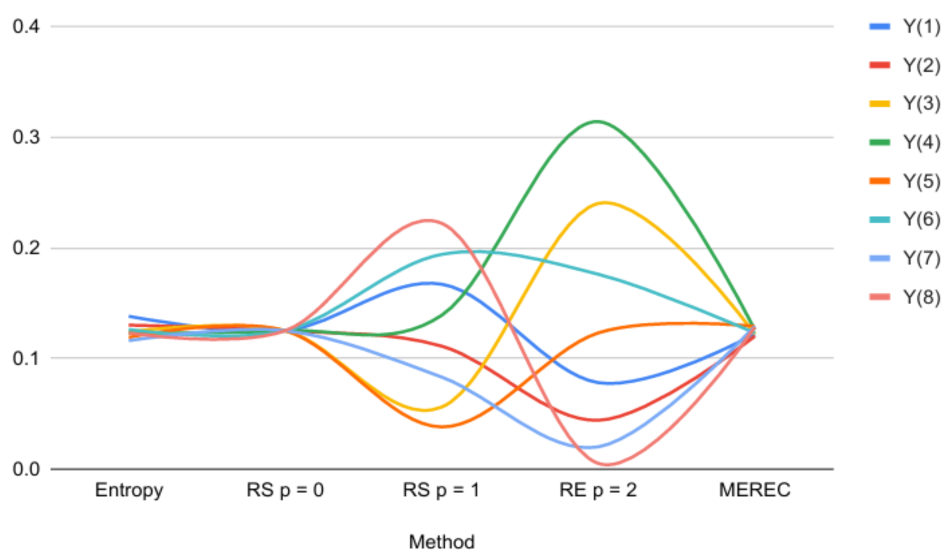

FIGURE 5. Comparison of performance scores of the options.

The performance scores of MAIRCA, EDAS, MABAC, and the proposed SVN-CoCoSo methods are within a very narrow range, as illustrated in figure 5. Conversely, the CODAS method exhibits a significantly higher performance score. Nevertheless, this observation does not significantly influence the ranking sequence of the options in various approaches. The alternative $\mathscr{O}_2$ ranks first in CODAS with a significant difference, whereas the same incident occurred in EDAS with a shallow margin. The reliability of $\mathscr{O}_2$ is uncertain due to its inconsistent performance across several methodologies. In MAIRCA, CODAS, and the proposed SVN-CoCoSo approaches, the performance of $\mathscr{O}_4$ is evident. However, in EDAS and MABAC, the performance is not as good, although the difference is minimal compared to the first. Therefore, $\mathscr{O}_4$ is a superior choice for a SEZ site. In conclusion, the proposed SVN-CoCoSo method exhibits a certain degree of similarity to the crisp approaches, with the distinction being the criteria analysis through neutrosophic information.

Conclusion

The advantages of carrying out the recommended N-CoCoSo method are as follows: (i) This strategy is significantly less complex compared to other fuzzy CoCoSo approaches, (ii) the suggested strategy evaluates the criteria using SVNS, which enhances its generality and adaptability, (iii) it employs the Entropy approach to determine the objective weights of the relevant criteria. Adopting and utilizing such emerging technology enhances the precision of the decision-making system, supports business policies, validates worldwide objectives, and yields advantageous outcomes for management control.

We have found that the land near the littoral area is significantly more advantageous than the plains far from the sea by utilizing the proposed N-CoCoSo approach for SEZ location selection. This may be because of proximity to the port, which is a critical requirement for SEZs. In the littoral region, agricultural land is more advantageous than forest land near the sea. The rationale is the straightforward and appropriate evaluation of the availability of large tracts of land and the environmental concerns. Mangroves frequently encircle the coastal forest areas, which substantially affects the preservation of biodiversity.

However, despite its numerous advantages, the proposed N-CoCoSo decision-making model has certain limitations. The limitations of the proposed approach are (i) The subjective bias and personal favoritism of the DM towards any specific criteria, and (ii) the fact that the criteria information needs a hesitancy component makes it impracticable to implement. Future research may include (i) the development of the suggested technique to accommodate more complex analyses in the context of Z-number, D-number, type II fuzzy, and hesitant fuzzy environments, (ii) the implementation of an appropriate blend of subjective and objective criteria preferences by the decision expert's qualifications; and (iii) the proposed N-CoCoSo method can be implemented to address decision-making challenges, including the evaluation of financial firms' performance and the selection of suppliers, ERP selection, and analysis of renewable energy sources.

Funding: This research received no external funding.

Conflicts of Interest: The authors declare no conflict of interest.

@articlemwansa2020special, title=Special economic zones: An evaluation of Lusaka south-multi facility economic zone, author=Mwansa, Stephen and Shaikh, Junaid and Mubanga, Phillip, journal=Journal of Social and Political Sciences, volume=3, number=2, year=2020, note=https://doi.org/10.31014/aior.1991.03.02.188

References

1. Mwansa, S., Shaikh, J., & Mubanga, P. (2020). Special economic zones: An evaluation of Lusaka south-multi facility economic zone. Journal of Social and Political Sciences. 3(2).
2. Wang, J. (2013). The economic impact of special economic zones: Evidence from Chinese municipalities. Journal of Development Economics. 101, 133-147.
3. Ginting, B., Sembiring, R., Siregar, M., & Abduh, A. (2018). The role of law in economic development: To develop a special economic zone in order to build a national and regional economy. Proceedings of MICoMS. 1, 209-214.
4. Frick, S.A., Andres, R., & Wong, M.D., (2019). Toward economically dynamic special economic zones in emerging countries. Economic Geography. 95(1), 30-64.
5. Naeem, S., Waheed, A., & Khan, M.N. (2020). Drivers and barriers for successful special economic zones (SEZs): Case of SEZs under China Pakistan economic corridor. Sustainability. 12(11), 1-18.
6. Jumaniyazov, I.T., & Hazratov, B., (2022). Foreign experience in the development of special economic zones in Uzbekistan. Science and Education. 3(5), 1628-1636.
7. Shabbir, S., Waqar, S., Ahmed, F., & Ahmed, S. (2021). Policy Reforms in Public Institutions to Regulate SEZ under CPEC: A Learning Example from Africa. Studies of Applied Economics. 39(8).
8. Dhingra, T., Singh, T., & Sinha, A. (2009). Location strategy for competitiveness of special economic zones: A generic framework for India. Competitiveness Review: An International Business Journal. 19(4), 272-289.
9. Triantaphyllou, E. (2000). Multi-criteria decision-making methods: A comparative study, 1st Ed. Springer New York.
10. Ahmed, W., Tan, Q., Solangi, Y.A. & Ali, S. (2020). Sustainable and special economic zone selection under fuzzy environment: A case of Pakistan. Symmetry. 12(2), 242.
11. Al-Ruzouq, R., Abdallah, M., Shanableh, A., Alani, S., Obaid, L., & Gibril, M.B.A. (2022). Waste to energy spatial suitability analysis using hybrid multi-criteria machine learning approach. Environmental Science and Pollution Research. 29, 2613-2628.
12. Zewdie, M.M., & Yeshanew, S.M., (2023). GIS based MCDM for waste disposal site selection in Dejen town, Ethiopia. Environmental and Sustainability Indicators. 18, 100228.
13. Roy, P. & Shaw, K., (2023). A fuzzy MCDM decision-making model for m-banking evaluations: comparing several m-banking applications. Journal of Ambient Intelligence and Humanized Computing. 14(9), 11873-11895.

14. Keshavarz-Ghorabaee, M., Amiri, M., Zavadskas, E.K., Turskis, Z., & Antucheviciene, J. (2021). Determination of objective weights using a new method based on the removal effects of criteria (MEREC). Symmetry. 13(4), 525.
15. Yazdani, M., Zarate, P., Zavadskas, E.K., & Turskis, Z. (2019). A combined compromise solution (CoCoSo) method for multi-criteria decision-making problems. Management decision. 57(9), 2501-2519.
16. Peng, X., & Luo, Z., (2021). Decision-making model for China's stock market bubble warning: the CoCoSo with picture fuzzy information. Artificial Intelligence Review. 54(8), 5675-5697.
17. Liu, P., Rani, P., & Mishra, A.R. (2021). A novel Pythagorean fuzzy combined compromise solution framework for the assessment of medical waste treatment technology. Journal of Cleaner Production. 292, 126047.
18. Zavadskas, E.K., Turskis, Z and Šliogerienė, J., and Vilutienė, T. (2021). An integrated assessment of the municipal buildings' use including sustainability criteria. Sustainable Cities and Society. 67, 102708.
19. Alrasheedi, M., Mardani, A., Mishra, A. R., Streimikiene, D., Liao, H., & Al-nefaie, A. H., (2021). Evaluating the green growth indicators to achieve sustainable development: A novel extended interval-valued intuitionistic fuzzy-combined compromise solution approach. Sustainable Development, 29(1), 120-142.
20. Torkayesh, A.E., Pamucar, D., Ecer, F., & Chatterjee, P. (2021). An integrated BWM-LBWA-CoCoSo framework for evaluation of healthcare sectors in Eastern Europe. Socio-Economic Planning Sciences. 78, 101052.
21. Pamucar, D., Deveci, M., Gokasar, I., Işık, M., & Zizovic, M. (2021). Circular economy concepts in urban mobility alternatives using integrated DIBR method and fuzzy Dombi CoCoSo model. Journal of Cleaner Production. 323, 129096.
22. Yousefi, S., Valipour, M., & Gul, M. (2021). Systems failure analysis using Z-number theory-based combined compromise solution and full consistency method. Applied Soft Computing. 113, 107902.
23. Peng, X., Krishankumar, R., & Ravichandran, K.S., (2021). A novel interval-valued fuzzy soft decision-making method based on CoCoSo and CRITIC for intelligent healthcare management evaluation. Soft Computing. 25, 4213-4241.
24. Yazdani, M., Wen, Z., Liao, H., Banaitis, A., & Turskis, Z., (2019). A grey combined compromise solution (CoCoSo-G) method for supplier selection in construction management. Journal of Civil Engineering and Management. 25(8), 858-874.
25. Ecer, F., & Pamucar, D., (2020). Sustainable supplier selection: A novel integrated fuzzy best worst method (F-BWM) and fuzzy CoCoSo with Bonferroni (CoCoSo'B) multi-criteria model. Journal of cleaner production, 266, 121981.
26. Peng, X., & Huang, H., (2020). Fuzzy decision-making method based on CoCoSo with critic for financial risk evaluation. Technological and Economic Development of Economy. 26(4), 695-724.
27. Peng, X., & Smarandache, F. (2020). A decision-making framework for China's rare earth industry security evaluation by neutrosophic soft CoCoSo method. Journal of Intelligent & Fuzzy Systems. 39(5), 7571-7585.
28. Liao, H., Qin, R., Wu, D., Yazdani, M., & Zavadskas, E.K., (2020). Pythagorean fuzzy combined compromise solution method integrating the cumulative prospect theory and combined weights for cold chain logistics distribution center selection. International Journal of Intelligent Systems. 35(12), 2009-2031.
29. Peng, X., Zhang, X., & Luo, Z. (2020). Pythagorean fuzzy MCDM method based on CoCoSo and CRITIC with score function for 5G industry evaluation. Artificial Intelligence Review. 53(5), 3813-3847.
30. Ulutas, A., Karakus, C., & Topal, A. (2020). Location selection for logistics center with fuzzy SWARA and CoCoSo methods. Journal of Intelligent & Fuzzy Systems. 38(4), 4693-4709.
31. Rani, P., & Mishra, A.R. (2020). Novel single-valued neutrosophic combined compromise solution approach for sustainable waste electrical and electronics equipment recycling partner selection. IEEE Transactions on Engineering Management. 69(6), 3139-3153.

32. Yazdani, M., Torkayesh, A.E., Stevic, Ž., Chatterjee, P., Ahari, S.A., & Hernandez, V.D. (2021). An interval valued neutrosophic decision-making structure for sustainable supplier selection. Expert Systems with Applications. 183, 115354.
33. Mishra, A.R., & Rani, P. (2021). Assessment of sustainable third party reverse logistic provider using the single-valued neutrosophic combined compromise solution framework. Cleaner and Responsible Consumption. 2, 100011.
34. Rani, P., Ali, J., Krishankumar, R., Mishra, A.R., Cavallaro, F., & Ravichandran, K.S. (2021). An integrated single-valued neutrosophic combined compromise solution methodology for renewable energy resource selection problem. Energies. 14(15), 4594.
35. Demir, G., Damjanovic, M., Matovic, B., & Vujadinovic, R. (2022). Toward sustainable urban mobility by using fuzzy-FUCOM and fuzzy-CoCoSo methods: the case of the SUMP podgorica. Sustainability. 14(9), 4972.
36. Qiyas, M., Naeem, M., Khan, Saifullah, Abdullah, S., Botmart, T., & Shah, T. (2022). Decision support system based on CoCoSo method with the picture fuzzy information. Journal of Mathematics. 2022(1), 1476233.
37. Chen, Q.Y., Liu, H.C., Wang, J.H., & Shi, H. (2022). New model for occupational health and safety risk assessment based on Fermatean fuzzy linguistic sets and CoCoSo approach. Applied Soft Computing. 126, 109262.
38. Pamucar, D., Gorcun, O. (2022). Evaluation of the European container ports using a new hybrid fuzzy LBWA-CoCoSo'B techniques, Expert Systems with Applications. 203, 117463.
39. Wei, L. An integrated decision-making framework for blended teaching quality evaluation in college English courses based on the double-valued neutrosophic sets. Journal of Intelligent & Fuzzy Systems. 45(2), 3259-3266.
40. Peng, X., Dai, J., & Smarandache, F. (2023). Research on the assessment of project-driven immersion teaching in extreme programming with neutrosophic linguistic information. International Journal of Machine Learning and Cybernetics. 14(3), 873-888.
41. Wen, X., & Pan, C. (2024). Enhanced CoCoSo Technique for Sport Teaching Quality Evaluation with Double-Valued Neutrosophic Number Multiple-Attribute Decision-Making. International Journal of Advanced Computer Science & Applications. 15(6).
42. Yang, L., & Li, Q. (2024). CoCoSo framework for multi-attribute decision-making with triangular fuzzy neutrosophic sets:"Innovation and entrepreneurship" evaluation case. International Journal of Knowledge-based and Intelligent Engineering Systems. 1-15.
43. Mohamed, R., & Ismail, M.M. (2024). Leveraging an Uncertainty Methodology to Appraise Risk Factors Threatening Sustainability of Food Supply Chain. Neutrosophic Systems with Applications. 19, 30-52.
44. Nabeeh, N.A., & Sallam, K.M. (2024) A Combined Compromise Solution (CoCoSo) of MCDM Problems for Selection of Medical Best Bearing Ring. Neutrosophic Optimization and Intelligent Systems. 1, 1-13.
45. Aytekin, A., Bozkurt, E., Orakci, E., Uysal, M., Simic, V., Korucuk, S., & Pamucar, D. (2024). A bipolar neutrosophic combined compromise solution-based hybrid model for identifying blockchain application barriers and Benchmarking consensus algorithms. Engineering Applications of Artificial Intelligence. 133, 108343.
46. Zak, J., & Weglinski, S. (2014). The selection of the logistics center location based on MCDM/A methodology. Transportation Research Procedia. 3, 555-564.
47. Mohan, V.G., & Naseer, M.A. (2022). Prioritisation of dry port locations using MCDM methods: A case of cochin port. Journal of The Institution of Engineers (India): Series A. 103(3), 841-856.

48. Kraisee K. (2020). Site Selection of SEZ-based Freight Village: A Case Study of Border Provinces in Thailand. NIDA Business Journal. 27, 136-161.
49. Armanuos, A.M., Elgaafary, K.A., & Gado, T.A. (2023). Landfill site selection using MCDM methods and GIS in the central part of the Nile Delta, Egypt. Environmental Monitoring and Assessment. 195(12), 1407.
50. Tercan, E., Dereli, M.A., and Saracoglu, B.O. (2022). Location alternatives generation and elimination of floatovoltaics with virtual power plant designs. Renewable Energy. 193, 1150-1163.
51. Saatsaz, M., Monsef, I., Rahmani, M., & Ghods, A. (2018). Site suitability evaluation of an old operating landfill using AHP and GIS techniques and integrated hydrogeological and geophysical surveys. Environmental monitoring and assessment. 190, 1-31.
52. Nguyen, T.M.H., van Binsbergen, A., & Dinh, C.T., (2024). Dry port location selection for integration with inland waterway transport in developing countries: A case study in Northern Vietnam. Journal of Supply Chain Management Science. 5(1-2), 1-29.
53. Rajput, L., Beg, I., & Kumar, S. (2024). Spherical fuzzy analytic hierarchy process and linear assignment model based MCGDM method with its application in ranking of states for their business climate. Expert Systems with Applications. 238, 122247.
54. Wang, H., Smarandache, F., Zhang, Y., & Sunderraman, R. (2010). Single valued neutrosophic sets. Infinite study.
55. Liu, P. & Wang, Y. (2014). Multiple attribute decision-making method based on single-valued neutrosophic normalized weighted Bonferroni mean. Neural Computing and Applications. 25(7), 2001-2010.
56. Haq, R.S.U., Saeed, M., Mateen, N., Siddiqui, F., Naqvi, M., Yi, J.B., & Ahmed, S. (2022). Sustainable material selection with crisp and ambiguous data using single-valued neutrosophic-MEREC-MARCOS framework. Applied Soft Computing. 128, 109546.
57. Roszkowska, E. (2013). Rank ordering criteria weighting methods-a comparative overview. Optimum. Studia Ekonomiczne. 5(65), 14-33.
58. Zou, Z.H., Yi, Y., & Sun, J.N. (2006). Entropy method for determination of weight of evaluating indicators in fuzzy synthetic evaluation for water quality assessment. Journal of Environmental sciences. 18(5), 1020-1023.
59. Pamucar, D., Vasin, L., & Lukovac, L. (2014). Selection of railway level crossings for investing in security equipment using hybrid DEMATEL-MARICA model. XVI international scientific-expert conference on railway, railcon. 89-92.
60. Keshavarz G.M., Zavadskas, E.K., Olfat, L. & Turskis, Z. (2015). Multi-criteria inventory classification using a new method of evaluation based on distance from average solution (EDAS). Informatica. 26(3), 435-451.
61. Keshavarz, G.M., Zavadskas, E.K., Turskis, Z., & Antuchevičienė, J. (2016). A new combinative distance-based assessment (CODAS) method for multi-criteria decision-making. Academy of Economic Studies.
62. Pamucar, D., & Cirovic, G. (2015). The selection of transport and handling resources in logistics centers using Multi-Attributive Border Approximation area Comparison (MABAC). Expert systems with applications. 42(6), 3016-3028.

Received: July 16, 2024. Accepted: September 07, 2024