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Article

New Generalized Aggregation Operator in Single Valued Neutrosophic Set Environment and Its Application to Crop Land Selection Problem

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Abstract: In real-life situation, making the right decision can significantly impact One's lifespan. Cropland selection for agriculture is a popular Multi Criteria Decision Making (MCDM)problem. Therefore, many researchers are interested in conducting research in the agricultural field. The main aim of farmer optimizing land and water resources and enhancing agricultural system. However, making the right decision in crop land selection is a challenging task due to the uncertainty of available information. Neutrosophic sets have the potential to deal with uncertain or incomplete data due to the independent components structure. In this paper, we have defined a gene5ralised aggregation operator in single valued Neutrosophic set (SVNS)context and its basic properties. We have designed a general structure for MCDM problem, followed by some steps. A real-life example of Crop land selection is also demonstrated to highlight effectiveness of the proposed operator and

MCDM method. The effectiveness of the proposed method was examined by comparing it with some existing methods.

Keywords: Single valued Neutrosophic set; Generalized Aggregation operator; Crop land selection; Multi Criteria Decision making.

1.Introduction

The invention of the neutrosophic set (NS) by F. Smarandache is a significant exploration in research. Neutrosophic set is the generalization of intuionistic fuzzy set (IFS). IFSs contain only two independent components: truth and falsity, whereas NSs contain three independent components: truth, falsity, and indeterminacy which are held in the $]^{-}0,1^{+}[$. In 2010 Wang et. al introduced Single Values Neutrosophic Set (SVNS) on the basis of standard interval [0,1]. Due to its three components, any incomplete and uncertain information can be easily handled by the SVNSs. The attractive structure of SVNSs has gained significant attention from many researchers, who are now focusing their work in the SVNS environment.

1.1 *Motivation of the study*

Senapati [2] in 2024 develop Aczel-Alsina aggregation operator in SVNSs and proved its necessary properties and construct a strategy for MADM issues in SVNS environment. Ye [3] introduced two aggregation operators for SVNSs, applying them to solve MCDM problems. Nancy and Garg [4] proposed some operations for SVNNs under Frank norm operations and developed averaging and geometric aggregation operators for decision-making problems. Liu et al. [5] proposed a MAGDM strategy based on power average operators in SVNSs and grey relational analysis (GRA) for the Ranking according to Compromise Solution (MARCOS) method. Liu et al. [6] integrated SVNS with Dombi extended power aggregation operators, proposing two weighted operators and applying them to an intelligent transportation system. Kara et al. [7] proposed the SVNS-ARLON method for service provider ranking, demonstrating its applicability in real-world scenarios. Garai et al. [8] proposed an SVNS-softmax aggregation approach, validating it through application to an MCDM problem. Agriculture is one of the fundamental resources of the global economy. Agricultural technology advancements are leading to higher crop yields, increased food production, and more efficient land use, revolutionizing farming practices. Sustainable farming methods play a vital role in guaranteeing food security and reducing ecological footprint simultaneously. The agricultural sector is crucial to India's economy, focusing on promoting equitable growth, boosting rural incomes, and strengthening food security measures. MCDM is a method that evaluates alternatives holistically, considering multiple conflicting criteria, and has been effectively used to assess various aspects of the agriculture sector. The presence of uncertainty significantly impacts on the assessment of agriculture land selection. Due to the advantages of TMF, FMF and IMF, SVNS can cope with incomplete information for selection agricultural decision-making problem. An SVN-distance measure was proposed by Mishra et al. [9] to determine the dissimilarity between SVNSs. They also proposed a hybrid ranking strategy in SVNS to assess the agro-climatic regions of India. An MCDM strategy was formulated by Garai & Garg [10] to tackle water resource management (WRM) issues in the Puruliya district of West Bengal, under a neutrosophic environment. In 2021 Zeng et. Al [11] defined SVN-Graph and applied this graph in Food and Agriculture Organization.

Inspired by these innovative ideas. We developed a generalized aggregation operator in an SVNS environment and proposed an MCDM technique based on the aggregation operator for agricultural land selection.

1.2 *Contribution of the study*

The purpose of this study is to design a method that recommends the best alternative from a collection of feasible options. For this decision-making purpose, at first, we develop a generalized aggregation operator and proves its related impotent properties. We also investigate the sensitivity analysis for this operator. A multi-step MCDM approach was developed and demonstrated through a numerical example focusing on crop land location selection based on key criteria. The main contributions of this study are that:

- We defined a generalized SVNS aggregation operator.
- We proved its basics properties.
- We design a MCDM framework for decision making based on proposed operator.
- we solve a real decision-making task to check validity and practicability of MCDM method.
- A comparative study with existing methods is conducted to verify the proposed approach and demonstrate its strengths.

*The results are outlined and discussed to assess the method's reliability and effectiveness.

Structure of this study

This manuscript is arranged into the following sections. Section 2 provides a brief overview of fundamental concepts related to SVNSs and their operations. In section 3 introduces a novel neutrosophic power mean aggregation operator, along with a discussion of its fundamental properties. In Sect. 4, we defined new power mean operator based MCDM decision making method. Section 5 provides a numerical illustration of land selection for agriculture. In section 6, we provide a comparative analysis. Finally, in Sect. 7 the paper is concluded.

2.**Basic Preliminaries**

Neutrosophic sets(N.S): [1] Let $\breve{X}$ be a universe. A neutrosophic set $\breve{A}$ over $\breve{X}$ is defined by $\breve{A}$ ={< $\breve{x}$, $(T_{\breve{A}}(\breve{x}), I_{\breve{A}}(\breve{x}), F_{\breve{A}}(\breve{x}))$ >: $\breve{x} \in \breve{X}$} where $T_{\breve{A}}(\breve{x}), I_{\breve{A}}(\breve{x})$ and $F_{\breve{A}}(\breve{x})$ are known as truth part, indeterminacy parts and falsity part, in function form respectively. These are in function form as :

$T_{\breve{A}}$: $\breve{X} \rightarrow]-_0, 1^+[$,$I_{\breve{A}}$: $\breve{X} \rightarrow]-_0, 1^+[$, $F_{\breve{A}}$: $\breve{X} \rightarrow]-_0, 1^+[$ such that $0^- \leq T_{\breve{A}}(\breve{x}) + I_{\breve{A}}(\breve{x}) + F_{\breve{A}}(\breve{x}) \leq 3^+$

Single valued Neutrosophic set (SVNS):[14] Let $\breve{X}$ be a universe. A single valued neutrosophic (SVN)set $\breve{A}$ over $\breve{X}$ is represent as

$T_{\breve{A}}$: $\breve{X} \rightarrow [0,1] I_{\breve{A}}$: $\breve{X} \rightarrow [0,1] F_{\breve{A}}$: $\breve{X} \rightarrow [0,1]$ such that $0 \leq T_{\breve{A}}(\breve{x}) + I_{\breve{A}}(\breve{x}) + F_{\breve{A}}(\breve{x}) \leq 3$. For simplicity, a SVNN can be written as $\breve{A} = (T_{\breve{A}}, I_{\breve{A}}, F_{\breve{A}}) T_{\breve{A}} \in [0,1]$,$I_{\breve{A}} \in [0,1], F_{\breve{A}} \in [0,1]$

and $0 \leq T_{\breve{A}} + I_{\breve{A}} + F_{\breve{A}} \leq 3$

2.1 *Some Operations [14]*

Let $\breve{A}$={<$\breve{x}$, $(T_{\breve{A}}(\breve{x}), I_{\breve{A}}(\breve{x}), F_{\breve{A}}(\breve{x}))$ >: $\breve{x} \in \breve{X}$} and $\breve{B}$={<$\breve{x}$, $(T_{\breve{B}}(\breve{x}), I_{\breve{B}}(\breve{x}), F_{\breve{B}}(\breve{x}))$ >: $\breve{x} \in \breve{X}$} be two SVNSs in $\breve{X}$,then operations between them defined by Wang *et al.* [14]as follows:

1.$\breve{A} \subseteq \breve{B} \leftrightarrow T_{\breve{A}}(\breve{x}) \leq T_{\breve{B}}(\breve{x})$,$I_{\breve{A}}(\breve{x}) \geq I_{\breve{B}}(\breve{x})$, ,$F_{\breve{A}}(\breve{x}) \geq F_{\breve{B}}(\breve{x})$,$\forall \breve{x} \in \breve{X}$

2.$\breve{A} = \breve{B}$ if and only if $\breve{A} \subseteq \breve{B}, \breve{B} \subseteq \breve{A}$,$\forall \breve{x} \in \breve{X}$

3.$\breve{A}^c$={<$\breve{x}$, $(F_{\breve{A}} 1 - I_{\breve{A}}, T_{\breve{A}})$ >: $\breve{x} \in \breve{X}$} ,$\forall \breve{x} \in \breve{X}$

However, the likely correction would be $\breve{A}^c$ = {< $\breve{x}$, $(F_{\breve{A}} 1 - I_{\breve{A}}, T_{\breve{A}})$ >: $\breve{x} \in \breve{X}$} should be $\breve{A}^c$={<$\breve{x}$, $(F_{\breve{A}}(\breve{x}), 1 - I_{\breve{A}}(\breve{x}), T_{\breve{A}}(\breve{x}))$ >: $\breve{x} \in \breve{X}$}

4. $\breve{A} \cup \breve{B} = \breve{A}$={<$\breve{x}$, $\left(\max(T_{\breve{A}}(\breve{x}), T_{\breve{B}}(\breve{x})), \min(I_{\breve{A}}(\breve{x}), I_{\breve{B}}(\breve{x})), \min(F_{\breve{A}}(\breve{x}), F_{\breve{B}}(\breve{x})\right)$ >: $\breve{x} \in \breve{X}$} ,$\forall \breve{x} \in \breve{X}$

5. $\breve{A} \cap \breve{B} = \breve{A}$={<$\breve{x}$, $\left(\min(T_{\breve{A}}(\breve{x}), T_{\breve{B}}(\breve{x})), \max(I_{\breve{A}}(\breve{x}), I_{\breve{B}}(\breve{x})), \max(F_{\breve{A}}(\breve{x}), F_{\breve{B}}(\breve{x})\right)$ >: $\breve{x} \in \breve{X}$} ,$\forall \breve{x} \in \breve{X}$

3.**New Neutrosophic Power mean operator**

Let,$\breve{N} = \breve{A}_1, \breve{A}_2, \breve{A}_3, \breve{A}_4, \ldots \ldots \ldots \ldots \ldots . \breve{A}_P$ be the set of P neutrosophic sets. The neutrosophic power mean operator $f_q: \breve{N}^P \rightarrow \breve{N}$is expressed as

$$f_q(\breve{x}) = (\frac{1}{p}\sum_{i=1}^{-p}\left(T_{\breve{A}_i}(\breve{x})\right)^q)^{\frac{1}{q}}, (\frac{1}{p}\sum_{i=1}^{-p}\left(I_{\breve{A}_i}(\breve{x})\right)^q)^{\frac{1}{q}}, (\frac{1}{p}\sum_{i=1}^{-p}\left(F_{\breve{A}_i}(\breve{x})\right)^q)^{\frac{1}{q}} \quad (1)$$

Where q>0, areal number and p is a positive number

Special Cases:

Case 1: when q=1, the Eq (1) reduces to the following form:

$$f_1(\breve{x})=(\frac{1}{p}\sum_{i=1}^{p} T_{\breve{A}_i}(\breve{x}), \frac{1}{p}\sum_{i=1}^{p} I_{\breve{A}_i}(\breve{x}), \frac{1}{p}\sum_{i=1}^{p} F_{\breve{A}_i}(\breve{x}),)$$

Case 2: when q=0, the Eq (1) reduces to the following form:

$$f_0(\breve{x}) = (\sqrt[p]{\prod_{i=1}^{p} T_{\breve{A}_i}(\breve{x}) \prod_{i=1}^{p} I_{\breve{A}_i}(\breve{x}), \prod_{i=1}^{p} F_{\breve{A}_i}(\breve{x}),},)$$

Case 3: Similarly, when q=2, 3,……… the Eq. (1) reduces to quadratic mean transformation function, cubic mean transformations functions and so on.

Case 4: When q→ ∞

$$f_\infty(\breve{x}) = (\max\{T_{\breve{A}_i}(\breve{x}),\}, \max\{I_{\breve{A}_i}(\breve{x})\}, \max\{F_{\breve{A}_i}(\breve{x})\})$$

3.1 ***Properties of power mean operator***

Property 1: Idempotency

If all $T_{\breve{A}_i}(i = 1,2,3, \dots\dots) I_{\breve{A}_i}(i = 1,2,3, \dots\dots) and F_{\breve{A}_i}(i = 1,2,3, \dots\dots)$ are equal, i,e, $T_{\breve{A}_1} = T_{\breve{A}_2} = T_{\breve{A}_3} = T_{\breve{A}_4} = T_{\breve{A}_5} = T_{\breve{A}_6} = \cdots \dots\dots.. T_{\breve{A}}, I_{\breve{A}_1} = I_{\breve{A}_2} = I_{\breve{A}_3} = I_{\breve{A}_4} = I_{\breve{A}_5} = I_{\breve{A}_6} = \cdots \dots\dots.. I_{\breve{A}}, F_{\breve{A}_1} = F_{\breve{A}_2} = F_{\breve{A}_3} = F_{\breve{A}_4} = F_{\breve{A}_5} = F_{\breve{A}_6} = \cdots \dots\dots.. F_{\breve{A}}$

Then $f_q(\breve{x}) = (\frac{1}{p}\sum_{i=1}^{-p}\left(T_{\breve{A}_i}(\breve{x})\right)^q)^{\frac{1}{q}}, (\frac{1}{p}\sum_{i=1}^{-p}\left(I_{\breve{A}_i}(\breve{x})\right)^q)^{\frac{1}{q}}, (\frac{1}{p}\sum_{i=1}^{-p}\left(F_{\breve{A}_i}(\breve{x})\right)^q)^{\frac{1}{q}}$

$$=((\frac{1}{p} \times p \times (T_{\breve{A}})^q)^{\frac{1}{q}}, (\frac{1}{p} \times p \times (I_{\breve{A}})^q)^{\frac{1}{q}}, (\frac{1}{p} \times p \times (F_{\breve{A}})^q)^{\frac{1}{q}}) = < T_{\breve{A}}, I_{\breve{A}}, F_{\breve{A}} >$$

Property 2: Monotonically

Let set of neutrosophic numbers $\breve{A}_i \leq \breve{B}_i$

i.e, $T_{\overline{A_i}}(\breve{x}) \leq T_{\overline{B_i}}(\breve{x})$,$I_{\overline{A_i}}(\breve{x}) \geq I_{\overline{B_i}}(\breve{x})$, ,$F_{\overline{A_i}}(\breve{x}) \geq F_{\overline{B_i}}(\breve{x})$,$\forall \breve{x} \in \breve{X}$

$f_q A(\breve{x})$={$\left(\frac{1}{p}\sum_{i=1}^{p}(T_{\breve{A}_i}(\breve{x}))^q\right)^{\frac{1}{q}}, \left(\frac{1}{p}\sum_{i=1}^{p}(I_{\breve{A}_i}(\breve{x}))^q\right)^{\frac{1}{q}}, \left(\frac{1}{p}\sum_{i=1}^{p}(F_{\breve{A}_i}(\breve{x}))^q\right)^{\frac{1}{q}}$} ≤{

$\left(\frac{1}{p}\sum_{i=1}^{p}(T_{\breve{B}_i}(\breve{x}))^q\right)^{\frac{1}{q}}, \left(\frac{1}{p}\sum_{i=1}^{p}((I_{\breve{B}_i}(\breve{x}))^q)^q\right)^{\frac{1}{q}}, \left(\frac{1}{p}\sum_{i=1}^{p}(F_{\breve{B}_i}(\breve{x}))^q\right)^{\frac{1}{q}}$}=$f_q B(\breve{x})$

Proof: since $T_{\overline{A_i}}(\breve{x}) \leq T_{\overline{B_i}}(\breve{x})$for every i

Then we have $\left(T_{\overline{A_i}}(\breve{x})\right)^q \leq \left(T_{\overline{B_i}}(\breve{x})\right)^q \Rightarrow \sum_{i=1}^{p}\left(T_{\overline{A_i}}(\breve{x})\right)^q \leq \sum_{i=1}^{p}\left(T_{\overline{B_i}}(\breve{x})\right)^q$

$$\Rightarrow \frac{1}{p}\sum_{i=1}^{p}\left(T_{\overline{A_i}}(\breve{x})\right)^q \leq \frac{1}{p}\sum_{i=1}^{p}\left(T_{\overline{B_i}}(\breve{x})\right)^q$$

$$\Rightarrow \left(\frac{1}{p}\sum_{i=1}^{p}\left(T_{\overline{A_i}}(\breve{x})\right)^q\right)^{\frac{1}{q}} \leq \left(\frac{1}{p}\sum_{i=1}^{p}\left(T_{\overline{B_i}}(\breve{x})\right)^q\right)^{\frac{1}{q}} \quad (5)$$

Further $I_{\overline{A_i}}(\breve{x}) \geq I_{\overline{B_i}}(\breve{x})$

$$\Rightarrow \left(I_{\overline{A_i}}(\breve{x})\right)^q \geq \left(I_{\overline{B_i}}(\breve{x})\right)^q$$

$$\Rightarrow \sum_{i=1}^{p}\left(\mathrm{I}_{\overline{A_i}}(\breve{x})\right)^q \geq \sum_{i=1}^{p}\left(I_{\overline{B_i}}(\breve{x})\right)^q$$

$$\Rightarrow \frac{1}{p}\sum_{i=1}^{p}\left(I_{\overline{A_i}}(\breve{x})\right)^q \geq \frac{1}{p}\sum_{i=1}^{p}\left(I_{\overline{B_i}}(\breve{x})\right)^q$$

$$\Rightarrow \left(\frac{1}{p}\sum_{i=1}^{p}\left(I_{\overline{A_i}}(\breve{x})\right)^q\right)^{\frac{1}{q}} \geq \left(\frac{1}{p}\sum_{i=1}^{p}\left(I_{\overline{B_i}}(\breve{x})\right)^q\right)^{\frac{1}{q}} \quad (6)$$

And

$$F_{\overline{A_i}}(\breve{x}) \geq F_{\overline{B_i}}(\breve{x})$$

$$\Rightarrow \left(F_{\overline{A_i}}(\breve{x})\right)^q \geq \left(F_{\overline{B_i}}(\breve{x})\right)^q$$

$$\Rightarrow \sum_{i=1}^{p}\left(F_{\overline{A_i}}(\breve{x})\right)^q \geq \sum_{i=1}^{p}\left(F_{\overline{B_i}}(\breve{x})\right)^q$$

$$\Rightarrow \frac{1}{p}\sum_{i=1}^{p}\left(F_{\overline{A_i}}(\breve{x})\right)^q \geq \frac{1}{p}\sum_{i=1}^{p}\left(F_{\overline{B_i}}(\breve{x})\right)^q$$

$$\Rightarrow \left(\frac{1}{p}\sum_{i=1}^{p}\left(F_{\overline{A_i}}(\breve{x})\right)^q\right)^{\frac{1}{q}} \geq \left(\frac{1}{p}\sum_{i=1}^{p}\left(F_{\overline{B_i}}(\breve{x})\right)^q\right)^{\frac{1}{q}} \qquad (7)$$

From Eq(5), Eq(6), Eq(7) we obtain

$$f_qA(\breve{x}) =< (\frac{1}{p}\sum_{i=1}^{p}\left(T_{\breve{A}_i}(\breve{x})\right)^q)^{\frac{1}{q}}, (\frac{1}{p}\sum_{i=1}^{p}\left(I_{\breve{A}_i}(\breve{x})\right)^q)^{\frac{1}{q}} (\frac{1}{p}\sum_{i=1}^{p}\left(F_{\breve{A}_i}(\breve{x})\right)^q)^{\frac{1}{q}} >\leq$$

$$< (\frac{1}{p}\sum_{i=1}^{p}\left(T_{\breve{B}_i}(\breve{x})\right)^q)^{\frac{1}{q}}, (\frac{1}{p}\sum_{i=1}^{p}\left(I_{\breve{B}_i}(\breve{x})\right)^q)^{\frac{1}{q}} (\frac{1}{p}\sum_{i=1}^{p}\left(F_{\breve{B}_i}(\breve{x})\right)^q)^{\frac{1}{q}} = f_qB(\breve{x})$$

Property 3: Boundness

Let $\breve{N} = N(\breve{x})$ be collection of Neutrosophic sets in$((\breve{X})$, and $\breve{N}^+ =<$ $\max_i\{T_{\breve{A}_i}(\breve{x})\}$,$\min_i\{I_{\breve{A}_i}(\breve{x})\}$ $\min_i\{F_{\breve{A}_i}(\breve{x})\}$>,$\breve{N}^- =<$ $\min_i\{T_{\breve{A}_i}(\breve{x})\}$,$\max_i\{I_{\breve{A}_i}(\breve{x})\}$ $\max_i\{F_{\breve{A}_i}(\breve{x})\}$>, then $\breve{N}^- \leq f_q(\breve{x}) \leq \breve{N}^+$

3.2 Score and accuracy function

Here, I adopted [12] score and accuracy function for comparing two single valued Neutrosophic number as follows:

Let $\breve{A} = (T_{\breve{A}}, I_{\breve{A}}, F_{\breve{A}})$,be a SVNN, then

i). S($\breve{A}$)=$\frac{1+(T_{\breve{A}}-F_{\breve{A}})-2I_{\breve{A}}}{2}$, where S($\breve{A}$) ∈ [0,1]

ii)$\delta(\breve{A}) = T_{\breve{A}} - I_{\breve{A}}(1 - T_{\breve{A}}) - F_{\breve{A}}(1 - I_{\breve{A}})$ where $\delta(\breve{A}) \in [-1,1]$

In [12], there is a order relation for two SVNNs, which is given as follows:

Let $\breve{P} = (T_{\breve{P}}, I_{\breve{P}}, F_{\breve{P}})$ and let $\breve{Q} = (T_{\breve{Q}}, I_{\breve{Q}}, F_{\breve{Q}})$ are two SVNNs.

If S($\breve{P}$)>S($\breve{Q}$)⟹ $\breve{P}$>$\breve{Q}$,again if S($\breve{P}$)=S($\breve{Q}$), then If $\delta(\breve{P})$>$\delta(\breve{Q})$⟹ $\breve{P}$>$\breve{Q}$

4 An MCDM technique constructed by employing the proposed aggregation operator in the SVNS setting

This part presents a systematic framework for assessing and prioritizing various options under neutrosophic sets, facilitating effective decision analysis. Let us assume that $\{\mathcal{L}_1, \mathcal{L}_2, \mathcal{L}_3, \mathcal{L}_4, \dots \dots \mathcal{L}_n\}$

represents n alternatives or options, which are ranked based on the attributes $\{\mathcal{C}_1, \mathcal{C}_2, \mathcal{C}_3, \mathcal{C}_4, \dots \dots \mathcal{C}_n\}$

The decision-maker expresses opinions for alternatives based on attributes in terms of single-valued neutrosophic numbers (SVNs). Now, we describe the MCDM framework using the following steps based on the proposed operators:

Step 1: Formation of alternatives versus attributes decision matrix

The interrelationship of the alternatives $\mathcal{L}_i (i = 1,2,3 \dots, n)$ and their corresponding criteria$\mathcal{C}_j (j = 1,2,3 \dots, n)$ is captured in terms of SVNs and can be illustrated through a matrix representation M^1: M^1: Alternatives versus attributes decision matrix

	$\mathcal{C}_1$	$\mathcal{C}_2$	………	$\mathcal{C}_n$
$\mathcal{L}_1$	$(\breve{T}_{11}, \breve{I}_{11}, \breve{F}_{11})$	$(\breve{T}_{12}, \breve{I}_{12}, \breve{F}_{12})$		$(\breve{T}_{1m}, \breve{I}_{1m}, \breve{F}_{1m})$
$\mathcal{L}_2$	$(\breve{T}_{21}, \breve{I}_{21}, \breve{F}_{21})$	$(\breve{T}_{22}, \breve{I}_{22}, \breve{F}_{22})$		$(\breve{T}_{2m}, \breve{I}_{2m}, \breve{F}_{2m})$
………	………	…….	………	
$\mathcal{L}_n$	$(\breve{T}_{n1}, \breve{I}_{n1}, \breve{F}_{n1})$	$(\breve{T}_{n2}, \breve{I}_{n2}, \breve{F}_{n2})$		$(\breve{T}_{nm}, \breve{I}_{nm}, \breve{F}_{nm})$

Step 2: Aggregate the decision matrix using proposed operator

Utilizing the proposed operator (Eq. 1), we aggregate the original decision matrix (M1) and derive a new decision matrix (M^2) that synthesizes the information in a structured form.

M^2: Aggregated decision matrix

	$\check{C}_{AGG}$
$\mathcal{L}_1$	$(T_{11}^{\breve{A}gg}, I_{11}^{\breve{A}gg}, F_{11}^{\breve{A}gg})$
$\mathcal{L}_2$	$\left(T_{21}^{\breve{A}gg}, I_{21}^{\breve{A}gg}, F_{21}^{\breve{A}gg}\right)$
	…….
$\mathcal{L}_n$	$(T_{n1}^{\breve{A}gg}, I_{n1}^{\breve{A}gg}, F_{n1}^{\breve{A}gg})$

Step 3: Calculate Score Values from Aggregate decision matrix using proposed Score function

Eq. (8) is employed to compute the score values of alternatives from matrix M2, resulting in real-valued scores that quantify their performance.

S**tep 4: Calculate Accuracy Values from Aggregate decision matrix using proposed Score function**

Eq. (9) is employed to compute the score values of alternatives from matrix M2, resulting in real-valued scores that quantify their performance.

Step 5: Prepare Ranking order based on score, accuracy and values

Alternatives are ranked according to the obtained score and accuracy measures. Alternatives with higher score values are considered the most preferable. When two alternatives have identical score values, their accuracy values are then used to differentiate them.

Step 6: End

5 Crop-land selection by the multi criteria decision making approach through SVNSs

Agricultural systems are vulnerable to climate change, with notable effects on water resources and crop output. Climate change poses serious threats to agricultural production, potentially escalating the likelihood of food scarcity and famine. The growing population's demands and natural resource degradation pose significant threats to sustainable agriculture. Advancements in agricultural technologies boost productivity, yet they gradually.

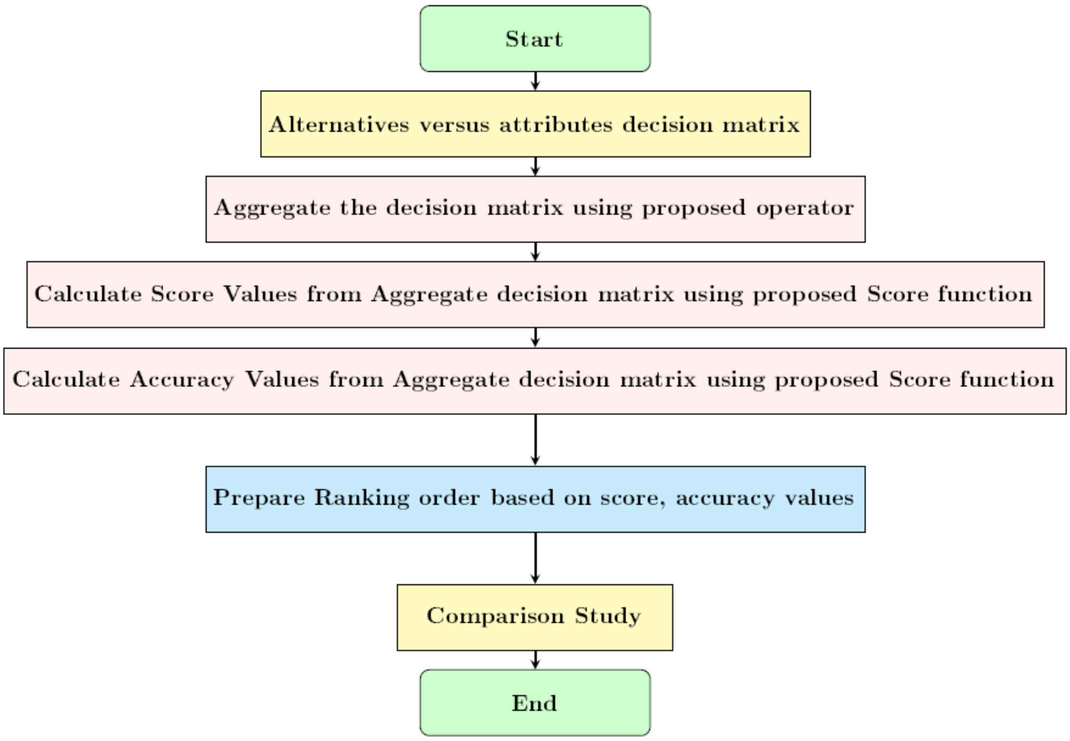

Figure 1: Flow chart of the decision-making process using power aggregation operator.

exhaust natural resources. Introducing technology in farming requires careful consideration of its ecological consequences. A plant needs rain for specific time frame, and the soil must contain moisture substance etc. Therefore, for selecting appropriate agricultural crop land is a challenging thing. Knowledgeable producers select farmland by examining soil conditions, water availability, and local climate to ensure optimal crop growth and limited environmental effects.

Properly chosen agricultural land supports efficient production, reducing input use and mitigating negative effects on the environment.

Determining the appropriate soil and climate conditions is a necessary prerequisite to starting agricultural production that reduce the farmer loss and increase the productivity. Here, I adapted [13] following criteria for choosing appropriate Crop land for planting.

($\breve{C}_1$) Climate
($\breve{C}_2$) Soil quality
($\breve{C}_3$) Water availability
($\breve{C}_4$) Transportation
($\breve{C}_5$) Energy access
($\breve{C}_6$) Biodiversity

Step 1: Formation of Land versus Criteria decision matrix

The decision maker provides the rating values of criteria in terms of neutrosophic number with respect to the land, and represents these values in matrix form for easy calculation and understanding. The following matrix $M^2$is presented below:

M^2: Land versus criteria decision matrix

	$\breve{C}_1$	$\breve{C}_2$	$\breve{C}_3$	$\breve{C}_4$	$\breve{C}_5$	$\breve{C}_6$
$\mathcal{L}_1$	(0.6,0.4,0.3)	(0.7,0.3,0.4)	(0.8,0.4,0.6)	(0.6,0.2,0.4)	(0.8,0.3,0.6)	(0.9,0.5,0.6)
$\mathcal{L}_2$	(0.3,0.1,0.4)	(0.5,0.2,0.2)	(0.8,0.3,0.4)	(0.6,0.3,0.5)	(0.7,0.4,0.3)	(0.4,0.5,0.6)
$\mathcal{L}_3$	(0.6,0.3,0.5)	(0.7,0.3,0.5)	(0.8,0.3,0.5)	(0.4,0.3,0.2)	(0.6,0.4,0.6)	(0.8,0.4,0.3)
$\mathcal{L}_4$	(0.7,0.3,0.3)	(0.3,0.4,0.3)	(0.7,0.4,0.5)	(0.8,0.3,0.4)	(0.7,0.3,0.5)	(0.5,0.3,0.6)

Step 2: Aggregated decision matrix using proposed operator

By using proposed operator (Eq. 1), the aggregate decision matrix of (M^2) and new decision matrix are obtained, synthesizing the information in a structured form.

Aggregated decision matrix

When q=1 the aggregate decision matrix is:

	$\breve{C}_{Agg}$
$\mathcal{L}_1$	(0.73,0.35,0.48)
$\mathcal{L}_2$	(0.55,0.30,0.42)
$\mathcal{L}_3$	(0.65,0.35,0.40)
$\mathcal{L}_4$	(0.62,0.33,0.42)

When q=2 the aggregate decision matrix is:

	$\breve{C}_{Agg}$
$\mathcal{L}_1$	(0.74,0.36,0.46)
$\mathcal{L}_2$	(0.58,0.34,0.43)
$\mathcal{L}_3$	(0.67,0.28,0.37)
$\mathcal{L}_4$	(0.61,0.27,0.43)

When q=0 the aggregate decision matrix is:

	$\breve{C}_{Agg}$
$\mathcal{L}_1$	(0.72,0.34,0.47)
$\mathcal{L}_2$	(0.52,0.27,0.40)
$\mathcal{L}_3$	(0.63,0.35,0.38)
$\mathcal{L}_4$	(0.59,0.33,0.40)

When q→∞the aggregate decision matrix is:

	$\breve{C}_{Agg}$
$\mathcal{L}_1$	(0.90,0.50,0.60)
$\mathcal{L}_2$	(0.80,0.50,0.60)
$\mathcal{L}_3$	(0.80,0.40,0.50)
$\mathcal{L}_4$	(0.80,0.40,0.60)

Step 3: Score values of Aggregated decision matrix

Eq (8) is employed to compute the score values of alternatives from aggregated decision matrix, resulting in real –valued score that quantify their performance.

When q=1,

S($\mathcal{L}_1$)=0.285, S($\mathcal{L}_2$)=0.265, S($\mathcal{L}_3$)=0.265, S($\mathcal{L}_4$)=0.27

When q=2,

S($\mathcal{L}_1$)=0.30, S($\mathcal{L}_2$)=0.235, S($\mathcal{L}_3$)=0.37, S($\mathcal{L}_4$)=0.32

When q=0

S($\mathcal{L}_1$)=0.285, S($\mathcal{L}_2$)=0.290, S($\mathcal{L}_3$)=0.275, S($\mathcal{L}_4$)=0.265

When q→∞, S($\mathcal{L}_1$)=0.15, S($\mathcal{L}_2$)=0.10, S($\mathcal{L}_3$)=0.20, S($\mathcal{L}_4$)=0.20

Step 4: Accuracy values of Aggregated decision matrix

Eq (9) is employed to compute the accuracy values of alternatives from aggregated decision matrix, resulting in real –valued score that quantify their performance

When q=1,

$\delta(\mathcal{L}_1)$=0.3505,δ ($\mathcal{L}_2$)=0.121, δ ($\mathcal{L}_3$)=0.268,δ ($\mathcal{L}_4$)=0.213.

When q=2,

$\delta(\mathcal{L}_1)$=0.348,δ ($\mathcal{L}_2$)=0.153, δ ($\mathcal{L}_3$)=0.311,δ ($\mathcal{L}_4$)=0.191.

When q=0,

$\delta(\mathcal{L}_1)$=0.315,δ ($\mathcal{L}_2$)=0.099, δ ($\mathcal{L}_3$)=0.254,δ ($\mathcal{L}_4$)=0.187.

When q→∞,

$\delta(\mathcal{L}_1)$=0.55,δ ($\mathcal{L}_2$)=0.40, δ ($\mathcal{L}_3$)=0.60,δ ($\mathcal{L}_4$)=0.36

Step 4: Ranking order based on score, accuracy values

When q=0,

Score ranking:

0.290>0.285>0.275>0.265⇒ $\mathcal{L}_2 > \mathcal{L}_1 > \mathcal{L}_3 > \mathcal{L}_4$

Accuracy ranking:

0.3146>0.2535>0.1867>0.0984 ⇒ $\mathcal{L}_1 > \mathcal{L}_3 > \mathcal{L}_4 > \mathcal{L}_2$

When q=`1,

Score ranking:

0.285>0.270>0.265(TWO)⇒ $\mathcal{L}_1 > \mathcal{L}_4 > \mathcal{L}_2 = \mathcal{L}_3$

Accuracy ranking:

0.3505>0.268>0.2132>0.121 ⇒ $\mathcal{L}_1 > \mathcal{L}_3 > \mathcal{L}_4 > \mathcal{L}_2$

When q=2,

Score ranking:

0.370>0.320>0.30>0.235⇒ $\mathcal{L}_3 > \mathcal{L}_4 > \mathcal{L}_1 > \mathcal{L}_2$

Accuracy ranking:

0.348>0.3112>0.1908>0.1534 ⇒ $\mathcal{L}_1 > \mathcal{L}_3 > \mathcal{L}_4 > \mathcal{L}_2$.

When q→∞

Score ranking:

0.20(two)>0.15>0.10⇒ $\mathcal{L}_3 = \mathcal{L}_4 > \mathcal{L}_1 > \mathcal{L}_2$
Accuracy ranking:
0.60>0.55>0.40>0.36 ⇒ $\mathcal{L}_3 > \mathcal{L}_1 > \mathcal{L}_2 > \mathcal{L}_4$
Step6: End

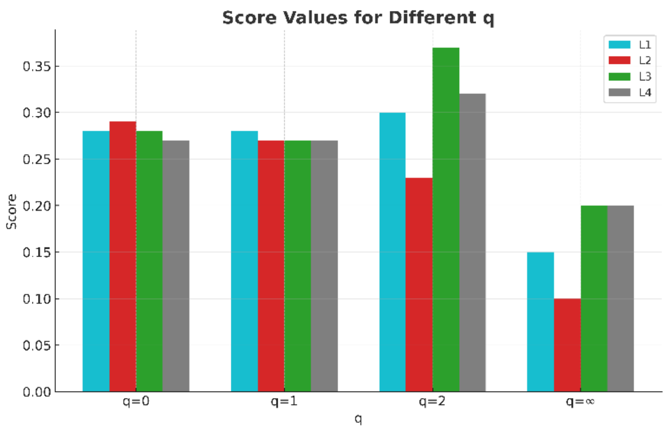

Figure 2: Score values for different $q$parameters for alternatives $\mathcal{L}_1, \mathcal{L}_2, \mathcal{L}_3$,and $\mathcal{L}_4$. This plot shows how scores vary with changing $q$values in our proposed method.

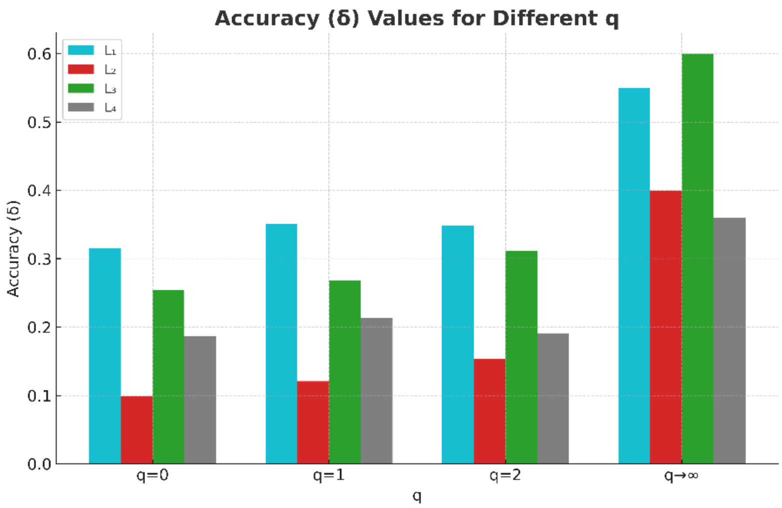

Figure 3: Accuracy (δ) values for different q parameters for alternatives $\mathcal{L}_1$, $\mathcal{L}_2$, $\mathcal{L}_3$and $\mathcal{L}_4$. This plot shows the variation in accuracy with changing q values in the proposed method.

Comparative study:

A comparative analysis is performed to evaluate the efficacy of the proposed ranking method against existing techniques, including [2], [4]

Operator	Ranking order alternatives	Best Alternatives
Senapati(2024)	$\mathcal{L}_1 > \mathcal{L}_2 > \mathcal{L}_3 > \mathcal{L}_4(\epsilon = 1)$	$\mathcal{L}_1$
Senapati(2024)	$\mathcal{L}_1 > \mathcal{L}_2 > \mathcal{L}_4 > \mathcal{L}_3(\epsilon = 2)$	$\mathcal{L}_1$
Nancy and Garg(2016)	$\mathcal{L}_3 > \mathcal{L}_4 > \mathcal{L}_2 > \mathcal{L}_1$	$\mathcal{L}_3$
Our Method	$\mathcal{L}_2 > \mathcal{L}_1 > \mathcal{L}_3 > \mathcal{L}_4(q = 0)$	$\mathcal{L}_2$
Our Method	$\mathcal{L}_1 > \mathcal{L}_4 > \mathcal{L}_2 = \mathcal{L}_3(q = 1)$	$\mathcal{L}_1$
Our Method	$\mathcal{L}_3 > \mathcal{L}_4 > \mathcal{L}_1 > \mathcal{L}_2(q = 2)$	$\mathcal{L}_3$
Our Method	$\mathcal{L}_3 = \mathcal{L}_4 > \mathcal{L}_1 > \mathcal{L}_2(q \to \infty)$	$\mathcal{L}_3$
…….	$\mathcal{L}_3 > \mathcal{L}_1 > \mathcal{L}_2 > \mathcal{L}_4(AccuracyRanking)$	$\mathcal{L}_3$

Table 1: Comparison of ranking results using different operators

In Table-1, we have presented a comparative analysis. By senapati [2] (2024) method, the best alternative is $\mathcal{L}_1$ and the worst one is $\mathcal{L}_3$. According to the Nancy and Garg (2016) method, the best alternative is $\mathcal{L}_2$, and the worst one is L1. By our proposed method, when q=1, the best alternative is $\mathcal{L}_1$ and the worst one is $\mathcal{L}$ 3. when q=2, the best alternative is $\mathcal{L}_3$and the worst one is $\mathcal{L}_2$. when q →∞, the best alternative is $\mathcal{L}_3$ and the worst one is $\mathcal{L}_4$. Based on the above comparative study, it is evident that the proposed method achieves better results more quickly than the existing methods.

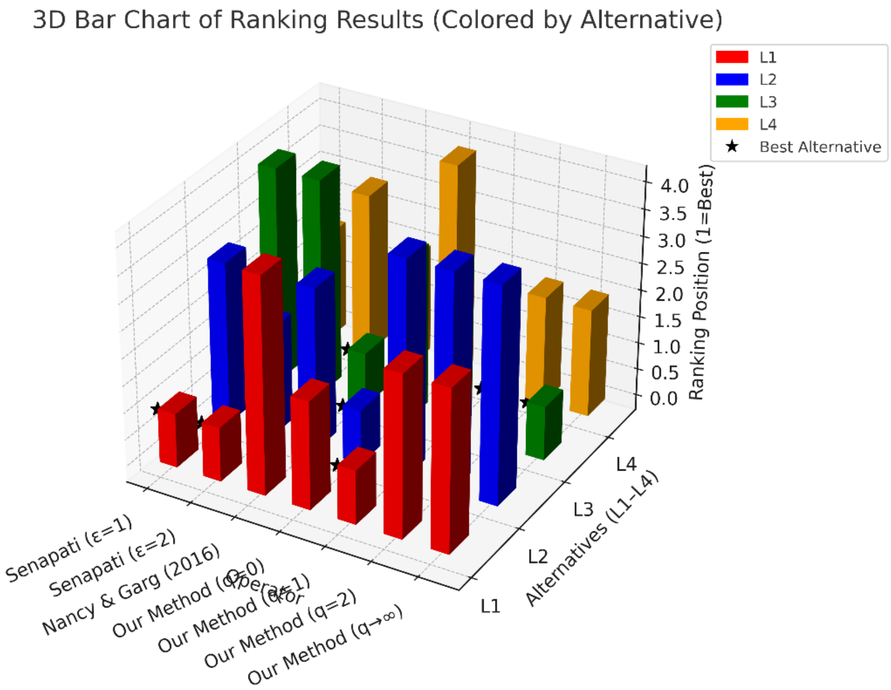

Figure 4: 3D bar chart showing ranking results of alternatives using different operators. The bars are colored by alternative, and stars indicate the best-performing alternatives.

Conclusions

In recent times, aggregation operators have emerged as a prominent area of research within decision-making contexts. Selecting suitable cropland is a crucial decision-making issue in agriculture. The decision-making method with an aggregation operator, which has been successfully applied in the agricultural field, is an interesting topic of research.In this study, we have proposed a new aggregation operator based on SVNSs and proved its necessary properties. We structured a general MCDM method to select cropland for agriculture. The introduced approach is tested on a cropland selection example based on standard criteria. We analyzed the ranking results of our proposed method with the help of a significant comparative study with existing methods. The results obtained for different values of q indicate that the proposed operator works stably and reliably. For q=1, it reflects the best alternative, which is the same as the best alternative obtained from the Senapati (2024) operator result and For q=2 and as q →∞, the best alternative is the same as the result obtained by Nancy and Garg (2016). This proves that the operator can efficiently handle the complexity and uncertainty of real problems. The proposed MCDM technique requires that each alternative be evaluated against the same set of criteria. This is a necessary condition because the aggregation operators used in this technique are designed to handle a uniform number of criteria across all alternatives enabling the calculation of overall aggregation values. It also has application potential in practical decision-making, especially in teachers' election processes, school management decisions, weather forecasting, and investment evaluation. Future research will concentrate on expanding this operator to other neutrosophic sets and applying it across diverse social and technological domains.

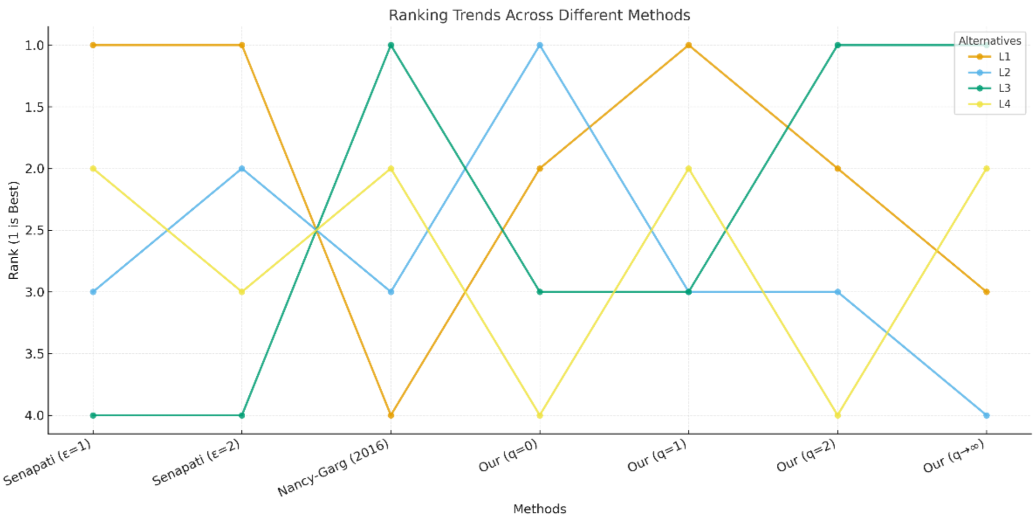

Figure 5: Line graph showing the ranking order of alternatives $\mathcal{L}_1, \mathcal{L}_2, \mathcal{L}_3, \mathcal{L}_4$ using differ-ent decision-making approaches. The methods compared include Senapati's operators for ϵ = 1, 2, Nancy-Garg (2016), and the proposed method for q = 0, 1, 2, ∞. A lower rank indicates a better performing alternative (Rank 1 being the best).

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References

1. Florentin Smarandache A unifying field in logics: Neutrosophic logic. In *Philosophy*; American Research Press: USA, 1999; pp. 1–141.
2. Tarun Senapati An Aczel-Alsina aggregation-based outranking method for multiple attribute decision-making using single-valued neutrosophic numbers. Complex Intelligent Systems 2024, 10, 1185–1199.
3. Jun Ye A multicriteria decision-making method using aggregation operators for simplified neutrosophic sets. Journal of Intelligent & Fuzzy Systems 2014, 26, 2459–2466.
4. Nancy; Harish Garg Novel single-valued neutrosophic decision making operators under Frank norm operations and its application. International Journal of Uncertainty Quantification 2016, 6, 361–375.
5. Peide Liu; Shen, J.; Zhang, P.; Ning, B. Multi-attribute group decision-making method using single-valued neutrosophic credibility numbers with fairly variable extended power average operators and GRA-MARCOS. Expert Systems with Applications 2025, 263, 125703.
6. Peide Liu; Shen, J.; Zhang, P. Multi-attribute group decision-making method using single-valued neutrosophic credibility numbers with the Dombi extended power aggregation operator and its application in intelligent transportation system data collection scheme selection. Engineering Applications of Artificial Intelligence 2024, 133, 108639.
7. Kara, K.; Yalcin, G.C.; Gurol, P.; Simic, V.; Pamucar, D. Enhancing decision support system for finished vehicle logistics service provider selection through a single-valued neutrosophic Dombi Bonferroni-based model. Engineering Applications of Artificial Intelligence 2024, 138, 109441.
8. Garai, T.; Dalapati, S.; Florentin Smarandache Softmax function based neutrosophic aggregation operators and application in multi-attribute decision making problem. Neutrosophic Sets and Systems 2023, 56, 16.
9. Mishra, A.R.; Rani, P.; Tirkolaee, E.B.; Alrasheedi, A.F.; Alshamrani, A.M. Assessment of agricultural sustainability in agro-climatic regions of India: A single-valued neutrosophic distance measure-based hybrid ranking framework. Advanced Engineering Informatics 2025, 65, 103323.
10. Garai, T.; Harish Garg Multi-criteria decision making of water resource management problem (in Agriculture field, Purulia district) based on possibility measures under generalized single valued non-linear bipolar neutrosophic environment. Expert Systems with Applications 2022, 205, 117715.
11. Zeng, S.; Shoaib, M.; Ali, S.; Florentin Smarandache; Rashmanlou, H.; Mofidnakhaei, F. Certain properties of single-valued neutrosophic graph with application in food and agriculture organization. International Journal of Computational Intelligence Systems 2021, 14, 1516–1540.

12. Rasim Şahin multi-criteria neutrosophic decision making method based on score and accuracy functions under neutrosophic environment. *arXiv* 2014, arXiv:1412.5202.
13. Tuncel, G.; Gunturk, B. A fuzzy multi-criteria decision-making approach for agricultural land selection. Sustainability 2024, 16, 10509.
14. Wang, H.; Florentin Smarandache; Zhang, Y.Q.; Sunderraman, R. Single valued neutrosophic sets. *Multispace and Multistructure* 2010, 4, 410–413.
15. Lotfi A. Zadeh Fuzzy sets. Information and Control 1965, 8, 338–356.
16. Krassimir Atanassov Intuitionistic fuzzy sets. Fuzzy Sets and Systems 1986, 20, 87–96.