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Safety Analysis of Natural Medicines Strategies based on SuperHyperSoft Set: Case Study and Analysis of Results

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Abstract: Natural medicines, derived from plant, animal, and mineral sources, have been widely used in traditional and modern healthcare systems due to their perceived effectiveness and minimal side effects. This study proposes a decision-making approach for safety evaluation of natural medicines. We used two methods, such as Entropy method to compute the criteria weights and the VIKOR method to rank the alternatives. These methods are used under the single valued neutrosophic sets (SVNSs) to deal with uncertainty and vague information. We used the SuperHyperSoft set to deal with the criteria and sub criteria values in this evaluation. We used six criteria and seven alternatives in this study. We conducted sensitivity analysis to show the stability of the ranks.

Keywords: Single Valued Neutrosophic Numbers (SVNNs); SuperHyperSoft; Natural Medicines; Strategies Selection.

1. Introduction and Literature Review

Natural medicines, derived from plant, animal, and mineral sources, have been widely used in traditional and modern healthcare systems due to their perceived effectiveness and minimal side effects. However, despite their therapeutic benefits, concerns about their safety, toxicity, and interactions with conventional drugs have led to an increasing demand for rigorous safety evaluation frameworks. Unlike synthetic pharmaceuticals, many natural medicines lack standardized formulations, making it essential to assess their chemical composition, dosage consistency, and potential risks before widespread clinical use[1], [2]. The safety evaluation of natural medicines is therefore crucial for ensuring their reliability and long-term health benefits.

A comprehensive safety evaluation framework must consider multiple factors, including toxicity levels, side effects, pharmacokinetics, and drug interactions. Some natural medicines contain potent bioactive compounds that, if improperly administered, may lead to adverse reactions or

long-term health risks. Additionally, variations in plant species, growing conditions, and extraction methods can influence the potency and purity of herbal products, further complicating safety assessments[3], [4]. As a result, pharmacovigilance programs and scientific validation studies are necessary to minimize risks and ensure the safe use of these remedies.

To enhance the safety of natural medicines, Multi-Criteria Decision-Making (MCDM) methodologies can be employed to systematically assess and rank different herbal products based on their safety profiles. MCDM techniques such as Entropy and VIKOR allow for the consideration of multiple evaluation criteria, such as toxicity levels, dosage safety, clinical validation, and long-term effects, enabling healthcare professionals and regulatory bodies to make informed decisions[5], [6]. By integrating quantitative and qualitative assessments, MCDM methods offer a structured approach to prioritizing safe and effective natural medicines.

Ultimately, the goal of safety evaluation is to establish a scientific and regulatory framework that ensures the responsible use of natural medicines while maintaining their therapeutic potential. Governments, researchers, and healthcare institutions must collaborate to develop standardized safety protocols, promote clinical trials, and enhance consumer awareness regarding the proper usage of herbal remedies[7]. Through rigorous risk assessment, regulatory compliance, and evidence-based research, natural medicines can be safely integrated into modern healthcare systems, bridging the gap between traditional healing practices and contemporary medical science.

By establishing membership measures in 1965, Zadeh [8] initially presented the fuzzy set to address uncertainty and modeling of practical and scientific situations. Bellman and Zadeh made significant contributions to the field of fuzzy decision-making by employing the max and min operators. In 1986, Atanassov [9] created the intuitionistic fuzzy set (IFS) by including the non-membership measure as a stand-alone component.

The literature has documented both theoretical and practical uses of IFSs in MCDM. In the fuzzy environment, Zadeh proposed the entropy measure. Burillo and Bustince [10] provided an axiomatic description of the entropy measure and suggested a distance measure between IFSs.

Following the release of the neutrosophic set (NS) and single-valued neutrosophic set (SVNS), the study of uncertainty underwent a transformation. Researchers are particularly drawn to SVNS because of its decision-making application[11].

Indeterminacy, inconsistency, and incompleteness are characteristics of uncertainty that may be expressed by a SVNS. The majority of the SVN cross entropy that is now in use exhibits asymmetrical behavior and occasionally results in an ill-defined phenomenon. To address these drawbacks, Pramanik et al. [12] provided a novel cross entropy metric, called NS-cross entropy, in a SVNS setting and demonstrate its fundamental characteristics. Additionally, they defined the weighted NS-cross entropy measure and examined its fundamental characteristics. They created a new MCDM approach that does not suffer from undefined phenomena or unbalanced behavior.

It can handle both an unknown weight of decision-makers and an unknown weight of characteristics. Lastly, a numerical illustration of a group decision-making issue with several attributes is provided.

The following is how the remainder of the paper is presented: A few SVNS ideas are explained in Section 2. We developed a decision-making approach using two methods Entropy and VIKOR to compute the criteria weights and rank the alternatives as in section 2 with the SuperHyperSoft set. To show the usefulness and effectiveness of the created Entropy and VIKOR techniques in the SVNS environment, an example problem is handled in Section 3. We provide sensitivity analysis and discussion in Section 4. Conclusions and the direction of future study are provided in Section 5.

2. SuperHyperSoft Set (SHS)

This section shows the definition of the SHS and the neutrosophic set to deal with uncertainty and vague information.

SHS is used to deal with the criteria and sub criteria with different values. It is defined based on the HyperSoft set[13], [14]. Let the universe set $U = \{Q_1, Q_2, \dots . Q_n\}$. The power set of U is a $P(U)$ and S_1, S_2, S_3 are select as a criteria. $P(S_1) \times P(S_2)$ and $P(S_3)$ are $powersets$ of S_1, S_2, S_3

Let F: $P(S_1) \times P(S_2) \times P(S_3) \to P(S)$ $where$ $\times refers$ to $cartesian$ $product$, and this called SHS over S.

$$P(S_1) \times P(S_2) \times P(S_3) = \left\{ \begin{matrix} \{S_{11}\}, \{S_{12}\}, \{S_{11}, S_{12}\} \times \\ \{S_{21}\}, \{S_{22}\}, \{S_{21}, S_{22}\} \times \\ \{S_{31}\}, \{S_{32}\}, \{S_{33}\}, \{S_{31}, S_{32}\}, \{S_{31}, S_{33}\}, \\ \{S_{32}, S_{33}\}, \{S_{31}, S_{32}, S_{33}\} \end{matrix} \right\} \quad (1)$$

Single Valued Neutrosophic Sets (SVNSs)

We can define some definitions of the SVNSs as[12]:

Definition 1

Neutrosophic set can be defined by truth, indeterminacy, and falsity values as $T_D(B), I_D(B), and\ F_D(B)$ (2)

$$D = \left(T_D(B), I_D(B), F_D(B)\right) \quad (3)$$

$$0 \le T_D(B) + I_D(B) + F_D(B) \le 3 \quad (4)$$

Example 1

We can define the neutrosophic number as:

$D = (0.6,0.3,0.4)$ these numbers present the truth, indeterminacy, and falsity functions.

Definition 2

We can define the inclusion of two single valued neutrosophic numbers (SVNNs) as:

$$D_1 \sqsubseteq D_2, T_{D_1}(B) \leq T_{D_2}(B), I_{D_1}(B) \geq I_{D_2}(B), F_{D_1}(B) \geq F_{D_2}(B) \quad (5)$$

Definition 3

The equality of two SVNNs can be defined as:

$$T_{D_1}(B) = T_{D_2}(B), I_{D_1}(B) = I_{D_2}(B), and\ F_{D_1}(B) = F_{D_2}(B) \quad (6)$$

Definition 4

The complement of the SVNN can be defined as:

$$D_1^c = \left(1 - T_{D_1}(B), 1 - I_{D_1}(B), 1 - F_{D_1}(B)\right) \quad (7)$$

Definition 5

The union of the SVNNs can be defined as:

$$D_1 \cup D_2 = \begin{pmatrix} \max\{T_{D_1}(B), T_{D_2}(B)\}, \\ \min\{I_{D_1}(B), I_{D_2}(B)\}, \\ \min\{F_{D_1}(B), F_{D_2}(B)\} \end{pmatrix} \quad (8)$$

Definition 6

The intersection of the SVNNs can be defined as:

$$D_1 \cap D_2 = \begin{pmatrix} \min\{T_{D_1}(B), T_{D_2}(B)\}, \\ \max\{I_{D_1}(B), I_{D_2}(B)\}, \\ \max\{F_{D_1}(B), F_{D_2}(B)\} \end{pmatrix} \quad (9)$$

SVN-Entropy-VIKOR Methodology

This part shows the steps of the SVN-Entropy methodology to compute the criteria weights and the SVN-VIKOR methodology to rank the alternatives.

SVN-Entropy

We use SVNNs to build the decision matrix between the criteria and alternatives. Then we obtain crisp values by the score function, then we combine these numbers.

Normalize the decision matrix

We can normalize the decision matrix by the Entropy method between the criteria and alternatives such as:

$$q_{ij} = \frac{y_{ij}}{\sum_{i=1}^{m} y_{ij}} \quad (10)$$

Where y_{ij} refers to the values in the combined decision matrix, m refers to the number of alternatives and n refers to the number of criteria.

Compute the entropy

$$r_j = -g \sum_{i=1}^{m} q_{ij} \ln q_{ij} \; i = 1, \dots m; j = 1, \dots, n \tag{11}$$

$$g = \frac{1}{\ln m} \tag{12}$$

Compute the criteria weights.

We can obtain the criteria weights such as:

$$w_j = \frac{(1-r_j)}{\sum_{j=1}^{n}(1-r_j)} \tag{13}$$

SVN-VIKOR method

The VIKOR method is used under the SVNS to rank the alternatives.

We start with the combined decision matrix between the criteria and alternatives.

Obtain the values of max and min values for positive and cost criteria such as:

$$p^* = \max y_{ij} \tag{14}$$

$$p^- = \min y_{ij} \tag{15}$$

And for cost criteria such as

$$p^* = \min y_{ij} \tag{16}$$

$$p^- = \max y_{ij} \tag{17}$$

Compute the S and R indexes

$$S_i = \sum_{j=1}^{n} w_j \left(\frac{(p^* - y_{ij})}{p^* - p^-} \right) \tag{18}$$

$$R_i = \max \left[w_j \left(\frac{(p^* - y_{ij})}{p^* - p^-} \right) \right] \tag{19}$$

Compute the VIKOR index

$$K_i = h \times \left[\frac{S_i - S^*}{S^- - S^*} \right] + (1-h) \times \left[\frac{R_i - R^*}{R^- - R^*} \right] \tag{20}$$

$$\begin{pmatrix} R^* = \min R_i \\ R^- = \max R_i \end{pmatrix} \tag{21}$$

$$\begin{pmatrix} S^* = \min S_i \\ S^- = \max S_i \end{pmatrix} \tag{22}$$

Rank the alternatives.

3. Case Study

In this section, we solve the MCDM issue by obtaining the criteria weights and ranking the alternatives. This study proposed a case study to evaluate a set of strategies for safety of natural medicines. These strategies are evaluated using the decision-making model based on a set of criteria to select the best one. We proposed a set of criteria and alternatives.

I. Integration with Modern Medicine
II. Scientific Research
III. Quality Control
IV. Standardization of Herbal Extracts
V. Public Awareness
VI. Risk Assessment
VII. Pharmacovigilance

The criteria of this study can be evaluated such as:

I. Side Effects {Rare, Mild, Severe}
II. Interaction with Other Drugs {Minimal, Moderate, Significant}
III. Scientific Validation {Strong, Moderate, Weak}
IV. Dosage Safety {Sufficient, Uncertain, Insufficient}
V. Toxicity Level {Low, High}
VI. Long-Term Safety {Safe, Risky}

We build the decision matrix by using the SVNNs between the criteria and alternatives as shown in Tables 1-3. Then we obtain crisp values. Then we combined these values.

Eq. (10) is used to normalize the decision matrix as shown in Table 4.

Then we compute the entropy using Eq. (11).

Then we compute the criteria weights using Eq. (13). The criteria weights of this study are organized as follows: C1= 0.273192556, C2= 0.203378481, C3= 0.08053423, C4= 0.106331396, C5= 0.31510081, C6= 0.021462523.

Table 1. The first SVNNs.

	C_1	C_2	C_3	C_4	C_5	C_6
A_1	(0.8,0.2,0.3)	(0.7,0.3,0.4)	(0.6,0.4,0.5)	(0.5,0.5,0.5)	(0.3,0.6,0.7)	(0.1,0.8,0.9)
A_2	(0.1,0.8,0.9)	(0.9,0.1,0.2)	(0.8,0.2,0.3)	(0.7,0.3,0.4)	(0.6,0.4,0.5)	(0.5,0.5,0.5)
A_3	(0.3,0.6,0.7)	(0.9,0.1,0.2)	(0.6,0.4,0.5)	(0.5,0.5,0.5)	(0.3,0.6,0.7)	(0.3,0.6,0.7)
A_4	(0.5,0.5,0.5)	(0.8,0.2,0.3)	(0.7,0.3,0.4)	(0.8,0.2,0.3)	(0.9,0.1,0.2)	(0.8,0.2,0.3)
A_5	(0.6,0.4,0.5)	(0.9,0.1,0.2)	(0.5,0.5,0.5)	(0.3,0.6,0.7)	(0.1,0.8,0.9)	(0.3,0.6,0.7)
A_6	(0.7,0.3,0.4)	(0.5,0.5,0.5)	(0.6,0.4,0.5)	(0.8,0.2,0.3)	(0.1,0.8,0.9)	(0.8,0.2,0.3)
A_7	(0.1,0.8,0.9)	(0.6,0.4,0.5)	(0.5,0.5,0.5)	(0.9,0.1,0.2)	(0.7,0.3,0.4)	(0.7,0.3,0.4)

Table 2. The second SVNNs.

	C_1	C_2	C_3	C_4	C_5	C_6
A_1	(0.9,0.1,0.2)	(0.7,0.3,0.4)	(0.6,0.4,0.5)	(0.5,0.5,0.5)	(0.3,0.6,0.7)	(0.8,0.2,0.3)
A_2	(0.8,0.2,0.3)	(0.3,0.6,0.7)	(0.8,0.2,0.3)	(0.7,0.3,0.4)	(0.6,0.4,0.5)	(0.5,0.5,0.5)
A_3	(0.7,0.3,0.4)	(0.3,0.6,0.7)	(0.6,0.4,0.5)	(0.5,0.5,0.5)	(0.3,0.6,0.7)	(0.9,0.1,0.2)
A_4	(0.6,0.4,0.5)	(0.8,0.2,0.3)	(0.7,0.3,0.4)	(0.1,0.8,0.9)	(0.9,0.1,0.2)	(0.1,0.8,0.9)
A_5	(0.5,0.5,0.5)	(0.3,0.6,0.7)	(0.5,0.5,0.5)	(0.9,0.1,0.2)	(0.8,0.2,0.3)	(0.7,0.3,0.4)
A_6	(0.7,0.3,0.4)	(0.1,0.8,0.9)	(0.9,0.1,0.2)	(0.8,0.2,0.3)	(0.7,0.3,0.4)	(0.6,0.4,0.5)
A_7	(0.1,0.8,0.9)	(0.7,0.3,0.4)	(0.8,0.2,0.3)	(0.7,0.3,0.4)	(0.6,0.4,0.5)	(0.5,0.5,0.5)

Table 3. The third SVNNs.

	C_1	C_2	C_3	C_4	C_5	C_6
A_1	(0.1,0.8,0.9)	(0.7,0.3,0.4)	(0.6,0.4,0.5)	(0.5,0.5,0.5)	(0.5,0.5,0.5)	(0.8,0.2,0.3)
A_2	(0.1,0.8,0.9)	(0.5,0.5,0.5)	(0.8,0.2,0.3)	(0.7,0.3,0.4)	(0.6,0.4,0.5)	(0.5,0.5,0.5)
A_3	(0.9,0.1,0.2)	(0.6,0.4,0.5)	(0.6,0.4,0.5)	(0.5,0.5,0.5)	(0.7,0.3,0.4)	(0.6,0.4,0.5)
A_4	(0.5,0.5,0.5)	(0.7,0.3,0.4)	(0.5,0.5,0.5)	(0.8,0.2,0.3)	(0.8,0.2,0.3)	(0.7,0.3,0.4)
A_5	(0.6,0.4,0.5)	(0.1,0.8,0.9)	(0.6,0.4,0.5)	(0.5,0.5,0.5)	(0.5,0.5,0.5)	(0.8,0.2,0.3)
A_6	(0.7,0.3,0.4)	(0.5,0.5,0.5)	(0.7,0.3,0.4)	(0.6,0.4,0.5)	(0.6,0.4,0.5)	(0.5,0.5,0.5)
A_7	(0.8,0.2,0.3)	(0.6,0.4,0.5)	(0.8,0.2,0.3)	(0.7,0.3,0.4)	(0.7,0.3,0.4)	(0.6,0.4,0.5)

Table 4. The normalized SVNNs.

	C_1	C_2	C_3	C_4	C_5	C_6
A_1	0.16208	0.167598	0.128463	0.118421	0.102639	0.140845
A_2	0.094801	0.142458	0.173804	0.157895	0.14956	0.126761
A_3	0.171254	0.148045	0.128463	0.118421	0.117302	0.149296
A_4	0.143731	0.184358	0.138539	0.131579	0.219941	0.132394
A_5	0.149847	0.111732	0.118388	0.134211	0.123167	0.149296
A_6	0.183486	0.094972	0.15869	0.165789	0.120235	0.15493
A_7	0.094801	0.150838	0.153652	0.173684	0.167155	0.146479

SVN-VIKOR method

This method is used to rank the alternatives. in the SuperHyperSoft set, we used the values of this study as:

I. {Severe}
II. {Significant}
III. {Strong}
IV. {Sufficient}
V. {Low, High}
VI. {Safe, Risky}

Then we proposed four portions such as:

Portion 1: Severe, Significant, Strong, sufficient, Low, and Safe.

Portion 2: Severe, Significant, Strong, sufficient, Low, and Risky.

Portion 3: Severe, Significant, Strong, sufficient, High, and Safe.

Portion 4: Severe, Significant, Strong, sufficient, High, and Risky.

We rank the alternative based on these portions such as:

Ranking the alternatives based on the Portion 1

We obtain the values of max and min values for positive and cost criteria using Eqs. (14-17).

We compute the S and R indexes using Eqs. (18 and 19). We show the S and R matrix as shown in Fig 1. Then we obtained the S and R index values as shown in Fig 2.

Then we compute the VIKOR index using Eq. (20). In this study we use the h value with 0.5.

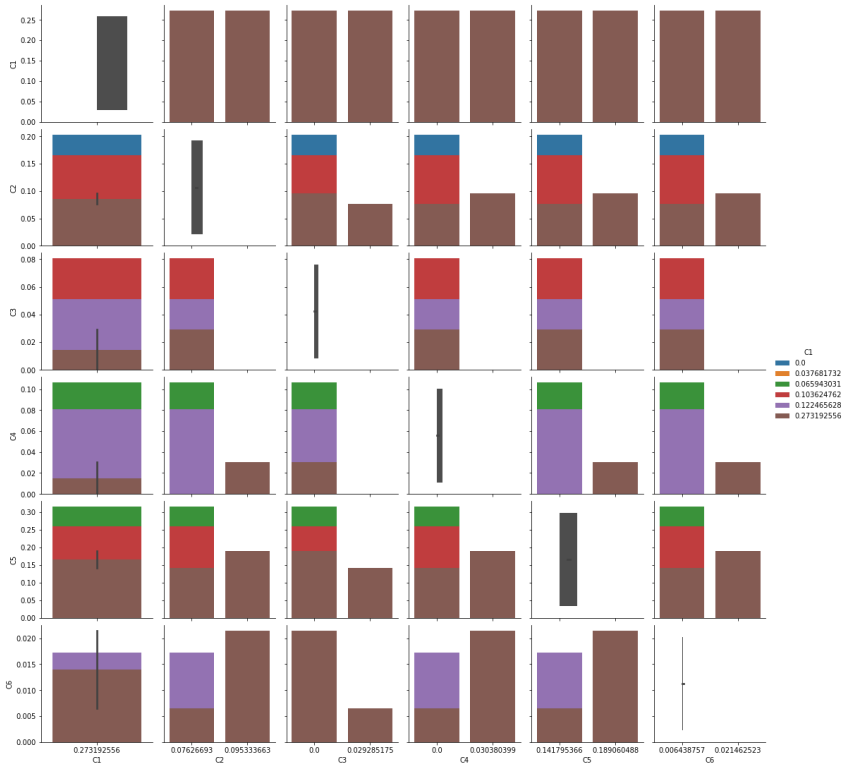

Fig 1. The S and R matrix

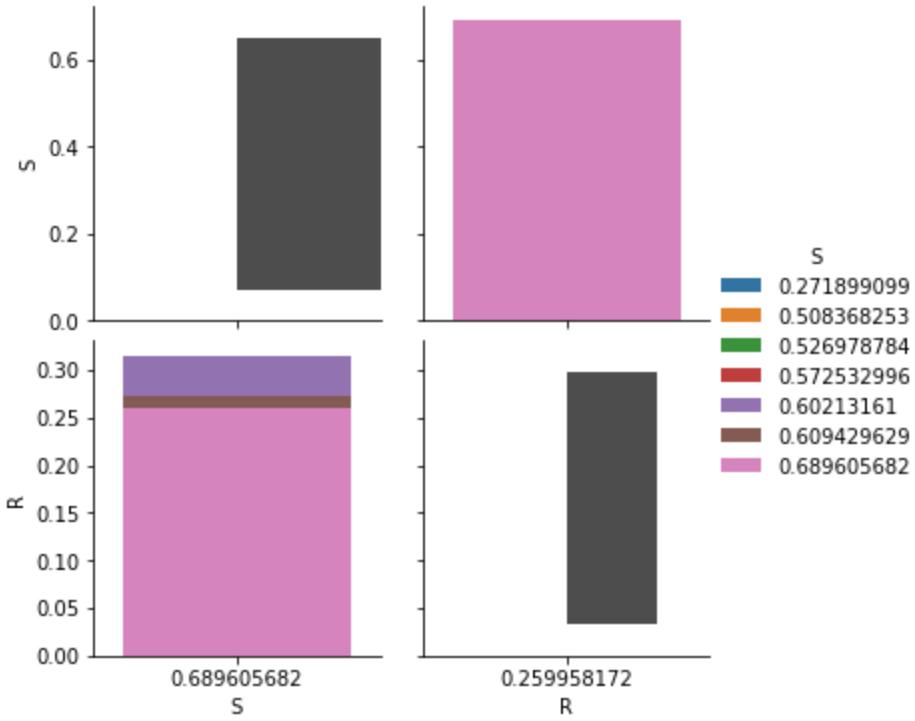

Fig 2. The S and R indexes values.

Ranking the alternatives based on the Portion 2

We compute the S and R indexes, then we show the S and R matrix as shown in Fig 2. Then we obtained the S and R index values as shown in Fig 4.

Then we computed the VIKOR index.

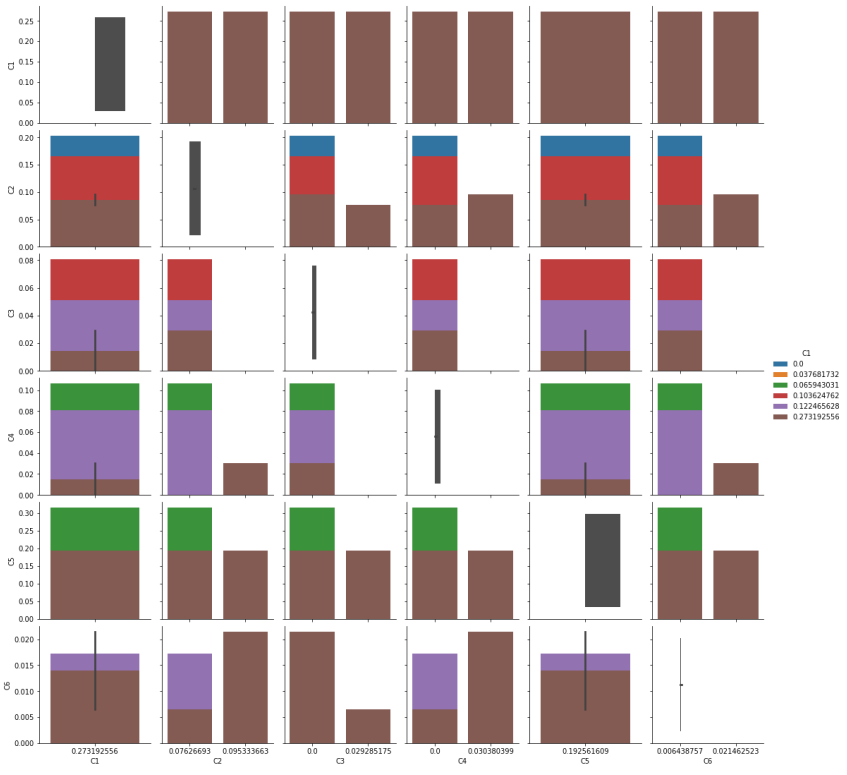

Fig 3. The S and R matrix

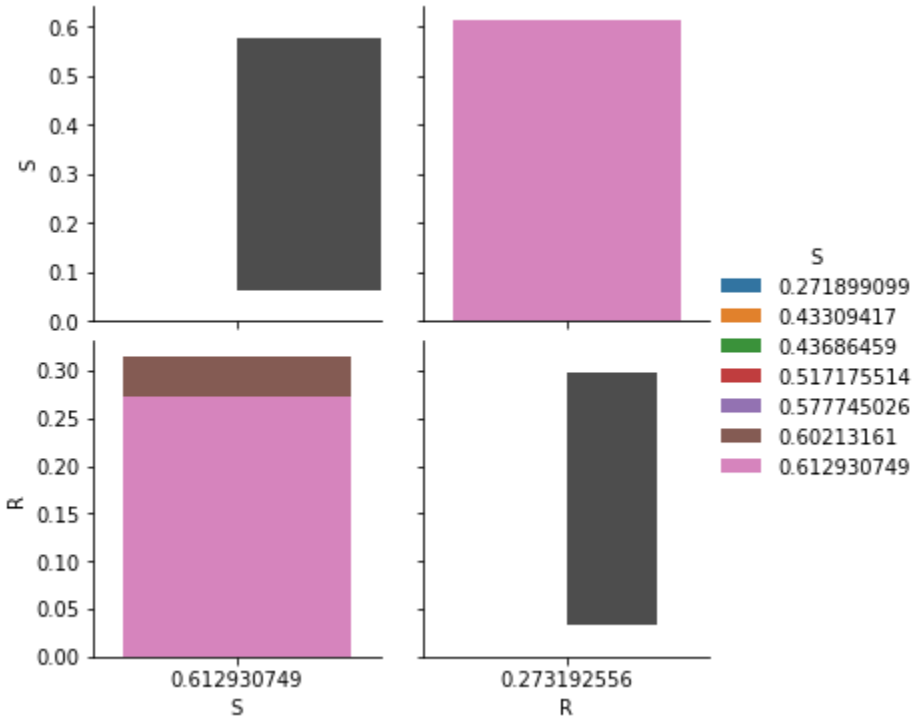

Fig 4. The S and R indexes values.

Ranking the alternatives based on the Portion 3

We compute the S and R indexes, then we show the S and R matrix as shown in Fig 5. Then we obtained the S and R index values as shown in Fig 6.

Then we computed the VIKOR index.

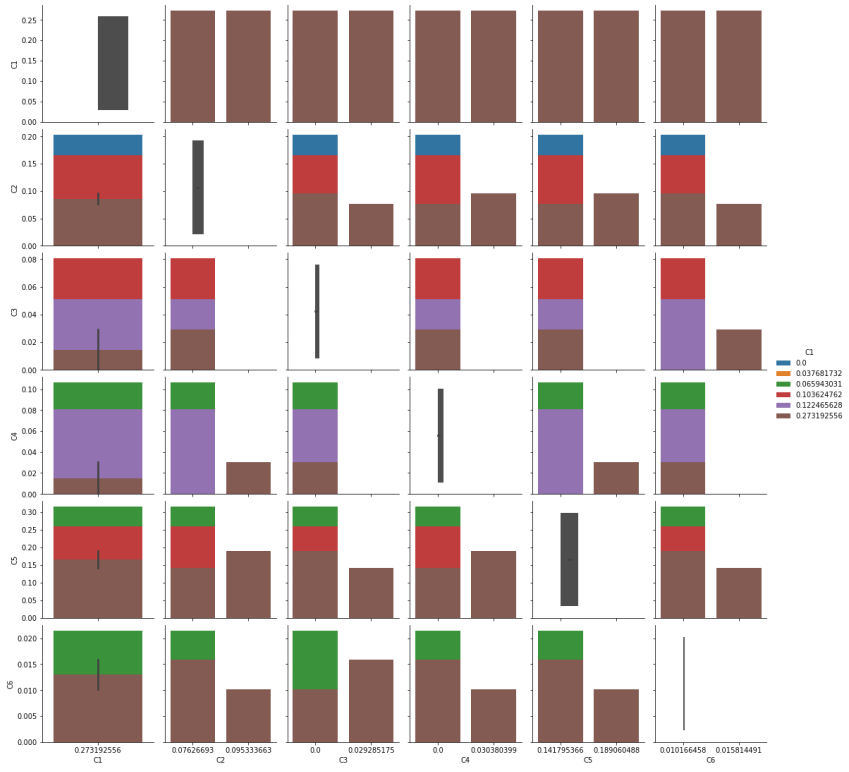

Fig 5. The S and R matrix

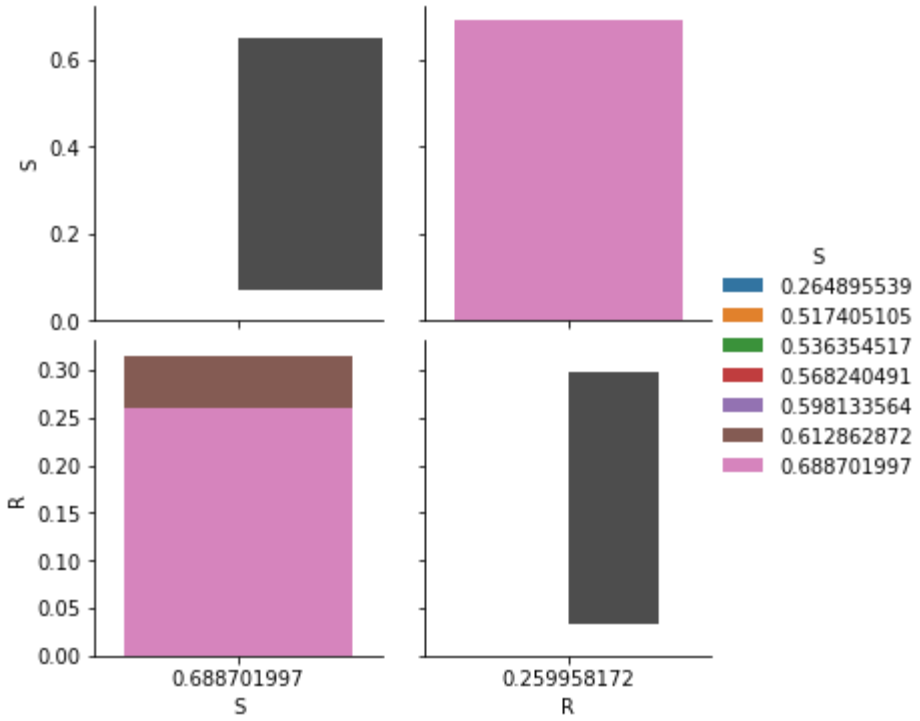

Fig 6. The S and R indexes values.

Ranking the alternatives based on the Portion 4

We compute the S and R indexes, then we show the S and R matrix as shown in Fig 7. Then we obtained the S and R index values as shown in Fig 8.

Then we computed the VIKOR index.

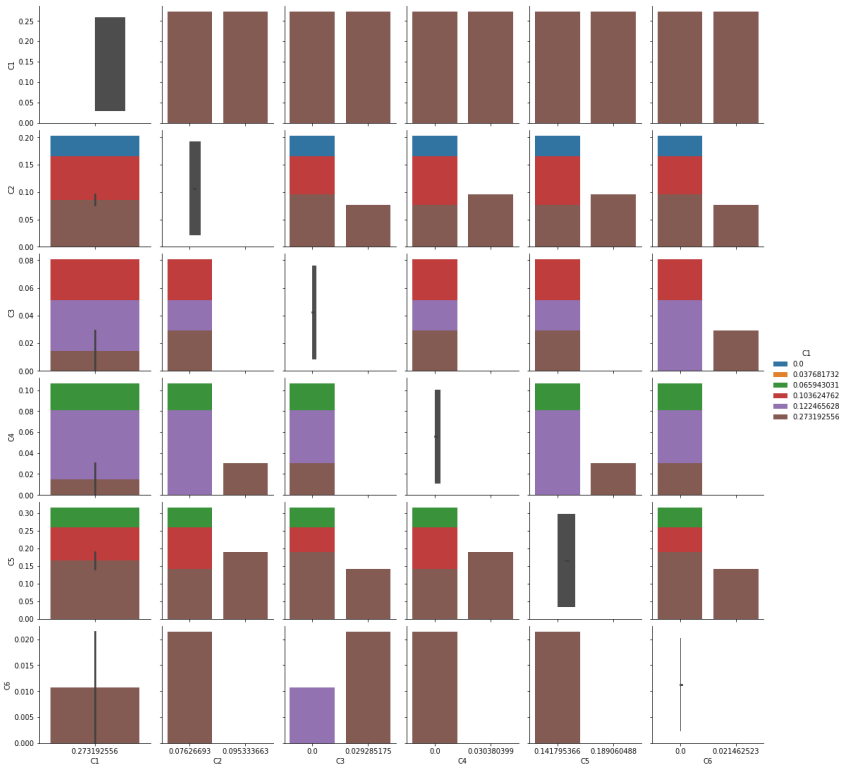

Fig 7. The S and R matrix

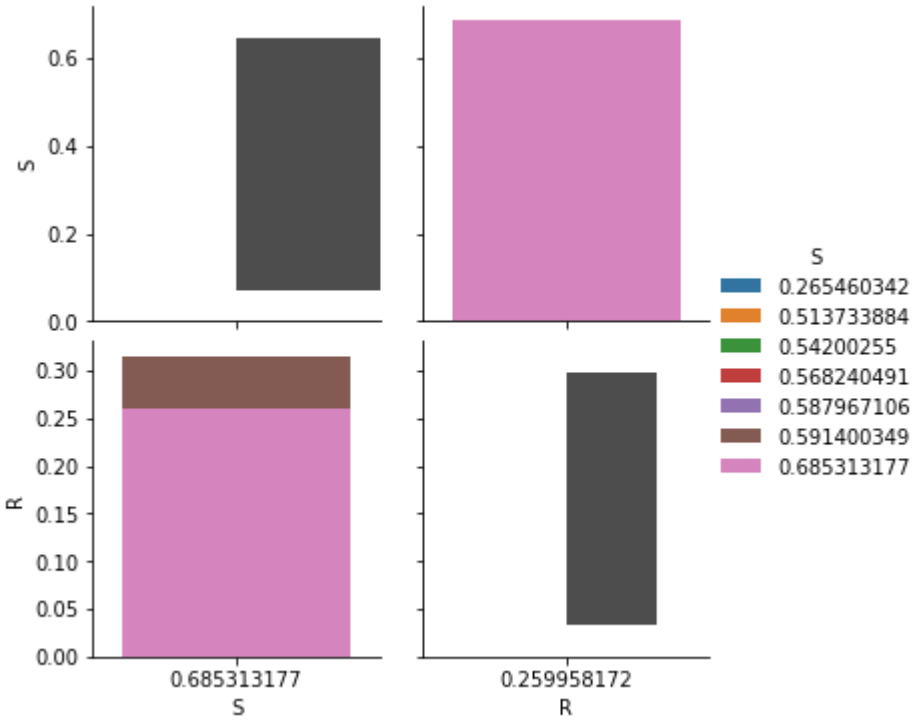

Fig 8. The S and R indexes values.

Then we obtained the VIKOR index values as shown in Fig 9. Then we ranked the alternatives based on each portion as shown in Fig 10.

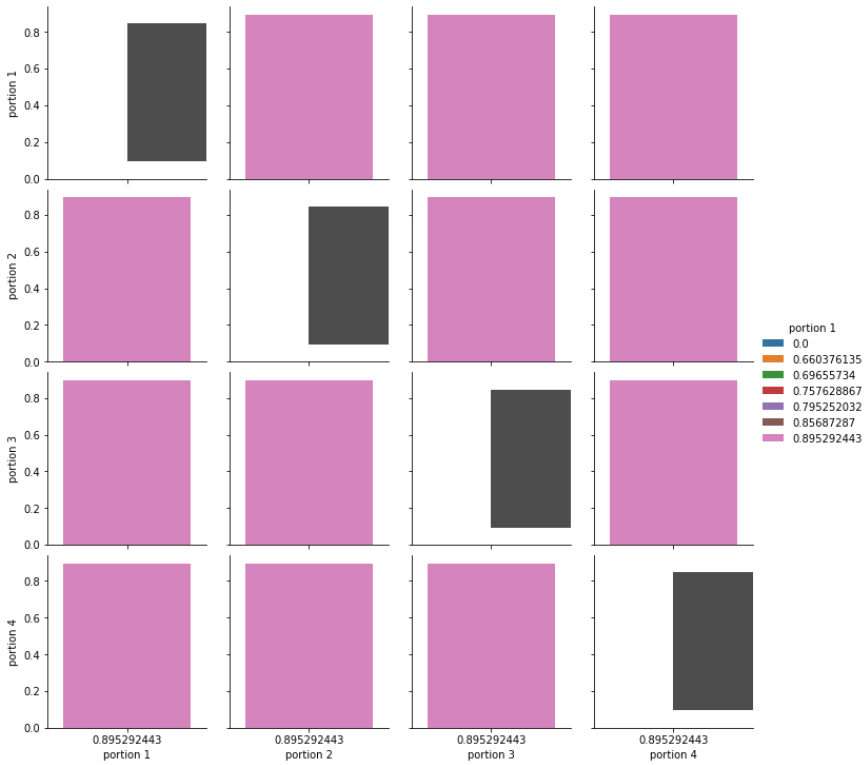

Fig 9. The VIKOR index values.

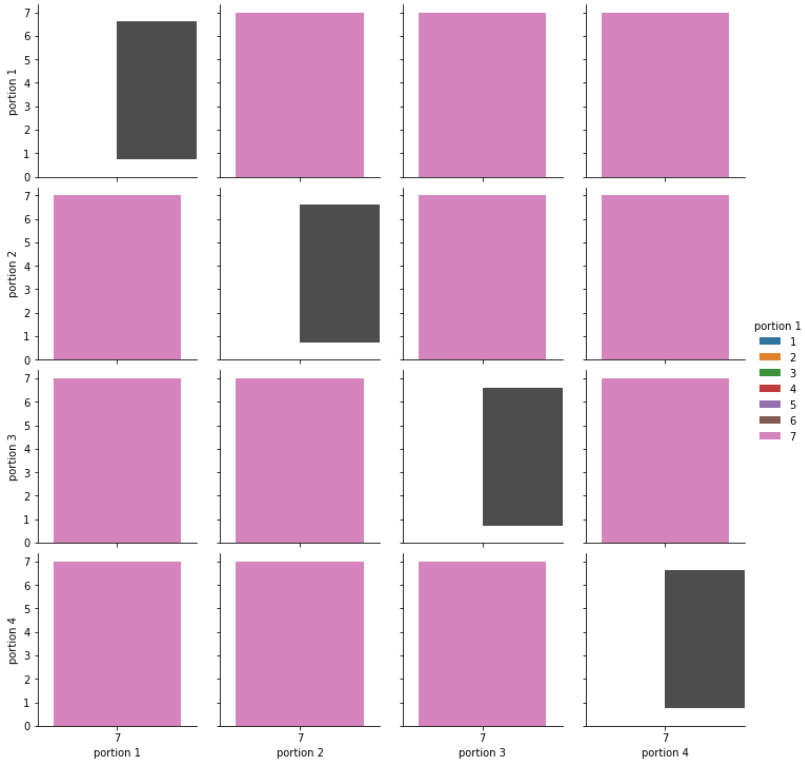

Fig 10. The final ranks.

4. Analysis

This section shows the sensitivity analysis to show the ranks of the alternatives under different cases. In this study, we change the h value between 0 and 1. Then we compute the VIKOR index based on these values as shown in Fig 11. Then we rank the alternatives under different cases as shown on Fig 12. We applied the VIKOR index based on the same weights of the criteria by the Entropy method.

In the first case, we show alternative 4 is the best, followed by alternative 5, alternative 6, and alternative 7. We show alternative 1 is the worst. In the second case, we show alternative 4 is the best, followed by alternative 5, alternative 6, and alternative 7. We show alternative 1 is the worst. In the tenth case, we show alternative 4 is the best, followed by alternative 5, alternative 7, and alternative 3. We show alternative 5 is the worst. In the ninth case, we show alternative 4 is the best, followed by alternative 5, alternative 7, and alternative 3. We show alternative 5 is the worst.

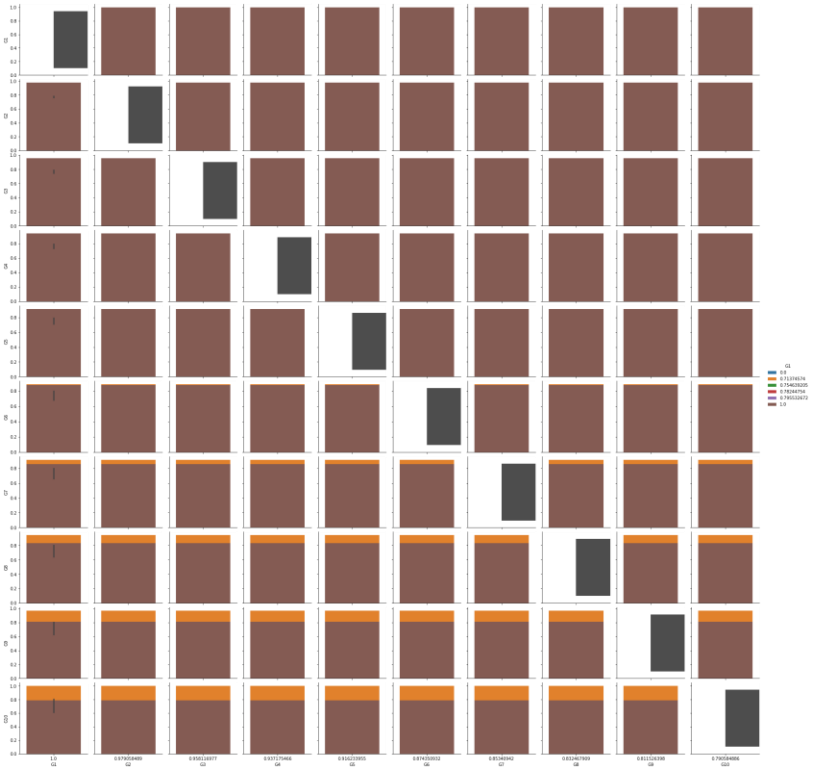

Fig 11. The different VIKOR index values.

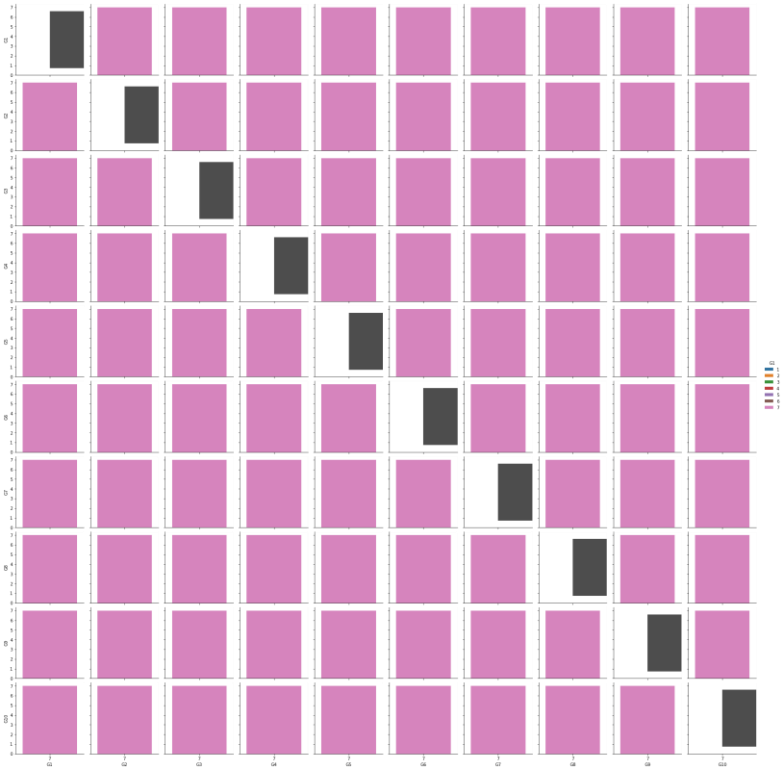

Fig 12. The different ranks.

5. Conclusions

This study evaluated the MCDM approach for safety evaluation of strategies for natural medicines. We used the MCDM approaches to compute the criteria weights and ranks the alternatives. The Entropy method is used to compute the criteria weights. The VIKOR method is used to rank alternatives. We used the single valued neutrosophic sets to deal with uncertainty and vague information. These methods used with the SuperHyperSoft set to treat various criteria and sub values. This study proposed four portions in the SuperHyperSoft set. In each portion we applied the VIKOR method to obtain the ranks of alternatives. Then we show the final ranks of alternatives. The results show the ranks of alternatives is stable. Then we conducted the sensitivity analysis between the ranks of alternatives. We proposed ten cases of ranks. The results show alternative 4 is the best and alternative 6 is the worst.

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