FUZZY IMPLEMENTATION ON MUSHROOM CULTIVATION BY NEUTROSOPHIC HESITANT MATRIX IN MULTI CRITERIA DECISION MAKING

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Abstract: This article uses fuzzy logic with a neutrosophic hesitant fuzzy matrix to implement the cultivation of mushrooms. Various types of mushrooms, such as button mushrooms, oyster mushrooms, milky mushrooms, shiitake mushrooms, and others, are thought to originate from various nations. By using a similarity measure, the cultivation can be described in terms of a single valued neutrosophic hesitant fuzzy matrix with substrate getting ready, which includes sawdust, natural rice, coffee grounds, and paddy straw. This is especially apparent in situations where decision-making involves many criteria. We have also suggested a ranking-based approach for the establishment of a multi-valued neutrosophic hesitant fuzzy network. Additionally, a comparative analysis is conducted using our suggested approach with a multivalued neutrosophic matrix. We also provide an example to illustrate our suggested methodology.

Keywords: Neutrosophic Hesitant Fuzzy Set, Neutrosophic Hesitant Fuzzy Matrix, Mushroom Cultivation, Spawn Production, Substrate Preparation, Harvesting, Similarity Measure

1. Introduction

The membership function (T), the non-membership function (F), and the indeterminacy function (I) are the three defining functions of each element in the Neutrosophic sets theory, which was put forth by Florentin Smarandache [17] in 1999. These functions have been identified on the discourse X universe and are completely independent of each other. The idea has been widely used to address confusing and inconsistent data in the real world in a variety of sectors. The concepts of interval valued fuzzy sets, intuitionistic fuzzy sets, classical fuzzy sets, and so on were improved upon by neutrophilic sets [20, 21].

Neutrosophic set theory, neutrosophic probability, neutrosophic statistics, and neutrosophic logic are just a few of the new mathematical theories that have their roots in neutrosophy and generalise both their classical and fuzzy equivalents. Neutron-sophic algebraic structures have also been studied recently[6]. Regarding applications, the neutrosophic framework has proven useful in numerous domains, including relational database systems, semantic web services, financial data set detection, growth and decline analysis of emerging economies, image processing, and medical diagnosis [7, 8, 9, 16]. It is evident that neutrosophy need more. Thus, several studies have clarified various facets and uses of neutrosophic sets and logic in recent years.

The neutrosophic set has been developed by Smarandache as a mathematical tool that dealt with problems of imprecise, indeterminate, and inconsistent data [14, 15]. In almost every scientific field, the concept of similarity is essential. There are several methods for determining how similar two fuzzy sets are (Chen et al., [3]; Hyung, Song, & Lee, [4]; Pappis&Karacapilidis, [12]; Vang, [18]). Yet the neutrosophic set (NS) similarity measures can not be handled with these methods. The neutrosophic set's similarity metrics have been the subject of very few investigations [5,13]. On interval neutrosophic sets, Jun[5] recently investigated similarity metrics based on Euclidean and Hamming distances and showed how these metrics could be used in decision-making situations.

In a wide range of fields, including coding theory, handwriting recognition [10], image processing, area extraction, psychology [11], pattern recognition, and decision making [19], similarity metrics appear frequently. Sorting through the options is one of the most crucial parts of the decision-making process.

In this study, we exhibit a multi-criteria cultivation with a range of mushroom species and substrate types. The top country for mushroom cultivation is determined using a ranking process. Similarity measures are created for fuzzy, uncertain neutrosophic matrix contexts.The paper's remaining sections are organized as follows. Section IV's goal is to use a similarity metric to give an example of a mushroom culture.

A summary of the Neutrosophic set is given in Section II, and our proposed method's strategy based on similarity measures is illustrated in Section III. Section V displays a comparison with our suggested approach as well. Section VI displays the outcome, and Section VII describes this discovery.

2. Preliminaries

Throughout this section, we briefly discuss several definitions that will be used throughout the rest of the study.

Definition 2.1

Assuming that W is a non-empty reference set, the mathematical formula N = $\{\langle w, t(w), i(w),\ f(w)\rangle / w \in W\}$,clarifies a Neutrosophic hesitant fuzzy set (NHFS), wheret(w), i(w) and f(w), t, i and f denote three different types of degrees, respectively. t: W→ [0,1] describes the truth membership degree, i: W→ [0, 1] denotes the indeterminacy membership degree, f: W→ [0, 1] represents the falsity membership degree. t(w), i(w) and f(w) satisfy the following criterion: 0 ≤ t(w) + i(w) + f(w) ≤ 3.

Definition 2.2

The definition of H of order m x n is H = $\left[\langle t_{ijh}, i_{ijh}, f_{ijh}\rangle\right]_{m\,Xn}$ where $t_{ijh}, i_{ijh}, f_{ijh}$ are between [0,1] and satisfies the condition for I = 1, 2, ...m and j = 1, 2, . . . n; 0 ≤ v_{ij}, v_{ij}, w_{ij} ≤ 1; 0 ≤ v_{ij}^+, v_{ij}^+, w_{ij}^+ ≤ 3 where $v_{ij} \in t_{ijh}$, $v_{ij} \in i_{ijh}$, $w_{ij} \in f_{ijh}$. v_{ij}^+ = sup t_{ijh}, v_{ij}^+ = sup i_{ijh}, w_{ij}^+ = sup f_{ijh} and crisp values between 0 and 1. For simplicity, H = $\left[h_{ijv},\ h_{ijv}, h_{ijw}\right]_{n\,X\,m}$is called as Neutrosophic Hesitant Fuzzy Matrix, where $h_{ijv}\ \in\ t_{ijh}$, $h_{ijv}\ \in\ i_{ijh}, h_{ijw}\ \in\ f_{ijh}$. Every element of NHFM contains any kind of hesitant values. If $t_{ijh}, i_{ijh}, f_{ijh}$ has only one value in each element of matrix and 0 ≤ v_{ij} + v_{ij} + w_{ij} ≤ 3, then the single valued Neutrosophic Hesitant Fuzzy Matrix (SVNHFM) is then obtained by reducing the NHFM.

Definition 2.3

A multi-valued neutrosophic fuzzy matrix P of order m x n can be described mathematically as P = $\left[\langle T_{ijP,} I_{ijP}, F_{ijP}\rangle\right]_{m\,X\,n}$ where $T_{ijP,} I_{ijP}, F_{ijP}$ are between [0,1] and satisfies the condition for I = 1, 2, …… m and j = 1,2, ….. n

$0 \leq \alpha_{ij}, \beta_{ij}, \gamma_{ij}\ \leq 1;\ \ 0 \leq {\alpha_{ij}}^+ + {\beta_{ij}}^+ + {\gamma_{ij}}^+ \leq 3$ where $\alpha_{ij}\ \in\ T_{ijP,}\beta_{ij}\ \in\ I_{ijP},\ \gamma_{ij\,\in}\ F_{ijP}$ and ${\alpha_{ij}}^+ = \sup T_{ijP,}\ \ {\beta_{ij}}^+ = \sup I_{ijP}, {\gamma_{ij}}^+ = \sup F_{ijP}$ and clear numbers ranging from 0 to 1.

For simplicity, P = $\left[P_{ij\alpha},\ P_{ij\beta}, P_{ij\gamma}\right]_{n\,X\,m}$ is called as Multi-Valued Neutrosophic Matrix where $P_{ij\alpha}\ \in T_{ijP,} P_{ij\beta}\ \in\ I_{ijP}, P_{ij\gamma}\ \in\ F_{ijP}$. If $T_{ijP,} I_{ijP}, F_{ijP}$ has only one value in each element of matrix, then the MVNM are reduced to an interval-valued neutrosophic matrix.

Definition 2.4

A neutrosophic set C is contained in another neutrosophic set D ie., C⊆ D if $for\ all\ w\ \in W, T_C(w) \leq\ T_D(w),\ I_C(w) \geq I_D(w), F_C(w) \geq\ F_D(x)$.

Definition 2.5

"w" is the Cartesian product of a mapping F: NHFS (W) X NHFS (W) → [0,1]. If F meets the four requirements listed below, it is then considered to be a distance measure of NHFS: D, E, and C are SVNHFS (W),

1. $0 \leq F(C, D) \leq 1$

2. F (C, D) = 0 iff C = D

3. F (C, D) = F (D, C);

4. If $C \subseteq D \subseteq E$, then $F(C, E) \geq F(C, D)$, $F(C, E) \geq F(D, E)$.

Definition 2.6

"w" is the Cartesian product of a mapping F: NHFS (W) X NHFS (W) → [0,1]. If S satisfies the following axioms, then F is defined as a similarity measure: D, E, and C are SVNHFS (W),

1. $0 \leq F(C, D) \leq 1$

2. F (C, D) = 1 iff C = D

3. F (C, D) = F (D, C);

4. If $C \subseteq D \subseteq E$, then $F(C, E) \geq F(C, D)$, $F(C, E) \geq F(D, E)$.

3. Methodology based on Similarity Measures

With the assistance of Hung and Yung, Yang and Hang, and Chen and Chen, we have suggested various similarity metrics for neutrosophic hesitant fuzzy matrices in this section. Our findings were then compared using the Ranking technique. Also covered is the distance-based similarity measure.

Definition 3.1

Let W = {$w_1, w_2, \ldots w_n$) be a discrete finite set. Consider a neutrosophic sets Dand Ein W where $T_{D(W_{ij})}, I_{D(W_{ij})}, F_{D(W_{ij})} \in [0,1]$, and $T_{E(W_{ij})}, I_{E(W_{ij})}, F_{E(W_{ij})} \in [0,1]$ for every $w_i \in W$, represent its membership, indeterminacy, and non membershipvalues respectively denoted by D = $\left\{\langle w_{ij},\ T_{D(W_{ij})}, I_{D(W_{ij})}, F_{D(W_{ij})}\rangle\right\}$ and E = $\left\{\langle w_{ij},\ T_{E(W_{ij})}, I_{E(W_{ij})}, F_{E(W_{ij})}\rangle\right\}$. Then the proposed distance between D∈NS and E∈ NS defined by $d_H(D, E) = \frac{1}{(n+m)} \sum_{i=1}^{n} \sum_{j=1}^{n} \max\left[\left|T_{D(X_{ij})} - T_{E(X_{ij})}\right|, \left|I_{D(X_{ij})} - I_{E(X_{ij})}\right|, \left|F_{D(X_{ij})} - F_{E(X_{ij})}\right|\right]$ where $d_H(D, E)$ denote the extended Hausdorff distance between two neutrosophic sets D and E.

Definition 3.2

Let D, E be two neutrosophic hesitant fuzzy matrix in W = {$w_{11}, w_{21}, \ldots w_{1n}, w_{21}, w_{22}, \ldots w_{mn}$} , if A = $\left\{\langle w,\ T_D(w_{ij}), I_D(w_{ij}), F_D(w_{ij})\rangle\right\}$ and E = $\left\{\langle w,\ T_E(w_{ij}), I_E(w_{ij}), F_E(w_{ij})\rangle\right\}$ are neutrosophic values of W in D and E respectively, then our proposed form of similarity measure between the neutrosophic Matrix D and E can be evaluated by the function for all w in W

$S^1(D, E) = \frac{1}{d_H(D,E)}$

Definition 3.3

Let D, E be two neutrosophichesitant fuzzy matrix in W = {$w_{11}, w_{21}, \ldots w_{1n}, w_{21}, w_{22}, \ldots w_{mn}$} , if D = $\left\{\langle w,\ T_D(w_{ij}), I_D(w_{ij}), F_D(w_{ij})\rangle\right\}$ and E = $\left\{\langle w,\ T_E(w_{ij}), I_E(w_{ij}), F_E(w_{ij})\rangle\right\}$ are neutrosophic values of W in D and Erespectively, then our proposed form of similarity measure between the neutrosophic Matrix D and E can be evaluated by the function for all w in W.

(i) Hung and Yung:

S^2_T (D, E) = $\sum_{i=1}^{n}\sum_{j=1}^{m}\left(\frac{\min\ (T_D(W_{ij}),\ T_E(W_{ij}))}{\max\ (T_D(W_{ij}),\ T_E(W_{ij}))}\right)$ /(n+m)

S^2_I (D, E) =1- $\sum_{i=1}^{n}\sum_{j=1}^{m}\left(\frac{\min\ (I_D(W_{ij}),I_E\ (W_{ij}))}{\max\ (I_D(W_{ij}),I_E\ (W_{ij}))}\right)$ /(n+m)

S^2_F (D, E) =1- $\sum_{i=1}^{n}\sum_{j=1}^{m}\left(\frac{\min\ (F_D(W_{ij}),F_E(W_{ij}))}{\max\ (F_D(W_{ij}),F_E(W_{ij}))}\right)$ /(n+m)

(ii) Yang and Hang:

S^3_T (D, E) =$\frac{1}{(m+n)}\sum_{i=1}^{n}\sum_{j=1}^{m}\left(1-\frac{[T_D(X_{ij})-T_E(X_{ij})]}{2}\right)$

S^3_I(D, E)=$\frac{1}{(m+n)}\sum_{i=1}^{n}\sum_{j=1}^{m}\left(\frac{[I_D(X_{ij})-I_E(X_{ij})]}{2}\right)$

S^3_F(D, E)=$\frac{1}{(m+n)}\sum_{i=1}^{n}\sum_{j=1}^{m}\left(\frac{[F_D(X_{ij})-F_E(X_{ij})]}{2}\right)$

(iii) Chen and Chen:

$$S^4(D, E)=\frac{\sum_{i=1}^{n}\sum_{j=1}^{m}\{T_D(X_{ij}).T_E(X_{ij})+T_D(X_{ij}).T_E(X_{ij})+T_D(X_{ij}).T_E(X_{ij})\}}{max\begin{Bmatrix}\sum_{i=1}^{n}\sum_{j=1}^{m}((T_D(X_{ij}))^2+(I_D(X_{ij})^2+(F_D(X_{ij}))^2),\\ \sum_{i=1}^{n}\sum_{j=1}^{m}((T_E(X_{ij}))^2)+(I_E(X_{ij})^2)+(F_E(X_{ij})^2))\end{Bmatrix}}$$

Definition 3.4

Let D, E be two neutrosophic hesitant fuzzy matrix in W = {w_{11}, w_{21}, ... w_{1n}, w_{21}, w_{22}, ... w_{mn}} , if D = $\{\langle w,\ T_D(w_{ij}), I_D(w_{ij}), F_D(w_{ij})\rangle\}$ andE = $\{\langle w,\ T_E(w_{ij}), I_E(w_{ij}), F_E(w_{ij})\rangle\}$ are neutrosophic values of W in D and E respectively, then our proposed Ranking Value for the similarity measure between the neutrosophic Matrix D and E can be evaluated by the function for all w in W.

R (D, E) = 2 S_T (D, E) + S_I (D, E) – S_F(D, E) where the highest ranking value will be the best one.

4. Numerical Example

This section applies the multi-criteria decision-making problem to our suggested approach.. In this problem, we have to select the country for harvesting the mushrooms in all the substrate. Here China (A_1), Italy (A_2) and USA (A_3) are considered. There are 4 mushrooms are taken as Button mushroom (D_1), Oyster mushroom (D_2), Milky mushroom (D_3) and Shiitake mushroom (D_4). There are 4 substrates to harvest the mushrooms which are poddy straw (c_1), Saw dust (c_2), Organic rice (c_3) and coffee grounds (c_4). In each mushroom substrate we are checking the growth, Bioactive compound and Toxic compound which will be $\langle T_{ij}, I_{ij}, F_{ij}\rangle$.

Step 1: Decision matrix for 3 countries.

Step 2: Calculating distance for 3 countries.

Step 3: Calculating similarity measure for all the 3 countries using distance-based similarity measure (3.2)

Step 4: Comparing the similarity measures with the Ranking function

Step 5: Comparing the values to find the best country for harvesting the mushroom which is having the highest ranking.

Step 1:

A_1 =

	D_1	D_2	D_3	D_4
C_1	(.5, .3, .2)	(.6, .4, .2)	(.8, .5, .1)	(.7, .4, .3)
C_2	(.8, .4, .1)	(.8, .2, .1)	(.7, .6, .2)	(.7, .2, .4)
C_3	(.6, .5, .4)	(.8, .3, .1)	(.5, .2, .1)	(.7, .3, .1)
C_4	(.7, .2, .4)	(.7, .1, .3)	(.8, .5, .2)	(-7, .3, .2)

A_2 =

	D1	D2	D3	D4
C_1	(.8, .2, .3)	(.7, .1, .3)	(.6, .5, .3)	(.8, .2, .7)
C_2	(.7, .2, .3)	(.7, .5, .3)	(.8, .3, .1)	(.8, .5, .2)
C_3	(.7, .6, .3)	(.6, .5, .1)	(.7, .3, .2)	(.7, .3, .1)
C_4	(-7, .1, .3)	(.8, .2, .1)	(.8, .6, .5)	(.6, .3, .2)

A_3=

	D1	D2	D3	D4
C_1	(.7 .2, .1)	(.7, .3, .5)	(.8, .3, .2)	(.8, .1, .5)
C_2	(.8, .5, .1)	(.8, .4, .2)	(.7, .3, .1)	(.7, .2, .1)
C_3	(.8, .6, .4)	(.8, .5, .3)	(.7, .5, .2)	(.7, .4, .1)
C_4	(.8, .3, .1)	(.7, .5, -1)	(.8, .6, .1)	(.8, .5, .4)

Step 2:

$d_H(A_1,A_2)=\frac{1}{16}\sum\{\max(0.3,-1,-1)+\max(.1,.3,.1)+\max(.2,.0,.2)+\max(.1,.2,.2)+\max(.1,.2,.2)+\max(.1,.3,.2)+\max(.1,.3,.1)+\max(.1,.3,.2)+\max(.1,.1,.1)+\max(.2,.2,.0)+\max(.2,.1,.1)+\max(.0,.1,.0)+\max(0,.1,.1)+\max(.1,.1,.2)+\max(0,.1,.3)+\max(.1,0,0)\}$

$=\frac{1}{16}[0.3+0.3+.2+.2+.2+.3+.3+.3+.1+.2+.2+.1+.1+.2+.3+.1]$

$=\frac{1}{16}[3.4]$

$= 0.2125$

$d_H(A_1,A_3)=\frac{1}{16}\sum\{\max(.2,.1,.1)+\max(.1,.1,.3)+\max(0,.2,.1)+\max(.1,.3,.2)+\max(0,.1,0)+\max(0,.2,.1)+\max(0,.3,.1)+\max(0,0,.3)+\max(.2,.1,0)+\max(0,.2,.2)+\max(.2,.3,.1)+\max(0,.1,0)+\max(.1,.1,.3)+\max(0,.4,.2)+\max(0,.1,.1)+\max(.1,.2,.2)\}$

$=\frac{1}{16}[.2+.3+.2+.3+.1+.2+.3+.3+.2+.2+.3+.1+.3+.4+.1+.2]$

$=\frac{1}{16}[3.7]$

$= 0.23125$

$d_H(A_2,A_3)=\frac{1}{16}\sum\{\max(.1,0,.2)+\max(0,.2,.2)+\max(.2,.2,.1)+\max(0,.1,.4)+\max(.1,.3,.2)+\max(.1,.1,.1)+\max(.1,0,0)+\max(.1,.3,.1)+\max(.1,0,.1)+\max(.2,0,.2)+\max(0,.2,0)+\max(0,.2,0)+\max(.1,.2,.2)+\max(.1,.3,0)+\max(0,0,.4)+\max(.2,.2,.2)\}$

$=\frac{1}{16}[.2+.2+.2+.4+.3+.1+.1+.3+.1+.2+.2+.2+.2+.3+.4+.2]$

$=\frac{1}{16}[3.6]$

$d_H(A_2,A_3) = 0.225$

Step 3:

$S^1(A_1,A_2) = 0.8247$

$S^1(A_1,A_3) = 0.8271$

$S^1(A_2,A_3) = 0.82633$

Step 4:

Here $S^1(A_1,A_3) > S^1(A_1,A_2)$

$S^1(A_1,A_3) > S^1(A_2,A_3)$

Hence $A_1 \subseteq A2 \subseteq A_3$

Step 5:

Hence China is the best country to harvest Mushroom than Italy and USA.

5. Comparison of Measures

In this section, we have compared all the similarity measures with the proposed ranking method. The decision-maker can easily choose the best country by comparing all the substrates. The procession method is make simple for decision makers and wherever we can easily know the separate ratio for growth, bioactive compound and the range of toxic compound.

(i) Hung and Yung:

$S^2_T(D, E) = \sum_{i=1}^{n} \sum_{j=1}^{m} \left(\frac{\min\ (T_D(W_{ij}),\ T_E(W_{ij}))}{\max\ (T_D(W_{ij}),\ T_E(W_{ij}))} \right) /(n+m)$

$S^2_T(A_1,A_2) = 0.8538$

$S^2_I(D, E) = 1- \sum_{i=1}^{n} \sum_{j=1}^{m} \left(\frac{\min\ (I_D(W_{ij}), I_E(W_{ij}))}{\max\ (I_D(W_{ij}), I_E(W_{ij}))} \right) /(n+m)$

$S^2_I(A_1,A_2) = 0.38646$

$S^2_F(D, E) = 1- \sum_{i=1}^{n} \sum_{j=1}^{m} \left(\frac{\min\ (F_D(W_{ij}), F_E(W_{ij}))}{\max\ (F_D(W_{ij}), F_E(W_{ij}))} \right) /(n+m)$

$S^2_F(A_1,A_2) = 0.41251$

Similarly,

$S^2_T(A_1,A_3) = 0.91629$

$S^2_I(A_1,A_3) = 0.37813$

$S^2_F(A_1,A_3) = 0.45834$

$S^2_T(A_2,A_3) = 0.89063$

$S^2_I(A_2,A_3) = 0.339584$

$S^2_F(A_2,A_3) = 0.414623$

(ii) Yang and Hang:

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$S^3_T(D, E) = \frac{1}{(m+n)} \sum_{i=1}^{n} \sum_{j=1}^{m} \left(1 - \frac{|T_D(X_{ij}) - T_E(X_{ij})|}{2}\right)$

$S^3_T(A_1, A_2) = 0.94375$

$S^3_I(D, E) = \frac{1}{(m+n)} \sum_{i=1}^{n} \sum_{j=1}^{m} \left(\frac{|I_D(X_{ij}) - I_E(X_{ij})|}{2}\right)$

$S^3_I(A_1, A_2) = 0.078125$

$S^3_F(D, E) = \frac{1}{(m+n)} \sum_{i=1}^{n} \sum_{j=1}^{m} \left(\frac{|F_D(X_{ij}) - F_E(X_{ij})|}{2}\right)$

$S^3_F(A_1, A_2) = 0.065625$

Similarly,

$S^3_T(A_1, A_3) = 0.96875$

$S^3_I(A_1, A_3) = 0.0875$

$S^3_F(A_1, A_3) = 0.071875$

$S^3_T(A_2, A_3) = 0.95625$

$S^3_I(A_2, A_3) = 0.071875$

$S^3_F(A_2, A_3) = 0.075$

(iii) Chen and Chen:

$$S^4(D, E) = \frac{\sum_{i=1}^{n} \sum_{j=1}^{m} \{T_D(X_{ij}).T_E(X_{ij}) + T_D(X_{ij}).T_E(X_{ij}) + T_D(X_{ij}).T_E(X_{ij})\}}{max\left\{\begin{array}{c} \sum_{i=1}^{n} \sum_{j=1}^{m} ((T_D(X_{ij})^2 + (I_D(X_{ij})^2 + (F_D(X_{ij})^2), \\ \sum_{i=1}^{n} \sum_{j=1}^{m} ((T_E(X_{ij})^2) + (I_E(X_{ij})^2) + (F_E(X_{ij})^2)) \end{array}\right\}}$$

$S^4(A_1, A_2) = 0.91559$

$S^4(A_1, A_3) = 0.92407$

$S^4(A_2, A_3) = 0.92071$

6. Result and Discussion

In this section, we delve into the implicationsand findings derived from the application of theNeutrosophic Hesitant Fuzzy Matrix (NHFM) inassessing the suitability of various countries formushroom harvesting. The focal points of ourinvestigation include the expansion of theoriesconcerning similarity measures within NFHM,exploration of different forms of fuzziness associatedwith uncertainty, and the development of matrices forrepresentation and analysis.

Improved comprehension of Similaritymeasurements: Our research makes a substantialcontribution to our knowledge of similaritymeasurements in the context of NHFM. We havebroadened the theoretical groundwork guiding thecomparison and assessment of heterogeneous entities byintroducing notions of fuzziness and uncertainty,especially with regard to the acceptability of mushroomharvesting in various other nations.

Examining Neutrosophic Hesitant Fuzzy Matrices: The investigation of neutrosophic fuzzy matrices, whichprovide a thorough method for expressing and evaluatingcomplicated data marked by ambiguity and imprecision,is a significant addition of our work. By means of athorough analysis, we have clarified the many types offuzziness included in the matrices, which has allowed usto offer important insights into how uncertainty ismanaged in decision-making processes.

Simplified Calculation Methods: Our researchprovides a new method for determining matrix valuesthat is both understandable and accessible. Through theuse of simple approaches, we make it easier tocomprehend the fundamental ideas that underpin matrixoperations, which improve the usefulness of NHFM inreal-world situations.

Creation of Ranking Measures: We have createdreliable metrics for classifying nations according to howwell-suited they are for mushroom harvesting. Throughthe integration of information from various sources andthe application of sophisticated analytical methods, wehave produced thorough rankings that accuratelyrepresent the inherent characteristics of every nation about the production of mushrooms.

Comparison and Evaluation Efficiencies: A criticalaspect of our research involves the comparison between the current ranking procedures and our suggested similarity metrics. We have proven the superioreffectiveness of our approach in assessing and choosingthe best nations for mushroom harvesting bypainstakingly tabulating and analyzing comparisonvalues.

Identification of Best Country for MushroomHarvesting: Based on our comprehensive analysis, weunequivocally conclude that China emerges as theoptimal choice for mushroom cultivation, surpassingItaly and the USA. Our evaluation, considering factors such as growth potential, bioactive components, and toxicity levels, unequivocally positions China as the preferred destination for maximizing the yield andquality of mushroom produce.Hence, our research not only advancestheoretical understanding within the realm of NHFM butalso offers practical insights that can significantlyenhance decision-making processes pertaining tomushroom harvesting. By elucidating complex conceptsin a clear and accessible manner, we provide valuableguidance for stakeholders seeking to optimize their agricultural practices and maximize yield potential.

Table 6.1
Comparison table

Similarity Measures with Ranking Values	$S(A_1, A_2)$	$S(A_1, A_3)$	$S(A_2, A_3)$	Ranking Values
S^1	0.8247	0.8271	0.82633	$S(A_1, A_3) \geq S(A_1, A_2)$ $S(A_1, A_3) \geq S(A_2, A_3)$
S^2	$\langle 0.8538, 0.39646, 0.41251 \rangle$	$\langle 0.91629, 0.37813, 0.45834 \rangle$	$\langle 0.8906, 0.33958, 0.41462 \rangle$	$S(A_1, A_3) \geq S(A_1, A_2)$ $S(A_1, A_3) \geq S(A_2, A_3)$
R^2	1.68155	1.75237	1.706221	
S^3	$\langle 0.94374, 0.078125, 0.065625 \rangle$	$\langle 0.96875, 0.0875, 0.071875 \rangle$	$\langle 0.95625, 0.071875, 0.075 \rangle$	$S(A_1, A_3) \geq S(A_1, A_2)$ $S(A_1, A_3) \geq S(A_2, A_3)$
R^3	1.9	1.953125	1.909375	
S^4	0.91559	0.92407	0.92071	$S(A_1, A_3) \geq S(A_1, A_2)$ $S(A_1, A_3) \geq S(A_2, A_3)$

Here A_2 is the best then A_3 and A_1. In all the method we are getting the unique values with growth, bioactive components and toxic components. Hence China is the best country to harvest mushroom rather than Italy and USA.

7. Conclusion

This study introduces a novel ranking technique that uses similarity measurements to compare every neutrosophic fuzzy matrix. In order to determine the similarity measure between neutrosophic fuzzy matrices, we define the similarity measures for neutrosophic fuzzy matrices. Choosing the optimal growth and the quantity of bioactive and harmful material to examine will be beneficial for all those involved in making decisions.

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