Assessment of NMOORA and NVIKOR MCDM methods in plant disease management

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Assessment of NMOORA and NVIKOR MCDM Methods in Plant Disease Management

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Abstract. Decision making is a concept extensively used in real world problems these days. Selecting an alternative from a set of given alternatives is not an easy task as it may vary depending on the prejudice of the decision maker and on their ignorance of the particular problem chosen. There exists a lot of multi criteria decision making methods. This research article deals with selecting the best alternative method for disease management in plants by comparing the results from MCDM methods. In order to introduce the notion of uncertainty in the field of agriculture, values collected from the decision maker are taken with truth, falsity and indeterminacy membership values. Hence, we incorporate the concept of neutrosophy with MCDM methods to select the best possible method for managing diseases in crops.

KEYWORDS: Neutrosophy, membership values, MOORA, VIKOR, Decision matrix.

1. INTRODUCTION

Decision Making involving multi criteria methods are widely in use where significant decisions are to be taken. Problems that involve multiple criteria are taken into consideration and with the aid of insignificant or uncertain information available at hand, significant decisions are made with the help of various decisions making models. A bunch of choices is provided and the various criterion/ attributes that affect each alternative is also chosen. On applying fitting strategies to the values provided, the best alternative is chosen which is superior to all the other alternatives. Hence, we provide a reliable solution to the investigator. The values provided may be significant or may not be. Therefore, inorder to rule out the hesitancy and inconsistency, the neutrosophy values of the values of the decision maker are considered. Here, we are provided with truth values, indeterminacy values and false values for the data considered. Taking all these three into account, the inconsistency is dealt with and on applying the MCDM methods, the best alternate is selected.

In the field of agriculture, there are a lot of problems and risks undertaken. One among them is management of diseases in plants. Disease management is not an easy task. It requires a lot of risk taking as once the crop is infected, the right treatment has to be provided at the right time so as to cure the crop of the infection. Hence, decision-making plays a very significant role in plant disease management and that is why we make use of the multi criteria decision methods to choose the right alternative.

2. LITERATURE REVIEW

Fuzzification of values was first introduced by Zadeh[1] in the year 1965. Crisp values were given membership values. This fuzzification was extended to allotting membership and non-membership values for the crisp number by Atanassov[2], which was termed as an intuitionistic number. Many researchers carried on their work with intuitionistic

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sets and also with its extension- intuitionistic fuzzy sets. Florentin Smarandache[3] introduced the neutrosophic set which is widely in use these days. This neutrosophic sets considers the indeterminacy membership value, the rate of how far it is neither true nor false.

Decision making problems were carried out with intuitionistic fuzzy sets. Taking into consideration, the bipolar intuitionistic fuzzy soft set, Anita[4] et al worked on a multi criteria decision making problem based on weighted geometric aggregation operator. Initially, decision making was done with fuzzy sets and it was later extended to intuitionistic fuzzy sets too. Perez[5] et al made use of the MOORA multi criteria decision making method to estimate the maintenance system in industries. Ryco[6] et al studied on the "supplier selection at ABC mining companies in Indonesia"[6] where the alternative was chosen based on the best worst method and making use of the MOORA and COPRAS decision making methods. The final alternative was chosen by comparing the results obtained from the MOORA and COPRAS methods. Zaitun[7] et al delved into implementing MOORA method for determining fund recipients in Indonesia. Zhi-Hui Li[8] extended MOORA method in multiplicative form for multiple criteria group decision making with hesitant fuzzy sets. Hamsa[9] and Veerabhadrappa studied on decision making under risky conditions in agriculture where values are uncertain and finding optimum solution was very important. Nieuwoudt[10] made a study on the risks and uncertainities faced in agriculture. Pavan[11] et al has recorded the various multi criteria decision strategical techniques that are used in agriculture.

Yalan[12] et al analysed"initial public offering using CRITIC and VIKOR methods". Ragunathan Krishnakumar[13] et al studied on applying hesitant fuzzy sets in linguistic form in decision making. Liao[14] et al applied hesitant fuzzy linguistic concept into VIKOR technique. Wang[15] et al discussed on single valued neutrosophic linguistic sets in decision making with Maclaurin symmetric mean operators. Jeya Giruba[16] and Vinodh applied fuzzy VIKOR method in selecting another material for instrument panel utilized in electric cars.VIKOR technique has been widely used in decision making processes, sustainability, renewable energy, operations research. Abbas Mardani[17] et al made a review on the various papersconnected to VIKOR procedure in several areas of application and also on the other MCDM methods in existence. Muhammet Gul[18] et al also studied on papers linkedwith VIKOR and its fuzzy extensions in the field of design, mechanical engineering and manufacturing, business management, logistics and supply chain management, natural resources, information technology, financial management, chemical and biochemical engineering, agriculture. Seraphim Opricovic[19] compared VIKOR and TOPSIS methods to attain a compromise solution using similarity differences and aggregating function. Alireza[20] et al have discussed on the major MCDM methods in use which deals with weighting methods and ranking methods.

In this paper, comparative investigation is done for the two multi criteria decision making methods, MOORA and VIKOR with neutrosophy. In section 3, the basic concepts are discussed about the neutrosophic set and single valued neutrosophic set. In section 4, the NMOORA and NVIKOR multi criteria decision making methods and its algorithms are discussed. In section 5, case study on plant disease management is chosen and selecting the best alternative is obtained by comparing the results of NMOORA and NVIKOR methods. In section 6, the outcomes are analysedand the best option/ alternative is chosen.

3. PRELIMINARIES

DEFINITION 3.1[3]:

Let X be a universe. A neutrosophic set A_N in X is defined by a truth membership function, an indeterminacy membership function and falsity membership function. $T(A_N)$, $I(A_N)$, $F(A_N)$ are the truth, indeterminacy and falsity membership functions and they are real non-standard subsets of $]0^-,1^+[$ and $0^- \leq T(A_N) \leq \sup\ I(A_N) \leq \sup F(A_N) \leq 3^+$

DEFINITION 3.2: (Single Valued Neutrosophic Set)[21]:

Let X be a universe of discourse. A single valued neutrosophic set $A_N$over X is an object having the form $A_N = \{<x, T(A_N), I(A_N), F(A_N)>; x \in X\}$ where $T(A_N)(x): X \to [0,1]$, $I(A_N)(x): X \to [0,1]$, $F(A_N)(x): X \to [0,1]$ with $0 \leq T(A_N) + I(A_N) + F(A_N) \leq 3$ for all $x \in X$.

DEFINITION 3.3[21]:

Consider a trapezoidal neutrosophic number$A_N = \left((a_1, a_2, a_3, a_4); w_{A_N}, u_{A_N}, y_{A_N}\right)$ whose truth membership, indeterminacy membership and falsity membership functions can be respectively defined by

$$\eta A_N(x)=\begin{cases}\frac{(x-a_1)w_{A_N}}{a_2-a_1} & a_1\le x\le a_2\\ w_{A_N} & a_2\le x\le a_3\\ \frac{(a_4-x)w_{A_N}}{a_4-a_3} & a_3\le x\le a_4\\ 0 & otherwise\end{cases}$$

$$\theta A_N(x)=\begin{cases}\frac{(a_2-x)+u_{A_N}(x-a_1)}{a_2-a_1} & a_1\le x\le a_2\\ u_{A_N} & a_2\le x\le a_3\\ \frac{(a_2-x)+u_{A_N}(x-a_1)}{a_2-a_1} & a_3\le x\le a_4\\ 0 & otherwise\end{cases}$$

$$\vartheta A_N(x)=\begin{cases}\frac{(a_2-x)+y_{A_N}(x-a_1)}{a_2-a_1} & a_1\le x\le a_2\\ y_{A_N} & a_2\le x\le a_3\\ \frac{(a_2-x)+y_{A_N}(x-a_1)}{a_2-a_1} & a_3\le x\le a_4\\ 0 & otherwise\end{cases}$$

4. PROPOSED ALGORITHM FOR MCDM WITH NEUTROSOPHY

4.1 Nmoora Method

NMOORA method is neutrosophic multi objective optimization method by ratio analysis. MOORA[20] was presented by Brauers in 2004. This is considered to be one of the easiest compensatory decision making methods as it involves easier simplifications. This is an objective method and the two main components are the ratio system approach and the reference point approach. Here, coordinating the neutrosophy with MOORA, we term it as NMOORA method. The initial values are taken as trapezoidal neutrosophic numbers to rule out the inconsistency hidden in the values given by the decision maker.

Step 1: A particular real world problem is chosen where the various alternatives are put forth and certain criteria based on the problem are chosen insuch a way that all the attributes/ criteria are independent. The attributes are further classified as favourable attributes and non-favourable attributes. The values provided by the decision maker with truth, indeterminacy and falsity values are recorded as neutrosophic decision matrix.

$$A_N=\begin{bmatrix} x_{11} & x_{12} & . & . & . & x_{1n}\\ . & & & & & \\ . & & & & & \\ x_{i1} & x_{i2} & . & . & . & x_{in}\\ . & & & & & \\ x_{m1} & x_{m2} & . & . & . & x_{mn}\end{bmatrix} \quad i=1,2\ldots.m, j=1,2,\ldots.n \tag{1}$$

Where x_{ij} denotes the element in the i^{th} row and j^{th} column of the decision matrix.

Step 2: The decision matrix values with neutrosophyare denoted in the form $\left((a_1,a_2,a_3,a_4);w_{A_N},u_{A_N},y_{A_N}\right)$ where a_1,a_2,a_3,a_4 denotes the trapezoidal neutrosophic number with its truth membership value, indeterminacy membership value and falsity membership value.

Step 3: The neutrosophic decision matrix is converted to its crisp form using the relation

$$A=\left(\frac{a_1+a_2+a_3+a_4}{4}\right)\left(\frac{w_{A_N}+\left(1-u_{A_N}\right)+\left(1-y_{A_N}\right)}{3}\right) \tag{2}$$

and are written as the new decision matrix A.

Step 4: Using the entropy measure for finding the weights of the selected attributes, the respective weights of the attributes are found and are denoted by $w_1, w_2, \ldots\ldots\ldots w_n$ such that $\sum_{j=1}^{n} w_j = 1$

Step 5: The decision matrix is then normalized using the equation

$$A_{ij}^{*} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^{2}}}, j = 1,2\ldots.n \quad (3)$$

and all the values are assigned to the matrix A_{ij}^{*}.

Step 6: The reference points are found with respect to the favourable and non-favourable attributes. The maximum values are chosen for the favourable attributes and minimum values are chosen for the non-favourable attributes.

Step 7: From the reference points and weights found by entropy measures, the assessment values for each attribute is found using the equation

$$\hat{f_j} = \sum_{j=1}^{s} x_{ij}^{*} w_j - \sum_{j=s+1}^{n} x_{ij}^{*} w_j \ , \quad i = 1,2,\ldots m \quad (4)$$

Here s denotes the number of favourable attributes and n-s denotes the number of non-favourable attributes.

Step 8: The alternatives are ranked finally by allotting ranks to the maximum values of $\hat{f_j}$. The best alternative is the one with the maximum value.

4.2 Nvikor Method

VIKOR[20] method is a MCDM method in use. This was introduced by Opricovic in 1998. This is one of the compromising methods where the nearest alternative to the ideal solution is selected.

Step 1: A particular real-world problem is chosen where the various alternatives are put forth and certain criteria based on the problem are chosen insuch a way that all the attributes/ criteria are independent. The attributes are further classified as favourable attributes and non-favourable attributes. The values provided by the decision maker with truth, indeterminacy and falsity values are recorded as neutrosophic decision matrix as given in eqn (1) where x_{ij}denotes the element in the i^{th} row and j^{th} column of the decision matrix.

Step 2: The neutrosophic decision matrix values are denoted in the form $\left((a_1, a_2, a_3, a_4); w_{A_N}, u_{A_N}, y_{A_N}\right)$ where a_1, a_2, a_3, a_4 denotes the trapezoidal neutrosophic number with its truth membership value, indeterminacy membership value and falsity membership value.

Step 3: The neutrosophic decision matrix is converted to its crisp form using the relationspecified in equation (2) and are written as the new decision matrix A. Here, we assume the elements of the decision matrix as f_{ij} , where ij represents element in the i^{th} row and j^{th} column.

Step 4: Using the entropy measure for finding the weights of the selected attributes, the respective weights of the attributes are found and are denoted by $w_1, w_2, \ldots\ldots\ldots w_n$ such that $\sum_{j=1}^{n} w_j = 1$

Step 5: The f_j^{*} *and* f_j^{-}indexes are found for each attribute in accordance with the decision matrix obtained. In the case of favourable attributes, f_j^{*} takes the best f_{ij} i.e., the maximum value in the decision matrix and f_j^{-} takes the worstf_{ij}. In the case of non-favourable attributes, it is the opposite to that of favourable attributes.

Favourable attribute: $f_j^{*} = \max_i f_{ij}\, , f_j^{-} = \min_i f_{ij}$

Non-favourable attribute: $f_j^{*} = \min_i f_{ij}\ , f_j^{-} = \max_i f_{ij}$ (5)

Step 6: The S-index and R-index for each alternative existing is found using the equations below:

$$S_i = \sum_{j=1}^{n} w_j \frac{\left(f_j^{*}-f_{ij}\right)}{\left(f_j^{*}-f_j^{-}\right)} \quad \text{for i=1,2…m and} \tag{6}$$

$$R_i = \max_j \left[w_j \frac{\left(f_j^{*}-f_{ij}\right)}{\left(f_j^{*}-f_j^{-}\right)} \right] \text{for i=1,2,..m and j=1,2,…n} \tag{7}$$

Step 7: S^*, R^* and S^-, R^- is found using the following formula

$$S^{*}=\min_i S_i \text{ , } S^{-}=\max_i S_i \text{ , } R^{*}=\min_i R_i, \;\; R^{-}=\max_i R_i \tag{8}$$

Step 8: Finally, the VIKOR index is calculated for each alternative by the equation

$$Q_i = v \times \left[\frac{S_i-S^*}{S^- -S^*}\right] + (1-\text{v}) \left[\frac{R_i-R^*}{R^- -R^*}\right] \tag{9}$$

where v stands for the strategic weight, whose value is taken to be 0.5.

Step 9: The ranking is done for S index, R index and VIKOR index whose values are arranged in descending order and the alternative with the least value is chosen as the best alternative and this ranking is reliable as three rankings are done.

5. CASE STUDY

In agriculture, there are a lot of problems faced by the farmer right from sowing seed to harvesting. The main problem faced is the occurrence of diseases in plants and their management. The alternatives chosen are the disease management procedures such as exclusion (A_1), protection (A_2) and therapy (A_3). The attributes chosen are cost for treatment of the disease (C_1), Required labour (C_2), Overall duration (C_3) and yield (C_4).

Here in this case study, we consider the favourable attributes to be C_3 and C_4 whereas $C_1$and C_2 are the non-favourable attributes.

5.1 Nmoora Method

The Neutrosophic Multi Objective Optimization by Ratio Analysis is started by collecting the values provided by the decision maker for the plant disease management with respect to the alternatives and attributes specified above. The neutrosophic decision matrix with trapezoidal numbers and with truth, indeterminacy and falsity membership values are given as follows:

$$A_N \begin{bmatrix} (1000,4000,12000,15000),(0.87,0.5,0.125) & (6,6.5,19.5,20),(0.7,0.4,0.2) & (90,102,127,140),(0.88,0.10,0.21) & (50,60,80,90),(0.85,0.14,0.28) \\ (1500,2875,8625,10000),(0.73,0.26,0.5) & (3.5,5,8,9.75),(0.75,0.3,0.5) & (100,105,115,120),(0.9,0.04,0.1) & (50,52.5,57.5,60),(0.90,0.04,0.1) \\ (5000,7500,22500,25000),(0.6,0.5,0.33) & (7.5,10,20,22.5),(0.6,0.5,0.5) & (120,122.5,127.5,130),(0.96,0.02,0.4) & (80,85,95,100),(0.88,0.05,0.11) \end{bmatrix}$$

The Neutrosophic decision matrix A_N is then converted to its crisp form by using equation (2) and we get the decision matrix as

$$A = \begin{bmatrix} 5986.67 & 9.1 & 98.30 & 56.7 \\ 3775.83 & 4.26 & 101.2 & 50.6 \\ 8850 & 8 & 105.83 & 81.6 \end{bmatrix}$$

Weights for this decision matrix A is calculated using entropy measures and weights for the alternatives A_1, A_2, A_3 are found and are tabulated in Table 5.1.1.

TABLE 1. Weights for the alternatives using entropy measure

Attributes	**C_1**	**C_2**	**C_3**	**C_4**
Weights	0.4545	0.3657	0.0037	0.1760

TABLE 2. Reference points for the alternatives

The reference points are calculated as specified in step 6 in NMOORA method and are tabulated in Table 5.1.2.

Attributes	**C_1**	**C_2**	**C_3**	**C_4**
Reference points	0.3332	0.3321	0.6001	0.7317

The assessment values with respect to the reference points and weights assigned to each alternative is found using equation (4) and is $\hat{f_j} = \begin{bmatrix} 0.089 & 0.138 & 0 & 0.039 \\ 0 & 0 & 0 & 0.049 \\ 0.204 & 0.106 & 0 & 0 \end{bmatrix}$

The highest value in each alternative is taken for ranking the alternative and are ranked in the descending order. The ranking table is given in Table 5.1.3.

TABLE 3. Ranking of alternatives

Alternatives	**values**	**Rank**
A_1	0.138	2
A_2	0.049	3
A_3	0.204	1

Hence the alternatives are ranked in the order $A_3 > A_1 > A_2$, which suggests that Therapy procedure can be preferred to Exclusion and Protection.

5.2 Nvikor Method

The NeutrosophicVIKOR is started by collecting the values provided by the decision maker for the plant disease management with respect to the alternatives and attributes specified above. The neutrosophic decision matrix with trapezoidal numbers and with truth, indeterminacy and falsity membership values are given as follows:

A_N

$$\begin{bmatrix} (1000,4000,12000,15000),(0.87,0.5,0.125) & (6,6.5,19.5,20),(0.7,0.4,0.2) & (90,102,127,140),(0.88,0.10,0.21) & (50,60,80,90),(0.85,0.14,0.28) \\ (1500,2875,8625,10000),(0.73,0.26,0.5) & (3.5,5,8,9.75),(0.75,0.3,0.5) & (100,105,115,120),(0.9,0.04,0.1) & (50,52.5,57.5,60),(0.90,0.04,0.1) \\ (5000,7500,22500,25000),(0.6,0.5,0.33) & (7.5,10,20,22.5),(0.6,0.5,0.5) & (120,122.5,127.5,130),(0.96,0.02,0.4) & (80,85,95,100),(0.88,0.05,0.11) \end{bmatrix}$$

The Neutrosophic decision matrix A_N is then converted to its crisp form by using equation (2) and we get the decision matrix as

$$A = \begin{bmatrix} 5986.67 & 9.1 & 98.30 & 56.7 \\ 3775.83 & 4.26 & 101.2 & 50.6 \\ 8850 & 8 & 105.83 & 81.6 \end{bmatrix}$$

Weights for this decision matrix A is calculated using entropy measures and weights for the alternatives A_1, A_2, A_3 are found and are tabulated in table 5.1.1.

From the decision matrix A, the $f_j^* \ and \ f_j^- \ values$ are calculated using equation (5) for the favourable and non-favourable attributes as follows in Table 5.2.1

TABLE 4. $f_j^* \ and \ f_j^- \ values$ FOR FAVOURABLE AND NON-FAVOURABLE ATTRIBUTES

	C_1	C_2	C_3	C_4
f_j^*	3775.83	4.26	105.83	81.6
f_j^-	8850	9.1	98.30	50.6

With reference to the weights found by entropy measure, the decision matrix and the $f_j^* \ and \ f_j^- \ values$, the S index and R index are found using equation (6) and (7) respectively.

S- index values are S_1 = 0.7087, S_2 =0.1983, S_3 =0.737.

R-index values are R_1 = 0.3657, R_2 =0.176, R_3 =0.4545.

The minimum and maximum values of S-index and R-index are calculated using equation (8) and are as follows:

S^* = 0.1783, S^- =0.737

R^* = 0.176, R^- =0.4545

Considering the strategic weight to be 0.5, the VIKOR index Q is calculated for the three alternatives using equation (9) and the Q -index values are Q_1 =0.8153, Q_2 =-0, Q_3 =1.

The ranking of S-index, R-index and Q-index are done starting with the lowest values and the lowest value is ranked the superior alternative. Hence, the ranking are

S INDEX ranking is $S_2<S_1<S_3$

R INDEX ranking is $R_2<R_1<R_3$

Q INDEX ranking is $Q_2<Q_1<Q_3$

Hence, the alternatives are ranked as $A_2>A_1>A_3$.

Therefore, in NVIKOR method, Protection procedure is suggested to be the best alternative than Exclusion and Therapy.

6. RESULTS & CONCLUSION

The NMOORA and NVIKOR decision making methods were discussed and assessments were made in selecting the best alternative for managing diseases in plants. Management of diseases is not an easy task as it involves lot of capital investment, labour and many other factors and the outcome differs based on the effects of the disease management technique. In our case study, we have assessed on three disease management methods which are in use i.e., exclusion, protection and therapy. In the process of choosing the best alternate for disease management, the NMOORA method suggested Therapy procedure as the best alternative whereas NVIKOR method suggested Protection over the other two methods. As both the decision making methods are putting forth different alternatives to be selected, we choose the one which is more reliable. Comparing the assessments made by the NMOORA and NVIKOR methods, we can prefer the selection suggested by the NVIKOR method as it recommends the alternative that is nearest to the ideal solution and moreover, we rank the S-index, R-index and Q-index, and hence the rate of accuracy of ranking the alternatives is high in NVIKOR method as compared to that of NMOORA. The LP metric method used in NVIKOR makes it acceptable a step higher than NMOORA. So, we conclude that the preference is given for the selection opted by the NVIKOR method. That is, Protection procedure of managing diseases in plants can be opted as the priority of the other alternatives- exclusion and therapy.

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