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APPLICATION OF NEUTROSOPHIC SOFT SET IN AGRICULTURE USING DECISION THOERY UNDER UNCERTAINITY

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Abstract: Decision making is a challenging task under uncertain conditions. Mathematically several theories have been developed to aid in making crucial decisions. This paper uses the concept of Neutrosophic Soft Set to analyze food grains produced by a set of farmers. Neutrosophic Soft payoff matrices are framed based on evaluation report of experts. The farmer producing best quality food grains with maximum profit is identified by applying the techniques of Laplace criterion, Criterion of Optimism and Savage Criterion.

Key words: Neutrosophic Soft Set,Uncertainty, Laplace Criterion, Criterion of Optimism and Savage Criterion.
Subject Classification: 03E72, 03E99

摘要：在不确定条件下，决策是一项具有挑战性的任务。 在数学上，已经发展出多种理论来帮助做出关键决策。 本文利用 Neutrosophic Soft Set 的概念来分析一组农民生产的粮食。 中智软支付矩阵是根据专家的评估报告构建的。 通过应用拉普拉斯准则、乐观准则和野蛮准则的技术，确定生产出利润最大的最优质粮食的农民。

关键词：中智软集，不确定性，拉普拉斯准则，乐观准则和野蛮准则。

学科分类：03E72、03E99

1. INTRODUCTION

Agriculture is the main source of income for a country’s development. India nearly produces world’s major food staples and India ranks third position for using organic wild culture in the world. In India cooperative societies for farming sectors has seen a huge growthand has wangled grain self-reliant. But there is a need to improve the regulation of agricultural practices on multifronts.

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Researchers had noted a new mathematical tool to overcome uncertainties,imprecise, incomplete and indeterminacy situations to hammer those difficulties.Florentine Smarandache [3] proposed a new theory named Neutrosophic Set and later Molodtsov [8] developed the soft set theory which is a major mathematical operator dealing decision-making problems in an indistinct environment. Maji [10] later modified soft set as neutrosophic soft set. Another important concept in decision-making problem is fuzzy soft matrices was formulated by Cagman [1] in 2010. Then in 2014 Broumi [2] et.al advanced different relations on inter-valued neutrosophic soft sets which is also implemented in various decision-making areas. Irfan Deli and Broumi [5] in 2014 defined neutrosophic soft matrices and implemented soft matrices in decision-making. Later, 2018 Loganathan and Pushpalatha [7] proposed an application using fuzzy matrices.In this paper, we considerMulti-Criteria Decision Making (MCDM) problem to solve usingNeutrosophic soft set ($\mathcal{N}_{SS}$) alongwith Decision theory underUncertainty. We use three criterion namely Laplace Criterion, Criterion of Optimism and Savage Criterion of decision under uncertainty. Finallyconcluding who has achieved the profit comparing with the evaluation making.

2. PRELIMINARIES

DEFINITION 2.1. [10]: The **Neutrosophic Set** A on the universe of discourse X is defined as A ={< x, $T_A(x)$, $I_A(x)$, $F_A(x)$ > : x ∈X}, where T_A , I_A , F_A : X→ (0, 1) and $^-0 \leq T_A(x) + I_A(x) + F_A(x) \leq 3^+$; T_A(truth), I_A(indeterminacy), F_A(falsity) are called N**eutrosophic Components**.

DEFINITION 2.2. [10]: If U is an initial universe set and E said to be a set of parameters. Let $A \subset E$, P (U) denotes the set of all neutrosophic sets of U. Then the collection (F, A) is termed to be the **Neutrosophic Soft Set** ($\mathcal{N}_{SS}$) over U, and F is a mapping given by F: A→ P (U).

DEFINITION 2.3. [4](**Single Valued Neutrosophic Set (SVNs)**): Let X be a space of points for x in X. TheSVNs A in X is characterized by truth-membership function T_A, indeterminacy-membership function I_A and falsity-membership function F_A, where $T_A(x)$, $I_A(x)$, $F_A(x) \in [0,1]$.

DEFINITION 2.4. [12]: If x_{ij} = ($T_A(u_i, e_j)$, $I_A(u_i, e_j)$, $F_A(u_i, e_j)$), then **Neutrosophic Soft Set Matrix($\mathcal{N}_{SSM}$) of order m x n** is$(\tilde{x}_{ij})_{m \times n} = (x_{ij})_{m \times n}$.

DEFINITION 2.5.[9] (**Addition of Neutrosophic Soft Matrices):** If A=$[(T_{ij}^A, I_{ij}^A, F_{ij}^A)] \in \mathcal{N}_{SSM\ m \times n}$,B=$[(T_{ij}^B, I_{ij}^B, F_{ij}^B)] \in \mathcal{N}_{SSM\ m \times n}$. Then the addition of A and B isC=$[(T_{ij}^C, I_{ij}^C, F_{ij}^C)] \in \mathcal{N}_{SSM\ m \times n}$,where $T_{ij}^C = max(T_{ij}^A, T_{ij}^B)$, $I_{ij}^C = \frac{I_{ij}^A + I_{ij}^B}{2}$, $F_{ij}^C = min(F_{ij}^A, F_{ij}^B)$ for all i and j.

DEFINITION 2.6. [9] **(Value Matrix):** Suppose A=$[(T_{ij}^A, I_{ij}^A, F_{ij}^A)] \in \mathcal{N}_{SSM\ m \times n}$ then, A is called the value of $\mathcal{N}_{SSM}$ denoted by V(A) and V(A)=$[(T_{ij}^A + I_{ij}^A - F_{ij}^A)]$ for all i and j, respectively where i=1,2,...m and j=1,2,...n.

3. PROCEDURE

Step 1: Construct two $\mathcal{N}_{SSM}$ A and B.

Step 2: Compute A+B, addition of two $\mathcal{N}_{SS}$ Matrices.

Step 3: Calculate the Value Matrix V(A+B).

Step 4: Apply decision theory techniques under uncertainty such as Laplace Criterion, Criterion of Optimism and Savage Criterion to the calculated value matrix V(A+B).

Step 5: Based on the results obtained in step 4, finalize the best quality product producer with maximum cost.

4. METHODOLOGY

Let F be a set of $\mathcal{N}_{SS}$ of farmers producing different grains to satisfy the needs of people throughout the year. Once the grains are ready,the farmers sell it in a market or directly to the customers and get either a profit or loss.Let us assume that a set of farmers selling their grains in two different markets M_1 and M_2. E is a set of parameters, the harvested products by farmers and let $A \subset E$ and $B \subset E$.The first $\mathcal{N}_{SS}$ (X, A) over F is the farmersproduction of grains sold in market M_1, where X: A→P(F). The second $\mathcal{N}_{SS}$ (X,B) over F is the farmers production of grains sold in market M_2, where Y:B→P(F), P(F) is the set of all neutrosophic soft subsets of F.

Let the universal set F={f_1,f_2,f_3,f_4} be four different farmers and E={e_1,e_2,e_3,e_4}be parameters representing the different grains like wheat, paddy, millets and pulses.Two experts P_1 and P_2 are evaluating the products of the farmers in the markets M_1 and M_2 respectively. Let D_1 and D_2 be payoff done by experts P_1 and P_2.

Report of expert P_1 in the market place M_1isrepresenting in the form of $\mathcal{N}_{SS}$ as

(X, A)={X(e_1), X(e_2), X(e_3), X(e_4)}

X(e_1)={(f_1(0.5,0.2,0.1),(f_2(0.6,0.4,0.9),(f_3(0.3,0.6,0.7),(f_4(0.2,0.4,0.3)}

X(e_2)={(f_1(0.1,0.5,0.7),(f_2(0.5,0.7,0.8),(f_3(0.4,0.5,0.2),(f_4(0.5,0.7,0.3)}

X(e_3)={(f_1(0.3,0.4,0.7),(f_2(0.2,0.5,0.6),(f_3(0.3,0.6,0.9),(f_4(0.5,0.3,0.6)}

X(e_4)={(f_1(0.1,0.6,0.5),(f_2(0.3,0.4,0.8),(f_3(0.4,0.6,0.7),(f_4(0.1,0.3,0.5)}

Report of expert P_2 in the market place M_2 is representing in the form of $\mathcal{N}_{SS}$ as

(Y, B) ={Y(e_1), Y(e_2), Y(e_3), Y(e_4)}

Y(e_1)={(f_1(0.2,0.4,0.6),(f_2(0.4,0.6,0.5),(f_3(0.2,0.7,0.3),(f_4(0.1,0.6,0.5)}

Y(e_2)={(f_1(0.1,0.4,0.3),(f_2(0.2,0.5,0.7),(f_3(0.3,0.7,0.5),(f_4(0.5,0.3,0.1)}

Y(e_3)={(f_1(0.4,0.2,0.6),(f_2(0.3,0.7,0.4),(f_3(0.3,0.5,0.7),(f_4(0.3,0.4,0.2)}

Y(e_4)={(f_1(0.3,0.4,0.5),(f_2(0.4,0.3,0.6),(f_3(0.3,0.4,0.5),(f_4(0.3,0.4,0.2)}

The payoff matrices D_1 and $D_2$are

$$\begin{array}{c} \quad e_1 \quad\quad e_2 \quad\quad e_3 \quad\quad e_4 \end{array}$$

$$D_1 = \begin{array}{c} f_1 \\ f_2 \\ f_3 \\ f_4 \end{array} \begin{bmatrix} (0.5,0.2,0.1) & (0.1,0.5,0.7) & (0.3,0.4,0.7) & (0.1,0.6,0.5) \\ (0.6,0.4,0.9) & (0.5,0.7,0.8) & (0.2,0.5,0.6) & (0.3,0.4,0.8) \\ (0.3,0.6,0.7) & (0.4,0.5,0.2) & (0.3,0.6,0.9) & (0.4,0.6,0.7) \\ (0.2,0.4,0.3) & (0.5,0.7,0.3) & (0.5,0.3,0.6) & (0.1,0.3,0.5) \end{bmatrix}$$

$$\begin{array}{c} \quad e_1 \quad\quad e_2 \quad\quad e_3 \quad\quad e_4 \end{array}$$

$$D_2 = \begin{array}{c} f_1 \\ f_2 \\ f_3 \\ f_4 \end{array} \begin{bmatrix} (0.2,0.4,0.6) & (0.1,0.4,0.3) & (0.4,0.2,0.6) & (0.3,0.4,0.5) \\ (0.4,0.6,0.5) & (0.2,0.5,0.7) & (0.3,0.7,0.4) & (0.4,0.3,0.6) \\ (0.2,0.7,0.3) & (0.3,0.7,0.5) & (0.3,0.5,0.7) & (0.3,0.4,0.5) \\ (0.1,0.6,0.5) & (0.5,0.3,0.1) & (0.3,0.4,0.2) & (0.3,0.4,0.2) \end{bmatrix}$$

$$\begin{array}{c} \quad e_1 \quad\quad e_2 \quad\quad e_3 \quad\quad e_4 \end{array}$$

$$D_1 + D_2 = \begin{array}{c} f_1 \\ f_2 \\ f_3 \\ f_4 \end{array} \begin{bmatrix} (0.5,0.3,0.1) & (0.1,0.45,0.3) & (0.4,0.3,0.6) & (0.3,0.5,0.5) \\ (0.6,0.5,0.5) & (0.5,0.6,0.7) & (0.3,0.6,0.4) & (0.4,0.35,0.6) \\ (0.3,0.65,0.3) & (0.4,0.6,0.2) & (0.3,0.55,0.7) & (0.4,0.5,0.5) \\ (0.2,0.5,0.3) & (0.5,0.5,0.1) & (0.5,0.35,0.2) & (0.3,0.35,0.2) \end{bmatrix}$$

$$\begin{array}{c} \quad e_1 \quad\quad e_2 \quad\quad e_3 \quad\quad e_4 \end{array}$$

$$V(D_1 + D_2) = \begin{array}{c} f_1 \\ f_2 \\ f_3 \\ f_4 \end{array} \begin{bmatrix} 0.7 & 0.25 & 0.1 & 0.3 \\ 0.6 & 0.4 & 0.5 & 0.15 \\ 0.65 & 0.8 & 0.15 & 0.4 \\ 0.4 & 0.9 & 0.65 & 0.45 \end{bmatrix}$$

Decision Under Uncertainty conditions areas follows:

1. Analysis by ***Laplace Criterion Method***

$$LaplaceCriterion = \frac{1}{n}[e_1 + e_2 + ... + e_n]$$

$$\begin{array}{c} \quad e_1 \quad\quad e_2 \quad\quad e_3 \quad\quad e_4 \end{array}$$

$$\begin{array}{c} f_1 \\ f_2 \\ f_3 \\ f_4 \end{array} \begin{bmatrix} 0.7 & 0.25 & 0.1 & 0.3 \\ 0.6 & 0.4 & 0.5 & 0.15 \\ 0.65 & 0.8 & 0.15 & 0.4 \\ 0.4 & 0.9 & 0.65 & 0.45 \end{bmatrix}$$

$$f_1 = \frac{1}{4}[0.7 + 0.25 + 0.1 + 0.3] = 0.3375$$

$$f_2 = \frac{1}{4}[0.6 + 0.4 + 0.5 + 0.15] = 0.4125$$

$$f_3 = \frac{1}{4}[0.65 + 0.8 + 0.15 + 0.4] = 0.5$$

$$f_4 = \frac{1}{4}[0.4 + 0.9 + 0.65 + 0.45] = 0.6$$

Therefore f_4 attainsmaximum profit.

2. Analysis by***Criterion ofOptimism Method***

$$\begin{array}{cc} \text{minimin} & \\ 0.1 & f_1 \\ 0.15 & f_2 \\ 0.15 & f_3 \\ 0.4 & f_4 \end{array} \begin{array}{c} \begin{array}{cccc} e_1 & e_2 & e_3 & e_4 \end{array} \\ \begin{bmatrix} 0.7 & 0.25 & 0.1 & 0.3 \\ 0.6 & 0.4 & 0.5 & 0.15 \\ 0.65 & 0.8 & 0.15 & 0.4 \\ 0.4 & 0.9 & 0.65 & 0.45 \end{bmatrix} \end{array} \begin{array}{c} \text{maximax} \\ 0.7 \\ 0.6 \\ 0.8 \\ 0.9 \end{array}$$

Therefore f_4 attains maximum profit.

3. Analysis by ***Savage Criterion Method***

a) Maximum regret

$$\begin{array}{c} \\ f_1 \\ f_2 \\ f_3 \\ f_4 \end{array} \begin{array}{c} \begin{array}{cccc} e_1 & e_2 & e_3 & e_4 \end{array} \\ \begin{bmatrix} 0.7 & 0.25 & 0.1 & 0.3 \\ 0.6 & 0.4 & 0.5 & 0.15 \\ 0.65 & 0.8 & 0.15 & 0.4 \\ 0.4 & 0.9 & 0.65 & 0.45 \end{bmatrix} \end{array}$$

Regret payoff = Maximum payoff from e_j - Payoff, (j=1,2,3,4)

Regret table for maximum

	e_1	e_2	e_3	e_4	Max
f_1	0	0.65	0.55	0.15	**0.65**
f_2	0.1	0.5	0.15	0.3	**0.5**
f_3	0.05	0.1	0.5	0.05	**0.5**
f_4	0.3	0	0	0	**0.3**

b) Minimum regret

$$\begin{array}{c} \\ f_1 \\ f_2 \\ f_3 \\ f_4 \end{array} \begin{array}{c} \begin{array}{cccc} e_1 & e_2 & e_3 & e_4 \end{array} \\ \begin{bmatrix} 0.7 & 0.25 & 0.1 & 0.3 \\ 0.6 & 0.4 & 0.5 & 0.15 \\ 0.65 & 0.8 & 0.15 & 0.4 \\ 0.4 & 0.9 & 0.65 & 0.45 \end{bmatrix} \end{array}$$

Regret payoff = Payoff- Minimum payoff from e_j,(j=1,2,3,4)

Regret table for minimum

	e_1	e_2	e_3	e_4	Max
f_1	0.3	0	0	0.15	**0.3**
f_2	0.2	0.15	0.4	0	**0.4**
f_3	0.25	0.55	0.05	0.25	**0.55**
f_4	0	0.65	0.55	0.3	**0.65**

Therefore, f_4 attains maximum profit.

5. Conclusion

Thus, by comparative analysis done in these three methods; thefourth farmer (f_4) obtains more profit from his production. The $\mathcal{N}_{SS}$ with decision under uncertainty helps the decision makers to finalize the accurate reports. Hence,in reality $\mathcal{N}_{SS}$ paves a wave of change in the decision making problems.

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