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Hexagon Hesitant Fuzzy Multi – Attribute Decision Making Based On TOPSIS

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Abstract: In this paper hexagon hesitant fuzzy set is used to solve the higher order uncertainties with TOPSIS method. Hexagon Hesitant Fuzzy Multi Attribute Decision Making problems faced by the farmer who plant monsoon crops in Villupuram District.

Key Words: Multi Attribute Decision Making, Hesitant Fuzzy Set, Hexagon Fuzzy Set, Technique for order preference by similarity to Ideal Solution, TOPSIS.

1. INTRODUCTION

Lotfi A. Zadeh introduce Fuzzy Set Theory in 1965 and further developed by Dubois and Prade, R.Yager Mizomoto, J.Buckly and many others. The most useful representation in fuzzy is membership function. Conception of fuzzy number and fuzzy arithmetic is first developed by Zadeh [8] and Dubois and Prade [2]. After the familiarization of fuzzy set Lotfi A.Zadeh bring in the concept of fuzzy number in 1975[7]. It is special type of fuzzy set and mainly used to quantify qualitative and linguistic variable which are uncertain and vague in nature. Different type of fuzzy set $[0,1]$ are explained to clear the vagueness. A fuzzy number is a number the estimation are not exactly correct in case of single valued function. Ranking Fuzzy Number reveals leading part in decision making. The main problem in decision making is electing one among the collection. The decision maker should use fuzzy number in particular parameter to avoid non-reliable values when the parameter value is more than one. To make this happen Zadeh [1965] [4] introduced fuzzy set theory. The subject has become an interesting bough of Pure and Applied Science. Solving of Multi – Attribute Decision Making is the most practical application. Hesitant Fuzzy Set is initiated by Torra [6] this allows a factor be a set of different estimation between 0 and 1. Wang Et Al furnishes a prominent near by with HFSs to solve MCDM problems. In this paper, an addition has been made and developed near the proper the Hexagonal Hesitant Fuzzy Set (HHFS) come by means of decision making bundle TOPSIS. The difficult situation met by the cultivator in Villupuram District are scrutinized by means of our recently made Hexagonal Hesitant Fuzzy Multi – Attribute Decision Making (HHF – MADM) method. This topic has been proceeded in the given below patten. The theory of HFS, HHFSs and some of its



fundamental things have been explained in division 2, division 3, is proceeded with Multi – Attribute Decision Making (MADM). In division 4 a petition which values hesitant information is presented. Division 5 manages through the final results.

2. PRELIMINARIES

2.1. Definition: Fuzzy set

A fuzzy set X is universal of discourse then fuzzy set $\tilde{A}$ explained on X can provided near by the collection belonging to commanded pairs

$$\tilde{A} = \{(x, \mu_{\tilde{A}}(x)) / x \in X\}.$$

The enrollment function of the fuzzy set is given by $\mu_{\tilde{A}}(x): X \rightarrow [0,1]$.

2.2. Definition: Hesitant Fuzzy Set

Let X be a firm set and a Hesitant fuzzy set (HFS) on X is in word of a function in order to X go back to a subset of $[0,1]$. Mathematical substitution of Hesitant fuzzy set :

$$A = \{ \langle x, h_A(x) \rangle / x \in X \}$$

Where $h_A(x)$ is a set of certain values in $[0,1]$, indicating the possible enrollment steps of the Element $x \in X$ to the set A .

2.3. Definition: Fuzzy number

To whole set of real numbers R is defined by a fuzzy set by the enrollment function $\mu_{\tilde{A}}(x)$ satisfied normality convexity and piecewise continuity.

2.4. Definition: Triangular Fuzzy Number

Membership function of triangular integer can be written as, If $\tilde{A} = \{a_1, a_2, a_3\}$

$$\mu_{\tilde{A}}(x) = \begin{cases} \frac{x-a_1}{a_2-a_1} & \text{for } a_1 \leq x \leq a_2 \\ \frac{a_3-x}{a_3-a_2} & \text{for } a_2 \leq x \leq a_3 \\ 0 & \text{otherwise} \end{cases}$$

2.5. Definition: Trapezoidal Fuzzy Number

Membership function of Trapezoidal fuzzy number is said by

If $\tilde{A} = (a_1, a_2, a_3, a_4)$ where $a_1 \leq a_2 \leq a_3 \leq a_4$

$$\mu_{\tilde{A}}(x) = \begin{cases} 0 & \text{for } x < a_1 \\ \frac{x-a_1}{a_2-a_1} & \text{for } a_1 \leq x \leq a_2 \\ 1 & \text{for } a_2 \leq x \leq a_3 \\ \frac{a_4-x}{a_4-a_3} & \text{for } a_3 \leq x \leq a_4 \\ 0 & \text{for } x \geq a_4 \end{cases}$$

2.6. Definition: Hexagon Fuzzy Number

Membership function of Hexagon Fuzzy Number can be given by

If $\tilde{A}_H = (a_1, a_2, a_3, a_4, a_5, a_6)$

$$\mu_{\tilde{A}}(x) = \begin{cases} 0 & \text{for } x < a_1 \\ \frac{1}{2} \left(\frac{x-a_1}{a_2-a_1} \right) & \text{for } a_1 \leq x \leq a_2 \\ \frac{1}{2} + \frac{1}{2} \left(\frac{x-a_2}{a_3-a_2} \right) & \text{for } a_2 \leq x \leq a_3 \\ 1 & \text{for } a_3 \leq x \leq a_4 \\ 1 - \frac{1}{2} \left(\frac{x-a_4}{a_5-a_4} \right) & \text{for } a_4 \leq x \leq a_5 \\ 0 & \text{for } x > a_5 \end{cases}$$

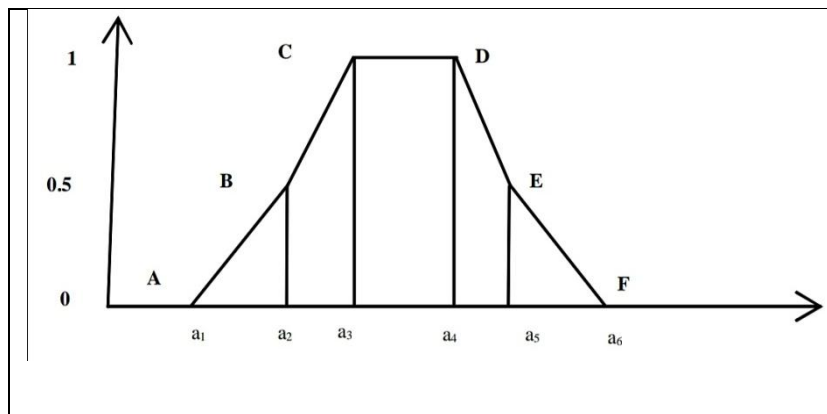


Figure1. Hexagon Fuzzy Number

2.7. Definition: Hexagon Hesitant fuzzy Set

Let X be a firm set, then a Hexagon Hesitant fuzzy Set (H_h FS) D on X is explained as:

$$D = \{ \langle x, H_g h_A(x) \rangle : x \in X \}$$

in which $H_g(x)$ is function $H_g h'_A(x)$ where $H_g h'_A(x) = (a^L, a^{M_1}, a^{M_2}, a^{M_3}, a^{M_4}, a^U)$.

2.8. Definition: Hexagon Hesitant fuzzy Element (H_h FE)

The quadruple $(a^L, a^{M_1}, a^{M_2}, a^{M_3}, a^{M_4}, a^U)$ is called hexagon fuzzy element.

2.9. Definition: Hesitant Multiplicative Aggregation

To quantify the inborn stating granted by the decision maker, we employ Saaty's 1-9 scale with its relative meaning.

Table1. The similarity among the 0.1-0.9 measurement and the 1-9 measurement

1-9 Measurement	0.1-0.9 Measurement	Meaning
1/9	0.1	Severely contradict lodged
1/7	0.2	Very firmly contradict lodged
1/5	0.3	Firmly contradict lodged
1/3	0.4	Temperately contradict lodged
1	0.5	Equally lodged
3	0.6	Temperately not lodged
5	0.7	Firmly lodged
7	0.8	Very firmly lodged
9	0.9	Severely lodged
Another values between 1 and 9 (2,4,6,8)	Another values between 0 and 1	Intermediate values used to present arrangement

3. HEXAGON HESITANT FUZZY ALGORITHM BASED ON TOPSIS

Hwang and Yoon introduced the Multi Attributes Decision Making and its application from which a familiar execution for rank performance through resemblance to perfect clarification (TOPSIS) is applied in this paper. A basic precept is that to choose the possibility under hesitant fuzzy neighborhood. This approach implies following steps:

Step 1:

Choose weight vector $W = \{w_1, w_2, w_3, w_4, w_5, w_6, \dots, w_m\}^H$ where $W_i \in [0,1]$ and $\sum_{i=1}^m W_i = 1$

For every assign according to their consequence over the problem, the hesitant value is given as

$$H = \begin{bmatrix} \{Hh_{11}\} & \{Hh_{12}\} & \cdots & \{Hh_{1j}\} \\ \{Hh_{21}\} & \{Hh_{22}\} & \{Hh_{23}\} & \{Hh_{2j}\} \\ \{Hh_{31}\} & \vdots & \ddots & \vdots \\ \{Hh_{mi}\} & \{Hh_{mi}\} & \cdots & \{Hh_{mn}\} \end{bmatrix}$$

Step 2:

The degree can be calculated by the positive ideal and negative ideal,

$$A^+ = \{< X_j, \max_i \{Hh_{ij}\} > \{j = 1, 2, 3, 4, 5, 6, \dots, m\} \rightarrow (1)$$

$$A^- = \{< X_j, \max_i \{Hh_{ij}\} > \{j = 1, 2, 3, 4, 5, 6, \dots, m\} \rightarrow (2)$$

Step 3:

The hexagon hesitant fuzzy positive ideal A^+ and negative ideal A^- is used to determine a partition size d_i^+ and d_i^- of every possibility A^i by the following aspects:

$$d_{i^+} = \left\{ \sum_{j=1}^m d(h_{ij}, h_{j^+}) W_j \right\} \dots \dots \dots \rightarrow (3)$$

$$d_i^- = \left\{ \sum_{j=1}^m d(h_{ij}, h_{j^-}) W_j \right\} \dots \dots \dots \rightarrow (4)$$

Step 4:

The relative togetherness of different A_i can be determined by the rule

$$C(A_i) = \frac{d_i^-}{d_i^+ + d_i^-} \dots \dots \dots \rightarrow (5)$$

Step 5:

Order the possibility agreeing to the cognate togetherness to the positive ideal and negative ideal clarification.

3.1 Hexagon Hesitant Fuzzy Function:

Johnson Savarimuthu .S and Kowsalya . S researched the dilemma faced the farmers who plant monsoon product in the Villupuram District. In this paper ,we broaden our research by investigation kharif crops farming in the same area. In Villupuram District, it has been noticed that the farmer reveal a much attention in vegetating kharif crops like Paddy ,Maize, Groundnut, Sugarcane, Turmeric ,Cotton, etc., kharif crops farming depends on natural source like rain and water reserves like river ,tanks and wells. Water sources of this district like Vidur , Sathanur and Komuki have rested serving water they perform only during rainy span.

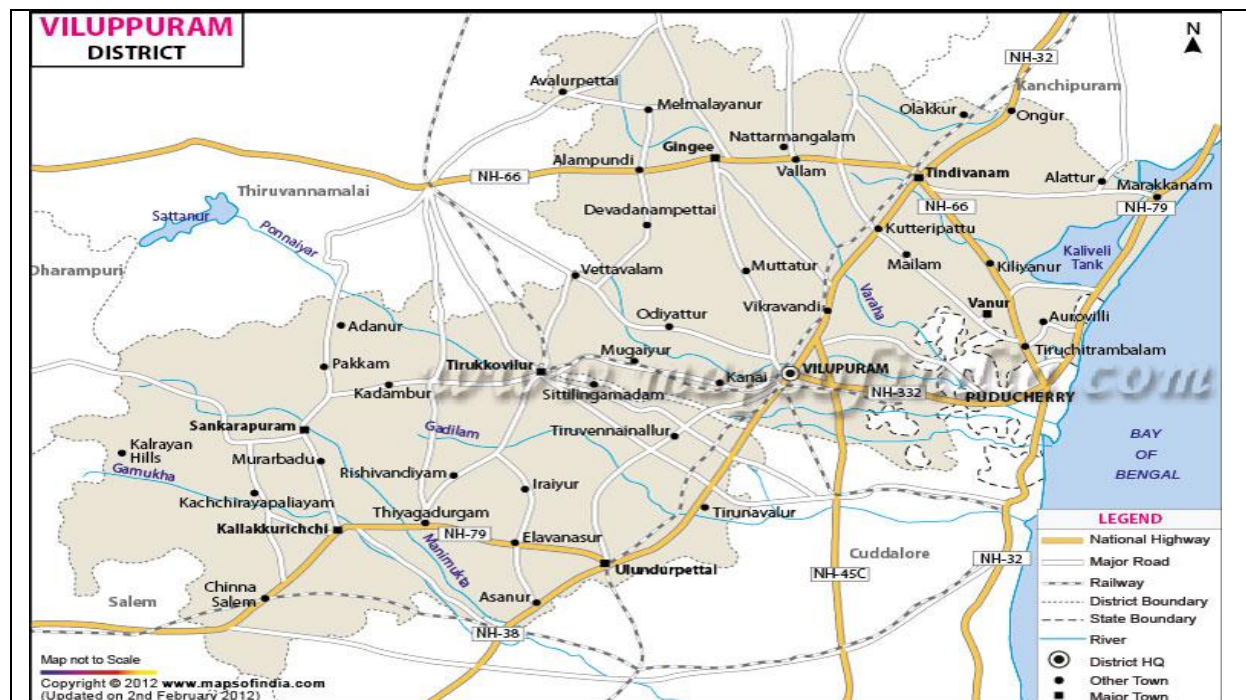


Figure2. Villupuram District

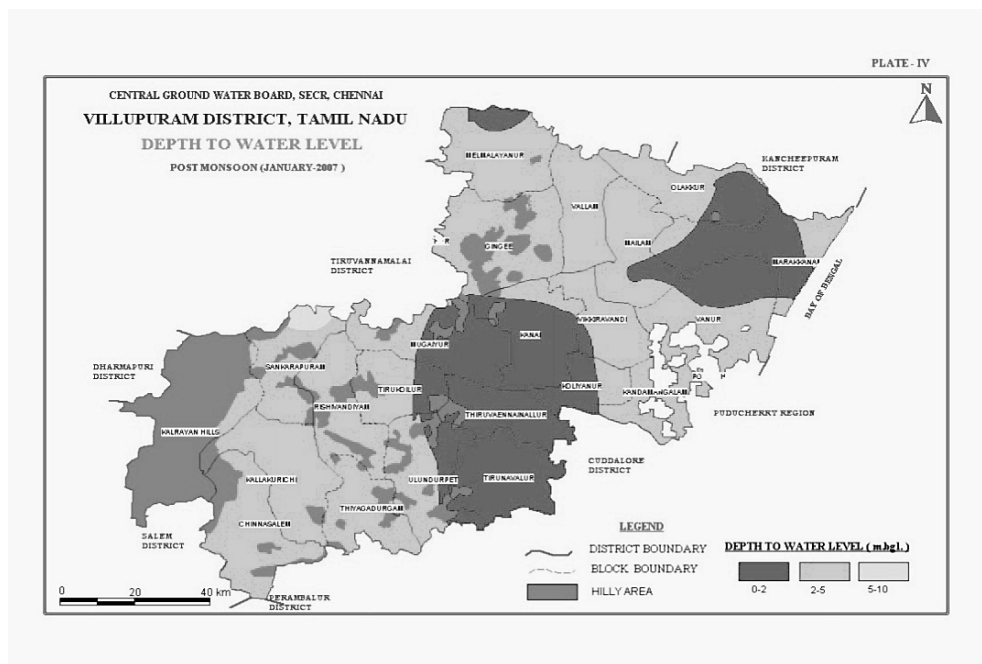


Figure3. Depth To Water Level

Water scarcity have become lot in this District due to collapse in the periodical rains. Scheduled to regular electricity failure tunnel hole cannot be operated. Because of this farmers has to buy diesel to operate diesel Engines.It is tough to buy loans from private bank and pay back their debts.

3.2. Experts (from Villupuram District)

Information regarding problems faced by farmers in Villupuram District:

DM₁. Mr. R. Sekar, (Agriculturist), Tiruvakkarai.

DM, Mr. S. Vetri, (Agriculturist), Thirukovillur.

DM₃.Mr.R. Kananan, (Agriculturist),Tindivanam.

DM₄.Mr.S . Manikandan,(Agriculturist),Kallakurichi.

DM₅.Mr. Anand,valavanur

DM₆.Mr. Ravi,Mailam.

3.3. Alternatives

The major kharif crops cultivated in Villupuram District. We acquired these yield as our preferences.

A₁.Paddy

A₂.Maize

A₃.Groundnut

A₄. Sugarcane

A₅.Turmeric

A₆.Cotton

3.4. Attributes

We gathered some great problems faced by the through investigation and merged them into six major attributes and estimated into two forms, namely;

(i) Profit Category (Distinguishing trait in universe)

(ii) Expense Category (Distinguishing trait in universe)

X_1 . Crop failure (Profit Category) - Crop failure results in drying of crop and uncapability to results the standing crops due to water shortage.

X_2 . Crop debt (Expense Category) - Funds borrowing from personal money lenders, farming arrears to gather expenditure extends the payment.

X_3 . Lack of water (Profit Category) - Water dearth in water reservoirs, absence of monsoon rains.

X_4 . Heavy Rain and Cyclone (Vardha) (Profit Category) - Soil corrosion, fertility of ground is caused by natural disaster like cyclone. In recent year vardha cyclone destroyed farming, lands in Villupuram District.

X_5 . Lack of Electricity (Expense Category) - Load garage the great cause for use of diesel engine, but buying diesel again a trouble for cultivators.

X_6 . Demand for Fertilizers and Pesticides (Expense Category) - Rarity manures and manures arising animosity against the administration.

3.5. Ranking Structure for H_gHFS

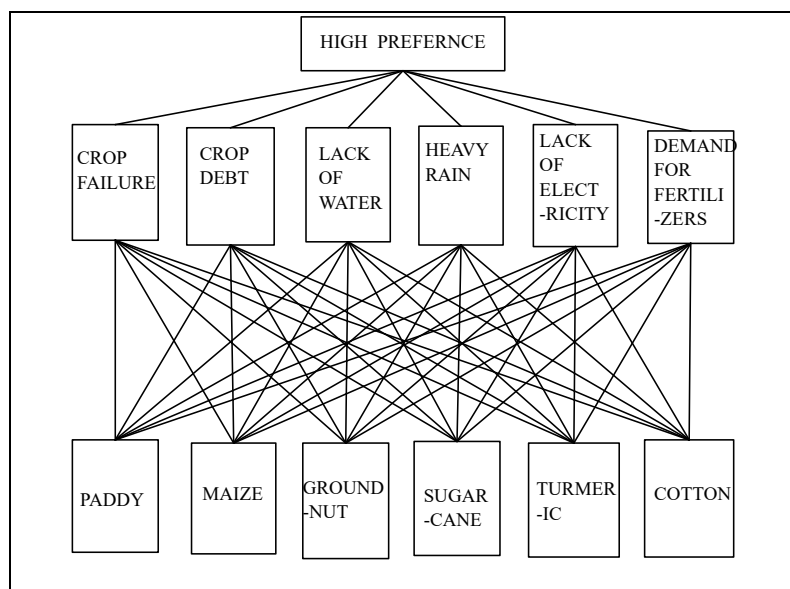


Figure4. Hierarchical Structure for H_gHFS

4. ADAPTATION AND DESCRIPTION OF THE PROBLEM

Considering every skilful judgement with their happened membership values opinion hesitant fuzzy decision matrix is obtained and they noted as follows:

Table2. Hesitant Fuzzy Decision Matrix (by analyzing step 1 in Algorithm)

	X_1	X_2	X_3	X_4	X_5	X_6
A_1	(0.6,0.4,0.2,0.3,0.5,0.1)	(0.5,0.2,0.4,0.3,0.1,-)	(0.7,0.5,0.3,0.1,0.2,0.4)	(0.2,-,0.5,0.4,0.1,-)	(0.2,0.3,0.1,0.7,0.6,0.4)	(0.9,0.9,0.9,-,0.9,-)
A_2	(0.5,0.1,-,0.4,0.6,-)	(0.3,0.5,0.1,0.4,0.2,-)	(0.4,-,0.3,0.2,0.7,0.5)	(0.5,0.4,0.1,-,0.2,0.1)	(0.5,0.4,0.3,0.2,0.1,-)	(0.9,-,0.9,0.9,-,0.9)
A_3	(0.5,0.1,0.3,-,0.2,-)	(0.5,0.4,0.3,0.2,-,0.1)	(0.2,-,0.3,0.5,0.4,0.7)	(0.1,0.2,-,0.5,-,0.4)	(0.7,0.4,0.3,0.2,0.1,0.5)	(-,0.9,0.9,0.9,-,0.9)
A_4	(0.5,0.4,0.1,-,0.2,-)	(0.5,0.3,0.1,-,-,0.2)	(0.5,0.1,0.4,0.7,-,0.2)	(0.5,-,0.1,0.2,0.4,-)	(0.5,0.4,0.3,0.6,0.1,0.2)	(0.9,-,-,0.9,0.9,0.9)
A_5	(0.4,0.1,-,0.5,0.3,0.2)	(0.1,-,0.3,-,0.5,0.2)	(0.6,0.2,-,0.5,0.3,0.7)	(0.2,0.4,-,0.5,0.2,0.1)	(0.7,0.6,0.5,0.2,0.3,-)	(0.9,-,-,0.9,0.9,0.9)
A_6	(0.5,0.3,0.2,0.6,-,0.1)	(0.5,0.4,0.3,0.2,0.1,0.5)	(0.3,0.5,0.1,-,0.6,0.4)	(0.4,0.1,0.5,0.2,-,0.2)	(0.1,0.2,0.3,0.4,0.5,-)	(0.9,-,0.9,0.9,0.9,0.9)

Where,

A_i , $i = 1,2,3,4,5,6$ (six preferences)

X_i , $i = 1,2,3,4,5,6$ (six ascribes) and

$A_i(X_i)$, $i = 1,2,3,4,5,6$ indicates preference 1(Paddy) by relating all six ascribes all these skilful are seeked provide to give their ideas and their ideas are scheduled.

$$A_1(X_i) = (HM_1, HM_2, HM_3, HM_4, HM_5, HM_6)$$

For instance,

$A_1(X_1) = (0.6, 0.4, 0.2, 0.3, 0.5, 0.1)$ indicates on examining alternative1 (Paddy) with attributes 1(Paddy) with attribute1(Crop Failure), decision maker 1 (HM_1) give 0.6 as the enrollment value, denotes crop failure evaluated to be the greatest load for a sharecropper who satisfy in paddy gardening.

Likely, HM_2 give 0.4 as the enrollment value and so on...

Assume, if $A_2(X_1) = (0.5, 0.1, -, 0.4, 0.6, 0.2)$ indicates on examining preference 2 (Maize) with the ascribe 1 (Crop failure), HM_3 miss to mark his value due to unusual about the respective preference over the ascribe.

Table3. Hesitant Fuzzy Decision Matrix

	X_1	X_2	X_3	X_4	X_5	X_6
A_1	(0.6,0.4,0.2,0.3,0.5,0.1)	(0.5,0.2,0.4,0.3,0.1,0.1)	(0.7,0.5,0.3,0.1,0.2,0.4)	(0.2,0.1,0.5,0.4,0.1,0.1)	(0.2,0.3,0.1,0.7,0.6,0.4)	(0.9,0.9,0.9,0.9,0.9,0.9)
A_2	(0.5,0.1,0.1,0.4,0.6,0.1)	(0.3,0.5,0.1,0.4,0.2,0.1)	(0.4,0.2,0.3,0.2,0.7,0.5)	(0.5,0.4,0.1,0.1,0.2,0.1)	(0.5,0.4,0.3,0.2,0.1,0.1)	(0.9,0.9,0.9,0.9,0.9,0.9)
A_3	(0.5,0.1,0.3,0.1,0.2,0.1)	(0.5,0.4,0.3,0.2,0.1,0.1)	(0.2,0.2,0.3,0.5,0.4,0.7)	(0.1,0.2,0.1,0.5,0.1,0.4)	(0.7,0.4,0.3,0.2,0.1,0.5)	(0.9,0.9,0.9,0.9,0.9,0.9)
A_4	(0.5,0.4,0.1,0.1,0.2,0.1)	(0.5,0.3,0.1,0.1,0.1,0.2)	(0.5,0.1,0.4,0.7,0.1,0.2)	(0.5,0.1,0.1,0.2,0.4,0.1)	(0.5,0.4,0.3,0.6,0.1,0.2)	(0.9,0.9,0.9,0.9,0.9,0.9)
A_5	(0.4,0.1,0.1,0.5,0.3,0.2)	(0.1,0.1,0.3,0.1,0.5,0.2)	(0.6,0.2,0.2,0.5,0.3,0.7)	(0.2,0.4,0.1,0.5,0.2,0.1)	(0.7,0.6,0.5,0.2,0.3,0.2)	(0.9,0.9,0.9,0.9,0.9,0.9)
A_6	(0.5,0.3,0.2,0.6,0.1,0.1)	(0.5,0.4,0.3,0.2,0.1,0.5)	(0.3,0.5,0.1,0.1,0.6,0.4)	(0.4,0.1,0.5,0.2,0.1,0.2)	(0.1,0.2,0.3,0.4,0.5,0.1)	(0.9,0.9,0.9,0.9,0.9,0.9)

Table4. Hexagon Hesitant Fuzzy Decision Making Matrix

[illegible]

Table5. Positive Ideal Solution (by equatio1)

Positive Ideal Solution		Negative Ideal Solution	
A_1^+	$\{< x_1: (0.3,0.4,0.5,0.6,0.7,0.8) >\}$	A_1^-	$\{< x_1: (0.1,0.2,0.3,0.4,0.5,0.6) >\}$
A_2^+	$\{< x_2: (0.3,0.4,0.5,0.6,0.7,0.8) >\}$	A_2^-	$\{< x_1: (0.1,0.2,0.3,0.4,0.5,0.6) >\}$
A_3^+	$\{< x_3: (0.4,0.5,0.6,0.7,0.8,0.9) >\}$	A_3^-	$\{< x_1: (0.1,0.2,0.3,0.4,0.5,0.6) >\}$
A_4^+	$\{< x_4: (0.2,0.3,0.4,0.5,0.6,0.7) >\}$	A_4^-	$\{< x_1: (0.1,0.2,0.3,0.4,0.5,0.6) >\}$
A_5^+	$\{< x_5: (0.4,0.5,0.6,0.7,0.8,0.9) >\}$	A_5^-	$\{< x_1: (0.1,0.2,0.3,0.4,0.5,0.6) >\}$
A_6^+	$\{< x_6: (0.9,0.9,0.9,0.9,0.9,0.9) >\}$	A_6^-	$\{< x_6: (0.9,0.9,0.9,0.9,0.9,0.9) >\}$

The following distance is obtained by make use of (3 and 4), we have the following values;

Determinations

$$\begin{aligned}
d_1^+ &= 0.25 \sqrt{\frac{|0.1 - 0.3|^2 + |0.2 - 0.4|^2 + |0.3 - 0.5|^2 + |0.4 - 0.6|^2 + |0.5 - 0.7|^2 + |0.6 - 0.8|^2}{6}} \\
&+ 0.10 \sqrt{\frac{|0.1 - 0.3|^2 + |0.2 - 0.4|^2 + |0.3 - 0.5|^2 + |0.4 - 0.6|^2 + |0.5 - 0.7|^2 + |0.6 - 0.8|^2}{6}} \\
&+ 0.20 \sqrt{\frac{|0.1 - 0.4|^2 + |0.2 - 0.5|^2 + |0.3 - 0.6|^2 + |0.4 - 0.7|^2 + |0.5 - 0.8|^2 + |0.6 - 0.9|^2}{6}} \\
&+ 0.30 \sqrt{\frac{|0.1 - 0.2|^2 + |0.2 - 0.3|^2 + |0.3 - 0.4|^2 + |0.4 - 0.5|^2 + |0.5 - 0.6|^2 + |0.6 - 0.7|^2}{6}} \\
&+ 0.15 \sqrt{\frac{|0.1 - 0.4|^2 + |0.2 - 0.5|^2 + |0.3 - 0.6|^2 + |0.4 - 0.7|^2 + |0.5 - 0.8|^2 + |0.6 - 0.9|^2}{6}}
\end{aligned}$$

$$= 0.05 + 0.02 + 0.3 + 0.03 + 0.045$$

$$d_1^+ = 0.176$$

$$\begin{aligned}
d_1^- &= 0.25 \sqrt{\frac{|0.3 - 0.1|^2 + |0.4 - 0.2|^2 + |0.5 - 0.3|^2 + |0.6 - 0.4|^2 + |0.7 - 0.5|^2 + |0.8 - 0.6|^2}{6}} \\
&+ 0.10 \sqrt{\frac{|0.3 - 0.1|^2 + |0.4 - 0.2|^2 + |0.5 - 0.3|^2 + |0.6 - 0.4|^2 + |0.7 - 0.5|^2 + |0.8 - 0.6|^2}{6}} \\
&+ 0.20 \sqrt{\frac{|0.4 - 0.1|^2 + |0.5 - 0.2|^2 + |0.6 - 0.3|^2 + |0.7 - 0.4|^2 + |0.8 - 0.5|^2 + |0.9 - 0.6|^2}{6}} \\
&+ 0.30 \sqrt{\frac{|0.2 - 0.1|^2 + |0.3 - 0.2|^2 + |0.4 - 0.3|^2 + |0.5 - 0.4|^2 + |0.6 - 0.5|^2 + |0.7 - 0.6|^2}{6}} \\
&+ 0.15 \sqrt{\frac{|0.4 - 0.1|^2 + |0.5 - 0.2|^2 + |0.6 - 0.3|^2 + |0.7 - 0.4|^2 + |0.8 - 0.5|^2 + |0.9 - 0.6|^2}{6}}
\end{aligned}$$

$$= 0.15 + 0.02 + 0.06 + 0.03 + 0.045$$

$$d_1^- = 0.205$$

Table6. Calculation for HFS (by equation 3)

d_i^+	P – Distance	d_i^-	N - Distance
d_1^+	0.176	d_1^-	0.205
d_2^+	0.2224	d_2^-	0.19
d_3^+	0.185	d_3^-	0.205
d_4^+	0.2466	d_4^-	0.165
d_5^+	0.1946	d_5^-	0.205
d_6^+	0.205	d_6^-	0.19

Table7. Togetherness for HFS (by equation 5)

	d_i^-	$d_i^+ - d_i^-$	$C(A_i)$
$C(A_1)$	0.205	0.381	0.5380
$C(A_2)$	0.19	0.4124	0.4607
$C(A_3)$	0.205	0.39	0.5256
$C(A_4)$	0.165	0.4116	0.4008
$C(A_5)$	0.205	0.3996	0.5130
$C(A_6)$	0.19	0.395	0.4810

above table we order the preference A_i ($i=1,2,3,4,5,6$) as:

$$A_1 > A_3 > A_5 > A_6 > A_2 > A_4$$

5. CONCLUSION

By intensifying the ideas gathered above the four decision makers in the table 7 we have the precedence positioning command connection as $A_1 > A_3 > A_5 > A_6 > A_2 > A_4$ are Preferences A_1 (Paddy) is prominent by all the other preferences. Groundnut(A_3), Turmeric(A_5), Cotton (A_6), Maize (A_2) and Sugarcane (A_4).

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