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PREFERENCE ASSESSMENTS AND ITS ASSOCIATION WITH COMPROMISE DECISIONS

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A B S T R A C T **RESEARCH ARTICLE**

Conflicts are very common among the group of decision makers. Agreement and disagreement over an alternative (option) vary among each individual. VIKOR decision making technique is a multi-criteria decision making tool to measure the group reconciliation solutions. In this paper, we propose a new methodology for comparing the decision makers' preference opinion with the observed compromise opinion. Also we have utilized analytic hierarchy process to assess the personal preference of an individual in choosing the most appropriate crop for cultivation. Further this paper compares the ranking of personal preferences with the results obtained from GIOWA-VIKOR method.

Keywords:

Pentagonal fuzzy number, VIKOR, OWA operator, GIOWA operator, compromise solution, analytic hierarchy process.

1. Introduction

VIKOR [3] is the most effective technique to resolve the conflicting situation that occurs in group decision making process. This technique is used to determine the compromise solution [12] among the group multiple solutions. VIKOR decision making technique is widely used to develop a group consensus [12-13] [15] in order to make a consistent solution.
In the early 2017, T. Pathinathan and S. Johnson Savarimuthu [4] introduced a new fuzzy set named weight based intuitionistic fuzzy set (WBIFS) to examine the external influencing factors upon the decision makers on choosing a suitable crop. In the year 2017, T. Pathinathan and S. Johnson Savarimuthu extended the VIKOR decision making method by characterizing the decision entries with pentagonal fuzzy numbers [6]. The extended technique exclusively depicts the decision makers' opinion over each alternative. Also, they made an extensive study on historical overview of VIKOR decision making technique [3]. The main objective of the study is to choose the best suitable crop by processing the opinions gathered from 142 respondents [6] of 22 blocks in Villupuram district, Tamil Nadu, India.

Usually the decision making technique confines the opinion of an alternative over each criteria [1]. VIKOR decision making technique provides consensus decision opinion which resolves the group regret. In this paper, we have tried to analyze the individual preference over an alternative based on cost and benefit criteria. Then we process the observed individual preference values by using analytic hierarchy process and rank them.

Analytic hierarchy process is a decision making technique which makes pair wise comparison between each alternative based on the decision criteria. Pairwise comparison depicts the personal preference assessment of an alternative over all other alternatives based on the available cost and benefit criteria. In this paper, we have employed analytic hierarchy process to examine the decision makers' personal preferences.

Then the result obtained from the individual preference assessment has been compared with the result obtained from the integrated generalized induced ordered weighted averaging operator VIKOR technique. We have collected opinions from 142 farmers of 22 blocks from Villupuram district and the entries are characterized by pentagonal fuzzy numbers.

This paper is organized in the following manner. Section two provides some of the basic definitions and preliminaries related with VIKOR multi-criteria decision making technique. Section three introduces the new algorithm which integrates GIOWA-VIKOR with AHP on considering personal preference opinion of each decision individual. Section four discusses the compromise solution obtained from GIOWA-VIKOR technique. Section five analyses individual preference opinion and then pairwise comparison has been made to obtain the relative advantage of each alternative. Section six compares the rank obtained from GIOWA-VIKOR and AHP followed by conclusion in section seven.

2. Basic Definitions and Notations

This section provides some of the basic definitions and concepts that have been included in the newly introduced integrated decision making technique.

2.1 Definition: Pentagonal Fuzzy Number [5]:Pentagonal Fuzzy Number is defined as $A_p = \{a_1, a_2, a_3, a_4, a_5\}$, where all a_1, a_2, a_3, a_4 and a_5 are real numbers and its membership function is given below.

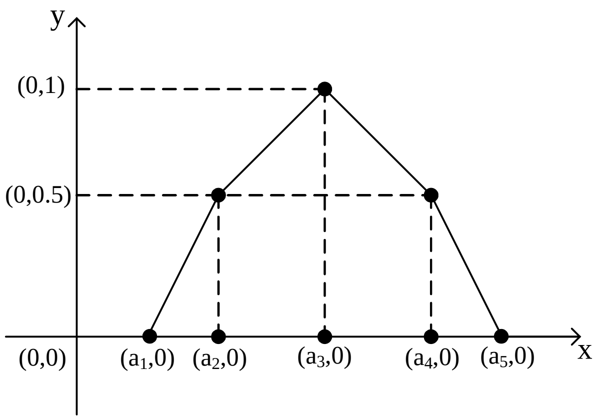


Figure 1 Pentagonal Fuzzy Number

$$\mu_{A_P}(x)=\begin{cases} 0 & ;\ for\ x<a_1, \\ \left(\dfrac{(x-a_1)}{(a_2-a_1)}\right) & ;\ for\ a_1\le x\le a_2, \\ \left(\dfrac{(x-a_2)}{(a_3-a_2)}\right) & ;\ for\ a_2\le x\le a_3, \\ 1 & ;\ for\ x=a_3, \\ \left(\dfrac{(a_4-x)}{(a_4-a_3)}\right) & ;\ for\ a_3\le x\le a_4, \\ \left(\dfrac{(a_5-x)}{(a_5-a_4)}\right) & ;\ for\ a_4\le x\le a_5, \\ 0 & ;\ for\ x>a_5. \end{cases}$$

2.2 Aggregation of individual decision opinions [6]

Decision matrix is made up of decision entries which denote the subjective opinion of each alternative over the criteria. Each decision entries characterized by pentagonal fuzzy numbers are aggregated by the following set of equations,

$$x_{ij} = \left(x_{ij1}, x_{ij2}, x_{ij3}, x_{ij4}, x_{ij5}\right) \quad (1)$$

where,

$$x_{ij1} = \min\left\{x_{ijk_1}\right\}, \quad (2)$$

$$x_{ij2} = \frac{1}{k}\sum_{k=1}^{k} x_{ijk_2}, \quad (3)$$

$$x_{ij3} = \frac{\dfrac{m}{2}+\dfrac{1}{4}\left(\sum_{k=1}^{k} x_{ijk_3}+\sum_{k=1}^{k} x_{ijk_3}\right)}{8}. \quad (4)$$

$$x_{ij4} = \frac{1}{k}\sum_{k=1}^{k} x_{ijk_4} \text{ and} \quad (5)$$

$$x_{ij5} = \max\left\{x_{ijk_5}\right\} \quad (6)$$

The importance of each criteria and its aggregation is determined the following set of equations:

$$w_{ij} = \left(w_{ij1}, w_{ij2}, w_{ij3}, w_{ij4}, w_{ij5}\right) \quad (7)$$

where,

$$w_{ij1} = \min\left\{w_{ijk_1}\right\} \quad (8)$$

$$w_{ij2} = \frac{1}{k}\sum_{k=1}^{k} w_{ijk_2} \quad (9)$$

$$w_{ij3} = \frac{\dfrac{m}{2}+\dfrac{1}{4}\left(\sum_{k=1}^{k} w_{ijk_3}+\sum_{k=1}^{k} w_{ijk_3}\right)}{8} \quad (10)$$

$$w_{ij4} = \frac{1}{k}\sum_{k=1}^{k} w_{ijk_4} \quad (11)$$

$$w_{ij5} = \max\left\{w_{ijk_5}\right\} \quad (12)$$

2.3 Ordered Weighted Averaging (OWA) Operator [11]

Ordered weighted averaging (OWA) operator calculates the importance associated with the criteria and it is given by the formula:

$$w_i(x) = Q\left(\frac{\sum_{k=1}^{i} c_k}{\sum_{k=1}^{n} c_k}\right) - Q\left(\frac{\sum_{k=1}^{i-1} c_k}{\sum_{k=1}^{n} c_k}\right) \quad (13)$$

where i=1,2,3,...n represents n criteria's and T represents the total sum of the importance of criteria's and it is given by,

$$T = \sum_{k=1}^{n} c_k \quad (14)$$

and linguistic quantifier Q is defined as:

$$Q(x) = x^2 \quad (15)$$

2.4 GIOWA Operator [10]

Generalized induced ordered weighted averaging operator (GIOWA) is a function to calculate the overall group assessment of each alternative over the criteria

$$GIOWA_w\left(\langle A_i, C_1, x_{i1}\rangle, \langle A_i, C_2, x_{i2}\rangle, \ldots, \langle A_i, C_n, x_{in}\rangle\right) = \sum_{j=1}^{n} w_j x_j \quad (16)$$

2.5 VIKOR [3]

VIKOR stands for Vise Kriterijumska Optimizacija I Kompromisno Resenje [3] predominantly assists in finding a multicriteria optimization and compromise solution among the choices. In the year 1973, P. L.Yu [12-13] and Milan Zeleny [14] introduced a methodology to determine compromise solution in conflict situations. Serafim Opricovic [2] established the basic theoretical idea of VIKOR in the year 1979 and applied fuzzy VIKOR in water resource planning in the year 2011.

2.6 Analytic Hierarchy Process [9]

Analytic hierarchy process is one of the popular decision making tool in multi-criteria decision making methods [7-8]. In the year 1980, Thomas. L. Saaty [9] developed analytic hierarchy process in order to compute the pair wise comparison among the alternatives.

2.7 Pentagonal Fuzzy Numbers and its linguistic gradation

The below table gives the linguistic relative importance of the variables based on pairwise comparison of each alternative with the respective criteria.

Table 2.1 Pentagonal fuzzy number scale value

Relative Importance Variables	**A_i compared with A_j (Actual value)**	**A_i compared with A_j (Reciprocal value)**
Indifference	(1,1,1,1,1)	(1,1,1,1,1)
Slightly Preferred	(1,2,3,4,5)	(0.2,0.25,0.3333,0.5,1.0)
Definitely Preferred	(3,4,5,6,7)	(0.1429,0.1667,0.2,0.25,0.3333)
Strongly Preferred	(5,6,7,8,9)	(0.1111,0.1250,0.1429,0.1667,0.2)
Extremely Preferred	(7,8,9,9,9)	(0.1111,0.1111,0.1111,0.125,0.1429)
Intermediate Values	(2,3,4,5,6)	(0.1667,0.2,0.25,0.3333,0.5)
	(4,5,6,7,8)	(0.125,0.1429,0.1667,0.2,0.25)
	(6,7,8,9,9)	(0.1111,0.1111,0.125,0.1429,0.1667)
	(8,9,9,9,9)	(0.1111,0.1111,0.1111,0.1111,0.125)

3. Proposed algorithm on finding individual preference assessments and its association with compromise solution

In this section, we introduce an algorithm for finding the individual preference assessments and its association with the compromise solution.

Step 1: Construct a decision matrix (DM) where the decision entries of the matrix are characterized by a pentagonal fuzzy number and it is given by:

$$DM = f_{ij\;n\times m}$$

(17)

$$DM_k = \begin{array}{c c} & \begin{array}{cccc} c_1 & c_2 & \cdots & c_m \end{array} \\ \begin{array}{c} a_1 \\ a_2 \\ \vdots \\ a_n \end{array} & \begin{pmatrix} (x_{111},x_{112},x_{113},x_{114},x_{115}) & (x_{121},x_{122},x_{123},x_{124},x_{125}) & \cdots & (x_{1m1},x_{1m2},x_{1m3},x_{1m4},x_{1m5}) \\ (x_{211},x_{212},x_{213},x_{214},x_{215}) & (x_{221},x_{222},x_{223},x_{224},x_{225}) & \cdots & (x_{2m1},x_{2m2},x_{2m3},x_{2m4},x_{2m5}) \\ \vdots & \vdots & \ddots & \vdots \\ (x_{n11},x_{n12},x_{n13},x_{n14},x_{n15}) & (x_{n21},x_{n22},x_{n23},x_{n24},x_{n25}) & \cdots & (x_{nm1},x_{nm2},x_{nm3},x_{nm4},x_{nm5}) \end{pmatrix} \end{array}$$

where, DM_k represents the k^{th} decision maker's opinion on each alternative based on the criteria.

Step 3: Construct an aggregated decision matrix from the group decision opinions using equations (2-6).

Step 4: The importance of the criteria and its respective weights has been calculated.

Step 5: Construct aggregated subjective weights of each criterion using equations (4-8).

Step 6: Construct a normalized decision matrix using the following equations

$$x_{ij5}^{+} = \max_i \left\{x_{ij5}\right\},\ C_j \in B \tag{18}$$

$$x_{ij1}^{-} = \min_i \left\{x_{ij1}\right\},\ C_j \in C \tag{19}$$

$$f_{ij} = \left(\frac{x_{ij1}}{x_{ij5}^{+}}, \frac{x_{ij2}}{x_{ij5}^{+}}, \frac{x_{ij3}}{x_{ij5}^{+}}, \frac{x_{ij4}}{x_{ij5}^{+}}, \frac{x_{ij5}}{x_{ij5}^{+}}\right),\ C_j \in B \tag{20}$$

$$f_{ij} = \left(\frac{x_{ij1}}{x_{ij5}^{-}}, \frac{x_{ij2}}{x_{ij5}^{-}}, \frac{x_{ij3}}{x_{ij5}^{-}}, \frac{x_{ij4}}{x_{ij5}^{-}}, \frac{x_{ij5}}{x_{ij5}^{-}}\right),\ C_j \in C \tag{21}$$

Step 7: Obtain a best value and worst value by using the following equations:

$$f_j^{+} = \max_i f_{ij}$$

(22)

$$f_j^{-} = \min_i f_{ij}$$

(23)

where f_j^{+} and f_j^{-} are the best and worst values of all criterion function.

Step 8: Calculate the values of S_i and R_i as follows:

$$S_i = \sum_{j=1}^{n} w_j \left(\frac{f_j^{+} - f_{ij}}{f_i^{+} - f_i^{-}}\right) \tag{24}$$

where, w_j is calculated by using the ordered weighted averaging (OWA) operator function, which has been adopted from step 6 of the previous algorithm.

$$R_i = \max_j \left\{ w_j \left(\frac{f_j^{+} - f_{ij}}{f_i^{+} - f_i^{-}}\right)\right\} \tag{25}$$

where w_j are the ordered weighted averaging weights of the criteria.

Step 9: Calculate the values of Q_i as follows:

$$Q_i = v\left(\frac{S_i - S^*}{S^- - S^*}\right) + (1-v)\left(\frac{R_i - R^*}{R^- - R^*}\right) \tag{26}$$

where v is the weight introduced for the strategy of maximum group utility, $1 - v$ is the weight of the individual regret, $S^* = \min_i S_i$, $S^- = \max_i S_i$, $R^* = \min_i R_i$ and $R^- = \max_i R_i$.

Step 10: Rank the alternatives sorting by values S, R and Q in an ascending order. In VIKOR, ascending order is used for ranking. The minimum value gets the maximum rank. The minimum value maintains the cooperative group utility in choosing a compromise solution.

Step 11: Construct an individual preference decision matrix (DM) based on pairwise comparison of each alternative with the respective criteria.

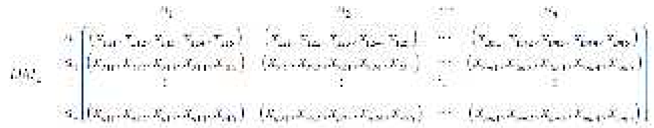
Step 12: Calculate fuzzy center value for each decision maker and their preferences are ranked.

Step 13: Comparing the results obtained from compromise solution with the individual preference assessments and hence finds the priority of each individual apart from the group compromise decision.

4. Case Study

Study area comprises opinions collected from all the 22 blocks of Villupuram district, Tamil Nadu, India. Based on the farming experience, the opinions are collected from 142 respondents and we have chosen the following 8 decision makers. The following table represents the farming experience of the farmers with maximum number of crops cultivation.

Table 4.1: Farming experience of the sample respondents



where, DM_k represents the k^{th} decision maker's opinion on each alternative based on the criteria.

	Name	Age	Farming Experience
D_1	R. Ezhumalai	46	Owns 4.5 acres of agricultural land, With 25 years of farming experience, Sadakatti village.
D_2	N. Sivasakthi	47	Owns 4.5 acres, with 15 years of experience, Kandamangalam village.
D_3	V. Vedagiri	56	Owns 8 acres, with 20 years of farming experience, Marakkanam.
D_4	M. Gopal	71	Owns 12 acres, with 50 years of farming experience, Sennagonam village.
D_5	P. Kuppusamy	62	Owns 6 acres, with 50 years of farming experience, Olakkoor village.
D_6	P. Pakkiri	50	Owns 7.5 acres, with 26 years of farming experience, Kannaarampattu village.
D_7	G. Narasingam	49	Owns 6.75 acres, with 25 years of farming experience, Thirumoondicharam village.
D_8	S.Kudiyarasum ani	60	Owns 10 acres, with 40 years of farming experience, Mettatthur village.

4.1 Adaptation of the problem

The following section gives the set of alternatives and criteria:

4.1.1 Alternatives

A_1 – Paddy
A_2 – Sugarcane
A_3 – Urad
A_4 – Groundnut
A_5 – Tapioca

4.1.2 Criteria

C_1 – Profit and loss in the yield
C_2 – Seed quality
C_3 – Soil quality
C_4 – Climatic (Sunlight) condition
C_5 – Water availability
C_6 – Assistance from government agencies
C_7 – Assistance from private agencies
C_8 – Level of underground water
C_9 – Fixation price of grains
C_{10} – Agriculture loan discount

The results obtained by processing the aggregated pentagonal decision matrix with the integrated GIOWA-VIKOR method are described as follows:

Table 4.2 Ranking of the alternatives by GIOWA

	GIOWA weights	Rank
Paddy (A_1)	0.4571	1^{st}
Sugarcane (A_2)	0.4086	4^{th}
Urad (A_3)	0.4164	2^{nd}
Groundnut (A_4)	0.4129	3^{rd}
Tapioca (A_5)	0.3686	5^{th}

Table 4.3 The ranking of the alternatives by GIOWA-VIKOR method

	Values induced by GIOWA – VIKOR method	Rank
Paddy (A_1)	0.0000	**1^{st}**
Sugarcane (A_2)	0.4102	**4^{th}**
Urad (A_3)	0.4077	**3^{rd}**
Groundnut (A_4)	0.3836	**2^{nd}**
Tapioca (A_5)	1.0000	**5^{th}**

The results (Table 4.3) obtained from the integrated GIOWA-VIKOR shows the compromise solution among the group decision makers. Almost all of them are satisfied with the results obtained from the integrated GIOWA-VIKOR technique. But the individual preference may vary from the compromise solution.

5. Individual Preference Ranking based on Analytic Hierarchy Process

By considering the following criteria, the individual preference over each alternative has been calculated by using analytic hierarchy process.

5.1 Criteria

C_1 - Cash crop / oil seed / food crop
C_2 - Amount of water needed
C_3 - Neighbors interest
C_4 - Climate suitability
C_5 - Regulated market price

5.2 Individual Preference Decision Matrices

The following tables (Table 5.1 - 5.6) show the pairwise preference value of each alternaive with respect to the criteria mentioned in the above section. The following tables (Table 5.1 - 5.6) represent the opinion collected from the decision maker (D_1 – Ezhumalai) based on his farming experience. Decision matrix has its entries as pentagonal fuzzy numbers which denotes the pairwise comparison of each alternative with other alternatives. Similarly the pairwise comparison has been made for all other decision makers (Table 4.1) and the results are tabulated (Table 5.7 – 5.14).

Table 5.1 Fuzzy centre values using traditional AHP by decision maker (D_1)

	A_1	**A_2**	**A_3**	**A_4**	**A_5**	**FCV**
A_1	(1,1,1,1,1)	(3,4,5,6,7)	(7,8,9,9,9)	(7,8,9,9,9)	(7,8,9,9,9)	0.7997
A_2	(0.1429, 0.1667, 0.2, 0.25, 0.3333)	(1,1,1,1,1)	(5,6,7,8,9)	(5,6,7,8,9)	(5,6,7,8,9)	0.7212
A_3	(0.1111,0.1111,0.1111,0.125, 0.1429)	(0.1111,0.1250, 0.1429, 0.1667, 0.2)	(1,1,1,1,1)	(1,2,3,4,5)	(1,2,3,4,5)	0.4430
A_4	(0.1111,0.1111,0.1111,0.125, 0.1429)	(0.1111,0.1250, 0.1429, 0.1667, 0.2)	(0.2, 0.25, 0.3333, 0.5, 1)	(1,1,1,1,1)	(1,2,3,4,5)	0.3432
A_5	(0.1111,0.1111,0.1111,0.125, 0.1429)	(0.1111,0.1250, 0.1429, 0.1667, 0.2)	(0.2, 0.25, 0.3333, 0.5, 1)	(0.2, 0.25, 0.3333,0.5, 1)	(1,1,1,1,1)	0.1929

Table 5.2 Fuzzy centre values using traditional AHP by decision maker (D_1**)** for C_1.

	A_1	**A_2**	**A_3**	**A_4**	**A_5**	**FCV**
A_1	(1,1,1,1,1)	(0.2, 0.25, 0.3333, 0.5, 1)	(3,4,5,6,7)	(3,4,5,6,7)	(3,4,5,6,7)	0.6760
A_2	(1,2,3,4,5)	(1,1,1,1,1)	(5,6,7,8,9)	(5,6,7,8,9)	(5,6,7,8,9)	0.7744
A_3	(0.1429, 0.1667, 0.2, 0.25, 0.3333)	(0.1111,0.1250, 0.1429, 0.1667, 0.2)	(1,1,1,1,1)	(0.2, 0.25, 0.3333, 0.5, 1)	(0.2, 0.25, 0.3333, 0.5, 1)	0.2099
A_4	(0.1429, 0.1667, 0.2, 0.25, 0.3333)	(0.1111,0.1250, 0.1429, 0.1667, 0.2)	(1,2,3,4,5)	(1,1,1,1,1)	(1,2,3,4,5)	0.4685
A_5	(0.1429, 0.1667, 0.2, 0.25, 0.3333)	(0.1111,0.1250, 0.1429, 0.1667, 0.2)	(1,2,3,4,5)	(0.2, 0.25, 0.3333, 0.5, 1)	(1,1,1,1,1)	0.3712

Table 5.3 Fuzzy centre values using traditional AHP by decision maker (D_1**)** for C_2.

	A_1	**A_2**	**A_3**	**A_4**	**A_5**	**FCV**
A_1	(1,1,1,1,1)	(0.2, 0.25, 0.3333, 0.5, 1)	(0.1667,0.2,0.25,0.3333,0.5)	(2,3,4,5,6)	(2,3,4,5,6)	0.5378
A_2	(1,2,3,4,5)	(1,1,1,1,1)	(0.1429, 0.1667, 0.2, 0.25, 0.3333)	(3,4,5,6,7)	(3,4,5,6,7)	0.6337
A_3	(2,3,4,5,6)	(3,4,5,6,7)	(1,1,1,1,1)	(4,5,6,7,8)	(5,6,7,8,9)	0.7525
A_4	(0.1667,0.2,0.25,0.3333,0.5)	(0.1429, 0.1667, 0.2, 0.25, 0.3333)	(0.1250,0.1429,0.1667,0.2,0.25)	(1,1,1,1,1)	(0.1667,0.2,0.25,0.3333,0.5)	0.1712
A_5	(0.1667,0.2,0.25,0.3333,0.5)	(0.1429, 0.1667, 0.2, 0.25, 0.3333)	(0.1111,0.1250, 0.1429, 0.1667, 0.2)	(2,3,4,5,6)	(1,1,1,1,1)	0.4047

Table 5.4: Fuzzy centre values using traditional AHP by decision maker (D_1**)** for C_3.

	A_1	A_2	A_3	A_4	A_5	FCV
A_1	(1,1,1,1,1)	(3,4,5,6,7)	(5,6,7,8,9)	(5,6,7,8,9)	(5,6,7,8,9)	0.8373
A_2	(0.1429, 0.1667, 0.2, 0.25, 0.3333)	(1,1,1,1,1)	(1,2,3,4,5)	(1,2,3,4,5)	(1,2,3,4,5)	0.5985
A_3	(0.1111,0.1250, 0.1429, 0.1667, 0.2)	(0.2, 0.25, 0.3333, 0.5, 1)	(1,1,1,1,1)	(1,1,1,1,1)	(1,1,1,1,1)	0.3547
A_4	(0.1111,0.1250, 0.1429, 0.1667, 0.2)	(0.2, 0.25, 0.3333, 0.5, 1)	(1,1,1,1,1)	(1,1,1,1,1)	(1,1,1,1,1)	0.3547
A_5	(0.1111,0.1250, 0.1429, 0.1667, 0.2)	(0.2, 0.25, 0.3333, 0.5, 1)	(1,1,1,1,1)	(1,1,1,1,1)	(1,1,1,1,1)	0.3547

Table 5.5 Fuzzy centre values using traditional AHP by decision maker (D_1**)** for C_4.

	A_1	A_2	A_3	A_4	A_5	FCV
A_1	(1,1,1,1,1)	(3,4,5,6,7)	(4,5,6,7,8)	(1,1,1,1,1)	(0.1429, 0.1667, 0.2, 0.25, 0.3333)	0.6105
A_2	(0.1429, 0.1667, 0.2, 0.25, 0.3333)	(1,1,1,1,1)	(4,5,6,7,8)	(6,7,8,9,9)	(1,1,1,1,1)	0.6637
A_3	(0.1250,0.1429,0.1667,0.2,0.25)	(0.1250,0.1429,0.1667,0.2,0.25)	(1,1,1,1,1)	(0.1429, 0.1667, 0.2, 0.25, 0.3333)	(0.1429, 0.1667, 0.2, 0.25, 0.3333)	0.1363
A_4	(1,1,1,1,1)	(0.1111,0.1111,0.1250,0.1429,0.1667)	(3,4,5,6,7)	(1,1,1,1,1)	(1,1,1,1,1)	0.4833
A_5	(3,4,5,6,7)	(1,1,1,1,1)	(3,4,5,6,7)	(1,1,1,1,1)	(1,1,1,1,1)	0.6062

Table 5.6 Fuzzy centre values using traditional AHP by decision maker (D_1**)** for C_5.

	A_1	A_2	A_3	A_4	A_5	FCV
A_1	(1,1,1,1,1)	(0.1250,0.1429,0.1667,0.2,0.25)	(3,4,5,6,7)	(0.1250,0.1429,0.1667,0.2,0.25)	(0.1667,0.2,0.25,0.3333,0.5)	0.4357
A_2	(4,5,6,7,8)	(1,1,1,1,1)	(3,4,5,6,7)	(3,4,5,6,7)	(3,4,5,6,7)	0.7378
A_3	(0.1429, 0.1667, 0.2, 0.25, 0.3333)	(0.1429, 0.1667, 0.2, 0.25, 0.3333)	(1,1,1,1,1)	(0.2, 0.25, 0.3333, 0.5, 1)	(0.2, 0.25, 0.3333, 0.5, 1)	0.1918
A_4	(4,5,6,7,8)	(0.1429, 0.1667, 0.2, 0.25, 0.3333)	(1,2,3,4,5)	(1,1,1,1,1)	(0.1667,0.2,0.25,0.3333,0.5)	0.5518
A_5	(2,3,4,5,6)	(0.1429, 0.1667, 0.2, 0.25, 0.3333)	(1,2,3,4,5)	(2,3,4,5,6)	(1,1,1,1,1)	0.5830

Table 5.7 Fuzzy centre values using traditional AHP method for decision maker (D_1)

FCV of Alternative	FCV of C_1	FCV of C_2	FCV of C_3	FCV of C_4	FCV of C_5	Normalized Composite Value	Rank
0.7997	0.6760	0.5378	0.8373	0.6105	0.4357	0.3638	1
0.7212	0.7744	0.6337	0.5985	0.6637	0.7378	0.3611	2
0.4430	0.2099	0.7525	0.3547	0.1363	0.1918	0.1071	3
0.3432	0.4685	0.1712	0.3547	0.4833	0.5518	0.1023	4
0.1929	0.3712	0.4047	0.3547	0.6062	0.5830	0.0657	5

Table 5.8 Fuzzy centre values using traditional AHP method for decision maker (D_2)

FCV of Alternative	FCV of C_1	FCV of C_2	FCV of C_3	FCV of C_4	FCV of C_5	Normalized Composite Value	Rank
0.6359	0.6851	0.6956	0.7361	0.5381	0.6162	0.3295	1
0.6890	0.4363	0.5097	0.6016	0.7536	0.4384	0.2990	2
0.1423	0.4363	0.5622	0.5945	0.4446	0.5372	0.0580	5
0.6203	0.1359	0.6032	0.4084	0.6485	0.5590	0.2314	3
0.4125	0.5049	0.1294	0.1593	0.1151	0.3492	0.0822	4

Table 5.9 Fuzzy centre values using traditional AHP method for decision maker (D_3)

FCV of Alternative	FCV of C_1	FCV of C_2	FCV of C_3	FCV of C_4	FCV of C_5	Normalized Composite Value	Rank
0.7254	0.7134	0.6991	0.7069	0.5726	0.7209	0.3528	1
0.6851	0.5500	0.3154	0.6516	0.4972	0.6630	0.2614	2
0.6110	0.4599	0.5382	0.5861	0.5201	0.5730	0.2331	3
0.3479	0.6785	0.5574	0.4617	0.5422	0.4458	0.1332	4
0.1306	0.0982	0.3898	0.0938	0.3679	0.0973	0.0195	5

Table 5.10 Fuzzy centre values using traditional AHP method for decision maker (D_4)

FCV of Alternative	FCV of C_1	FCV of C_2	FCV of C_3	FCV of C_4	FCV of C_5	Normalized Composite Value	Rank
0.7331	0.7026	0.2238	0.5932	0.5425	0.5525	0.3059	1
0.6825	0.6776	0.1813	0.5248	0.5551	0.6118	0.2778	2
0.4030	0.5645	0.7939	0.3659	0.4883	0.5537	0.1779	4
0.5793	0.4609	0.7004	0.3610	0.5323	0.0972	0.1989	3
0.1021	0.0943	0.6006	0.6551	0.3818	0.6849	0.0394	5

Table 5.11 Fuzzy centre values using traditional AHP method for decision maker (D_5)

FCV of Alternative	FCV of C_1	FCV of C_2	FCV of C_3	FCV of C_4	FCV of C_5	Normalized Composite Value	Rank
0.6071	0.6697	0.6577	0.7060	0.5319	0.4525	0.2630	2
0.5485	0.5729	0.3281	0.5706	0.7119	0.5865	0.2181	4
0.5720	0.5017	0.6947	0.6130	0.2814	0.7334	0.2319	3
0.6788	0.6385	0.6541	0.5010	0.3764	0.6261	0.2724	1
0.0936	0.1172	0.1653	0.1095	0.5986	0.1014	0.0147	5

Table 5.12 Fuzzy centre values using traditional AHP method for decision maker (D_6)

FCV of Alternative	FCV of C_1	FCV of C_2	FCV of C_3	FCV of C_4	FCV of C_5	Normalized Composite Value	Rank
0.7187	0.6606	0.7129	0.7236	0.6845	0.5713	0.3313	1
0.4925	0.4773	0.4718	0.6761	0.4725	0.4624	0.1734	4
0.6161	0.6428	0.6257	0.5227	0.6395	0.6629	0.2621	2
0.5601	0.6113	0.5770	0.4367	0.6015	0.6930	0.2248	3
0.1126	0.1080	0.1125	0.1110	0.1020	0.1104	0.0084	5

Table 5.13 Fuzzy centre values using traditional AHP method for decision maker (D_7)

FCV of Alternative	FCV of C_1	FCV of C_2	FCV of C_3	FCV of C_4	FCV of C_5	Normalized Composite Value	Rank
0.7147	0.6952	0.6779	0.7041	0.6347	0.6668	0.3344	1
0.4682	0.4675	0.6019	0.6148	0.5592	0.6217	0.1858	4
0.5800	0.6383	0.6276	0.6291	0.7544	0.6142	0.2622	2
0.6336	0.5938	0.4772	0.3737	0.4492	0.4858	0.2088	3
0.1035	0.1052	0.1154	0.1783	0.1025	0.1116	0.0088	5

Table 5.14 Fuzzy centre values using traditional AHP method for decision maker (D_8)

FCV of Alternative	FCV of C_1	FCV of C_2	FCV of C_3	FCV of C_4	FCV of C_5	Normalized Composite Value	Rank
0.6760	0.7367	0.7314	0.5142	0.6639	0.5731	0.3012	1
0.5542	0.5735	0.5647	0.5756	0.5605	0.6516	0.2244	3
0.6194	0.5540	0.6571	0.6197	0.7238	0.5162	0.2632	2
0.5287	0.5329	0.4526	0.6871	0.4465	0.6490	0.2025	4
0.1218	0.1029	0.0941	0.1034	0.1053	0.1100	0.0087	5

6. Comparison of preference assessment with compromise solution

The following tables (Table 6.1 – 6.8) compare the result obtained from both GIOWA-VIKOR and AHP. PAW denotes preference assessment weights obtained by AHP.

Table 6.1: Preference assessment and compromise ranking for decision maker (D_1)

Alternatives	GIOWA-VIKOR weights	Rank	PAW by D_1	Rank
Paddy (A_1)	0.0000	**1**	0.3638	**1**

Sugarcane (A_2)	0.4102	**4**	0.3611	**2**
Urad (A_3)	0.4077	**3**	0.1071	**3**
Groundnut (A_4)	0.3836	**2**	0.1023	**4**
Tapioca (A_5)	1.0000	**5**	0.0657	**5**

Table 6.2: Preference assessment and compromise ranking for decision maker (D_2)

Alternatives	GIOWA-VIKOR weights	Rank	PAW by D_2	Rank
Paddy (A_1)	0.0000	**1**	0.3295	**1**
Sugarcane (A_2)	0.4102	**4**	0.2990	**2**
Urad (A_3)	0.4077	**3**	0.0580	**5**
Groundnut (A_4)	0.3836	**2**	0.2314	**3**
Tapioca (A_5)	1.0000	**5**	0.0822	**4**

Table 6.3: Preference assessment and compromise ranking for decision maker (D_3)

Alternatives	GIOWA-VIKOR weights	Rank	PAW by D_3	Rank
Paddy (A_1)	0.0000	**1**	0.3528	**1**
Sugarcane (A_2)	0.4102	**4**	0.2614	**2**
Urad (A_3)	0.4077	**3**	0.2331	**3**
Groundnut (A_4)	0.3836	**2**	0.1332	**4**
Tapioca (A_5)	1.0000	**5**	0.0195	**5**

Table 6.4: Preference assessment and compromise ranking for decision maker (D_4)

Alternatives	GIOWA-VIKOR weights	Rank	PAW by D_4	Rank
Paddy (A_1)	0.0000	**1**	0.3059	**1**
Sugarcane (A_2)	0.4102	**4**	0.2778	**2**
Urad (A_3)	0.4077	**3**	0.1779	**4**
Groundnut (A_4)	0.3836	**2**	0.1989	**3**
Tapioca (A_5)	1.0000	**5**	0.0394	**5**

Table 6.5: Preference assessment and compromise ranking for decision maker (D_5)

Alternatives	GIOWA-VIKOR weights	Rank	PAW by D_5	Rank
Paddy (A_1)	0.0000	**1**	0.2630	**2**
Sugarcane (A_2)	0.4102	**4**	0.2181	**4**
Urad (A_3)	0.4077	**3**	0.2319	**3**
Groundnut (A_4)	0.3836	**2**	0.2724	**1**
Tapioca (A_5)	1.0000	**5**	0.0147	**5**

Table 6.6: Preference assessment and compromise ranking for decision maker (D_6)

Alternatives	GIOWA-VIKOR weights	Rank	PAW by D_6	Rank
Paddy (A_1)	0.0000	**1**	0.3313	**1**
Sugarcane (A_2)	0.4102	**4**	0.1734	**4**
Urad (A_3)	0.4077	**3**	0.2621	**2**
Groundnut (A_4)	0.3836	**2**	0.2248	**3**
Tapioca (A_5)	1.0000	**5**	0.0084	**5**

Table 6.7: Preference assessment and compromise ranking for decision maker (D_7)

Alternatives	GIOWA-VIKOR weights	Rank	PAW by D_7	Rank
Paddy (A_1)	0.0000	**1**	0.3344	**1**
Sugarcane (A_2)	0.4102	**4**	0.1858	**4**
Urad (A_3)	0.4077	**3**	0.2622	**2**
Groundnut (A_4)	0.3836	**2**	0.2088	**3**
Tapioca (A_5)	1.0000	**5**	0.0088	**5**

Table 6.8: Preference assessment and compromise ranking for decision maker (D_8)

Alternatives	GIOWA-VIKOR weights	Rank	PAW by D_8	Rank
Paddy (A_1)	0.0000	**1**	0.3012	**1**
Sugarcane (A_2)	0.4102	**4**	0.2244	**3**
Urad (A_3)	0.4077	**3**	0.2632	**2**
Groundnut (A_4)	0.3836	**2**	0.2025	**4**
Tapioca (A_5)	1.0000	**5**	0.0087	**5**

From the above tables (Table 6.1 – 6.8), we make the following observations. Among eight decision makers, seven individuals preferred alternative A_1 (Paddy) as their main priority when compared to the other alternatives. Also, their preference A_1 (Paddy) is satisfied with the compromise solution obtained from integrated GIOWA-VIKOR method (Table 5.2). Four among eight decision makers have opted alternative A_2 (Sugarcane) as their second preferred crop next to A_1 (Paddy). Whereas A_2 (Sugarcane) ranks fourth position on group compromise decision. Six among eight decision makers preferred A_3 (Urad) as their suitable crop in the third position and also the rank obtained from GIOWA-VIKOR results the same. Few among eight decision makers preferred A_4 (Groundnut) as their fourth priority. Whereas A_4 (Groundnut) ranks second from GIOWA-VIKOR method. A_5 (Tapioca) be their least priority when compared with the other alternatives and their preference gets coincide with the result obtained from GIOWA-VIKOR method.

The results obtained from integrated GIOWA-VIKOR and AHP decision making technique has been compared and the alternative A_1 (Paddy) ranks first among all the other alternatives. And also we have observed that the results obtained from group decision making technique GIOWA-VIKOR and individual preference assessment technique AHP shows identically preferred alternatives.

Conclusion

The newly introduced integrated GIOWA-VIKOR and AHP decision making technique produced results based on the individual preference assessment over each alternative with their respective criteria. Along with the compromise solution obtained from GIOWA-VIKOR decision making technique, the obtained preference assessment values are compared. From the newly introduced integrated decision making technique, it is experimentally verified that alternative A_1 (Paddy) is the most preferred crop for cultivation among the farmers in Villupuram district. Further it is revealed that the compromise solutions obtained from GIOWA-VIKOR is closer to the individual preference opinion obtained from analytic hierarchy process.

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