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Sieving out the Poor using Fuzzy Decision Making Tools

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Abstract

Background/Objectives: The study of poverty and analysis of the set of 'poor' in terms of exact or classical (crisp set) is unrealistic because the concept of 'poor' is non-exact. This paper uses multi-criteria fuzzy decision-making tools and fuzzy set theory to capture the extent of poverty of a household both in terms of quantitative and qualitative factors. **Methods/Statistical Analysis:** This paper introduces pentagonal fuzzy numbers to analyze the level of poverty of a household. Stratified Fuzzy Analytical Hierarchy Process (SFAHP) has been utilized to compare the alternatives (different households) with respect to various criteria to estimate the fuzzy criteria weights based on the membership function. **Findings:** Impreciseness is accounted as measureable factor using Stratified Fuzzy AHP and Pentagonal Fuzzy Numbers approach. With help of this method a position of one's level of poverty has been captured. Thus it has logically been argued that one can overcome the dichotomy existing in the traditional method of analyzing poverty. **Applications/Improvements:** This article represents the subjective arguments by establishing the qualitative multi-criteria fuzzy variables into membership grades like very poor, almost very poor, poor, rather poor and non-poor. Thus the whole data of the subset of the poor has been categorized by sieving out technique. This way the impreciseness is accounted as measureable factor using Stratified Fuzzy AHP and Pentagonal Fuzzy Numbers approach. Thus with help of this method the decision makers can identify a poor person in any existing socio-economical situations.

Keywords: Decision, Pentagonal Fuzzy Numbers, Poverty, SFAHP

1. Introduction

Poverty is conventionally analyzed by splitting the households in a population into two groups: 'poor and non-poor' defined in relation to the poverty line. This means that the set of poor is a crisp set. There is no partially poor person. The conventional method for poverty measurement depends too much on an arbitrary decision like setting a poverty line.

The 'poor and non-poor' are not two mutually exclusive sets. Hence, the distinction between the poor and non-poor is fuzzy or vague. This paper argues that using a method based on 'fuzzy decision making' can be a unique tool to deal with the vagueness that lies between the poor and non-poor. This paper asserts that poverty is a multi-dimensional concept and it integrates multiple dimensions in an intuitive way to arrive at a reliable conclusion.

The scope of this paper is to develop and refine fuzzy poverty measurement tools which commenced with the contribution of Andrea Cerioli and Sergio Zani in the year 1990[1]. This method introduces pair-wise comparison judgment matrix using pentagonal fuzzy numbers based on the stratified fuzzy hierarchy process. We use scale 1 to 9 which was introduced in the year 1980 by Thomas L. Saaty[2] in the context of decision making process. In this case two additional factors have been introduced:

- The choice of membership functions with fuzzy pentagonal numbers for the quantitative and qualitative specification of households' degree of poverty.
- The choice of rules for the fuzzification of the resulting fuzzy sets for normalizing the input and output data and aggregation of the fuzzy weights as defuzzification of the data for sieving the poor in a given population of subgroup of poor.

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Further, poverty category is calculated using Sieving method. This way we make sure that the result is accurate and precise incorporating both qualitative and quantitative empirical data. Primary data is collected from various households of 20 blocks of Nalanda district, Bihar to substantiate the methodology. Thus we help the policy makers to sharpen the measure of poverty for their future planning.

In this paper we describe the nature of poverty can be constituted by a number of sets or attributes of non-monetary categories such as food (Roti), clothing (Kapda), housing (Makaan), employment (Kaam) and social status (Samman). These components are used as the part of multi-criteria fuzzy decision poverty analysis.

2. Stratified Fuzzy AHP Approach and its Development

Analytic Hierarchy Process (AHP) was introduced by Thomas L. Saaty in the year 1980. The major characteristic of the AHP method is the use of pair-wise comparisons, which are used to compare with respect to the various criteria, sub-criteria and alternatives to estimate criteria weights. Van Laarhoven and Pedrycg introduced Fuzzy AHP in the year 1983[3]. They proposed a method of fuzzy judgment by comparison of the triangular fuzzy numbers. They also used fuzzy numbers with triangular membership function with simple operation laws and the logarithmic least squares method to obtain element sequencing. Later in the year 1985, J.J. Buckley extended Saaty's method to incorporate fuzzy comparison ratio by using fuzzy trapezoidal fuzzy numbers. In 1995 Again Chang proposed the principle for comparison between the elements of the fuzzy numbers. In 2002, Cebeci and Cengiz Kahraman compared some catering firms using four attributes and fuzzy AHP.

The aim of the AHP is to capture the expert's knowledge and the conventional AHP still cannot reflect the human thinking style. Therefore, a fuzzy extension of AHP was developed to address and to solve imprecision inherent in the real world problem. We have evolved Stratified Fuzzy AHP method as one of the Multi-Criteria Decision Making tools.

2.1 Pentagonal Fuzzy Numbers and Stratified Fuzzy AHP Approach to Poverty Analysis

2.1.1 Poverty

A person who is poor implies poverty as lack of security, low wages, lack of employment opportunity, poor nutrition, poor access to safe drinking water, having too many children to feed, children being engaged in work to bring money to a family, poor educational opportunities and misuse of resources etc. whereas, for a non-poor person poverty is a lack of income. There is a general consensus that poverty is multi-dimensional. This view is clearly expressed by the following definition given by the World Bank in the year 2002.

Poverty is hunger. Poverty is lack of shelter. Poverty is being sick and not being able to see a doctor. Poverty is not being able to go to school and not knowing how to read. Poverty is not having a job, is fear for the future, living one day at time. Poverty is losing a child to illness brought by unclean water. Poverty is powerless, lack of representation and freedom[4,5].

It is in this context Mozaffar Qizilbash defines poverty as a vague concept. Thus we propose to measure the degree of poverty incorporating multi-dimensional aspects of deprivation into the definition.

2.1.2 Poor: A Vague Predicate

Poor is a vague predicate because, 1. It involves borderline cases (a person is not clearly poor and not clearly non-poor), 2. It lacks sharp boundaries (along a hypothetical scale of well- being, an exact point at which a poor ceases to be poor does not really exist).

2.2 Poverty Set: A Matter of Degree

Poverty Set can be defined as a matter of degree based on the fuzzy logic concept. The fuzzy decision making tool approach considers poverty as a matter of degree rather than an attribute that is simply present or absent for a household in a given population. In fuzzy logic a statement can be true to a certain degree. Therefore, the poor individual or a household are assigned a degree in relation to the membership functions. A poor person belonging to a given set in a varying degree is assigned with membership values 1 (the poorest person) and 0 (the non-poorest person). In mathematical terms it can be represented as follows: False: Truth value = 0, True: truth value = 1, Uncertain: 0 < Truth value < 1.

2.3 Fuzzy Subset Approach to Poverty Analysis

Let us consider a set E of n individuals or households and let $\underset{\sim}{A}$ be a subset of E consisting of the poor, such that a fuzzy membership is given by $\mu_{\underset{\sim}{A}}(x_i)$ where

(i = 1, 2, 3, ..., n) denote for each individual or household in $\underset{\sim}{A}$ and $\mu : \underset{\sim}{A} \rightarrow [0,1]$. Then the membership function for the poor is defined by

- $\mu_{\underset{\sim}{A}}(x_i) = 0$, if i^{th} individual is certainly not poor;
- $\mu_{\underset{\sim}{A}}(x_i) = 1$, if i^{th} individual is poor;
- $0 < \mu_{\underset{\sim}{A}}(x_i) < 1$, if i^{th} individual exhibits a partial membership in the subset of $\underset{\sim}{A}$.

Fuzzy approach tries to answer: 1. How can we assign memberships to elements in a fuzzy set? 2. How can the notion of fuzzy sets be applied to practical problems? The first question concerns the construction of a numerical scale for membership values in such a way that the scale satisfies some conditions imposed on rational measurement system. It is done through assigning membership function to the criteria and alternatives.

3. Stratified Fuzzy AHP-Pentagonal Fuzzy Numbers: Methodology

3.1 Pentagonal Fuzzy Numbers

Pentagonal Fuzzy Number is defined as $\underset{\sim}{A}_P = \{a_{-2}, a_{-1}, a_0, a_1, a_2\}$, where a_{-1} and a_{-2} denotes the smallest possible values (in decreasing order), a_0 the most promising value and a_1, a_2 the largest possible value (in increasing order) are real numbers and its membership function[6] is Figure 1. defined by

$$\mu_{\underset{\sim}{A}}(x) = \begin{cases} \dfrac{(x - a_{-2})}{(a_{-1} - a_{-2})} & for\ a_{-2} \le x \le a_{-1} \\ \dfrac{(x - a_{-1})}{(a_0 - a_{-1})} & for\ a_{-1} \le x \le a_0 \\ 1 & x = a_0 \\ \dfrac{(x - a_1)}{(a_0 - a_1)} & for\ a_0 \le x \le a_1 \\ \dfrac{(x - a_2)}{(a_1 - a_2)} & for\ a_1 d \le x \le a_2 \end{cases} \tag{1}$$

3.1.1 Conditions on Pentagonal Fuzzy Numbers

A Pentagonal Fuzzy Numbers $\underset{\sim}{A}_p(x)$, should satisfy the following conditions;

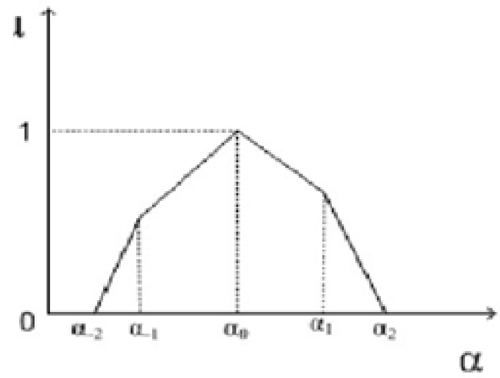

Figure 1. Pentagonal Fuzzy Number.

- $\underset{\sim}{A}_p(x)$ is a continuous function in the interval [0,1].
- $\underset{\sim}{A}_p(x)$ is strictly increasing and continuous function on $[a_{-2}, a_{-1}]$ and $[a_{-1}, a_0]$.
- $\underset{\sim}{A}_p(x)$ is strictly decreasing and continuous function on $[a_0, a_1]$ and $[a_1, a_2]$.

3.1.2 Construction of Pentagonal Fuzzy Numbers

The Pentagonal Fuzzy Number is represented by the five parameters such as a_0, a_1, a_2, a_{-1}, and a_{-2}, where a_{-1} and a_{-2} denotes the smallest possible values (decreasing order), a_0 the most promising value and a_1, a_2 the largest possible value (increasing order) respectively.

Since each number in the pair wise comparison represents the subjective judgments opinion of the decision maker is a vague judgment. Therefore, the Fuzzy Numbers work the best to consolidate the fragmented judgments of the expert opinions.

Formula to Generate fuzzy pentagonal numbers defined as follows:

$$\underset{\sim}{a} = (a-2, a-1, a, a+1, a+2), \forall\ a = 3, \ldots, 7.$$

and defined by $\underset{\sim}{1}$ = (1, 1, 1, 1, 1), $\underset{\sim}{2}$ = (1, 1, 2, 3, 4), $\underset{\sim}{8}$ = (6, 7, 8, 9, 9), and $\underset{\sim}{9}$ = (7, 8, 9, 9, 9). Since fuzzy numbers scale is defined from $\underset{\sim}{1}$ to $\underset{\sim}{9}$.

3.2 Definition of Fuzzy Centre Value

Let $\underset{\sim}{c}$ be a Fuzzy Number and $\mu_{\underset{\sim}{c}}$ be its membership function the for a given Fuzzy Number $\underset{\sim}{c}$, let a_0 be a core element of $\underset{\sim}{c}$ such that

$$F_{\underset{\sim}{c}} = a_0 - \frac{1}{2}\int_{-\infty}^{a_0} \mu_{\underset{\sim}{c}}(x)dx + \frac{1}{2}\int_{a_0}^{\infty} \mu_{\underset{\sim}{c}}(x)dx$$

Therefore, for Pentagonal Fuzzy Numbers $\underset{\sim}{A}_P = \{a_{-2}, a_{-1}, a_0, a_1, a_2\}$ and its fuzzy centre value[7] is derived by the following expressions as defined:

$$F_{\underset{\sim}{c}} = a_0 - \frac{1}{2}\int_{a_{-2}}^{a_{-1}} \frac{(x-a_{-2})}{(a_{-1}-a_{-2})}dx - \frac{1}{2}\int_{a_{-1}}^{a_0} \frac{(x-a_{-1})}{(a_0-a_{-1})}dx - \frac{1}{2}$$

$$dx - \frac{1}{2}\int_{a_0}^{a_1} \frac{(x-a_1)}{(a_0-a_1)}dx - \frac{1}{2}\int_{a_1}^{a_2} \frac{(x-a_2)}{(a_1-a_2)}dx$$

where, $\mu_{\underset{\sim}{c}}(x) = \frac{(x-a_{-2})}{(a_{-1}-a_{-2})}$, $\mu_{\underset{\sim}{c}}(x) = \frac{(x-a_{-1})}{(a_0-a_{-1})}$, $\mu_{\underset{\sim}{c}}(x) = \frac{(x-a_1)}{(a_0-a_1)}$ and $\mu_{\underset{\sim}{c}}(x) = \frac{(x-a_2)}{(a_1-a_2)}$ and then $F_{\underset{\sim}{c}}$ is called a fuzzy centre value of $\underset{\sim}{c}$. Where real – valued parameters $\underset{\sim}{A}_P = \{a_{-2}, a_{-1}, a_0, a_1, a_2\}$ satisfy $a_{-2} \le a_{-1} \le a_0 \le a_1 \le a_2$, and its fuzzy centre value is defined by $F_{\underset{\sim}{c}} = \frac{a_0}{2} + \frac{1}{4}(a_l + a_r)$

Where a_l and a_r are left arm minimum fuzzy weights and right arms maximum fuzzy weight and a_0 is the core value of the pentagonal numbers respectively.

3.3 Construction of Fuzzy Pair-Wise Comparison Matrix (Fuzzification)

$$\underset{\sim}{M} = \left[\underset{\sim}{a}_{ij}\right]_{m\times n} = \begin{cases} \underset{\sim}{a}_{ij} = \frac{E_i}{E_j} & \text{How importance more (less) is } E_i \text{ w.r.t } E_j \\ \underset{\sim}{a}_{ij} = 1 & \text{Every element has the same importance} \\ \underset{\sim}{a}_{ij} = \frac{1}{\underset{\sim}{a}_{ij}} & \text{if } E_i \text{ is } \underset{\sim}{a}_{ij} \text{ times more (less) importance than } E_j\text{, otherwise vice versa} \end{cases}$$

Where, E_i and E_j are the criteria compared one over the other and $\underset{\sim}{a}_{ij}$ are the values assigned to the criteria.

3.3.1 *Establishment of Scale*

- If a criterion on the Left is more important than the one matching on the Right, assign actual judgments value to the Left criterion.
- If a criterion on the Left is less important than the one matching on the Right, assign the reciprocal value to the right criterion.
- While comparing one household with the other, we relate one activity over another by favoring the highest possible affirmation.

3.3.2 *Fuzzy Pentagon Scale Values*

Fuzzy Numbers	Relative Importance variables	Scale of a fuzzy pentagonal numbers
$\underset{\sim}{1}$	Equally Important	(1,1,1,1,1)
$\underset{\sim}{3}$	Slightly Important	(1,2,3,4,5)
$\underset{\sim}{5}$	Strongly Important	(3,4,5,6,7)
$\underset{\sim}{7}$	Very Strongly Important	(5,6,7,8,9)
$\underset{\sim}{9}$	Extremely or absolutely Important	(7,8,9,9,9)
$\underset{\sim}{2}, \underset{\sim}{4}, \underset{\sim}{6}, \underset{\sim}{8}$	Intermediate Values	$(a-2, a-1, a, a+1, a+2)$
$1/\underset{\sim}{a}$	Reciprocal Values	$\left(1/a+2, 1/a+1, 1/\underset{\sim}{a}, 1/a-1, 1/a-2\right)$

3.4 Computational Procedures of Stratified Fuzzy AHP

To assign the weights of criteria, sub-criteria and alternatives, we proceed as given below:

Step-1: Construction of the hierarchical structure with decision elements: criteria and sub-criteria. Each decision maker is asked to express relative importance of the decision elements in the same level with help of a reference scale values: 1-9 scale.

Step-2: Collect the score of pair wise comparison and form pair wise comparison matrices for each of the *n* decision makers. It is done at each level using the scale response on the questionnaire. How important is one element when it is compared with the other element?

Step-3: Construction of a fuzzy judgment Matrix which are represented by the positive triangular numbers.

Step-4: Fuzzification is done by normalizing the fuzzy pentagonal Membership values.

Step-5: Calculation of the fuzzy Centre Membership values.

Step-6: Computation of the composite weight and finally obtaining the poverty status category of the households using fuzzy sieving technique.

3.4 Comparison Judgment Matrix is Defined as Follows

Consider the pentagonal fuzzy comparison matrix expressed by

$$\underset{\sim}{M}=[\underset{\sim}{a}_{ij}]_{n\times n}=\begin{bmatrix} (\underset{\sim}{1},\underset{\sim}{1},\underset{\sim}{1},\underset{\sim}{1},\underset{\sim}{1}) & (\underset{\sim}{a}_{12},\underset{\sim}{a}_{12},\underset{\sim}{a}_{12},\underset{\sim}{a}_{12},\underset{\sim}{a}_{12}) & . & . & (\underset{\sim}{a}_{1n},\underset{\sim}{a}_{1n},\underset{\sim}{a}_{1n},\underset{\sim}{a}_{1n},\underset{\sim}{a}_{1n}) \\ (\underset{\sim}{a}_{21},\underset{\sim}{a}_{21},\underset{\sim}{a}_{21},\underset{\sim}{a}_{21},\underset{\sim}{a}_{21}) & \underset{\sim}{1} & . & . & (\underset{\sim}{a}_{2n},\underset{\sim}{a}_{2n},\underset{\sim}{a}_{2n},\underset{\sim}{a}_{2n},\underset{\sim}{a}_{2n}) \\ . & . & \underset{\sim}{1} & . & . \\ . & . & . & \underset{\sim}{1} & . \\ (\underset{\sim}{a}_{m1},\underset{\sim}{a}_{m1},\underset{\sim}{a}_{m1},\underset{\sim}{a}_{m1},\underset{\sim}{a}_{m1}) & . & . & . & (\underset{\sim}{1},\underset{\sim}{1},\underset{\sim}{1},\underset{\sim}{1},\underset{\sim}{1}) \end{bmatrix} \tag{2}$$

3.5 Normalization of the Fuzzy Comparison Judgments to Obtain Fuzzy the Weights

$$\underset{\sim}{M}=[\underset{\sim}{a}_{ij}]_{n\times n}=\begin{bmatrix} \frac{w_1}{w_1+w_1} & \frac{w_1}{w_1+w_2} & . & . & \frac{w_1}{w_1+w_n} \\ \frac{w_2}{w_2+w_1} & \frac{w_2}{w_2+w_2} & . & . & \frac{w_2}{w_2+w_n} \\ . & . & . & . & . \\ . & . & . & . & . \\ \frac{w_n}{w_n+w_1} & . & . & . & \frac{w_n}{w_n+w_n} \end{bmatrix} \tag{3}$$

where, $w_i=\sum_{j=1}^{n}\underset{\sim}{a}_{ij}=\left(\sum_{j}^{n}a_{-2_{ij}},\sum_{j}^{n}a_{-1_{ij}},\sum_{j}^{n}a_{1_{ij}},\sum_{j}^{n}a_{2_{ij}}\right),i,$ $j=1,2,3\ldots n$, and $\underset{\sim}{a}_{ij}$ is the fuzzy Pentagonal numbers. This can also be expressed as $\underset{\sim}{w}_1=w_1\otimes[w_1\oplus w_2]^{-1}$

Next step we sum up each row of the above normalized matrix of $\underset{\sim}{M}$ by interval fuzzy arithmetic operations then row sums divided to n.

3.6 Shifting Formula

Sieving formula gives the final fuzzy membership weights. In other words the defuzzification is done by using the sieving formula defined as:

$$\mu(\mathrm{h_i})=\frac{\mathrm{h_i}-\min(\mathrm{h_i})}{\mathrm{Max}(\mathrm{h_i})-\min(\mathrm{h_i})} \tag{4}$$

Where, h_i is variable denoting normalized household weights,

i = 1, 2, 3 ... 100 (Total number of households),
min (h_i) denotes minimum of all the h_i and
max (h_i) denotes maximum of all the h_i.

3.7 Fuzzy Sieve Grade Values for Poverty Evaluation

To categorize a set of population of poor, the following set of distinct fuzzy membership values is defined by

$\varphi(h_i)$ = {non poor (NP), rather poor (RP), poor (P), almost very poor (AVP), very poor (VP)}

3.8 Fuzzy Sieve Technique (FST)

Fuzzy sieving constraints category is defined by,
FST = {T_1, T_2, T_3, T_4, T_5},
Where,

$$\left.\begin{array}{l} \mathrm{T_1}=\{\mathrm{h_i}\,|\,0.0\le \mathrm{h_i}\le 0.2\}, \\ \text{Seive Result}: \mathrm{h_i}=\textit{non poor} \\ \mathrm{T_2}=\{\mathrm{h_i}\,|\,0.2<\mathrm{h_i}\le 0.4\}, \\ \text{Seive Result}: \mathrm{h_i}=\textit{rather poor} \\ \mathrm{T_3}=\{\mathrm{h_i}\,|\,0.4<\mathrm{h_i}\le 0.6\}, \\ \text{Seive Result}: \mathrm{h_i}=\textit{poor} \\ \mathrm{T_4}=\{\mathrm{h_i}\,|\,0.6<\mathrm{h_i}\le 0.8\} \\ \text{Seive Result}: \mathrm{h_i}=\textit{almost very poor} \\ \mathrm{T_5}=\{\mathrm{h_i}\,|\,0.8<\mathrm{h_i}\le 1\} \\ \text{Seive Result}: \mathrm{h_i}=\textit{very poor} \end{array}\right\} \tag{5}$$

4. Case Study

We selected a random sample of 5 households from Ben Block, Nalanda District, Bihar, India from the available data by field work done by us. They are represented Figure 2. by Household-1, Household-2 … Household-5.

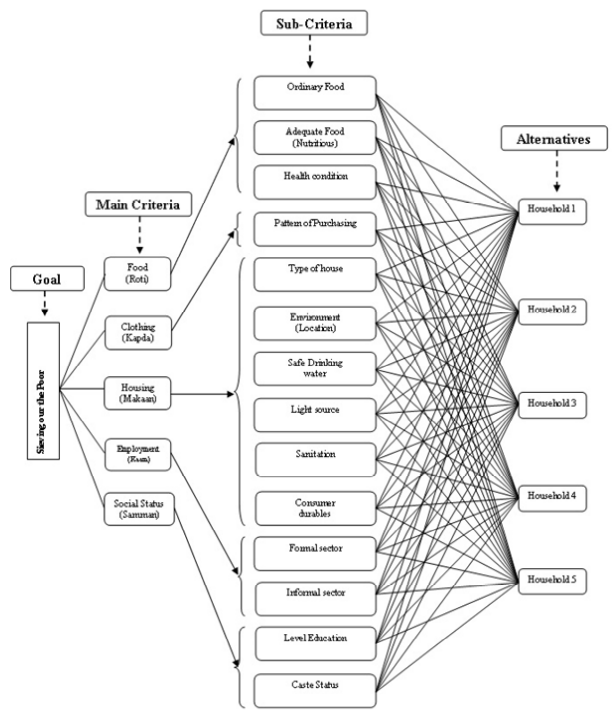

Figure 2. Alternative (Households) Hierarchy Tree for five households (H-1,…H-5).

4.1 Pair –Wise Comparison of the Main Criteria using Fuzzy Pentagonal Numbers

Table 1. Fuzzy Decision Matrix: calculating the intensity of importance of main criteria

	Roti	Kapda	Makaan	Kaam	Samman
Roti	(1,1,1,1,1)	(5,6,7,8,9)	(6,7,8,9,9)	(1/9,1/9,1/9,1/8,1/7)	(1/6,1/5,1/4,1/3,1/2)
Kapda	(1/9,1/8,1/7,1/6,1/5)	(1,1,1,1,1)	(5,6,7,8,9)	(1/9,1/9,1/9,1/8,1/7)	(6,7,8,9,9)
Makaan	(1/9,1/9,1/8,1/7,1/6)	(1/9,1/8,1/7,1/6,1/5)	(1,1,1,1,1)	(1/9,1/9,1/9,1/8,1/7)	(7,8,9,9,9)
Kaam	(7,8,9,9,9)	(7,8,9,9,9)	(7,8,9,9,9)	(1,1,1,1,1)	(7,8,9,9,9)
Samman	(2,3,4,5,6)	(1/9,1/9,1/8,1/7,1/6)	(1/9,1/9,1/9,1/8,1/7)	(1/9,1/9,1/9,1/8,1/7)	(1,1,1,1,1)

4.1.1 Normalization of Main Criteria

Table 2. Aggregate sum of main criteria

Roti	(1,1,1,1,1)	1.0000	5.0000	6.0000	0.1111	0.1667	**12.2778**
	(5,6,7,8,9)	1.0000	6.0000	7.0000	0.1111	0.2000	**14.3111**
	(6,7,8,9,9)	1.0000	7.0000	8.0000	0.1111	0.2500	**16.3611**
	(1/9,1/9,1/9,1/8,1/7)	1.0000	8.0000	9.0000	0.1250	0.3333	**18.4583**
	(1/6,1/5,1/4,1/3,1/2)	1.0000	9.0000	9.0000	0.1429	0.5000	**19.6429**
Kapda	(1/9,1/8,1/7,1/6,1/5)	0.1111	1.0000	5.0000	0.1111	6.0000	**12.2222**
	(1,1,1,1,1)	0.1250	1.0000	6.0000	0.1111	7.0000	**14.2361**
	(5,6,7,8,9)	0.1429	1.0000	7.0000	0.1111	8.0000	**16.2540**
	(1/9,1/9,1/9,1/8,1/7)	0.1667	1.0000	8.0000	0.1250	9.0000	**18.2917**
	(6,7,8,9,9)	0.2000	1.0000	9.0000	0.1429	9.0000	**19.3429**
Makaan	(1/9,1/9,1/8,1/7,1/6)	0.1111	0.1111	1.0000	0.1111	7.0000	**8.3333**
	(1/9,1/8,1/7,1/6,1/5)	0.1111	0.1250	1.0000	0.1111	8.0000	**9.3472**
	(1,1,1,1,1)	0.1250	0.1429	1.0000	0.1111	9.0000	**10.3790**
	(1/9,1/9,1/9,1/8,1/7)	0.1429	0.1667	1.0000	0.1250	9.0000	**10.4345**
	(7,8,9,9,9)	0.1667	0.2000	1.0000	0.1429	9.0000	**10.5095**
Kaam	(7,8,9,9,9)	7.0000	7.0000	7.0000	1.0000	7.0000	**29.0000**
	(7,8,9,9,9)	8.0000	8.0000	8.0000	1.0000	8.0000	**33.0000**
	(7,8,9,9,9)	9.0000	9.0000	9.0000	1.0000	9.0000	**37.0000**
	(1,1,1,1,1)	9.0000	9.0000	9.0000	1.0000	9.0000	**37.0000**
	(7,8,9,9,9)	9.0000	9.0000	9.0000	1.0000	9.0000	**37.0000**
Samman	(2,3,4,5,6)	2.0000	0.1111	0.1111	0.1111	1.0000	**3.3333**
	(1/9,1/9,1/8,1/7,1/6)	3.0000	0.1111	0.1111	0.1111	1.0000	**4.3333**
	(1/9,1/9,1/9,1/8,1/7)	4.0000	0.1250	0.1111	0.1111	1.0000	**5.3472**
	(1/9,1/9,1/9,1/8,1/7)	5.0000	0.1429	0.1250	0.1250	1.0000	**6.3929**
	(1,1,1,1,1)	6.0000	0.1667	0.1429	0.1429	1.0000	**7.4524**

4.1.1.1 Fuzzy Centre Normalized Weight with Pentagonal Fuzzy Number

Table 3. Normalized centre weight of main criteria

Criteria	Normalized Fuzzy Weights								Average	Fuzzy Centre Weight
Roti	31.6206	0.3883	22.7873	0.5388	49.2778	0.2492	19.7302	0.6223	0.4496	0.5452
	32.6028	0.4390	24.7456	0.5783	51.3111	0.2789	20.7040	0.6912	0.4969	
	32.6151	0.5016	26.7401	0.6119	53.3611	0.3066	21.7083	0.7537	0.5434	
	32.6944	0.5646	27.8056	0.6638	51.4583	0.3587	22.7917	0.8099	0.5992	
	31.8651	0.6164	27.9762	0.7021	48.6429	0.4038	22.9762	0.8549	0.6443	
Kapda	22.7317	0.5377	49.2222	0.2483	19.6746	0.6212	31.8651	0.3836	0.4477	0.5429
	24.6706	0.5770	51.2361	0.2779	20.6290	0.6901	32.6944	0.4354	0.4951	
	26.6329	0.6103	53.2540	0.3052	21.6012	0.7525	32.6151	0.4984	0.5416	
	27.6389	0.6618	51.2917	0.3566	22.6250	0.8085	32.6028	0.5610	0.5970	
	27.6762	0.6989	48.3429	0.4001	22.6762	0.8530	31.6206	0.6117	0.6409	
Makaan	45.3333	0.1838	15.7857	0.5279	27.9762	0.2979	27.6762	0.3011	0.3277	0.4108
	46.3472	0.2017	15.7401	0.5938	27.8056	0.3362	27.6389	0.3382	0.3675	
	47.3790	0.2191	15.7262	0.6600	26.7401	0.3881	26.6329	0.3897	0.4142	
	43.4345	0.2402	14.7679	0.7066	24.7456	0.4217	24.6706	0.4230	0.4479	
	39.5095	0.2660	13.8429	0.7592	22.7873	0.4612	22.7317	0.4623	0.4872	
Kaam	36.4524	0.7956	48.6429	0.5962	48.3429	0.5999	39.5095	0.7340	0.6814	0.7530
	39.3929	0.8377	51.4583	0.6413	51.2917	0.6434	43.4345	0.7598	0.7205	
	42.3472	0.8737	53.3611	0.6934	53.2540	0.6948	47.3790	0.7809	0.7607	
	41.3333	0.8952	51.3111	0.7211	51.2361	0.7221	46.3472	0.7983	0.7842	
	40.3333	0.9174	49.2778	0.7508	49.2222	0.7517	45.3333	0.8162	0.8090	
Samman	22.9762	0.1451	22.6762	0.1470	13.8429	0.2408	40.3333	0.0826	0.1539	0.2481
	22.7917	0.1901	22.6250	0.1915	14.7679	0.2934	41.3333	0.1048	0.1950	
	21.7083	0.2463	21.6012	0.2475	15.7262	0.3400	42.3472	0.1263	0.2400	
	20.7040	0.3088	20.6290	0.3099	15.7401	0.4062	39.3929	0.1623	0.2968	
	19.7302	0.3777	19.6746	0.3788	15.7857	0.4721	36.4524	0.2044	0.3583	

4.1.2 Normalization of Sub-Criteria Food (ROTI)

Table 4. Relative weight importance of the food – sub-criteria

	Staple Food Intake	Adequate Food (Notorious) Intake	Health Condition
Staple Food Intake	(1,1,1,1,1)	(1/9, 1/8, 1/7, 1/6, 1/5)	(1/8, 1/7, 1/6, 1/5, 1/4)
Adequate Food	(5,6,7,8,9)	(1,1,1,1,1)	(1,1,1,1,1)
Health Condition	(4,5,6,7,8)	(1,1,1,1,1)	(1,1,1,1,1)

Table 5. Aggregated sum of the relative weight

W 1	W 2	W 3	RW1	RW2	RW3
1.236111	7	6	1.45	11	10
1.267857	8	7	1.366667	10	9
1.309524	9	8	1.309524	9	8
1.366667	10	9	1.267857	8	7
1.45	11	10	1.236111	7	6

4.1.2.1 Fuzzy Centre Normalized Weight with Pentagonal Fuzzy Number for ROTI

Table 6. Normalized centre weight of sub-criteria ROTI

Normalized Fuzzy Weights		Average	Fuzzy Centre Weight	RW2	RW3
0.101022	0.110012	0.105517	0.139079	11	10
0.11252	0.123478	0.117999		10	9
0.127021	0.140665	0.133843		9	8
0.145907	0.163347	0.154627		8	7
0.171598	0.194631	0.183114		7	6
Normalized Fuzzy Weights		**Average**	**Fuzzy Centre Weight**	**RW1**	**RW3**
0.828402	0.411765	0.620084	0.698873	1.45	10
0.854093	0.470588	0.66234		1.366667	9
0.872979	0.529412	0.701195		1.309524	8
0.88748	0.588235	0.737858		1.267857	7
0.898978	0.647059	0.773019		1.236111	6
Normalized Fuzzy Weights		**Average**	**Fuzzy Centre Weight**	**RW1**	**RW2**
0.805369	0.352941	0.579155	0.662047	1.45	11
0.836653	0.411765	0.624209		1.366667	10
0.859335	0.470588	0.664962		1.309524	9
0.876522	0.529412	0.702967		1.267857	8
0.889988	0.588235	0.739111		1.236111	7

4.1.3 Normalization of Sub-Criteria Housing (MAKAAN)

4.1.3.1 Pair-Wise Comparison Decision Matrix for Housing

	Types of Housing	Environment	Safe drinking water	Light sources	Sanitation	Consumer durables
Types of Housing	(1,1,1,1,1)	(1/5, 1/4, 1/3, 1/2, 1)	(1/7, 1/6, 1/5, 1/4, 1/3)	(1/7, 1/6, 1/5, 1/4, 1/3)	(1/7, 1/6, 1/5, 1/4, 1/3)	(1,2,3,4,5)
Environment	(1,2,3,4,5)	(1,1,1,1,1)	(1,1,1,1,1)	(1,2,3,4,5)	(1,2,3,4,5)	(2,3,4,5,6)
Safe drinking water	(3,4,5,6,7)	(1,1,1,1,1)	(1,1,1,1,1)	(5,6,7,8,9)	(3,4,5,6,7)	(4,5,6,7,8)
Light sources	(3,4,5,6,7)	(1/5, 1/4, 1/3, 1/2, 1)	(1/9, 1/8, 1/7, 1/6, 1/5)	(1,1,1,1,1)	(1,2,3,4,5)	(1,2,3,4,5)
Sanitation	(3,4,5,6,7)	(1/5, 1/4, 1/3, 1/2, 1)	(1/7, 1/6, 1/5, 1/4, 1/3)	(1/5, 1/4, 1/3, 1/2, 1)	(1,1,1,1,1)	(1/5, 1/4, 1/3, 1/2, 1)
Consumer durables	(1/5, 1/4, 1/3, 1/2, 1)	(1/6, 1/5, 1/4, 1/3, 1/2)	(1/8, 1/7, 1/6, 1/5, 1/4)	(1/5, 1/4, 1/3, 1/2, 1)	(1,2,3,4,5)	(1,1,1,1,1)

Table 7. Aggregated sum of the relative weight

W 1	W 2	W 3	W 4	W 5	W 6
2.628571	7	17	6.311111	4.742857	2.691667
3.75	11	21	9.375	5.916667	3.842857
4.933333	15	25	12.47619	7.2	5.083333
6.25	19	29	15.66667	8.75	6.533333
8	23	33	19.2	11.33333	8.75

Table 8. Aggregated sum of the relative weight

RW1	RW2	RW3	RW4	RW5	RW6
8	23	33	19.2	11.33333	8.75
6.25	19	29	15.66667	8.75	6.533333
4.933333	15	25	12.47619	7.2	5.083333
3.75	11	21	9.375	5.916667	3.842857
2.628571	7	17	6.311111	4.742857	2.691667

4.1.3.2 Fuzzy Centre Normalized Weight with Pentagonal Fuzzy Number for MAKAAN

Table 9. Normalized centre weight of sub-criteria MAKAAN.

Normalized Fuzzy Weights					AVERAGE	FCW	RW2	RW3	RW4	RW5	RW6
0.1026	0.0738	0.1204	0.1883	0.2310	0.1432		23.0000	33.0000	19.2000	11.3333	8.7500
0.1648	0.1145	0.1931	0.3000	0.3647	0.2274		19.0000	29.0000	15.6667	8.7500	6.5333
0.2475	0.1648	0.2834	0.4066	0.4925	0.3190	0.3347	15.0000	25.0000	12.4762	7.2000	5.0833
0.3623	0.2294	0.4000	0.5137	0.6192	0.4249		11.0000	21.0000	9.3750	5.9167	3.8429
0.5333	0.3200	0.5590	0.6278	0.7482	0.5577		7.0000	17.0000	6.3111	4.7429	2.6917
Normalized Fuzzy Weights					**AVERAGE**	**FCW**	**RW1**	**RW3**	**RW4**	**RW5**	**RW6**
0.4667	0.1750	0.2672	0.3818	0.4444	0.3470		8.0000	33.0000	19.2000	11.3333	8.7500
0.6377	0.2750	0.4125	0.5570	0.6274	0.5019		6.2500	29.0000	15.6667	8.7500	6.5333
0.7525	0.3750	0.5459	0.6757	0.7469	0.6192	0.5954	4.9333	25.0000	12.4762	7.2000	5.0833
0.8352	0.4750	0.6696	0.7625	0.8318	0.7148		3.7500	21.0000	9.3750	5.9167	3.8429
0.8974	0.5750	0.7847	0.8290	0.8952	0.7963		2.6286	17.0000	6.3111	4.7429	2.6917
Normalized Fuzzy Weights					**AVERAGE**	**FCW**	**RW1**	**RW2**	**RW4**	**RW5**	**RW6**
0.6800	0.4250	0.4696	0.6000	0.6602	0.0957		8.0000	23.0000	19.2000	11.3333	8.7500
0.7706	0.5250	0.5727	0.7059	0.7627	0.0948		6.2500	19.0000	15.6667	8.7500	6.5333
0.8352	0.6250	0.6671	0.7764	0.8310	0.0807	0.0738	4.9333	15.0000	12.4762	7.2000	5.0833
0.8855	0.7250	0.7557	0.8305	0.8830	0.0605		3.7500	11.0000	9.3750	5.9167	3.8429
0.9262	0.8250	0.8395	0.8743	0.9246	0.0380		2.6286	7.0000	6.3111	4.7429	2.6917
Normalized Fuzzy Weights					**AVERAGE**	**FCW**	**RW1**	**RW2**	**RW3**	**RW5**	**RW6**
0.4410	0.2153	0.1605	0.3577	0.4190	0.3187		8.0000	23.0000	33.0000	11.3333	8.7500
0.6000	0.3304	0.2443	0.5172	0.5893	0.4563		6.2500	19.0000	29.0000	8.7500	6.5333
0.7166	0.4541	0.3329	0.6341	0.7105	0.5696	0.5556	4.9333	15.0000	25.0000	7.2000	5.0833
0.8069	0.5875	0.4273	0.7259	0.8030	0.6701		3.7500	11.0000	21.0000	5.9167	3.8429
0.8796	0.7328	0.5304	0.8019	0.8770	0.7643		2.6286	7.0000	17.0000	4.7429	2.6917
Normalized Fuzzy Weights					**AVERAGE**	**FCW**	**RW1**	**RW2**	**RW3**	**RW4**	**RW6**
0.3722	0.1710	0.1257	0.1981	0.3515	0.2437		8.0000	23.0000	33.0000	19.2000	8.7500
0.4863	0.2375	0.1695	0.2741	0.4752	0.3285		6.2500	19.0000	29.0000	15.6667	6.5333
0.5934	0.3243	0.2236	0.3659	0.5862	0.4187	0.4343	4.9333	15.0000	25.0000	12.4762	5.0833
0.7000	0.4430	0.2941	0.4828	0.6948	0.5230		3.7500	11.0000	21.0000	9.3750	3.8429
0.8117	0.6182	0.4000	0.6423	0.8081	0.6561		2.6286	7.0000	17.0000	6.3111	2.6917

(*Continued*)

Table 9. Continued

Normalized Fuzzy Weights					AVERAGE	FCW	RW1	RW2	RW3	RW4	RW5
0.2518	0.1048	0.0754	0.1230	0.1919	0.1494		8.0000	23.0000	33.0000	19.2000	11.3333
0.3808	0.1682	0.1170	0.1970	0.3052	0.2336		6.2500	19.0000	29.0000	15.6667	8.7500
0.5075	0.2531	0.1690	0.2895	0.4138	0.3266	0.3453	4.9333	15.0000	25.0000	12.4762	7.2000
0.6353	0.3726	0.2373	0.4107	0.5248	0.4361		3.7500	11.0000	21.0000	9.3750	5.9167
0.7690	0.5556	0.3398	0.5810	0.6485	0.5788		2.6286	7.0000	17.0000	6.3111	4.7429

4.1.4 Normalization of Sub-Criteria Employment Status (KAAM)

4.1.4.1 Pairwise Comparison Decision Matrix for Employment Status

	Formal Sector	Informal Sector
Formal Sector	(1,1,1,1,1)	(5,6,7,8,9)
Informal Sector	(1/9,1/8,1/7,1/6,1/5)	(1,1,1,1,1)

Table 10. Aggregated sum of the relative weight

W 1	W 2	RW1	RW2
6	1.111111	10	1.2
7	1.125	9	1.166667
8	1.142857	8	1.142857
9	1.166667	7	1.125
10	1.2	6	1.111111

4.1.4.2 Fuzzy Centre Normalized Weight with Pentagonal Fuzzy Number for KAAM

Table 11. Normalized centre weight of sub-criteria KAAM

Normalized Fuzzy Weights				AVERAGE	FCW	RW2
0.833333	0	0	0	0.833333		1.2
0.857143	0	0	0	0.857143		1.166667
0.875	0	0	0	0.875	0.870833	1.142857
0.888889	0	0	0	0.888889		1.125
0.9	0	0	0	0.9		1.111111
Normalized Fuzzy Weights				**AVERAGE**	**FCW**	**RW1**
0.1	0	0	0	0.1		10
0.111111	0	0	0	0.111111		9
0.125	0	0	0	0.125	0.129167	8
0.142857	0	0	0	0.142857		7
0.166667	0	0	0	0.166667		6

4.1.5 Normalization of Sub-Criteria (SAMMAN)

4.1.5.1 Pair Wise Comparison Decision Matrix for Social Status

	Education	Caste Status
Education	(1,1,1,1,1)	(7,8,9,9,9)
Caste Status	(1/9,1/9,1/9,1/8,1/7)	(1,1,1,1,1)

Table 12. Aggregated sum of the relative weight

W 1	W 2	RW1	RW2
10.0000	1.1111	10.0000	1.1111
10.0000	1.1111	10.0000	1.1111
10.0000	1.1111	10.0000	1.1111
10.0000	1.1111	10.0000	1.1111
10.0000	1.1111	10.0000	1.1111

4.1.5.2 Fuzzy Centre Normalized Weight with Pentagonal Fuzzy Number for SAMMAN

Table 13. Normalized centre weight of sub-criteria SAMMAN

Normalized Fuzzy Weights				AVERAGE	FCW	RW2
0.9000	0.0000	0.0000	0.0000	0.9000		1.1111
0.9000	0.0000	0.0000	0.0000	0.9000		1.1111
0.9000	0.0000	0.0000	0.0000	0.9000	0.9000	1.1111
0.9000	0.0000	0.0000	0.0000	0.9000		1.1111
0.9000	0.0000	0.0000	0.0000	0.9000		1.1111
Normalized Fuzzy Weights				**AVERAGE**	**FCW**	**RW1**
0.1000	0.0000	0.0000	0.0000	0.1000		10.0000
0.1000	0.0000	0.0000	0.0000	0.1000		10.0000
0.1000	0.0000	0.0000	0.0000	0.1000	0.1000	10.0000
0.1000	0.0000	0.0000	0.0000	0.1000		10.0000
0.1000	0.0000	0.0000	0.0000	0.1000		10.0000

4.2 Block BEN

Table 14. Pair wise comparison of five households for the staple food

	H_1	H_2	H_3	H_4	H_5
H_1	(1,1,1,1,1)	(1,2,3,4,5)	(3,4,5,6,7)	(4,5,6,7,8)	(3,4,5,6,7)
H_2	(1/5,1/4,1/3,1/2,1)	(1,1,1,1,1)	(2,3,4,5,6)	(3,4,5,6,7)	(4,5,6,7,8)
H_3	(1/7,1/6,1/5,1/4,1/3,)	(1/6,1/5,1/4,1/3,1/2)	(1,1,1,1,1)	(1,2,3,4,5)	(2,3,4,5,6)
H_4	(1/8,1/7,1/6,1/5,1/4)	(1/7,1/6,1/5,1/4,1/3,)	(1/5,1/4,1/3,1/2,1)	(1,1,1,1,1)	(3,4,5,6,7)
H_5	(1/7,1/6,1/5,1/4,1/3,)	(1/8,1/7,1/6,1/5,1/4)	(1/6,1/5,1/4,1/3,1/2)	(1/7,1/6,1/5,1/4,1/3,)	(1,1,1,1,1)
Normalized Fuzzy Centre Weight	**0.7176**	**0.6726**	**0.5006**	**0.4465**	**0.1627**

Table 15. Pair wise comparison of five households for the adequate food

	H_1	H_2	H_3	H_4	H_5
H_1	(1,1,1,1,1)	(3,4,5,6,7)	(4,5,6,7,8)	(5,6,7,8,9)	(5,6,7,8,9)
H_2	(1/7,1/6,1/5,1/4,1/3,)	(1,1,1,1,1)	(4,5,6,7,8)	(3,4,5,6,7)	(3,4,5,6,7)
H_3	(1/8,1/7,1/6,1/5,1/4)	(1/8,1/7,1/6,1/5,1/4)	(1,1,1,1,1)	(2,3,4,5,6)	(4,5,6,7,8)
H_4	(1/9,1/8,1/7,1/6,1/5)	(1/7,1/6,1/5,1/4,1/3,)	(1/6,1/5,1/4,1/3,1/2)	(1,1,1,1,1)	(5,6,7,8,9)
H_5	(1/9,1/8,1/7,1/6,1/5)	(1/7,1/6,1/5,1/4,1/3,)	(1/8,1/7,1/6,1/5,1/4)	(1/9,1/8,1/7,1/6,1/5)	(1,1,1,1,1)
Normalized Fuzzy Centre Weight	**0.7406**	**0.6393**	**0.5339**	**0.4685**	**0.1176**

Table 16. Pair wise comparison of five households for the health condition

	H_1	H_2	H_3	H_4	H_5
H_1	(1,1,1,1,1)	(3,4,5,6,7)	(3,4,5,6,7)	(5,6,7,8,9)	(6,7,8,9,9)
H_2	(1/7,1/6,1/5,1/4,1/3)	(1,1,1,1,1)	(4,5,6,7,8)	(5,6,7,8,9)	(5,6,7,8,9)
H_3	(1/7,1/6,1/5,1/4,1/3)	(1/8,1/7,1/6,1/5,1/4)	(1,1,1,1,1)	(4,5,6,7,8)	(5,6,7,8,9)
H_4	(1/9,1/8,1/7,1/6,1/5)	(1/9,1/8,1/7,1/6,1/5)	(1/8,1/7,1/6,1/5,1/4)	(1,1,1,1,1)	(6,7,8,9,9)
H_5	(1/9,1/9,1/8,1/7,1/6)	(1/9,1/8,1/7,1/6,1/5)	(1/9,1/8,1/7,1/6,1/5)	(1/9,1/9,1/8,1/7,1/6)	(1,1,1,1,1)
Normalized Fuzzy Centre Weight	**0.7124**	**0.6659**	**0.5683**	**0.4578**	**0.0956**

Table 17. Pair wise comparison of five households for the clothing

	H_1	H_2	H_3	H_4	H_5
H_1	(1,1,1,1,1)	(2,3,4,5,6)	(2,3,4,5,6)	(4,5,6,7,8)	(4,5,6,7,8)
H_2	(1/6,1/5,1/4,1/3,1/2)	(1,1,1,1,1)	(4,5,6,7,8)	(5,6,7,8,9)	(4,5,6,7,8)
H_3	(1/6,1/5,1/4,1/3,1/2)	(1/8,1/7,1/6,1/5,1/4)	(1,1,1,1,1)	(6,7,8,9,9)	(5,6,7,8,9)
H_4	(1/8,1/7,1/6,1/5,1/4)	(1/9,1/8,1/7,1/6,1/5)	(1/9,1/9,1/8,1/7,1/6)	(1,1,1,1,1)	(6,7,8,9,9)
H_5	(1/8,1/7,1/6,1/5,1/4)	(1/8,1/7,1/6,1/5,1/4)	(1/9,1/8,1/7,1/6,1/5)	(1/9,1/9,1/8,1/7,1/6)	(1,1,1,1,1)
Normalized Fuzzy Centre Weight	**0.6659**	**0.6618**	**0.6081**	**0.4627**	**0.1015**

Table 18. Pair wise comparison of five households for the types of house

	H_1	H_2	H_3	H_4	H_5
H_1	(1,1,1,1,1)	(1,2,3,4,5)	(4,5,6,7,8)	(4,5,6,7,8)	(5,6,7,8,9)
H_2	(1/5,1/4,1/3,1/2,1)	(1,1,1,1,1)	(3,4,5,6,7)	(3,4,5,6,7)	(4,5,6,7,8)
H_3	(1/8,1/7,1/6,1/5,1/4)	(1/7,1/6,1/5,1/4,1/3)	(1,1,1,1,1)	(2,3,4,5,6)	(4,5,6,7,8)
H_4	(1/8,1/7,1/6,1/5,1/4)	(1/7,1/6,1/5,1/4,1/3)	(1/6,1/5,1/4,1/3,1/2)	(1,1,1,1,1)	(5,6,7,8,9)
H_5	(1/9,1/8,1/7,1/6,1/5)	(1/8,1/7,1/6,1/5,1/4)	(1/8,1/7,1/6,1/5,1/4)	(1/9,1/8,1/7,1/6,1/5)	(1,1,1,1,1)
Normalized Fuzzy Centre Weight	**0.7429**	**0.6782**	**0.4306**	**0.5096**	**0.1387**

Table 19. Pair wise comparison of five households for the environment

	H_1	H_2	H_3	H_4	H_5
H_1	(1,1,1,1,1)	(2,3,4,5,6)	(3,4,5,6,7)	(5,6,7,8,9)	(5,6,7,8,9)
H_2	(1/6,1/5,1/4,1/3,1/2)	(1,1,1,1,1)	(3,4,5,6,7)	(6,7,8,9,9)	(6,7,8,9,9)
H_3	(1/7,1/6,1/5,1/4,1/3)	(1/7,1/6,1/5,1/4,1/3)	(1,1,1,1,1)	(4,5,6,7,8)	(5,6,7,8,9)
H_4	(1/9,1/8,1/7,1/6,1/5)	(1/9,1/9,1/8,1/7,1/6)	(1/8,1/7,1/6,1/5,1/4)	(1,1,1,1,1)	(6,7,8,9,9)
H_5	(1/9,1/8,1/7,1/6,1/5)	(1/9,1/9,1/8,1/7,1/6)	(1/9,1/8,1/7,1/6,1/5)	(1/9,1/9,1/8,1/7,1/6)	(1,1,1,1,1)
Normalized Fuzzy Centre Weight	**0.6960**	**0.6771**	**0.5714**	**0.4594**	**0.0961**

Table 20. Pair wise comparison of five households for the safe drinking water

	H_1	H_2	H_3	H_4	H_5
H_1	(1,1,1,1,1)	(1,1,2,3,4)	(3,4,5,6,7)	(2,3,4,5,6)	(4,5,6,7,8)
H_2	(1/4,1/3,1/2,1,1)	(1,1,1,1,1)	(1,2,3,4,5)	(2,3,4,5,6)	(3,4,5,6,7)
H_3	(1/7,1/6,1/5,1/4,1/3)	(1/5,1/4,1/3,1/2,1)	(1,1,1,1,1)	(5,6,7,8,9)	(6,7,8,9,9)
H_4	(1/6,1/5,1/4,1/3,1/2)	(1/6,1/5,1/4,1/3,1/2)	(1/9,1/8,1/7,1/6,1/5)	(1,1,1,1,1)	(3,4,5,6,7)
H_5	(1/8,1/7,1/6,1/5,1/4)	(1/7,1/6,1/5,1/4,1/3)	(1/9,1/9,1/8,1/7,1/6)	(1/7,1/6,1/5,1/4,1/3)	(1,1,1,1,1)
Normalized Fuzzy Centre Weight	**0.6765**	**0.5990**	**0.6605**	**0.4284**	**0.1356**

Table 21. Pair wise comparison of five households for the light source

	H_1	H_2	H_3	H_4	H_5
H_1	(1,1,1,1,1)	(2,3,4,5,6)	(3,4,5,6,7)	(4,5,6,7,8)	(5,6,7,8,9)
H_2	(1/6,1/5,1/4,1/3,1/2)	(1,1,1,1,1)	(1,2,3,4,5)	(3,4,5,6,7)	(4,5,6,7,8)
H_3	(1/7,1/6,1/5,1/4,1/3)	(1/5,1/4,1/3,1/2,1)	(1,1,1,1,1)	(6,7,8,9,9)	(4,5,6,7,8)
H_4	(1/8,1/7,1/6,1/5,1/4)	(1/7,1/6,1/5,1/4,1/3)	(1/9,1/9,1/8,1/7,1/6)	(1,1,1,1,1)	(5,6,7,8,9)
H_5	(1/9,1/8,1/7,1/6,1/5)	(1/8,1/7,1/6,1/5,1/4)	(1/8,1/7,1/6,1/5,1/4)	(1/9,1/8,1/7,1/6,1/5)	(1,1,1,1,1)
Normalized Fuzzy Centre Weight	**0.7082**	**0.6044**	**0.6141**	**0.4614**	**0.1119**

Table 22. Pairwise comparison of five households for the sanitary facility

	H_1	H_2	H_3	H_4	H_5
H_1	(1,1,1,1,1)	(3,4,5,6,7)	(4,5,6,7,8)	(5,6,7,8,9)	(6,7,8,9,9)
H_2	(1/7,1/6,1/5,1/4,1/3)	(1,1,1,1,1)	(2,3,4,5,6)	(3,4,5,6,7)	(4,5,6,7,8)
H_3	(1/8,1/7,1/6,1/5,1/4)	(1/6,1/5,1/4,1/3,1/2)	(1,1,1,1,1)	(5,6,7,8,9)	(6,7,8,9,9)
H_4	(1/9,1/8,1/7,1/6,1/5)	(1/7,1/6,1/5,1/4,1/3)	(1/9,1/8,1/7,1/6,1/5)	(1,1,1,1,1)	(6,7,8,9,9)
H_5	(1/9,1/9,1/8,1/7,1/6)	(1/8,1/7,1/6,1/5,1/4)	(1/9,1/9,1/8,1/7,1/6)	(1/9,1/9,1/8,1/7,1/6)	(1,1,1,1,1)
Normalized Fuzzy Centre Weight	**0.7285**	**0.6009**	**0.6074**	**0.4649**	**0.0983**

Table 23. Pair wise comparison of five households for the consumer durables

	H_1	H_2	H_3	H_4	H_5
H_1	(1,1,1,1,1)	(4,5,6,7,8)	(5,6,7,8,9)	(6,7,8,9,9)	(4,5,6,7,8)
H_2	(1/8,1/7,1/6,1/5,1/4)	(1,1,1,1,1)	(3,4,5,6,7)	(3,4,5,6,7)	(4,5,6,7,8)
H_3	(1/9,1/8,1/7,1/6,1/5)	(1/7,1/6,1/5,1/4,1/3)	(1,1,1,1,1)	(4,5,6,7,8)	(5,6,7,8,9)
H_4	(1/9,1/9,1/8,1/7,1/6)	(1/7,1/6,1/5,1/4,1/3)	(1/8,1/7,1/6,1/5,1/4)	(1,1,1,1,1)	(6,7,8,9,9)
H_5	(1/8,1/7,1/6,1/5,1/4)	(1/8,1/7,1/6,1/5,1/4)	(1/9,1/8,1/7,1/6,1/5)	(1/9,1/9,1/8,1/7,1/6)	(1,1,1,1,1)
Normalized Fuzzy Centre Weight	**0.7383**	**0.6175**	**0.5753**	**0.4660**	**0.1030**

Table 24. Pair wise comparison of five households for the employment – Formal Sector

	H_1	H_2	H_3	H_4	H_5
H_1	(1,1,1,1,1)	(3,4,5,6,7)	(4,5,6,7,8)	(4,5,6,7,8)	(5,6,7,8,9)
H_2	(1/7,1/6,1/5,1/4,1/3)	(1,1,1,1,1)	(4,5,6,7,8)	(5,6,7,8,9)	(5,6,7,8,9)
H_3	(1/8,1/7,1/6,1/5,1/4)	(1/8,1/7,1/6,1/5,1/4)	(1,1,1,1,1)	(6,7,8,9,9)	(3,4,5,6,7)
H_4	(1/8,1/7,1/6,1/5,1/4)	(1/9,1/8,1/7,1/6,1/5)	(1/9,1/9,1/8,1/7,1/6)	(1,1,1,1,1)	(6,7,8,9,9)
H_5	(1/9,1/8,1/7,1/6,1/5)	(1/9,1/8,1/7,1/6,1/5)	(1/7,1/6,1/5,1/4,1/3)	(1/9,1/9,1/8,1/7,1/6)	(1,1,1,1,1)
Normalized Fuzzy Centre Weight	**0.7062**	**0.6681**	**0.5659**	**0.4584**	**0.1015**

Table 25. Pair wise comparison of five households for the employment – Informal Sector

	H_1	H_2	H_3	H_4	H_5
H_1	(1,1,1,1,1)	(3,4,5,6,7)	(5,6,7,8,9)	(6,7,8,9,9)	(6,7,8,9,9)
H_2	(1/7,1/6,1/5,1/4,1/3)	(1,1,1,1,1)	(4,5,6,7,8)	(5,6,7,8,9)	(6,7,8,9,9)
H_3	(1/9,1/8,1/7,1/6,1/5)	(1/8,1/7,1/6,1/5,1/4)	(1,1,1,1,1)	(4,5,6,7,8)	(5,6,7,8,9)
H_4	(1/9,1/9,1/8,1/7,1/6)	(1/9,1/8,1/7,1/6,1/5)	(1/8,1/7,1/6,1/5,1/4)	(1,1,1,1,1)	(4,5,6,7,8)
H_5	(1/9,1/9,1/8,1/7,1/6)	(1/9,1/9,1/8,1/7,1/6)	(1/9,1/8,1/7,1/6,1/5)	(1/8,1/7,1/6,1/5,1/4)	(1,1,1,1,1)
Normalized Fuzzy Centre Weight	**0.7389**	**0.6774**	**0.5708**	**0.4099**	**0.1030**

Table 26. Pair wise comparison of five households for the education

	H_1	H_2	H_3	H_4	H_5
H_1	(1,1,1,1,1)	(4,5,6,7,8)	(5,6,7,8,9)	(6,7,8,9,9)	(7,8,9,9,9)
H_2	(1/8,1/7,1/6,1/5,1/4)	(1,1,1,1,1)	(3,4,5,6,7)	(5,6,7,8,9)	(6,7,8,9,9)
H_3	(1/9,1/8,1/7,1/6,1/5)	(1/7,1/6,1/5,1/4,1/3)	(1,1,1,1,1)	(6,7,8,9,9)	(5,6,7,8,9)
H_4	(1/9,1/9,1/8,1/7,1/6)	(1/9,1/8,1/7,1/6,1/5)	(1/9,1/9,1/8,1/7,1/6)	(1,1,1,1,1)	(4,5,6,7,8)
H_5	(1/9,1/9,1/9,1/8,1/7)	(1/9,1/9,1/8,1/7,1/6)	(1/9,1/8,1/7,1/6,1/5)	(1/8,1/7,1/6,1/5,1/4)	(1,1,1,1,1)
Normalized Fuzzy Centre Weight	**0.7465**	**0.6576**	**0.5946**	**0.4018**	**0.0995**

Table 27. Pair wise comparison of five households for the caste status

	H_1	H_2	H_3	H_4	H_5
H_1	(1,1,1,1,1)	(1,2,3,4,5)	(3,4,5,6,7)	(4,5,6,7,8)	(3,4,5,6,7)
H_2	(1/5,1/4,1/3,1/2,1)	(1,1,1,1,1)	(4,5,6,7,8)	(5,6,7,8,9)	(6,7,8,9,9)
H_3	(1/7,1/6,1/5,1/4,1/3)	(1/8,1/7,1/6,1/5,1/4)	(1,1,1,1,1)	(4,5,6,7,8)	(5,6,7,8,9)
H_4	(1/8,1/7,1/6,1/5,1/4)	(1/9,1/8,1/7,1/6,1/5)	(1/8,1/7,1/6,1/5,1/4)	(1,1,1,1,1)	(6,7,8,9,9)
H_5	(1/7,1/6,1/5,1/4,1/3)	(1/9,1/9,1/8,1/7,1/6)	(1/9,1/8,1/7,1/6,1/5)	(1/9,1/9,1/8,1/7,1/6)	(1,1,1,1,1)
Normalized Fuzzy Centre Weight	**0.6570**	**0.6905**	**0.5801**	**0.4689**	**0.1036**

Table 28. Confuzzy composite weight for BEN block

Criteria	Weights of main criteria(W_m)	Pairwise compared weights (W_c)					Fuzzy Composite Weights ($W_m \times W_c$)				
Staple Food	**0.0758**	0.7176	0.6726	0.5006	0.4465	0.1627	0.0544	0.0510	0.0379	0.0338	0.0123
Adequate Food	**0.3810**	0.7406	0.6393	0.5339	0.4685	0.1176	0.2822	0.2436	0.2034	0.1785	0.0448
Health Condition	**0.3609**	0.7124	0.6659	0.5683	0.4578	0.0956	0.2571	0.2403	0.2051	0.1652	0.0345
Kapda	**0.2948**	0.6659	0.6618	0.6081	0.4627	0.1015	0.1963	0.1951	0.1793	0.1364	0.0299
Types of House	**0.1375**	0.7429	0.6782	0.4306	0.5096	0.1387	0.1021	0.0932	0.0592	0.0701	0.0191
Environment	**0.2446**	0.6960	0.6771	0.5714	0.4594	0.0961	0.1702	0.1656	0.1398	0.1124	0.0235
Safe drinking water facility	**0.2620**	0.6765	0.5990	0.6605	0.4284	0.1356	0.1773	0.1569	0.1731	0.1122	0.0355
Light sources	**0.2283**	0.7082	0.6044	0.6141	0.4614	0.1119	0.1617	0.1380	0.1402	0.1053	0.0255
Sanitation facility	**0.1784**	0.7285	0.6009	0.6074	0.4649	0.0983	0.1299	0.1072	0.1083	0.0829	0.0175
Consumer durables	**0.1419**	0.7383	0.6175	0.5753	0.4660	0.1030	0.1047	0.0876	0.0816	0.0661	0.0146
Formal sector	**0.6557**	0.7062	0.6681	0.5659	0.4584	0.1015	0.4630	0.4380	0.3710	0.3005	0.0665
Informal sector	**0.0972**	0.7389	0.6774	0.5708	0.4099	0.1030	0.0718	0.0658	0.0555	0.0398	0.0100
Education	**0.2232**	0.7465	0.6576	0.5946	0.4018	0.0995	0.1667	0.1468	0.1327	0.0897	0.0222
Caste status	**0.0248**	0.6570	0.6905	0.5801	0.4689	0.1036	0.0163	0.0171	0.0144	0.0116	0.0026
Aggregate Weight							**2.3538**	**2.1463**	**1.9016**	**1.5047**	**0.3587**

Using the sieve formula we get the Membership values of five households from Ben blocks.

$$\mu_{\underset{\sim}{A_P}}(h_i) = \frac{h_i - \min(h_i)}{Max(h_i) - \min(h_i)} \Rightarrow \begin{cases} H_1 = \dfrac{2.3538 - 0.3587}{1.9951} = \dfrac{1.9951}{1.9951} = 1 \\ H_2 = \dfrac{2.1463 - 0.3587}{1.9951} = \dfrac{1.7876}{1.9951} = 0.8959 \\ H_3 = \dfrac{1.9016 - 0.3587}{1.9951} = \dfrac{1.5429}{1.9951} = 0.7733 \\ H_4 = \dfrac{1.5047 - 0.3587}{1.9951} = \dfrac{1.1460}{1.9951} = 0.5744 \\ H_5 = \dfrac{03587 - 0.3587}{1.9951} = \dfrac{0}{1.9951} = 0 \end{cases}$$

where Minimum Sieve value ($\min(h_i)$) is 0.3587 and Maximum Sieve value ($\max(h_i)$) is 2.3538. These data is obtained from the overall aggregate fuzzy weights across the BEN block of Nalanda district, Bihar.

4.3 Poverty Status Category

Table 29. Poverty Status of BEN block

Households	Membership values	Poverty Status
H-1	1	Very Poor
H-2	0.8957	Almost Very poor
H-3	0.7733	Poor
H-4	0.5744	Rather poor
H-5	0	Non-poor

5. Result and Interpretation: Poverty Categories

From the Stratified Fuzzy AHP, it is clear that the problem of identifying the poor takes a combination of many process factors. Household-1 with membership value (1.0) is stated very poor, household-2 with membership weight (0.8957) is stated almost very poor, household-3 with membership weight (0.7733) is stated poor, household-4 with membership weight (0.5744) is stated rather poor and household-5 with membership weight (0.0) is stated non-poor.

6. Conclusion

An analysis of poverty is an apt example for working in a fuzzy environment. Impreciseness existing in the crisp decision methodology of estimating poverty had been captured through this paper. It used intrinsic fuzzy decision making technique to capture the level of poverty of the five households. This article represents the subjective arguments by establishing the qualitative multi-criteria fuzzy variables into membership grades like very poor, almost very poor, poor, rather poor and non-poor. Thus the whole data of the subset of the poor has been categorized by sieving out technique. This way the impreciseness or vagueness or uncertainty is accounted as measureable factor using Stratified Fuzzy AHP and Pentagonal Fuzzy Numbers approach. With help of this method the position of one's level of poverty has been identified. Thus it has been claimed that, with this method one can overcome the dichotomy existing in the traditional (crisp) method of analyzing poverty. Fuzzy set theory can be propagated as further scope to address the real world problem.

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