

# Poverty Measurement by Fuzzy MADM Approach

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**ABSTRACT:** Poverty in a rural area is and is a leading problem to be evaluated. During the process of traditional evaluation, the consideration of the attributes and assuming their nature affect the algorithmic structure. It is not easy to mathematically represent them. A significant number of attempts have been proposed towards this problem. In this paper, a new approach is provided based on Multi Attribute Decision Making solution. A case study is also demonstrated to support the method's applicability.

**KEYWORDS:** Poverty, Poverty estimation, Fuzzy Logic, MADM, Fuzzy MADM.

## I. INTRODUCTION

The literature of last 30 years or so reveals that an immense number of works got published concerning decision theory and multi attribute decision making. It includes system engineering, management sciences, decision science, operations research, social science, investment decisions, economy, project evaluation, and military affairs and so on. Now-a-days in most of the decision making problems, many decision indexes are qualitatively defined, i.e., the available information about them is uncertain. Thus the decisions in real life often need to be executed in Fuzzy environment. At that time its attribute values are random variables varying with the natural state. So, it is impossible for the decision makers to view the actual state, accurately. While trying to make a decision, the inherent uncertainty builds the consumption of precise numbers, baffling in multi attribute model. The problems of MADM are virtually visible in any topic as they are diverse, in nature. Over 200 years ago, Ben Franklin spotted the presence of MADM in everyday situations. From the Decision Maker's points of view, they may encounter in measuring and processing linguistic statements. Since human judgments and preferences are often complex and vague, the Decision Makers cannot value their preferences over an exact scaling. So while trying to cover every possible natural state they deliver linguistic terms to quantify the impreciseness. These linguistic terms can be estimated by different fuzzy numbers.

A number of quantitative techniques have been used for MADM problem by Triantaphyllou and Lin (1996), Kenny and Kirkwood (1975), Satty (1980), Liu and Liu (2010) and many others. Some of them are weighing methods, Analytical Hierarchy Process (AHP), data envelopment analysis (DEA), TOPSIS (Technique for Ordered Preference by Similarity to Ideal Solution), ANP (Analytical Network Process) methods, etc. Research reveals that the application of AHP raises the decision making process and reduces the time taken to select the optimum alternative. TOPSIS assumes that each attribute has a tendency toward monotonically increasing or decreasing utility. So it is obvious that there exists one positive ideal and one negative ideal solution.

In this paper the problem of poverty estimation has been visited with the help of Fuzzy MADM approaches. Sen (1976) ([8], [9]) rolled over the problem of poverty index in two ways: poor household identification and aggregation of the attributes of the poor in an overall indicator which quantifies the poverty index. The transfer axiom proposed by Sen stipulates that a transfer of income from a poor to a rich person certainly increases the poverty degree when other attributes are fixed. Another axiom in this context is population monotonicity axiom which states that an addition of a person below the poverty line should increase the poverty degree and the addition of a person above the poverty line should decrease the degree when other attributes are fixed. The introduction of these two axioms leads to a certain

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anomaly regarding the possibility of any poverty index. The poverty index of a society certainly depends on the individual poverty degree of each household. So this problem has been taken into consideration with great importance. Some poverty models are also proposed on the basis of these methods, e.g., the logit model, conditional income distribution model, Fuzzy set theoretic model, etc.

In section II, a case study is provided and in section III a comparative analysis has been demonstrated.

## II. CASE STUDY

This case study is on the poverty measurement of some districts in a state in india.

To conform to the algorithm we have considered the problem in the following manner.

From a rural area of North East India, five Districts (respectively Murshidabad, Malda, Birbhum, Burdwan and Nadia)  $X_i$  ( $i=1, 2, 3, 4, 5$ ) have been chosen. Five attributes  $T_i$  ( $i=1, 2, 3, 4, 5$ ) that are being considered here are Housing Condition ( $T_1$ ), Clothing Status ( $T_2$ ), Educational Status ( $T_3$ ), Average monthly income per capita ( $T_4$ ) and Food Security ( $T_5$ ). One surveyor is appointed to collect the conditions of the districts in linguistic terms from the set {Very Poor (VP), Poor (P), Fair (F), Medium Good (MG), Good (G), Very Good (VG)}. The TFN of the terms are listed in table in [8]. For more computational accuracy one can appoint more DMs (surveyors) for this purpose and obtain the average of the TFNs of the linguistic variables as equivalent to the single surveyor's data. Now a group of four DMs  $\{D_1, D_2, D_3, D_4\}$  is constituted to order the attributes in linguistic terms from the set {Very Low (VL), Low (L), Medium (M), Medium High (MH), High (H), Very High (VH)}. The TFN of the terms are listed in table 5.2. The collected data of the surveyor is recorded in table 5.48 and that of the four DMs in table 2.1.

The problem of identifying poor districts in rural areas is not as simple as stated here. More accurate modeling of the problem has been discussed in Mukherjee and Kar's method (2011). Here in this work the model has been reconstructed to fit with the algorithm.

According to the methodology, we first compute the weights of the attributes. The weights are evaluated and displayed in table 2.2.

From table 2.1, the linguistic terms are substituted by the corresponding TFNs, as shown in table 5.51. This matrix is the Fuzzy decision matrix (FDM).

The elements of FDM are normalized by division by the maximum element 10. The resulting TFNs are multiplied by their corresponding attribute weights. Table 2.4 shows the normalized Fuzzy decision matrix and table 2.5 shows the weighted normalized Fuzzy decision matrix.

Table 2.1: Decision matrix on the rating of Districts

	$T_1$	$T_2$	$T_3$	$T_4$	$T_5$
$X_1$	P	MP	VP	MP	MP
$X_2$	MP	F	F	MP	MG
$X_3$	VP	P	VP	P	F
$X_4$	F	F	MG	MG	P
$X_5$	MP	MPG	G	F	VP

Table 2.2: Decision matrix for attribute rating

	$D_1$	$D_2$	$D_3$	$D_4$
$T_1$	MH	M	M	M
$T_2$	L	ML	L	L
$T_3$	L	L	VL	L
$T_4$	VH	VH	VH	VH
$T_5$	M	M	MH	M

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Table 2.3: Weights of the attributes

	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T <sub>5</sub>
Weights	(0.4, 0.55, 0.8)	(0.1, 0.25, 0.5)	(0.1, 0.18, 0.3)	(0.9, 1.0, 1.0)	(0.4, 0.55, 0.8)

Table 2.4: Fuzzy Decision matrix (FDM)

	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T <sub>5</sub>
X <sub>1</sub>	(1, 2, 3)	(3, 4, 5)	(1, 1, 2)	(3, 4, 5)	(3, 4, 5)
X <sub>2</sub>	(3, 4, 5)	(4, 5, 6)	(4, 5, 6)	(3, 4, 5)	(6, 7, 8)
X <sub>3</sub>	(1, 1, 2)	(1, 2, 3)	(1, 1, 2)	(1, 2, 3)	(4, 5, 6)
X <sub>4</sub>	(4, 5, 6)	(4, 5, 6)	(6, 7, 8)	(6, 7, 8)	(1, 2, 3)
X <sub>5</sub>	(3, 4, 5)	(3, 4, 5)	(8, 9, 10)	(4, 5, 6)	(1, 1, 2)

Table 2.5: Normalized Fuzzy Decision matrix

	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T <sub>5</sub>
X <sub>1</sub>	(0.1, 0.2, 0.3)	(0.3, 0.4, 0.5)	(0.1, 0.1, 0.2)	(0.3, 0.4, 0.5)	(0.3, 0.4, 0.5)
X <sub>2</sub>	(0.3, 0.4, 0.5)	(0.4, 0.5, 0.6)	(0.4, 0.5, 0.6)	(0.3, 0.4, 0.5)	(0.6, 0.7, 0.8)
X <sub>3</sub>	(0.1, 0.1, 0.2)	(0.1, 0.2, 0.3)	(0.1, 0.1, 0.2)	(0.1, 0.2, 0.3)	(0.4, 0.5, 0.6)
X <sub>4</sub>	(0.4, 0.5, 0.6)	(0.4, 0.5, 0.6)	(0.6, 0.7, 0.8)	(0.6, 0.7, 0.8)	(0.1, 0.2, 0.3)
X <sub>5</sub>	(0.3, 0.4, 0.5)	(0.3, 0.4, 0.5)	(0.8, 0.9, 1.0)	(0.4, 0.5, 0.6)	(0.1, 0.1, 0.2)

Table 2.6: Weighted Normalized Fuzzy Decision matrix

	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T <sub>5</sub>
X <sub>1</sub>	(0.04, 0.11, 0.24)	(0.03, 0.1, 0.25)	(0.01, 0.0175, 0.06)	(0.27, 0.4, 0.5)	(0.12, 0.22, 0.4)
X <sub>2</sub>	(0.12, 0.22, 0.4)	(0.04, 0.125, 0.3)	(0.04, 0.0875, 0.18)	(0.27, 0.4, 0.5)	(0.24, 0.385, 0.64)
X <sub>3</sub>	(0.04, 0.11, 0.24)	(0.01, 0.05, 0.15)	(0.01, 0.0175, 0.06)	(0.09, 0.2, 0.3)	(0.16, 0.275, 0.48)
X <sub>4</sub>	(0.16, 0.275, 0.48)	(0.04, 0.125, 0.3)	(0.06, 0.1225, 0.24)	(0.54, 0.7, 0.8)	(0.04, 0.11, 0.24)
X <sub>5</sub>	(0.12, 0.22, 0.4)	(0.03, 0.1, 0.25)	(0.08, 0.1575, 0.3)	(0.36, 0.5, 0.6)	(0.04, 0.055, 0.16)

Table 2.7: total distances from the pseudo District and closeness coefficients

	d <sub>i</sub> (X <sub>i</sub> , X <sup>Max</sup> )	d <sub>i</sub> (X <sub>i</sub> , X <sup>Min</sup> )	CC <sub>i</sub>
X <sub>1</sub>	0.8523	0.4336	0.3372
X <sub>2</sub>	0.4344	0.8508	0.6620
X <sub>3</sub>	1.0518	0.2347	0.1824
X <sub>4</sub>	0.3448	0.9439	0.7324
X <sub>5</sub>	0.6426	0.6425	0.5000

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## III. COMPARATIVE ANALYSIS

In this section a comparative analysis is allocated to illustrate the effectiveness of the approach. Before we conclude, let us compare the current method with some of the existing approaches. We follow up some criteria for the evaluation process and see whether these approaches fulfill them or not. In table 3.1 the comparison is illustrated.

Table 3.1: comparative analysis

Authors	Whether Linguistic Terms are considered or not	Whether criteria's weights are considered or not	Whether individuals are compared to each other or not	Whether there is any specific method to draw the line(s) of separation
J. Vero (1998)	No	No	Yes	No
S. Mukherjee et al. (2011)	Yes	Yes	Yes	No
S. Mukherjee and Kar (2011)	Yes	Yes	No	No
Proposed Method	Yes	Yes	No	Yes

As far as the use of linguistic variables is concerned, we have already expressed the necessity of using this in section 1. Apart from Vero's approach (1998), all the other include linguistic variables as some or all input decisions. It is also very obvious that the attributes should not be taken as equally important, e.g., the attribute "income per capita" is more important than the attribute "clothing status" for a particular household. Here also Vero's approach lacks. Thirdly the first two approaches involve the mutual comparison of the households with respect to all the attributes. The identification of poor household is a global problem. For a particular country or for a particular region of a country, there would be a huge number of households. So this type of comparison is also a huge task there. On the other hand, if two or more households from different regions are asked to be compared on their poverty, the first two approaches fail to suggest any decision. Finally, apart from the proposed approach, none of the other shows any direction to draw the poverty lines logically, which is a challenging task. If this logic is not defined in the methodology, the approach is then nothing but a simple multi attribute decision making approach. So, in all respect, this proposed approach survives best in the comparison.

## IV. CONCLUSION

The current approach towards the evaluation of individualistic poverty status of rural regions is supported by a suitable case study. This way of dealing with this problem is new and it can be extended upto any satisfactory number of attributes. Also, the approach can be applied to other multi attribute problems, like supplier selection, etc. The present methodology can be enriched more by applying grey based MADM approach also.

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## REFERENCES

- [1] Betti G, Verma VK, Measuring the degree of poverty in a dynamic and comparative context; a multidimensional approach using fuzzy set theory, working paper n. 22, Department of Quantitative Methods, University of Siena, 1998
- [2] Chakravarty SR, Ethically flexible measures of poverty, Canadian Journal of Economics, vol. 16, pp 74-85, 1983a

## International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

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- [3] Chakravarty SR, A new index of poverty, *Mathematical Social Sciences*, vol. 6, pp 307-313, 1983b
- [4] Cheli B, Lemmi A, A “Totally” fuzzy and relative approach to the multidimensional analysis of poverty, *Economic Notes*, vol. 24, pp 115-134, 1995
- [5] Kundu A, Smith TE, An impossibility theorem on poverty indices, *International Economic Review*, vol. 24, pp 423-434, 1983
- [6] Guo-Dong L, Dasiuke Y, Masatake N, A Grey-based decision-making approach to the supplier selection problem, *Mathematical and Computer Modelling*, vol. 46, pp 573-581, 2007
- [7] Sen AK, Poverty: on ordinal approach to measurement, *Econometrica*, vol. 44, pp 219-231, 1976
- [8] Sen AK, Issue in the measurement of poverty, *Scandinavian Journal of Economics*, vol. 81, pp 285-307, 1979
- [9] D Dutta Majumder, R Bhattacharyya, S. Mukherjee, *Methods of Evaluation and Extraction of membership Functions- Review with a new Approach*, pp 277-281, ICCTA'07, IEEE Computer Press, London
- [10] S Mukherjee, S Kar, *Philosophy of Fuzzy Mathematics*, *Journal of Computer and Mathematical Sciences*, vol. 1, issue 4, pp 497-500, 2010
- [11] Hagenars AJM, A Class of Poverty Indices. *International Economic Review*, vol. 28, pp 583-607, 1987
- [12] A de Janvry, E. Sadoulet, *World Poverty and the Role of Agricultural Technology: Direct and Indirect Effects*, *The Journal of Development Studies*, vol. 38:4, pp 1-26
- [13] Cerioli A, Zani S, A Fuzzy approach to the Measurement of Poverty, In: Dagum C, Zenga M (eds) *Income and Wealth Distribution, Inequality and Poverty*, Springer-Verlag, New York, pp 272-284, 1990
- [14] Vero J, Werquin P, Un reexamen de la mesure de la pauvreté. Comment s'en sortent les jeunes en phase d'insertion professionnelle? *Economie et Statistique*, 308-309-310, pp 143-148, 1997
- [15] L. A. Zadeh, (1965) *Fuzzy Sets*, *Information and Control*, 8, pp. 338-353.
- [16] S. Mukherjee, A. Chatterjee, R. Bhattacharya, S. Kar, (2011) *A Fuzzy mathematics based approach for poor household identification*, *International Journal of Mathematics and Scientific Computing*, Vol. 1, No. 1, pp. 22-27.
- [17] S. Mukherjee, S. Kar (2012), *Multi attribute decision making based on Fuzzy logic and its application in supplier selection problem*, *Operations and Supply Chain Management: An International Journal*, vol. 5, NO. 2, pp. 76-83.
- [18] S. Mukherjee, S.Kar (2010) *Philosophy of Fuzzy Mathematics*, *Journal of Computer and Mathematical Sciences*, vol. 1, issue 4, pp. 497-500.