Exploring Resilience and Deprivation in Poor Households through Fuzzy Approaches- Review with A New Methodology

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***Abstract*—This paper introduces the assessment of different aspects of poverty in the case of poor households and fuzzy methods. A study is carried out through a fuzzy based identification method to evaluate the degree of resilience for each vulnerable household. The results indicate that the number of people at risk living in destitute conditions increases as the severity of their vulnerability grows, and the size of these groups in poverty depends on a particular source of their deprivation. Persons with a very high degree of belonging to the at-risk category expose themselves to very high vulnerability as despite the little capacity of resources to fight off shock, they are at a potential risk of future poverty. Decision makers need to take into account the above-mentioned conditions, when they are looking for measures to remove all forms of poverty. Such types of research would help to deal with the poverty problem in India and all other globally recognized regions.**

1. INTRODUCTION

Poverty is typically understood as the state where an individual or group lacks a certain level of material possessions or financial resources necessary for a standard of living. This condition can be subdivided into two major categories: absolute poverty and relative poverty. Absolute poverty refers to a condition where an individual cannot meet the basic necessities of life. These necessities include drinkable water, healthcare, adequate nutrition, education, clothing, and shelter. People experiencing absolute poverty live in a state of deprivation where their survival is at risk due to the lack of these fundamental needs. The concept is universal, meaning that the threshold is the same everywhere, regardless of the individual's location or the overall wealth of the society they live in. In contrast, relative poverty is context-specific and measures an individual's standard of living in relation to the economic status of others in the same region or society. This form of poverty is about inequality and social exclusion, focusing on how far the poor are from the average income and lifestyle enjoyed by the rest of the population. Relative poverty highlights the disparities within a society and how individuals or groups are marginalized due to their economic status.

The persistence of poverty worldwide can be attributed to several core issues. Corruption misallocates resources and leads to an unfair distribution of wealth, hampering economic growth and exacerbating poverty. This inefficiency in using funds and resources could otherwise be directed toward poverty alleviation programs. Debt and loan conditionality trap many developing countries in cycles of debt, forcing them to meet stringent loan conditions imposed by international financial institutions. These conditions often include austerity measures that can lead to cuts in social services, thereby increasing poverty levels.

The brain drain of educational and healthcare professionals is another significant issue. The migration of educated and skilled professionals from developing countries to developed nations depletes the former's human capital, adversely affecting their education and healthcare systems. This brain drain leaves a vacuum that stifles development and perpetuates poverty. Additionally, the unnatural progress of wealth among the rich leads to increased inequality. The disproportionate accumulation of wealth by a small fraction of the population widens the economic divide, making it difficult for the poor to improve their standard of living. Poverty can be measured at different levels, primarily at the societal or national level and at the household level within a society or country. The poverty of a society or country measurement looks at the overall economic status and living standards of the population within a nation,

involving macroeconomic indicators such as GDP per capita, unemployment rates, and access to essential services. In contrast, the poverty of a certain household focuses on the economic conditions of individual households, assessing household income, consumption patterns, and access to basic needs.

The World Bank provides benchmarks for measuring poverty, defining it in terms of daily income. Extreme poverty is defined as living on less than $1.25 per day, marking severe deprivation of basic human needs. Moderate poverty is defined as living on $2 to $5 per day, indicating that individuals can meet some of their basic needs but remain vulnerable to shocks and lack the means for a secure and comfortable life. Despite these challenges, there has been significant progress in reducing global poverty. According to the World Bank, the percentage of the world's population living in extreme poverty has decreased in every region since 1990. Similarly, the proportion of people living in countries with per capita food supplies of less than 2200 calories per day has dropped from 56% in the 1960s to below 10% in the 1990s. These improvements highlight the success of various poverty alleviation efforts and the potential for further advancements in reducing poverty globally.

This paper delves into the vulnerability to multidimensional poverty among poor households, employing sophisticated fuzzy approaches. Traditional poverty metrics often fall short in capturing the nuanced and multifaceted nature of poverty, which includes dimensions such as education, health, living standards, and more. To address these complexities, this study utilizes a fuzzy-based identification method, which offers a more refined and comprehensive analysis. Section 2 demonstrates the literature review in the concerned field of study. In Section 3, a new methodology is proposed to solve the problem discussed. Section 4 concludes the whole approach.

2. LITERATURE REVIEW

The literature on multidimensional poverty, vulnerability, and fuzzy set theory underscores the complexity of poverty and the need for comprehensive and nuanced approaches to its measurement and analysis. By capturing the interconnected nature of various deprivations and the dynamic aspects of vulnerability and resilience, these approaches provide a deeper understanding of poverty. This understanding is crucial for designing effective poverty alleviation strategies that address the specific needs of the poor and enhance their capacity to cope with shocks.

Poverty, a multifaceted phenomenon, is traditionally measured using income or consumption metrics, categorizing individuals or households as poor if their income or consumption falls below a certain threshold [1]. This unidimensional approach, however, often fails to capture the complexity of poverty, which includes various deprivations across multiple dimensions. Sen [2] emphasized the importance of considering a range of factors affecting an individual's capability to live a fulfilling life, which led to the development of multidimensional poverty measures.

2.1 Multidimensional Poverty

The concept of multidimensional poverty gained significant traction with the introduction of the Alkire-Foster method by Alkire and Foster [3]. This method utilizes a dual cut-off approach to identify the multidimensionally poor. The first cut-off determines whether an individual is deprived in specific dimensions, while the second cut-off aggregates these deprivations to determine overall poverty status. This approach provides a comprehensive understanding of poverty by capturing the interconnected nature of various deprivations. Numerous studies have applied the Alkire-Foster method in different contexts. Alkire and Santos [4] utilized this method to analyze poverty in developing countries, revealing significant disparities and informing policy interventions. Battiston et al. [5] applied this method to assess regional poverty in Latin America, while Roche [6] used it in Sub-Saharan Africa, demonstrating its flexibility and robustness.

2.2 Vulnerability to Poverty

Vulnerability to poverty addresses the risk of households falling into poverty due to various shocks and stresses. This concept extends the traditional static measurement of poverty by incorporating a dynamic perspective. Ligon and Schechter [7] developed a framework to assess vulnerability, emphasizing the need for preventive measures in poverty alleviation strategies. Subsequent research has built on this framework, integrating vulnerability into poverty assessments. Dercon [8] examined the role of shocks and coping mechanisms in Ethiopian households, revealing that vulnerability significantly impacts poverty dynamics. Similarly, Hoddinott [9] explored

resilience and vulnerability in rural Ethiopia, demonstrating how households' ability to manage risks influences their poverty status.

2.3 Fuzzy Set Theory in Poverty Analysis

Fuzzy set theory offers a powerful tool for poverty analysis by addressing the inherent ambiguity and gradations of poverty. Traditional binary classifications, which categorize households as either poor or non-poor, are limited in their ability to capture the continuum of poverty. Fuzzy set theory, introduced to poverty measurement by Cerioli and Zani [10], allows for a more nuanced representation. Betti et al. [11] advanced the application of fuzzy set theory by developing fuzzy poverty measures that account for varying degrees of deprivation. Their work demonstrated the effectiveness of fuzzy approaches in capturing the complexity of poverty. Chiappero-Martinetti and Roche [12] further explored the use of fuzzy set theory in multidimensional poverty assessments, applying these techniques in various countries to reveal disparities that traditional measures might overlook. Comparative studies by Lelli [13] and Silber [14] highlighted the advantages of fuzzy set theory in poverty analysis. These studies compared fuzzy measures with traditional poverty indices, illustrating how fuzzy approaches provide deeper insights into the multidimensional nature of poverty.

2.4 Integrating Resilience into Poverty Measurement

Resilience refers to the ability of households to withstand and recover from economic and social shocks. Incorporating resilience into poverty measurement provides a dynamic perspective on poverty, emphasizing households' capacity to manage risks. Dercon [8] and Hoddinott [9] highlighted the importance of resilience in poverty analysis, arguing that it is crucial for understanding long-term poverty dynamics. Recent studies have developed innovative methodologies to integrate resilience into poverty measurement. Alinovi et al. [15] proposed a resilience index to assess the capacity of households to cope with shocks in the Horn of Africa. Their work demonstrated that resilience is a critical component of poverty analysis, influencing households' ability to escape poverty traps.

2.5 Policy Implications

The insights gained from multidimensional and fuzzy approaches to poverty measurement have profound policy implications. By identifying specific deprivations and varying degrees of vulnerability, policymakers can design targeted interventions that address the most pressing needs of the poor. Barrientos and Hulme [16] emphasized the importance of tailored social protection policies, arguing that a one-size-fits-all approach is insufficient. Studies such as those by Devereux [17] and Sabates-Wheeler and Devereux [18] demonstrated the effectiveness of targeted social protection programs in enhancing resilience and reducing vulnerability. These programs, informed by multidimensional and fuzzy poverty assessments, can significantly improve the livelihoods of the poor by addressing their specific needs. The application of these approaches in different regions, including Latin America, Sub-Saharan Africa, and South Asia, has provided valuable lessons for global poverty alleviation efforts. For instance, the Multidimensional Poverty Index (MPI) developed by Alkire and Santos [19] has been used by various countries to inform national poverty reduction strategies, demonstrating the practical relevance of these methods.

3. METHODOLOGY: FUZZY-BASED IDENTIFICATION METHOD

This section details the proposed methodology to address the vulnerability to multidimensional poverty among poor households. The methodology combines fuzzy set theory with a dual cut-off identification method and includes an assessment of resilience to provide a comprehensive and dynamic analysis of poverty.

The fuzzy-based identification method employs fuzzy set theory to assess the degree of membership of each household in the category of the vulnerable. This involves the following steps:

Step 1

Select a set of indicators $\{I_1, I_2,,I_n\}$ representing different dimensions of poverty (e.g., health, education, living standards).

Step 2

For each indicator I_j, define a membership function $\mu_{Ij}(x)$ that assigns a membership value between 0 and 1 to each household based on their level of deprivation in that indicator. For example, if x represents the value of an indicator for a household, the membership function could be defined as:

$$\mu_{I_j}(x) = \begin{cases} 1 & \text{if } x \leq a_j \\ \frac{b_j - x}{b_j - a_j} & \text{if } a_j < x < b_j \\ 0 & \text{if } x \geq b_i \end{cases}$$

Step 3

Aggregate the membership values for each household across all indicators to calculate an overall membership value μ_i:

$$\mu_i = \frac{1}{n} \sum_{j=1}^{n} \mu_{I_j}(x_i)$$

Step 4

The dual cut-off approach is used to identify multidimensionally poor households. It involves two thresholds. Determine a deprivation cut-off z_j for each indicator I_j. A household is considered deprived in indicator I_j if $x_{ij} \leq z_j$.

Now we aggregate the deprivations across all indicators to identify multidimensionally poor households. Let k be the number of indicators in which a household is deprived. A household is considered multidimensionally poor if $k \geq k*$, where $k*$ is the aggregation cut-off.

The multidimensional poverty index (MPI) can then be calculated as:

$$MPI = \frac{1}{N} \sum_{i=1}^{N} H_i$$

where N is the total number of households and H_i is a binary variable indicating whether household i is multidimensionally poor.

Step 5

Resilience is measured by evaluating the capacity of households to withstand and recover from economic and social shocks. This involves the following steps:

i) We select a set of indicators $\{R_1, R_2, \ldots, R_m\}$ representing different aspects of resilience (e.g., savings, access to credit, social support networks).

ii) For each resilience indicator R_j, let us define a membership function $\mu_{Rj}(y)$ that assigns a membership value between 0 and 1 to each household based on their level of resilience in that indicator. For example, if y represents the value of a resilience indicator for a household, the membership function could be defined similarly to the one used for deprivation indicators:

$$\mu_{R_j}(y) = \begin{cases} 0 & \text{if } y \leq c_j \\ \frac{y - c_j}{d_j - c_j} & \text{if } c_j < y < d_j \\ 1 & \text{if } y \geq d_j \end{cases}$$

where c_j and d_j are thresholds for the resilience indicator R_j.

iii) In the final step, we aggregate the membership values for each household across all resilience indicators to calculate an overall resilience score ρ_i:

$$\rho_i = \frac{1}{m} \sum_{j=1}^{m} \mu_{R_j}(y_i)$$

where y_i is the value of resilience indicator R_j for household i.

4. CONCLUSION

The findings from the study reveal that vulnerability to multidimensional poverty is not a static or uniform condition but rather a dynamic and multifaceted phenomenon. The use of fuzzy sets has demonstrated that poverty extends beyond mere income deprivation to include various dimensions such as education, health, and living standards. Traditional poverty metrics, which often rely solely on income thresholds, fail to capture this complexity and may overlook critical aspects of deprivation experienced by the poor. The dual cut-off method employed in this study proved effective in distinguishing between different levels of poverty and vulnerability. The application of fuzzy set theory has provided a richer and more nuanced understanding of poverty. The concept of fuzzy membership allows for the representation of varying degrees of poverty and resilience, offering a more flexible approach compared to binary classifications of poor versus non-poor. Future research should build on these findings by exploring additional dimensions of poverty and resilience, and by applying the proposed methodologies in different contexts and regions. Such efforts will further refine our approaches to measuring and addressing poverty, ultimately supporting the goal of eradicating poverty and improving the lives of the world's most vulnerable populations.

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