Growth
Vol. 9, No. 1, 31-41, 2022
ISSN(E) 2412-2068 / ISSN(P) 2518-0185
DOI: 10.20448/growth.v9i1.4306

Multi-Poverty and Deprivation in Chad: Multidimensional Approach Using the Fuzzy Set Theory

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Abstract

The general objective of this paper is to analyze the configuration of poverty in Chad using a multidimensional approach, while previous work has for the most part favored the monetary or one-dimensional approach. The multidimensional approach adopted is based on the fuzzy-set also called the fuzzy set theory. To achieve this objective, multidimensional poverty indices are calculated by the formulations of membership functions called "totally fuzzy approach (TF)" by Cerioli and Zani. They are broken down according to the Camilo Dagum's method. The data are the Household Budget and Consumption Surveys in 2003 (ECOSIT2) of 7,008 households and in 2011 (ECOSIT3) of 10,200 households. The results show that the multidimensional poverty index (fuzzy poverty index) is 48.47% in 2003 and increases unlike in 2011 to 58.89% while monetary poverty is 55% in 2003 and 46. 67% in 2011. In Chad, in all areas, poverty persists. The energy dimension is the one where we find more poor people followed in descending order of housing, sanitation and education. We recommend that the public authorities prioritize, within the framework of the fight against poverty, the electrification of all regions because energy contributes more than 90% to the construction of poverty in 2003 and 2011, etc.

Keywords: Configuration of poverty, Decomposition by groups and attributes, Ecosit, Fuzzy poverty, Fuzzy set, Membership functions, Multidimensional poverty.

Citation | Themoi, D. (2022). Multi-poverty and deprivation in chad: Multidimensional approach using the fuzzy set theory. *Growth*, 9(1), 31-41. 10.20448/growth.v9i1.4306
History:
Received: 19 November 2021
Revised: 6 October 2022
Accepted: 21 October 2022
Published: 24 November 2022

Publisher: Asian Online Journal Publishing Group

Funding: This study received no specific financial support.
Competing Interests: The author declares that there are no conflicts of interests regarding the publication of this paper.
Transparency: The author confirms that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained.
Ethical: This study followed all ethical practices during writing.

Contents

Contribution of this paper to the literature

The contribution of this paper to the analysis of poverty has the double advantage of not defining threshold values, giving arbitrary weights to attributes and of adopting a relative approach to poverty. Here again, the fuzzy poverty index can be broken down simultaneously by subgroup and by attribute.

1. Introduction

Poverty is a widespread phenomenon in Chad according to the National Institute of Statistics and Demographic Studies of Chad. In 2003, the total household living in Chad below the poverty line, that is to say that has a subsistence minimum below 396 CFA (Financial Cooperation in Central Africa) francs per person, represented 55% of the total households of the country. Within this group, almost 36% of households are in a situation of extreme poverty, i.e. 280 CFA francs per person per day. The Chadian household living in 2011 below the poverty line, that is to say that has a consumption per capita below 652 CFA francs per person per day, represents 46.67%. Up to this date, 29% of households are in a situation of extreme poverty, that is to say living with an income below 438 CFA francs per capita and per day. The monetary approach used considers poor households (individuals) whose income (consumption expenditure) is below a threshold which changes according to the distribution of living standards. It largely depends on the definition of income and the setting of the threshold. Income is defined as monetary disposable income, which ignores certain components of well-being such as non-monetary components. The threshold is set either at half the median standard of living or at the income level (consumption expenditure) of a quantity of goods necessary for the basic needs of a household (individual). In terms of the concept of poverty, there are two main schools. These two schools are not directly opposed to the definition of poverty, always defined as an important deprivation of well-being, but rather to the concept of well-being to be considered. The utilitarian approach aims to base comparisons of well-being, as well as decisions relating to public policy, solely on the "usefulness" of individuals, that is, on their preferences. The non-utilitarian approach which brings together schools for basic needs, social exclusion and that of abilities / functioning prefers, for its part, to assess the situation according to certain elementary faculties, such as the possibility of feeding or dress appropriately and may pay little or no attention to usefulness of information as such. Non-welfarists define well-being on the basis of what they consider to be desirable for the individual from a social point of view. In this group of non-welfarist schools, we can cite Rowntree (1901) for basic needs, Townsend (1962) for social exclusion and Sen (1983) for capacities / functioning.

Poverty is often defined as a situation of lack of monetary resources allowing households to obtain the elements necessary for the survival of the members composing them. The question of identifying the populations concerned is therefore essential. For effective targeting of economic policies to fight poverty, it is essential to know and identify vulnerable groups. In this sense, the monetary approach to poverty allows a distinction to be made between poor and non-poor groups. Among the measures of multidimensional poverty, the method of the fuzzy set theory is the one used in this paper to analyze the configuration of multi-poverty in Chad, that of Alkire-Foster (AF) (Alkire & Foster, 2011) therefore confine themselves to narrow fields of measures of multidimensional poverty and do not approach other relevant and interesting measures, which call upon the information theory (Deutsch & Silber, 2005), to the techniques of latent variables (Kakwani & Silber, 2008), to the analysis multiple correspondences (Asselin, 2009), to alternative metering approaches (Atkinson, 2003), to alternative axiomatic approaches (Bossert, D'AMBROSIO, & Peragine, 2007) or predominantly (Duclos, Sahn, & Younger, 2006). Although certain approaches share the same problems, the fuzzy set theory method has an advantage and allows: (a) identification: how to identify the poor in the total population; (b) aggregation: how to build a poverty index using the information available on the poor; (c) the breakdown into sub-groups (place of residence, gender, etc.) and the dimensions / indicators and (d) The contribution of each sub-group or dimension / indicator can be determined. This method constitutes tools for targeting poverty reduction policies and programs. The general objective of this paper is to analyze the configuration of poverty in Chad using a multidimensional approach based on the fuzzy-set. Multidimensional poverty indices are calculated by the formulations of membership functions called "totally fuzzy approach (TF)" of Cerioli and Zani (1990). They are broken down according to the method of Dagum (2002). The data used are those of 2003 Household Budget and Consumption Surveys (ECOSIT2) of 7,008 households and in 2011 (ECOSIT3) of 10,200 households. It is organized as follows: section 2 is devoted to empirical reviews of theory-based multi-poverty of the fuzzy set, section 3 presents the methodology and section 4 analyzes the empirical results in the context of Chad. And finally section 5 concludes this paper.

2. Empirical Works of Multi-Poverty Based on the Fuzzy Set Theory

With many methods of analyzing poverty and well-being, there seems to be no methodological consensus on how to measure multidimensional poverty. To identify the poor, it is necessary to determine threshold values for each attribute in order to distinguish the poor from the non-poor. This poverty line can be absolute or relative. In both cases, the choice of the poverty line is arbitrary (Filippone, Cheli, & D'Agostino, 2001) in that it establishes an artificial dichotomy between poor and non-poor. As pointed out Cerioli and Zani (1990); Cheli and Lemmi (1995) and Fusco (2003) the problem is partly due to the fact that a clear division of households between poor and non-poor is unrealistic. This leads Qizilbash (2002) to describe poverty as a vague concept, because there seems to be no clear separation between poor and non-poor. Likewise, Mack and Lansley (1985) point out that there is probably a continuum of living standards from the poor to the non-poor, which makes any threshold somewhat arbitrary. This requires a theoretical mathematical approach such as fuzzy set theory which seems particularly suitable for modeling vague concepts such as poverty. Recent attempts to develop a framework allowing multidimensionality, vagueness and ambiguity of poverty seem to focus on the use of the fuzzy theoretical overall approach Martinetti (2000) and Lelli (2001). This is consistent with Sen (1992), who argues that, as poverty is a vague and ambiguous concept, its degree of ambiguity should not be removed. then Zadeh (1965) developed the theory of "fuzzy sets" on the premise that certain classes of objects cannot be defined by very precise membership criteria. In other words, it is sometimes impossible to determine which elements belong to a given set and which ones are not. Cerioli and Zani (1990) were the first to apply the concept of fuzzy sets to the measurement of poverty, their approach is called the totally fuzzy approach. The idea is to take into account a whole series of variables each supposed to measure a particular aspect of

poverty. Some authors Cheli and Betti (1999) and Cheli and Lemmi (1995) have proposed to modify the approach of Cerioli and Zani (1990) and have proposed what they have called the totally fuzzy and relative approach. Dagum and Costa (2004) recently introduced, based on the work of Cerioli and Zani (1990), a new approach to the fuzzy study of multidimensional poverty. It is this new approach that we will use for this study. The fuzzy approach of Dagum and Costa (2004) has drawn our attention to other multidimensional poverty methods, because it has the double advantage of not defining threshold values, giving arbitrary weights to attributes and of adopting a relative approach to poverty. Again, the fuzzy poverty index can be broken down simultaneously by subgroup and by attribute. These are interesting properties of a poverty index that provide the information necessary to reduce the intensity of poverty. Thus, the concept of fuzzy sets constitutes an ideal framework for dealing with problems in the absence of a precise criterion allowing to determine which elements belong or not to a given set. It is therefore a very interesting concept for solving the problem of identifying the poor. With this type of approach, it is not necessary to specify an arbitrary poverty line for each dimension in order to estimate poverty rates. Several empirical studies on multidimensional poverty in the rest of the world use the fuzzy set theory. Appiah-Kubi, Amanning-Ampomah, and Ahortor (2007) in Ghana, Stéphane and Noel (2005) in Argentina, Mussard and Alperin (2005) for Senegal, in Switzerland and Costa (2003) on the European countries Diallo (2010) and finally that of Oyekale and Okunmadewa (2008) for Nigeria, Ambapour (2009) for the Congo, Chameni Nembua and Miamo Wendji (2010), etc.

The theoretical foundations of the fuzzy-set or the fuzzy set go back to the work of Zadeh (1965). The basic idea is that there are object classes whose members cannot be defined on the basis of objective criteria. In other words, there are individuals whose identification of the group to which they belong does not follow a rigorous logic. The works of Cerioli and Zani (1990); Cheli and Lemmi (1995) have clarified the forms of the membership function in the case of three types of variables. Binary variables that indicate whether an individual owns a property or not. Polytomic variables which reflect a situation where a well-being indicator includes more than two modalities. Continuous variables such as income or expenditure. The construction of the Composite Indicator of Well-Being (CIBE) in fuzzy set approaches involves two successive stages. The first consists in measuring the state of deprivation of individuals on each of the basic indicators. Thus, the less there are deprivations on an indicator, the more weight is given to it. The idea underlying this logic is for example the following: if the majority of a population owns a mobile phone while very few of them have a landline, weight will be given to the mobile phone so that its non-possession has a considerable importance in the deprivation of individuals. At the end of the process, each individual is characterized by a numerical value of the membership function aggregated on all the well-being indicators. Vero and Werquin (1997) have improved the construction of wj by taking into account possible collinearities between the indicators. Since then, both theoretical work (Cheli & Lemmi, 1995; Dagum, 2002; Martinetti, 1994) that practical Betti and Lemmi (2006); Cheli and Lemmi (1995); Dagum and Costa (2004) and Wagle (2009) abound in this domain. It allows politicians and decision-makers to target groups concerned and to know the causes of poverty.

3. Methodology

3.1. Formulation of the Fuzzy Index of Multi-Poverty

The classic set theory is based on the Boolean relation: given an element x and a set B, we have x belongs to B ($x \in B$) or x does not belong to B ($x \notin B$). As for the theory of fuzzy sets, for an element x and a set B, we have x belongs completely to B, x does not belong to B, and x belongs partially to B. We recall in some definitions and basic notions for the fuzzy set theory. The multidimensional approach based on the fuzzy set theory makes it possible to define a poverty index in relation to: each household, all the households considered in the study, and the population by attribute. This multivariate method by Cerioli and Zani (1990) and deepened by Dagum and Costa (2004). This approach of Dagum and Costa requires the definition of two concepts: (1) Economic entities or the set of households located in an economic space $A = (a_1, a_2, \ldots, a_i, \ldots, a_n)$ et (2) An order vector m of socio-economic attributes to study the poverty state of $A : X = (X_1, X_2, \ldots, X_j, \ldots, X_m)$.

Let B be a subset of A such that $a_i \in B$ has a degree of deprivation in at least one of the m attributes X_j.

The weight wj represents the intensity of deprivation linked to the attribute X_j. Cerioli and Zani (1990) defined it according to an inverse relation to the average degree of deprivation relative to the indicator j. According to this weighting system, greater weight is assigned to the indicators the most widespread. Thus, its formula is given by:

$$w_j = \mathrm{Log}\left(\sum_{i=1}^{n} f(a_i) \Big/ \sum_{i=1}^{n} x_{ij}\, f(a_i)\right) > 0$$

and $f(a_i)$ is the weight of household a_i in the sample, by imposing:

- $\sum_{i=1}^{n} x_{ij}\, f(a_i) > 0$, to exclude the attribute X_j such that $x_{ij} = 0$, $\forall\, a_i \in A$. That is, we exclude the attribute whose deprivation level is zero for all households, in other words, all households a_i have the attribute X_j.
- $\sum_{i=1}^{n} f(a_i) = n$.
- $\sum_{i=1}^{n} x_{ij}\, f(a_i) \neq n$, to exclude the attribute X_j / $x_{ij} = 1$, $\forall\, a_i \in A$. That is, we exclude the attribute whose deprivation level is 1 for all households, in other words, no household a_i has the attribute X_j.

The use of fuzzy set theory also allows the calculation of a one-dimensional for each of the attributes considered:

$$\mu_B(X_j) = \sum_{i=1}^{n} x_{ij}\, f(a_i) \Big/ \sum_{i=1}^{n} f(a_i)$$

One-dimensional attribute indices identify related variables with poverty, and thus traces strategic axes of intervention to decision-makers in the context of poverty reduction.

The ration μ_B (X_j) reflects the degree of deprivation of the attribute X_j for the population of n households. The overall poverty index can also be calculated by averaging the weighted one-dimensional indices for each attribute.

The overall fuzzy poverty index is also defined as a weighted average degree of deprivation of the attribute X_j for the population of n households $\mu_B(X_j)$ with w_j.

$$\mu_B = \sum_{j=1}^{m} \mu_B(X_j) w_j \Big/ \sum_{i=1}^{n} w_j$$

The method of breaking down fuzzy poverty indices provides a framework that allows better understand poverty through its multiple facets. Before proceeding to decompose the fuzzy household poverty index, it would be advisable to define subsets of the poorest households in order to see the degree of belonging of these households.

For the decomposition of the fuzzy poverty index, we repeat here the methods of decomposition of the fuzzy multidimensional poverty index introduced and developed in a previous work (Mussard & Alperin, 2005). Suppose that the total economic area is subdivided into k groups S_k of size n_k $(k = 1, \ldots, s)$. intensity of the household poverty a_i of S_k is given by:

$$\mu_B(a_i^k) = \sum_{j=1}^{m} x_{ij}^k w_j \Big/ \sum_{j=1}^{m} w_j$$

where w_j is the weight attached to the attribute X_j and xijk is the membership function of the fuzzy subset B of the household a_i $(i = 1, \ldots, nk)$ of S_k compared to the attribute X_j $(j = 1, \ldots, m)$.

The multidimensional poverty index associated with the S_k group is then defined as follows:

$$\mu_B^k = \sum_{i=1}^{n_k} \mu_B(a_i^k) f(a_i^k) \Big/ \sum_{i=1}^{n_k} f(a_i^k)$$

The overall fuzzy poverty index is also defined as the sum of the fuzzy poverty indices associated with the groups S_k $(k = 1, \ldots, s)$:

$\mu_B = \sum_{k=1}^{s} \mu_B^k = \sum_{k=1}^{s} \sum_{i=1}^{n_k} \mu_B(a_i^k) f(a_i^k) / \sum_{i=1}^{n} f(a_i)$.

We can measure the contribution of the S_k group to the total poverty index :

$$C_{\mu_B}^k = \sum_{i=1}^{n_k} \mu_B(a_i^k) f(a_i^k) \Big/ \sum_{i=1}^{n} f(a_i)$$

Now suppose that each of the groups S_k $(k = 1, \ldots, s)$ is subdivided into b subgroups S_{kb} $(b = 1, \ldots, p)$ of size n_{kb}.

The poverty intensity of household a_i de S_{kb} is given by:

$$\mu_B(a_i^{kb}) = \sum_{j=1}^{m} x_{ij}^{kb} w_j / \sum_{j=1}^{m} w_j.$$

where w_j is the weight attached to the attribute X_j and x_{ij}^{kb} is the membership function of the fuzzy subset B of the household a_i (i = 1,…, n_{kb}) of S_{kb} compared to the attribute X_j $(j = 1, \ldots, m)$.

The multidimensional poverty index associated with the S_{kb} group is then defined as follows: $\mu_B^{kb} =$

$$\sum_{i=1}^{n_{kb}} \mu_B(a_i^{kb}) f(a_i^{kb}) / \sum_{i=1}^{n_{kb}} f(a_i^{kb}).$$

The fuzzy poverty index associated with the S_k group is also defined as the sum of the fuzzy poverty indices associated with the S_{kb} groups $(b = 1, \ldots, p)$.

$$\mu_B^k = \sum_{b=1}^{p} \mu_B^{kb} = \sum_{b=1}^{p} \sum_{i=1}^{n_{kb}} \mu_B(a_i^{kb}) f(a_i^{kb}) / \sum_{i=1}^{n_k} f(a_i^k).$$

From there, it is possible to measure the contribution of the S_{kb} group to the fuzzy poverty index associated with the S_k group

$$C_{\mu_B^k}^{kb} = \sum_{i=1}^{n_{kb}} \mu_B(a_i^{kb}) f(a_i^{kb}) / \sum_{i=1}^{n_k} f(a_i^k):$$

The fuzzy poverty index is also defined as the sum of the fuzzy poverty indices associated with the groups S_{kb} $(b = 1, \ldots, p)$:

$$\mu_B = \sum_{k=1}^{s} \sum_{b=1}^{p} \sum_{i=1}^{n_{kb}} \mu_B(a_i^{kb}) f(a_i^{kb}) / \sum_{i=1}^{n} f(a_i).$$

We also have

$$\mu_B = \sum_{b=1}^{p} \sum_{k=1}^{s} \sum_{i=1}^{n_{kb}} \mu_B(a_i^{kb}) f(a_i^{kb}) \Big/ \sum_{i=1}^{n} f(a_i)$$

Consequently, the contribution of the S_{kb} group to the overall fuzzy poverty index:

$$C_{\mu_B}^{kb} = \sum_{i=1}^{n_{kb}} \mu_B(a_i^{kb}) f(a_i^{kb}) \Big/ \sum_{i=1}^{n} f(a_i^k)$$

Dagum and Costa (2004) introduced the decomposition by attribute by demonstrating that it is possible to calculate the contribution of the attribute X_j to the overall poverty index.

As, $\mu_B = \sum_{j=1}^{m} \mu_B(X_j) w_j / \sum_{i=1}^{n} w_j$, the authors obtain the (absolute) contribution of the attribute X_j to the multidimensional poverty index:

$$C_{\mu_B}^j = \mu_B(X_j) w_j / \sum_{j=1}^{m} w_j.$$

Furthermore, from this expression, it is possible to calculate the contribution of the attribute X_j to the group S_k. To do this, we introduce the one-dimensional poverty index of the attribute X_j for the group S_k.

$$\mu_B(X_j^k) = \sum_{i=1}^{n_k} x_{ij}^k f(a_i^k) \Big/ \sum_{i=1}^{n_k} f(a_i^k)$$

We can use this expression to calculate the absolute contribution of the attribute X_j to the group S_k.

$$C^{j}_{\mu_B^k} = \mu_B(X_j^k)w_j \Big/ \sum_{j=1}^{m} w_j$$

We can calculate the one-dimensional poverty index of attribute X_j for the subgroup S_{kb} of the group S_k.

$$\mu_B(X_j^{kb}) = \sum_{i=1}^{n_{kb}} x_{ij}^{kb} f(a_i^{kb}) / \sum_{i=1}^{n_{kb}} f(a_i^{kb}).$$

We have the absolute contribution of the attribute X_j to the subgroup S_{kb} of the group S_k.

$$C^{j}_{\mu_B^{kb}} = \mu_B(X_j^{kb})w_j \Big/ \sum_{j=1}^{m} w_j$$

Unlike the breakdown by group by subgroup, the breakdown by attribute allows decision-makers to obtain more information on the different dimensions of poverty. Chakravarty, Mukherjee, and Ranade (1998) introduced a class of poverty indices that can be decomposed by attributes and by groups. As Stéphane and Noel (2005) have shown, the fuzzy poverty index satisfies this μ_B property. From the expression:

$$\mu_B(X_j^k) = \sum_{i=1}^{n_k} x_{ij}^k f(a_i^k) / \sum_{i=1}^{n_k} f(a_i^k).$$

We define the poverty index as a weighted function of the one-dimensional indices of the attribute in the group S_k:

$$\mu_B = \sum_{k=1}^{s} \mu_B^k = \sum_{k=1}^{s} \sum_{j=1}^{m} \mu_B(X_j^k)w_j \Big/ \sum_{j=1}^{m} w_j$$

Therefore, it is possible to calculate the contribution of the attribute X_j and of the group S_k to the overall poverty index is:

$$C^{jk}_{\mu_B} = \mu_B(X_j^k)w_j \Big/ \sum_{j=1}^{m} w_j$$

If we consider the one-dimensional index of the attribute X_j in the subgroup S_{kb} of the group S_k :

$$\mu_B = \sum_{k=1}^{s} \sum_{b=1}^{p} \sum_{j=1}^{m} \mu_B(X_j^{kp})w_j \Big/ \sum_{j=1}^{m} w_j$$

We can measure the contribution of the couple subgroup S_{kb} and of the attribute X_j to the overall poverty index is:

$$C^{jkb}_{\mu_B} = \mu_B(X_j^{kb})w_j / \sum_{j=1}^{m} w_j.$$

3.2. Data Sources

We have a total of 1, 784, 037 households estimated at ECOSIT3 level, i.e. 524, 539 households more than the workforce found in 2003 (1,259,498 households), representing an average annual growth rate of 4.3%. The estimated households are distributed between 2003 and 2011 as follows: those headed by men (79.5% -79.2%) and those headed by women (20.5 % -20.8%) at the national level. It is estimated that around the whole territory and between 2003 and 2011 that 4 out of 5 heads of household are male.

3.3. Choice of Indicators and Cut-Offs

The question of the choice of deprivation indicators has been discussed at length by Cheli and Lemmi (1995) and by Cheli and Lemmi (1995). These authors note that the choice of deprivation indicators is of fundamental importance in this type of research; because each indicator describes a particular aspect of poverty. Furthermore, they recommend, in the analysis, to clearly distinguish the effect variables (such as the possession of durable goods) and the cause variables (such as unemployment) from poverty. Pi Mussard and Alperin (2005) emphasize that the importance of structural socio-economic policies aimed at reducing the main causes of poverty depends on the choice of indicators representing states of deprivation and social exclusion. Finally, Miceli (2006) points out that the choice of deprivation indicators is particularly delicate and cannot intervene without a dose of arbitrary more or less and that, the fuzzy measurement obtained is ultimately conditioned by the data availability. The selection of socio-economic attributes to study the state of poverty was made on the basis of multidimensional notions of poverty, information from the Ecosit3 and Ecosit2 surveys and the Sustainable Development Goals (SDGs). This selection is very important because each of the selected attributes explains the degree of deprivation and social exclusion of the households studied (Mussard & Alperin, 2005) and Ambapour (2009). For questions related to the choice of dimensions and capacities, see Sen (1992); Atkinson (2003). The selected variables are in the Table 1 and the lack of the income dimension would be justified by the fact that it would already act on almost all the other dimensions selected (for example having a permanent home depends on its income, energy, etc.)

Table 1. List of attributes.

Variables	Variables
Education	Housing
Literacy	Roof
Attendance	Wall
Instruction	Floor
Health	Sanitation
Access to health centers	Household waste
Morbidity	Existence of WC
Drinking water	Energy
Source of drinking water	Existence of electricity
Access to water within 30 minutes	Combustible

These are the main indicators of household well-being. The indicators thus selected are considered as dichotomous variables. For all these indicators, the thresholds we use are the minimums that a person should have to lead a decent life. Thus, the threshold divides the population into two groups: people who suffer deprivation in the dimension in question and others. The deprivation thresholds first identify people experiencing deprivation in each of the selected indicators. Deprivations are dichotomous: each household is identified as being deprived or not of deprivations in each indicator according to a threshold specific to the indicator concerned. The respective deprivation thresholds are described as follows:

- **Education**: - A household is declared private for literacy if none of its members can read, write and count. In other words, the household is not deprived in this dimension if at least one of its members can read, or write or count in French.
- It is considered private in terms of attendance if a member of school age does not attend due to financial impossibility, school is too far away and school is useless and irrelevant to the household.
- Finally, he is deprived of education if the head of household is uneducated.
- **Housing**: - A household is deprived of soil materials if the materials of the floor of its dwelling are not made of cement, tiles and concrete.
- He is deprived of materials for the roof if the materials for the roof of his accommodation are not sheet metal / tile and concrete.
- It is declared private with regard to wall materials if the materials of the exterior walls are not cement (hard).
- **Health:** - A household is considered devoid of morbidity if one of its members has been sick or injured during the 30 days.
- It is also private, its access to the nearest health center is more than 5 km away.
- **Sanitation**: - A household is considered to lack this indicator, since every household does not have a toilet.
- It is private if its mode of disposal of household waste is not the city hall bin / garbage bag and the sanitation committee.
- **Drinking water**: - A household is deprived of drinking water if its main source of water is not tap water and bottled water.
- Is considered private in access to drinking water if its access is located more than 30 minutes round trip.
- **Energy:** - A household is declared private if it does not have access to electricity and to the generator (if the household accommodation does not have electricity).
- It is also considered to be deprived of fuel if its source is not electricity and gas.

The weight w_j represents the intensity of deprivation linked to the attribute X_j. the weights of Cerioli and Zani (1990) defined according to an inverse relation of the average degree of deprivation relative to the indicator j. According to this weighting system, more weight is assigned to the most common indicators. The Table 2 presents the weights of each dimension and indicator.

Table 2. The weights of each dimension and indicator.

Attributes/Dimensions	Weight (2003)	Weight (2011)
Literacy	0.0886	0.0682
Attendance	0.0074	0.1000
Instruction	0.0766	0.0975
Education	0.1726	0.2657
Roof	0.0275	0.0175
Wall	0.0455	0.0440
Floor	0.0353	0.0397
Housing	0.1083	0.1012
Access to health centers	0.2032	0.2013
Morbidity	0.1139	0.1172
Health	0.3171	0.3185
Household waste	0.0107	0.0078
Existence of WC	0.0648	0.0682
Sanitation	0.0755	0.0760
Source of drinking water	0.2571	0.1387
Access to water within 30 minutes	0.0595	0.0941
Drinking water	0.3166	0.2328
Existence of electricity	0.0057	0.0024
Combustible	0.0042	0.0034
Energy	0.0099	0.0058

4. Empirical Results

The data used in this paper are taken from the Budget and Consumption Surveys in 2003 (ECOSIT2) for 7,008 households and in 2011 (ECOSIT3) for 10, 200 households.

4.1. Fuzzy Poverty Index at National Level

The multidimensional poverty indices in Chad are: 0.4874 in 2003 and 0.5899 in 2011. In other words, Chadian households are 48.74% structural poor in 2003 against 58.89% in 2011. Between 2003 and 2011, structural poverty increased by 20.82%.

4.2. Decomposition of Fuzzy Poverty by Attribute

According to the decomposition by attribute developed by Dagum and Costa (2004), in the Table 3, the indices dimensions of poverty which have important parts in the construction of the fuzzy one-dimensional index of poverty in 2003 are : education: 0.638; housing: 0. 808; sanitation : 0.727; energy : 0.972. And in 2011, education: 0.643; housing: 0.833; sanitation: 0.742; energy: 0.986 have important parts in the construction of the fuzzy one-dimensional

index of poverty. Between 2003 and 2011, we find that the indices of all 6 dimensions have increased. According to the table below, the contribution of each variable to the fuzzy index of global multidimensional poverty, we observe the strong contributions for the variables in 2003 following: Literacy (11%), Education (10.20%), Access to health centers (12.20%), Morbidity (13.10%), Access to water within 30 minutes (12.20%). The strong contributions of 2011 are: attendance (10.40%), education (10.30%), access to health centers (11.20%), morbidity (12.80%), access to drinking water (10. 10%), Access to water of less than 30 minutes (12%).

We note from this table below that we have a global view on the causes of poverty, the methods of decomposition give us more detailed and precise information on the true causes of the determination of the multidimensional phenomenon of poverty. We have made the following decompositions to obtain more information on the true causes of the multidimensional phenomenon of poverty: gender; and residence (urban and rural). We first analyze the breakdown by group. The Table 3 presents two types of information: (i). multidimensional poverty indices (MPI) for each group after decomposition; absolute contributions and relative contributions.

Table 3. Decomposition of fuzzy poverty by attribute.

Attributes/ Dimensions	2003			2011		
	Poverty	Absolute contribution	Relative contribution	Poverty	Absolute contribution	Relative contribution
literacy	0.604	0.053	0.11	0.717	0.049	0.083
attendance	0.959	0.007	0.015	0.614	0.061	0.104
Instruction	0.647	0.05	0.102	0.622	0.061	0.103
Education	0.638	0.11	0,226	0,643	0.171	0.29
Roof	0.772	0.035	0.072	0.807	0.036	0.06
wall	0.818	0.029	0.059	0.824	0.033	0.056
Floor	0.855	0.024	0.048	0.918	0.016	0.027
Housing	0.808	0.088	0.18	0.833	0.084	0.143
Access to health centers	0.523	0.06	0.122	0.565	0.066	0.112
Morbidity	0.314	0.064	0.131	0.375	0.075	0.128
Health	0.389	0.123	0.253	0.445	0.142	0.24
Household waste	0.941	0.01	0.021	0.963	0.007	0.013
Existence of WC	0.691	0.045	0.092	0.717	0.049	0.083
Sanitation	0.727	0.055	0.113	0.742	0.056	0.096
Source of drinking water	0.713	0.042	0.087	0.632	0.059	0.101
Access to water within 30 minutes	0.231	0.059	0.122	0.508	0.071	0.12
Drinking water	0.322	0.102	0.209	0.558	0.13	0.221
Existence of electricity	0.968	0.006	0.011	0.988	0.002	0.004
Combustible	0.976	0.004	0.008	0.984	0.003	0.006
Energy	0.972	0.010	0.020	0.986	0.006	0.010

4.3. Decomposition of Fuzzy Poverty by Gender

Understanding the phenomenon of poverty through the sex of the head of household can provide useful elements for targeting actions aimed at improving the living conditions of the poor. Indeed, to propose policies that can help reduce poverty, the authorities need to know whether the phenomenon of poverty is linked to the gender of the head of household or not. For the breakdown by sex in the Table 4, we note the households with female heads of households, are the poorest (50.92%) compared to households of male heads (47.31%) in 2003 and we have the same situation in 2011, the poverty of female households is at 64.18% while that of households headed by men is at 56.52%. As there are more Chadian households headed by men, they account for around 77.73% in 2003 and 76.10% in 2011.

Table 4. Decomposition by gender.

	2003			2011		
	Poverty	Absolute contribution	Relative contribution	Poverty	Absolute contribution	Relative contribution
Male	0.4731	0.3789	0.7773	0.5652	0.4479	0.761
Female	0.5092	0.1086	0.2227	0.6418	0.141	0.239

4.4. Decomposition of Fuzzy Poverty by Residence

In the Table 5, the decomposition by residence indicates that poverty is accentuated in rural areas with rates of 49.16% in 2003 and 60.46% in 2011 against 24.37% in 2003 and 32.02 % in 2011. We observe that rural poverty increases unlike urban poverty between 2003 and 2011. Poverty during the two years are almost explained by rural poverty, their contributions are at 93.66 % in 2003 and 87.94% in 2011.

Table 5. Decomposition by residence.

	2003			2011		
	Poverty	Absolute contribution	Relative contribution	Poverty	Absolute contribution	Relative contribution
Rural	0.4916	0.4565	0.9366	0.6046	0.5179	0.8794
Urban	0.2437	0.0309	0.0634	0.3202	0.0710	0.1206

Table 6. Decomposition of fuzzy poverty by attribute and by gender.

	2003						2011					
	Poverty		Absolute Contribution		Relative contribution		Poverty		Absolute Contribution		Relative Contribution	
Attributes	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
Literacy	0.590	0.659	0.042	0.012	0.085	0.025	0.664	0.917	0.036	0.013	0.061	0.022
Attendance	0.959	0.958	0.006	0.001	0.012	0.003	0.555	0.838	0.044	0.017	0.075	0.030
Instruction	0.594	0.851	0.036	0.013	0.074	0.027	0.562	0.849	0.043	0.017	0.074	0.029
Education	0.606	0.730	0.083	0.027	0.171	0.055	0.586	0.858	0.123	0.048	0.209	0.081
Roof	0.771	0.773	0.028	0.007	0.057	0.015	0.800	0.833	0.028	0.008	0.047	0.013
Wall	0.809	0.852	0.023	0.006	0.047	0.013	0.811	0.873	0.026	0.007	0.043	0.012
Floor	0.858	0.842	0.019	0.005	0.039	0.010	0.918	0.919	0.013	0.003	0.022	0.006
Housing	0.805	0.815	0.069	0.018	0.142	0.037	0.824	0.865	0.066	0.018	0.112	0.031
Access to health centers	0.527	0.506	0.048	0.012	0.098	0.024	0.560	0.583	0.052	0.014	0.088	0.024
Morbidity	0.286	0.423	0.046	0.018	0.095	0.036	0.350	0.469	0.056	0.020	0.095	0.033
Health	0.368	0.460	0.094	0.029	0.193	0.060	0.424	0.517	0.108	0.034	0.183	0.058
Household waste	0.943	0.935	0.008	0.002	0.016	0.004	0.963	0.962	0.006	0.002	0.010	0.003
Existence of WC	0.688	0.704	0.035	0.009	0.073	0.019	0.712	0.734	0.038	0.010	0.065	0.018
Sanitation	0.723	0.741	0.043	0.011	0.089	0.023	0.738	0.760	0.044	0.012	0.075	0.020
Source of drinking water	0.713	0.712	0.034	0.009	0.069	0.018	0.631	0.635	0.047	0.012	0.080	0.021
Access to water within 30 minutes	0.224	0.224	0.047	0.012	0.097	0.025	0.502	0.533	0.055	0.015	0.094	0.026
Drinking water	0.314	0.314	0.081	0.021	0.166	0.043	0.554	0.576	0.102	0.028	0.173	0.047
Existence of electricity	0.966	0.976	0.004	0.001	0.009	0.002	0.988	0.989	0.002	0.000	0.003	0.001
Combustible	0.975	0.982	0.003	0.001	0.007	0.002	0.985	0.980	0.003	0.001	0.005	0.001
Energy	0.970	0.979	0.008	0.002	0.016	0.004	0.986	0.983	0.005	0.001	0.008	0.002
Chad	0.473	0.509	0.379	0.109	0.777	0.223	0.565	0.642	0.448	0.141	0.761	0.239

Table 7. Decomposition of fuzzy poverty by attribute and by residence.

	2003									2011								
	Poverty			Absolute Contribution			Relative Contribution			Poverty			Absolute Contribution			Relative Contribution		
	Rural	Urban	Chad	Rural	Urban	Chad	Rural	Urban	Chad	Rural	Urban	Chad	Rural	Urban	Chad	Rural	Urban	Chad
Literacy	0.636	0.345	0.604	0.050	0.003	0.053	0.103	0.007	0.110	0.764	0.523	0.717	0.042	0.007	0.049	0.071	0.012	0.083
Attendance	0.961	0.940	0.959	0.006	0.001	0.007	0.013	0.002	0.015	0.651	0.460	0.614	0.052	0.009	0.061	0.089	0.015	0.104
Instruction	0.672	0.440	0.647	0.046	0.004	0.050	0.094	0.008	0.102	0.660	0.464	0.622	0.052	0.009	0.061	0.088	0.015	0.103
Education	0.666	0.404	0.638	0.102	0.008	0.110	0.210	0.016	0.226	0.682	0.480	0.643	0.146	0.025	0.171	0.248	0.042	0.290
Roof	0.865	0.770	0.855	0.032	0.003	0.035	0.065	0.007	0.072	0.960	0.744	0.918	0.030	0.006	0.036	0.051	0.009	0.060
Wall	0.852	0.116	0.772	0.028	0.000	0.029	0.058	0.001	0.059	0.932	0.285	0.807	0.030	0.002	0.033	0.052	0.004	0.056
Floor	0.837	0.662	0.818	0.021	0.002	0.024	0.044	0.004	0.048	0.890	0.550	0.824	0.014	0.002	0.016	0.024	0.004	0.027
Housing	0.850	0.257	0.808	0.082	0.006	0.088	0.167	0.012	0.180	0.916	0.422	0.833	0.074	0.010	0.084	0.126	0.017	0.143
Access to health centers	0.324	0.235	0.314	0.055	0.005	0.060	0.112	0.010	0.122	0.391	0.305	0.375	0.056	0.010	0.066	0.095	0.018	0.112
Morbidity	0.537	0.403	0.523	0.059	0.005	0.064	0.120	0.011	0.131	0.685	0.065	0.565	0.074	0.002	0.075	0.125	0.003	0.128
Health	0.400	0.300	0.389	0.113	0.010	0.123	0.232	0.021	0.253	0.476	0.137	0.445	0.129	0.012	0.142	0.220	0.021	0.240
Household waste	0.975	0.661	0.941	0.009	0.001	0.010	0.019	0.002	0.021	1.000	0.808	0.963	0.006	0.001	0.007	0.011	0.002	0.013
Existence of WC (Water Closet)	0.769	0.058	0.691	0.044	0.000	0.045	0.091	0.001	0.092	0.845	0.185	0.717	0.046	0.002	0.049	0.079	0.004	0.083
Sanitation	0.787	0.134	0.727	0.054	0.001	0.055	0.110	0.002	0.113	0.845	0.255	0.742	0.053	0.004	0.056	0.090	0.006	0.096
Source of drinking water	0.245	0.117	0.231	0.040	0.002	0.042	0.082	0.005	0.087	0.514	0.484	0.508	0.048	0.011	0.059	0.082	0.019	0.101
Access to water within 30 minutes	0.768	0.261	0.713	0.057	0.002	0.059	0.117	0.005	0.122	0.688	0.398	0.632	0.062	0.009	0.071	0.105	0.015	0.120
Drinking water	0.328	0.173	0.322	0.097	0.005	0.102	0.199	0.010	0.209	0.577	0.436	0.558	0.110	0.020	0.130	0.187	0.033	0.221
Existence of electricity	0.979	0.876	0.968	0.005	0.001	0.006	0.010	0.001	0.011	1.000	0.940	0.988	0.002	0.000	0.002	0.003	0.001	0.004
Combustible	0.980	0.944	0.976	0.004	0.000	0.004	0.008	0.001	0.008	0.996	0.932	0.984	0.003	0.001	0.003	0.005	0.001	0.006
Energy	0.980	0.897	0.972	0.009	0.001	0.010	0.018	0.002	0.020	0.996	0.936	0.986	0.005	0.001	0.006	0.008	0.002	0.010
Chad	0.492	0.244	0.487	0.456	0.031	0.487	0.937	0.063	1.000	0.605	0.320	0.589	0.518	0.071	0.589	0.879	0.121	1.000

4.5. Decomposition of Fuzzy Poverty by Attribute and by Gender

According to the Table 6, the decomposition by attribute and by gender in 2003, it appears that for all attributes except the attributes Morbidity and Access to water within 30 minutes (round trip) play an important role in determining the level of structural poverty for men and women. In 2011, for men, the Attendance attributes, education, access to health centers, morbidity, access to water of less than 30 minutes (round trip) are not determinative for poverty, unlike for women, these are the attributes access to health centers, morbidity, access to water of less than 30 minutes (round trip) and access to drinking water. Between 2003 and 2011, only the attendance and education attributes experienced slight decreases in men, as in women.

4.6. Decomposition of Fuzzy Poverty by Attribute and by Residence

As national multidimensional poverty is strongly determined by multidimensional rural poverty in 2003 and in 2011, in 2003, national multidimensional poverty was around 48.70% compared to 49.20% in rural areas, and in 2011 it was 58.9% against 60, 50%. We have the same observations for one-dimensional poverty. In addition, one-dimensional rural poverty contributes very strongly to the multidimensional poverty determinations of 2003 and 2011 in the reading of Table 7.

5. Conclusion

The fuzzy sets approach (2003; 2011) was used to analyze multidimensional poverty. The results tell us that the multidimensional poverty indices in Chad are 0.4874 in 2003 and 0.5889 in 2011. In other words, Chadian households are 48.74% structurally poor in 2003 compared to 58.89% in 2011. Between 2003 and 2011, structural poverty increased by 20.82%. The most important one-dimensional fuzzy poverty indices in 2003 are: education: 0.638; housing: 0.808; sanitation: 0.727; energy: 0.972, health: 0.389, drinking water: 0.322. And in 2011, we have: education: 0.643; housing: 0.833; sanitation: 0.742; energy: 0.986, health: 0.445 drinking water: 0.558. One-dimensional fuzzy poverty indices indicate a deterioration in the social situation between 2003 and 2011. Households with female heads of households are the poorest (50.92%) compared to households of male heads (47.31%) in 2003 and we have the same situation in 2011, the poverty of female households is 64.18% while that of households headed by men is 56.52%. Poverty is accentuated in rural with rates of 49.16% in 2003 and 60.46% in 2011 against 24.37% in 2003 and 32.02% in 2011 for the urban.

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