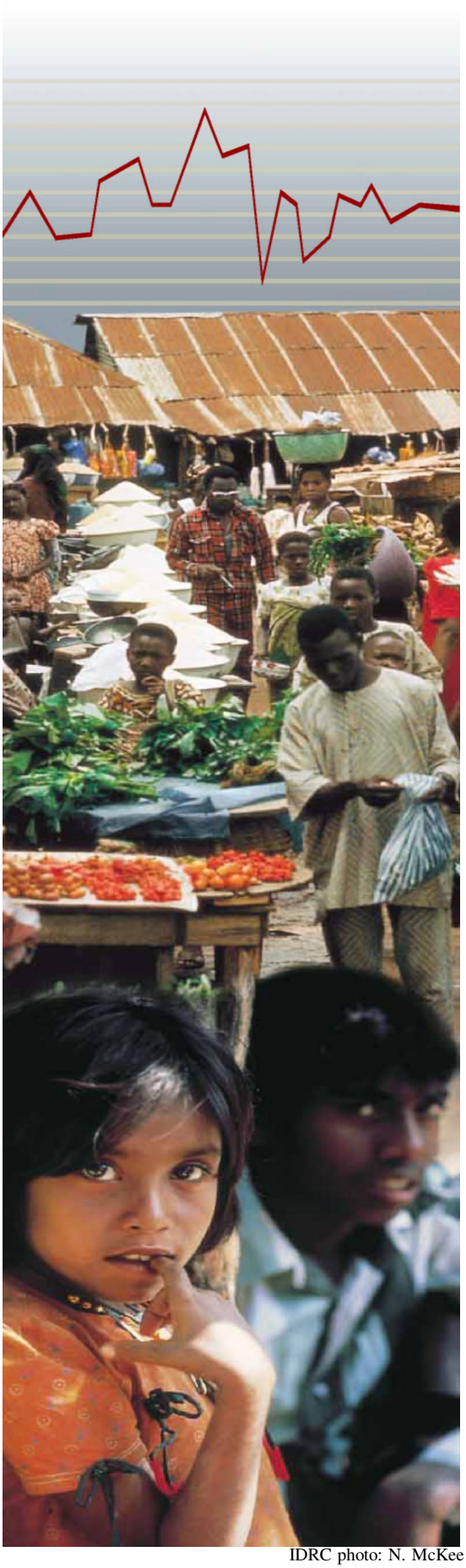

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Multi-Dimensional Analysis of Poverty in Ghana Using Fuzzy Sets Theory

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Abstract

The paper studies the multidimensional aspects of poverty and living conditions in Ghana. The aim is to fill the vacuum that has been left by traditional uni-dimensional measures of deprivation based on poverty lines, exclusively estimated on the basis of monetary variables such as income or consumption expenditure. It combines monetary and non-monetary, and qualitative and quantitative indicators, including housing conditions, the possession of durable goods, equivalent disposable income, and equivalent expenditure, with a number of composite human welfare measures. The study employs the fuzzy-set theoretic framework to compare levels of deprivation in Ghana over time using micro data from the last two rounds of the Ghana Living Standard Surveys (1991/1992 and 1998/1999). The estimation results of the membership functions, depicting the levels of deprivation for the various categories of deprivation indicators, show a composite deprivation degree of 0.2137 for the whole country in 1998/99 as compared to 0.2123 in 1991/92. This deprivation trend reveals that poverty levels had scarcely changed in Ghana. In fact, it even rose slightly during the nineties, contrary to the uni-dimensional analytical GLSS 4 report of an overall broadly favourable trend in poverty in Ghana during the 1990s.

Keywords : Ghana, fuzzy set, multi-dimensional poverty, composite deprivation or poverty index,

JEL codes : A1, A2, A23, A29, I3, I32, I38, I39, R2, R20, R21, R22

1. Introduction

Poverty, as a serious problem in most developing countries, has attracted a lot of attention among analysts in Ghana during the last decade. The country can therefore boast of several reports on poverty trends, i.e. changes in the incidence, depth, and severity of poverty over time (Boateng *et al.* 2000; Canagarajah *et al.* 1998, Seini *et al.* 1997; Asenso-Okyere *et al,* 1997; Boateng *et al*. 1992; Glewwe and Twum-Baah, 1991). However, most of these studies have tended to focus on poverty at a point in time, and their analytical methods have usually suffered from a uni-dimensional limitation (Filippone et al 2001), where they referred to only a unique proxy of poverty, namely equivalent income or consumption[1]. They have also shared the traditional need to dichotomise the population into the poor and the non poor by means of the so called poverty line. While this reductionism simplifies the analysis, as argued by Cheli (1995), it all but wipes out the complexity and multidimensionality of this phenomenon.

Thus in the view of Satterthwaite (2001) uni-dimensional poverty measures, at best, can lead to only a partial understanding of poverty, and often to unfocused or ineffective poverty reduction programs. They fail to capture many aspects of deprivation, including lack of access to the services essential for health and literacy, as well as a lack of political voice and legal protection. Consequently the policy recommendations from such traditional analysis only dwell on transfer policies that alleviate poverty in the short-term (Fusco 2003), while leaving untouched the structural socio-economic policies that could instead break the inter-generational reproduction mechanism of poverty in the long-term (Dagum 2002). These limitations of uni-dimensional poverty measures are also compounded by other technical difficulties of income measurement, especially in developing countries that reduce the value of such income-based uni-dimensional poverty results[2].

All these give indications of serious limitations to poverty measures based on a single monetary indicator of resources (Atkinson and Bourguignon 1982, Maasoumi 1998) and underscore the strong need for a multidimensional approach to poverty analysis that widens the concept of poverty to reflect, for instance, dimensions other than just the monetary one. It is believed that the inclusion of other non-market dimensions in normative poverty analysis would help to reveal complexities and ambiguities in the distribution of well-being that income-based poverty analysis cannot capture (Robeyns 2003). This can also facilitate analysts to describe the household's life-style and thereby go deeper into the meaning and nature of poverty, thus considering poverty in a more modern light, as deprivation that people suffer throughout their lives[3] (Pochun 2002). Such a definition may make it possible to differentiate

[1] In the view of Maasoumi (1998) such limitation tends to make the meaning of "income" poverty or inequality ambiguous since households and individuals are known to have different characteristics and needs (Maasoumi 1999; 1986). Moreover, it is difficult to have meaningful conceptualization of "income inequality" because of life-cycle differences in incomes, in addition to the fact that not all (non-monetizable or non-tradable) benefits that affect well being have income dimensions.

[2] As noted by Sahn and Stifel (1999), the vast majority of African countries, for instance, suffer from paucity of data, which makes it almost impossible to make inter-temporal comparisons of poverty. And where survey data are available at more than one point in time, the determination of changes has proven problematic. This may be due to changes in survey designs and a lack of reliable deflators such as consumer price indices, resulting from serious weaknesses in data collection and related analytical procedures.

[3] It must be mentioned that other opinions hold poverty to go beyond the basic needs perspective of poverty to include the capability perspective, which also refers to the possibilities of enjoying some

economic well-being (i.e. increased material prosperity) from *human* well-being (Baliamoune 2003) along the lines of Sen's notion of *functionings* and *capability*[4].

In Ghana very little work has been done hitherto by way of analysing poverty in a multi-dimensional sense. This can partly be attributed to paucity of data and lack of reliable deflators, which make it almost impossible to make inter-temporal comparisons of poverty (Sahn and Stifel 1999). Apart from the UNDP Human Development Index (HDI), the only multi-dimensional poverty analysis in Ghana known to the writers is the attempt by Sahn and Stifel (1999) to construct a welfare index for some nine African countries and provide evidence of declining poverty in most of the studied African countries[5]. Even though their approach successfully reduces the potential arbitrariness of deciding the threshold values (as in the traditional approach) and weights for the resource index[6], the results lead to unrealistically large weights being assigned to ownership of certain assets like television and radio, and low weights to more valuable assets like vehicles and other means of transport[7].

The aim of this paper therefore is to fill the vacuum that has been left over by the traditional measures of deprivation based on poverty lines, exclusively estimated on the basis of monetary variables such as income or consumption expenditure. It purports to assess living conditions in Ghana with the help of several quantitative and qualitative variables on actual living conditions. These include housing conditions, the possession of durable goods, equivalent disposable income and expenditure. The objective is to provide a more complete picture of poverty, which is closer to what is perceived by just observing reality, than the use of one common indicator such as disposable income or expenditure. Such multidimensional summary measures, decomposed variously as the basic needs indicators, similar to those produced by Brazil[8], can be used for effective cross section and inter-temporal poverty comparisons and for geographical poverty mappings. Similarly they can be used to rank geographical areas of the country according to their level of welfare for better policy targeting.

The analysis on poverty has basically ranged its methodological choices from descriptive statistics to multivariate methods of factor analysis (Sahn and Stifel 1999; Lelli 2001). But if we side with Cheli (1995) in that poverty is not a discrete attribute characterised in terms of presence or absence, but rather a vague *(fuzzy)* predicate that manifests itself in different shades and degrees, then a methodological framework that uses fuzzy-sets theory to

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minimum level of human self-esteem, including participation in community life and governance (UNDP 1997). The World Bank (1990, 2001), for instance, broadens the notion of poverty to include other forms of deprivation such as vulnerability and exposure to risk—and voicelessness and powerlessness.

[4] Functionings refer to various doings and beings of a person, the achievements of an individual determined by the particular way in which he is able to "let the available goods function". Capability, on the other hand, portrays one's freedom to choose what kind of life to live and, therefore the actual autonomy in pursuing and achieving those doings and beings one deems valuable (Lelli 2001).

[5] Their attempt used data sets from Demographic and Heath Surveys of some 9 African countries and employed factor analysis of various household characteristics and durables.

[6] They allow the data to determine the weights for each asset included in the analysis using factor analysis and imposing a structure on the variance-covariance of each observed asset (Sahn and Stifel 1999).

[7] Moreover, due to data constraints, they confine their chosen variables of welfare to only qualitative indicators and exclude the quantitative element of income, hence the composite index, as an equivalent of full income (Travers and Richardson 1993) fails to give a more complete picture of living conditions of individuals or allow the measure of the volatility of the income with respect to durable goods or housing conditions (Betti *et al.* 2000).

[8] See also McGillivray and Shorrocks 2005.

analyse poverty may seem appropriate. Fuzzy sets theory has gained popularity in recent times[9] because it does not dichotomise the population into poor and non-poor through an arbitrary poverty line like the traditional methods. In this way it is also able to circumscribe targeting errors associated with the drastic differentiation between the poor and the non-poor, particularly between those in similar circumstances but who just happen to lie on opposite sides of a poverty line (Makdissi and Wodon 2004). Hence many analysts including Shorrocks and Subramanian (1994) and Schaich and Munich (1996) have applied it to analyse multi-dimensional poverty (Chiappero Martinetti 1994, 2000).

This study therefore employs the fuzzy-set theoretic framework to compare levels of deprivation in Ghana over time using micro data from the last two rounds of the Ghana Living Standard Surveys (1991 /1992 and 1998/1999). In the context of poverty as a multi-dimensional construct, we attempt here to construct a composite index comprising of several poverty-related indicators, to gauge human deprivation. We also use the factor analytical approach to analyse poverty to determine which methodology gives a better explanation of the poverty situation in Ghana in a multi-dimensional sense.

The rest of the paper is organized as follows: After a brief review of the literature in the next section, we follow up with an overview of the poverty situation in Ghana. The subsequent section presents the methodology for estimating the poverty indices for the various dimensions, to be followed by presentation of the results. A final section presents a summary of the results and concluding remarks.

2. Multi-dimensional Poverty – A Literature Review

The use of indicators to gauge human progress is common and well understood. For a long time, particularly since the introduction of the economic concept of poverty together with that of the poverty line and head count ratio, by Booth (1892) and Rowntree (1901), the reference indicator for poverty has almost always been the equivalent income or consumption. But while these indicators act as reasonably accurate and useful measures of economic performance, and thus can give a workable impression of material well-being, they are by far no precise indicators of poverty.

This has engendered attempts to find appropriate multi-dimensional indicators which can portray the different facets of poverty in any particular country, and in poverty comparisons between countries (Kolm 1977). Also contributing to this increased interest in multidimensional poverty measures is the evolution in conceptual thinking on poverty towards functionings and capabilities as initiated by Amartya Sen's (1993) well known critique of an income-based analysis of poverty. The consequence is a broadened notion of poverty to include even vulnerability and exposure to risk — and voicelessness and powerlessness (World Bank 2001, 2000) — on the basis that considerations of risk and uncertainty are key to understanding the dynamics leading to and perpetuating poverty (Rosenzweig and Binswanger, 1993; Banerjee and Newman, 1994)[10]. Hence today poverty is no longer confined to the lack of the ability of

[9] See Lemmi and Betti 2006, Barán et al 2006, Makdissi and Wodon 2004, Baliamoune 2004

[10] It must be mentioned that other opinions hold poverty to go beyond the basic needs perspective of poverty to include the capability perspective, which also refers to the possibilities of enjoying some

people to command sufficient resources to satisfy their basic needs (Piachaud 1987; Townsend 1993) nor considered as a mere economic and monetary dimension, but rather increasingly considered as human deprivation that people suffer throughout their lives. This deprivation in the multi-dimensional sense includes both quantitative and qualitative measures such as the joy of choices, opportunities and others which are most basic to human development and can paint quite different and multi-dimensional pictures of the poverty situation in any particular country, and in poverty comparisons among countries.

The search for suitable ways of measuring multi-dimensional poverty, in the past few decades, has thus led to methodological choices that have been characterised by innovative mixing of quantitative and qualitative methods that address the multi-dimensional nature of poverty and explore poverty dynamics and vulnerability. For this reason there is now a considerable and growing literature on multi-dimensional measures of poverty using several different approaches. These approaches include the social exclusion approach of René Lenoir (1974)[11], the work of Townsend (1993, 1979), Sen's *capabilities* and *functionings* approach, and the UNDP Human Poverty Index (1997). Another group includes studies derived from the concept of stochastic dominance, which uses *union* and *intersection* approaches to dealing with multidimensional indicators of poverty as developed by Duclos *et al.* (1999, 2003) as well as other multivariate factor analytical techniques. For instance, Duclos *et al. (*2003) adapted the stochastic dominance to what can be defined as *union, intersection*, or *intermediate* approaches to measure well-being in Uganda in a multi-dimensional sense. Their results revealed regional bivariate poverty comparisons to be similar to univariate comparisons based on expenditures alone, but at odds with univariate comparisons in several ways, comparing results for urban areas in one region with rural areas in another. Even though the poverty orderings seem to be robust to the choice of multidimensional poverty lines and indices, they admittedly concede that the difference in their results obtained from the more complex methods compared with that from the univariate methods do not seem to have been worth the effort.

From the literature on multi-dimensional analysis it can be noted that the factor analytical technique has often been used in empirical research in the social sciences for solving the problem of a definite number of well interpretable dimensions of well-being (Lelli 2001; Filmer and Pritchett 2001; Sahn and Stifel 1999). This can be attributed to the ease by which the technique grasps empirical relationships among many different variables[12] and the suitability of the technique in situations where there are no reliable household surveys to inform income (or consumption) distribution[13]. Others have also used different multivariate statistical variants of factorial analysis (Nolan and Whelan, 1996; Layte *et al.* 2000), principal

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minimum level of human self-esteem, including participation in community life and governance (UNDP 1997). The World Bank (1990, 2001), for instance, broadens the notion of poverty to include other forms of deprivation such as vulnerability and exposure to risk—and voicelessness and powerlessness.

[11] This was cited from Evans et al (1995).

[12] It also facilitates the exploitation of presumed correspondence between the system of latent factors and the set of observed variables in order to identify the separate dimensions for the given data and determine the extent to which each variable is explained by each dimension. Further fuzzy aggregates, compared with other approaches such as factor analysis, are insensitive to the choice of the form of membership functions (Lelli 2001).

components analysis (Ram 1982; Maasoumi and Nickelsburg 1988; and Maasoumi 1989), cluster analysis (Hirschberg *et al.* 1991) or latent class model (Pérez-Mayo 2003). Apart from the stochastic dominance approach (Duclos *et al.* 2003, 1999) mentioned above, recent approaches to multi-dimensional poverty studies have included FGT poverty measures (D'Ambrosio 2005; Foster and Shorrocks 1988; Atkinson 1987) and other multivariate approaches (Dagum 2002; Costa 2003). A particular case of general stochastic conditions is the approach that ranks income distributions where households differ in non-income characteristics, denoted by a discrete variable, and which helps to avoid the use of equivalence scales that are sensitive to assumptions that may not have widespread agreement (Diaz 2003; Dagum 2002). Considering the numerous methods used in analysing poverty and well-being, it appears that there exists a lack of methodological consensus on how multi-dimensional poverty should be measured, despite the limitations of the one-dimensional framework. This leads Qizilbash (2001) to characterise poverty as a vague concept, since there seems to be no clear-cut line between the "poor" and the "non-poor". Similarly, Mack and Lansley (1985) point out that there is a likely continuum of living standards from the poor to the rich that makes any cut-off point somewhat arbitrary. This calls for a mathematically vague theoretical approach such as fuzzy sets theory, which can also reduce the level of arbitrariness found in ordinary uni-dimensional approaches[14].

Of late, this has led to rising interest in the application of the fuzzy sets theory for poverty analysis (Cerioli and Zani (1990); Cheli and Lemmi (1995); Chiappero Martinetti (1994, 2000); Costa (2002, 2003); Dagum (2002); Vero (1999); Miceli (1998)).and Qizilbash (2002), for instance, have applied it to construct poverty measures to explore vulnerability in South Africa. Lelli (2001) has also used it to compare with the results of factor analysis and has found the fuzzy aggregates to be insensitive to the choice of the form of the membership function. Other people have also of late applied it to evaluate living conditions in countries like Italy (Cerioli and Zani 1990), Poland (Cheli *et al.* 1994) Switzerland (Miceli 1998), South Africa (Qizilbash 2002), and others (see Cheli and Lemmi 1995 or Chiappero-Martinetti 1994, Filipone *et al.* 2001). Ghellini *et al.* (1995) for example, have used this methodology to offer a multidimensional and dynamic analysis of deprivation to estimate transition matrices between the deprivation states in the US for the period 1984-1988.

The fuzzy sets theory, despite its increasing application in poverty analysis, has been criticised as ordinal measures, whose values do not have any intrinsic meaning and so put limits both on their interpretability and the possibility of comparing with one another the indices that account for different aspects of poverty. Successive refinements such as the totally fuzzy relative (TFR) proposed by Cheli and Lemmi (1995), have led to alternative specifications of membership functions leading to an expanded interpretability framework of fuzzy indices, and

[13] Lelli (2001), for instance, applied factor analysis to measure well-being in Belgium and found that income accounts only for a very limited part of the story and argued for multi-dimensional approaches like that of Sen (Balimoune 2001) to analyse well-being.

[14] It must be pointed out that while this may be true for the headcount ratio setting, the arbitrary choice of a (uni-dimensional and multi-dimensional) poverty line and poverty measure could be addressed using robustness methods or stochastic dominance tests (Duclos *et al* 2003; Atkinson 1987; Foster and Shorrocks 1988). Moreover, the fuzzy approach is not totally free from arbitrariness

so have made aggregation measures relative to different aspects of poverty less controversial.

2.1 Ghana -- An Overview

Ghana lies on the west coast of Africa, about 5º north of the Equator and is about 238,537 square kilometres in size. It attained independence from British colonial rule in 1957 and became a republic in 1960. It presently has a population of about 20 million people, 40 percent of whom are below 15 years, 3 percent above 65 years and the remaining 57 percent between 16 and 64 years. The population is divided geographically between urban dwellers, which make about 38 percent of the total population and 62 percent rural dwellers. Economically Ghana is a low income country with an estimated per capita income of US$420. Economic growth rates have ranged from 3.3 percent and 5.8 percent over the fifteen-year period 1990-2005. Agriculture contributes the largest share to the gross domestic product (46% in 2004), followed by services (24.3%) and industry (22.1%) (ISSER 2005). In 1983, amid rapidly deteriorating macro-economic indicators, Ghana introduced a World Bank-sponsored Structural Adjustment Programme. This appears to have contributed to some improvements at the macro-economic level. Government domestic revenue as percentage of GDP, for instance, has increased from 6 percent in 1983 to 23.8 percent in 2004. Inflation has also subsided from a high level of 122 percent in 1983 to about 12.8 percent in 2004 (Appiah-Kubi 2003). However, improvements in the country's international trade and payments situation have been mixed. After the initial improvements in the eighties, the current account balance has remained negative since 1990 due to rapid growth in merchandise imports, while the capital accounts had largely shown a positive balance. This has often led to a negative balance of payment account. However, from year 2000 onwards Ghana has witnessed successive substantial improvement in its balance of payments, with 2003 experiencing a surplus of almost US$600 million (ISSER 2005).

The country has also incurred debts for its development programmes over the years, and owed about US$6.2 million - or the equivalent of 91 percent of its GDP - to external partners as of the end of 2004; this in addition to a huge domestic debt equivalent to 30 percent of GDP at the end of 2003. The burden of this huge indebtedness caused the nation to apply for the IMF's HIPC facility in 2001. After having successfully passed the decision point in 2002 and the completion point of the programme in 2004, the country was expected to save approximately $230 million (¢2.093 trillion) annually in debt service costs (ISSER 2005).

It is hoped that these relief efforts would go to improve social indicators so as to reduce the prevailing high poverty levels. Even though Ghana has made considerable progress in the overall levels of social indicators, life expectancy at birth continues to linger around 58 years and below the world's average of 65 years. Infant and under-five mortality rates are still high at 62 and 102 per 1000 births respectively (GDHS 2004). To add, Ghana's gross primary school enrolment rate of 79 percent is still lower than the average of lower income countries. Only about 44 percent and 31 percent of all Ghanaians are estimated to have access to piped-borne water and sanitation (disposable liquid waste) in their households. All these factors point to the

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because since there is no axiomatic basis for justifying the choice of a weighting system under the fuzzy analysis, the results then depend critically on that choice.

endemic nature of poverty in Ghana (ISSER 2005).

2.2 Poverty Analysis in Ghana

Official estimates of poverty in Ghana have been obtained using consumption expenditure per adult equivalent as the welfare measure (GSS, 2000). Using the traditional uni-dimensional approach to poverty analysis, the Ghana Statistical Service defines two nutrition-based poverty lines *viz:* an upper poverty line of 900,000 cedis and a lower poverty line of 700,000 cedis per adult per year. While the upper poverty line incorporates both essential food and essential non-food consumption, the lower poverty focuses on what is needed to meet the minimum nutritional requirements of household members. On the basis of the upper poverty line, poverty in Ghana is said to have declined in the 1990s from an estimate of 51.7 percent in 1991/92 to 39.5 percent in 1998/99. Similarly, the proportion of Ghanaians living under extreme poverty, i.e. below the lower poverty line seems to have fallen from 36.5 percent to approximately 27 percent of the total population during the same period. However, the favourable trend in the average masks wide spatial disparities. For instance, the headcount index among rural communities compared to urban communities is higher (Table 1). Extreme poverty is also higher in the country's three northern regions, ranging between 57 percent and 80 percent (Table 1) and lower (2%) in the Greater Accra Region. Moreover, the above-mentioned decline in overall poverty level did not occur in all the regions of the country; on the contrary, poverty levels even increased in the 1990s in three regions (Central, Northern and Upper East), two of which (Northern and Upper East) being among the poorest in the country. The above evidence of a general improvement in household welfare had however already been provided by Demery and Squire in 1996. In a study on macro-economic adjustment and poverty in six African countries, they found that the change in poverty in Ghana to reflect the joint impact of a growth in mean income as well as a change in inequality. They also noted that economic growth played a principal role in poverty reduction, particularly between1988-1992.

Table 1: Incidence of Poverty by Region and Location in the 1990s

Region	Proportion below the Lower Poverty line		Proportion below the Upper Poverty line	
	1991/92	1998/99	1991/92	1998/99
Western	0.42	0.14	0.6	0.27
Central	0.24	0.31	0.44	0.48
Greater Accra	0.13	0.02	0.26	0.05
Eastern	0.35	0.3	0.48	0.44
Volta	0.42	0.2	0.57	0.38
Ashanti	0.25	0.16	0.41	0.28
Brong-Ahafo	0.46	0.19	0.65	0.36
Northern	0.54	0.57	0.63	0.7
Upper West	0.74	0.68	0.88	0.84
Upper East	0.53	0.8	0.67	0.88
Urban	15.1	11.6	27.7	19.4
Rural	47.2	34.4	63.6	49.5
Total	39.5	26.8	51.7	39.5

Source: GSS (Ghana Statistical Service) (2000) *Poverty Trends in Ghana in the 1990s,* Ghana Statistical Service, October, Accra.

3. Methodology

As stated earlier, the various recent attempts to develop a framework - which allows for the multi-dimensionality, vagueness, and ambiguity of poverty - appear to concentrate on the use of the fuzzy-set theoretic approach (Chiappero Martinetti 1994 and 2000 and Lelli, 2001). The notion of fuzzy-sets was first conceptualised by Zadeh in 1965, (see also 1978) when he defined fuzzy-sets as "a class of objects with a continuum of grades of membership". This implies that, given some classes of objects do not have precisely defined criteria of membership, it can thus be asserted that these sets do not constitute classes or sets in the usual way in mathematics. Thus the concept of fuzzy sets provides an ideal framework to deal with problems in the absence of a definite criterion for discerning what elements belong or do not belong to a given set. This is particularly the case for solving the problem of identifying the poor in a particular society. With this kind of approach, it is not necessary to specify an arbitrary poverty line as may be required in the case of a head count poverty approach.

For a short mathematical exposition of the fuzzy sets principle, let us consider X as a set and x an element of X. A fuzzy subset P of X can therefore be defined as follows: $\{x_1 \mu_P(x)\}$ for all $x \in X$, where μ_P is a membership function which takes its values in the closed interval [0:1]. Each value $\mu_P(x)$ is the degree of membership of x to P.

In a simple application to poverty measurement we can let X be a set of n individuals ($i = 1...n$) and P, a fuzzy subset of X, the set of poor people. In the fuzzy approach $\mu_p(x_i)$, the membership function of the poor set (of individual i) is defined as:

$x_{ij} = 0$, if individual i is absolutely non-poor,

$x_{ij} = 1$, if individual i completely belongs to the poor set, and

$0 < x_{ij} < 1$, if individual i reveals a partial membership to the poor set.

The main issue here therefore is the determination of the individual membership function $\mu_p(x_i)$. In its empirical application to poverty Cerioli and Zani (1990) developed a fuzzy theoretical model to multi-dimensional analysis. This was later improved upon by Cheli and

Lemmi (1995) by deriving the deprivation indices directly from the distribution function of the attributes measured and called this method the ***Totally Fuzzy and Relative*** (TFR) method.

Various techniques for the estimation of the membership function have been proposed in the literature. These include the distance and frequency approaches, which may also take the form of (i) quadratic, similar to the sigmoid curve or simply the logistic function, (ii) linear membership function, which is well known and very simple in its application (Lelli 2001). The modalities involved in the selection of a method for estimating the membership function depends upon the ability to identify and specify the variety of variables to which such an indicator may be assigned, as well as the type of variable. Variables can be differentiated into (i) *dichotomous* or (ii) *categorical,* which can take on *continuous* or *discrete* values. For the aggregation of the indicators in their elementary units (categories) it is appropriate to categorise the steps into two operational stages: (i) the specification of membership for each indicator, and (ii) the specification of the weighting structure.

3.1 Dichotomous variables

Dichotomous variables are those variables whose attributes are defined from the questions of possession or non-possession of durable goods, e.g.: furniture, TV, electrical appliances, etc. The 'have' attribute is assumed to have a low risk of deprivation, while the 'have not' has a high risk of deprivation. The two attributes have the values of 0 and 1 in the closed set, i.e. [0, 1], whereby 0 takes the low risk of deprivation and 1 takes the high risk of deprivation. Following Costa (2002), upon definition of

i) the set *P* of poor households;
ii) the degree of membership to the set *P* of the $a_{i\text{-}th}$ household;
iii) the deprivation ratio of the $a_{i\text{-}th}$ household; and
iv) the deprivation ratio of the population,

we can define the $degree\ of\ membership$ to the fuzzy set *P* of the $a_{i\text{-}th}$ household *(i=1,..., n)* with respect to the *j-th* attribute *(j=1,..., m)* as in equation 1.

$$x_{ij} = \mu_p(X_j(a_i)) \qquad (1)$$

Given a population *A* of n households, $A = \{a_1, a_2, \ldots, a_n\}$, μ_p means membership of the subset of poor households *P* of which includes any household a_i having some degree of poverty in at least one of the *m* attributes of *X*. In other words $X_j(a_i)$ represents an *m*-order vector of socio-economic attributes which will result in the state of poverty of a household a_i if partially or not possessed by the household.

In this case:

$x_{ij} = 1$ iff the $a_{i\text{-}th}$ household does not possess the *j-th* attribute.

$x_{ij} = 0$ iff the $a_{i\text{-}th}$ household possesses the *j-th* attribute.

Thus the deprivation index of the $a_{i\text{-}th}$ household, $\mu_p(a_i)$ (i.e. the degree of membership of the $a_{i\text{-}th}$ household to the fuzzy set *P*), can be defined as the weighted average of x_{ij}:

$$\mu_p(a_i) = \sum_{j=1}^{m} x_{ij} w_j \Big/ \sum_{j=1}^{m} w_j \qquad (2)$$

Whereby w_j is the weight attached to the *j-th* attribute, which stands for the intensity of deprivation of attribute X_j. The weight w_j has an inverse relationship with the degree of deprivation: the smaller the household population (and the lower the level of deprivation), the greater is the weight w_j. This essentially implies that the more an attribute is present in the population, the fewer the number of households deprived and the more important it becomes. Consequently, such an attribute is likely to attract a greater weight among the attributes included in *X*. In order to reduce the arbitrariness involved in the estimation of the weights, Cerioli and Zani (1990) propose a logarithmic function, which they define as in equation 3:

where $$w_j = \log\left[n \Big/ \sum_{i=1}^{n} x_{ij} n_i \right] \geq 0 \qquad (3)$$

n_i represents the weight attached to each household a_i. In the case sample of a survey data, n_i is equivalent to *n* times the relative frequency of households in the total population. It follows that $\sum_{i=1}^{n} n_i = n$.[15] Dagum (2002) specifies the fuzzy poverty index of the population as a weighted average of the poverty ratio of the $a_{i\text{-}th}$ household which is stated in equation 4.

$$\mu_p = \sum_{i=1}^{n} \mu_p(a_i) n_i \Big/ \sum_{i=1}^{n} n_i = \frac{1}{n} \sum_{i=1}^{n} \mu_p(a_i) n_i \qquad (4)$$

However, if the data is obtained from a random sample or census of households, the weight will be constant and $n_i / \sum_{i=1}^{n} n_i = 1/n$. Thus the poverty ratio of the population could be constructed as in equation 5 (Cerioli and Zani 1990).

$$\mu_p = \frac{1}{n} \sum_{i=1}^{n} \mu_p(a_i) \qquad (5)$$

In a further refinement Costa (2002) defines another technique for aggregating the membership degrees into a multi-dimensional composite deprivation or poverty index, which allows the fuzzy set framework to simply obtain a uni-dimensional poverty ratio for each of the j attributes considered. This is in addition to the multi-dimensional poverty ratio of the $a_{i\text{-}th}$ household $\mu_p(a_i)$ and of the population μ_p. . In this case the difference between the multi-dimensional and uni-dimensional poverty ratios lies in the weight. While the multi-dimensional poverty ratio for the $a_{i\text{-}th}$ household $\mu_p(a_i)$ is the weighted average of x_{ij}, with weight w_j, the uni-dimensional poverty ratio for the *j-th* indicator is the weighted average of x_{ij}, with weight n_i:

$$\mu_p(X_j) = \sum_{i=1}^{n} x_{ij} n_i \Big/ \sum_{i=1}^{n} n_i \qquad (6)$$

This allows the multi-dimensional poverty ratio of the population μ_p as the weighted average of $\mu_p(X_j)$, with the weight w_j as defined in equation 7.

$$\mu_p = \sum_{i=1}^{n} \mu_p(a_i) n_i \Big/ \sum_{i=1}^{n} n_i = \sum_{j=1}^{m} \mu_p(X_j) w_j \Big/ \sum_{j=1}^{m} w_j \qquad (7)$$

[15] Equation 3 allows the weight assigned to the *jth* attribute not to be arbitrarily imposed but to be determined by the sample size and the deprivation index of the $a_{i\text{-}th}$ household in respect of the *jth* attribute. Other past studies have used other techniques for creating index weights, including giving all items equal weight, using the reciprocal of the proportion of households with the items as a proxy for their relative values (Morris et al. 1999), principal components analysis (Filmer and Pritchett 2001), and factor analysis (Sahn and Stifel 1999).

Where μ_p (composite deprivation index) is a monotonic increasing function of the degree of deprivation or poverty of each individual. In this case a deterioration of the living conditions of a subset of the population, other things remaining unchanged, results in an increase in the composite deprivation index μ_p.

The above transformation is done after noting that

$$\mu_p\,(X_j) = \frac{1}{n}\sum_{1}^{n} x_{ij} \qquad (8)$$

For the estimation of the global overall poverty index *P* (also for discrete and continuous variables), we apply equation 9 first, which combines the multiple indicators of deprivation at the individual level. In the second step we then aggregate them across individuals into an overall index to satisfy the double decomposability feature (namely subgroup and attribute). This double decomposition is to facilitate the design of inexpensive and efficient programmes for poverty alleviation mainly when financial constraints preclude the elimination of poverty in an entire population segment or by a specific attribute.

$$P = \sum_{t=1}^{n}\sum_{j=1}^{m}\{[\mu_p(a_i)][\mu_p(X_j)]\} \qquad (9)$$

3.2 Discrete Categorical Variables

Like all discrete variables, which may take on only one of a certain number of possible values, e.g. gender or marital status, discrete categorical variables are those with definite and discrete fixed points of values at any given time. Such indicators specifically have linear functions since their values at any given interval can be determined, for example, education. Using basic linear frequency technique[16] that is commonly applied in empirical studies and whose extreme values depend exclusively on the variable *x*[17], we shall define the membership function, μ_y, as an increasing function in equation 10:

$$\mu_y = \begin{cases} 1 & \text{if } xij = xmin,j \\ \dfrac{xij - xmin}{xmax,\,j - xmin,\,j} & \text{if } xmin,j < x < \\ 0 & \text{if } xij \geq xmax,\,j \end{cases} \qquad (10)$$

Where:

$x_{max,\,j}$ and $x_{min,j}$ represent the two thresholds (or extreme) values. If the values are

[16] An alternative linear approach also mentioned in the literature is the *trapezoidal specification* that takes two thresholds a_1 and a_2 (which are larger than the minimum and smaller than the maximum) with respect to the variable *x*. With this approach all the elements of the domain falling within a given set will be given a particular membership function. It is, however, opened to criticism because of its potential arbitrariness. It requires the preliminary definition of two critical values to separate the definitely deprived and the definitely non-deprived, hence lays open to an obvious critique in what concerns the grounds on which the choice of the thresholds takes place. Usually, the subjective beliefs of the researcher performing the analysis represent the rationale for discriminating among the given modalities, thus introducing precise normative assumptions in the whole procedure (Lelli 2001).

[17] These, easy to specify, interpret and visualize membership functions, presuppose the variables' modalities to be equidistant from one another and assume a direct proportionality between the elements of the domain and the membership grade; a very restrictive and not always appropriate assumption (Lelli (2001).

arranged in increasing order of deprivation, x_{min} represents the extreme threshold under which the individual is seen as more deprived in the dimension represented by the indicator *j*, and $x_{max,\ j}$ is the threshold above which an individual is not deprived in the said indicator. The individual *i* can be said to be partially deprived in cases where x_{ij} lies between the two thresholds.

Where there exists a non-linear and monotonic relation between the indicator variable *x* and the degrees of membership, it is proposed to order the modalities of *x* with respect to the risk of deprivation *k=1,...,K* associated to them using the following specification recommended by Cheli and Lemmi (1995)[18]:

$$\mu y = \mu(xk-1) + \begin{cases} 0 & \text{if } x = xk;\ k = 1 \\ \dfrac{\beta(xk) - \beta(xk-1)}{1 - \beta(x1)} & \text{if } x = xk;\ (k > 1) \\ 1 & \text{if } x = x^k;\ (k = K) \end{cases} \qquad (11)$$

Where $\beta(x^k)$ represents the cumulative distribution of x ranked according to *k*.

In the view of Lelli (2001) this method offers a way out from the issue of aprioristic choices to intuition by allowing the membership function to be based exclusively on the empirical evidence of the real valued functions of the various categories in each indicator.

3.3 Continuous Categorical Variables

An indicator is said to be continuous categorical if its mass function has no definite or discrete fixed points of values. An obvious example of a quantitative continuous variable is income or expenditure. However, such an indicator can be categorised in stages or in groups such that their relative membership functions can be assigned to each category to allow a general membership function to such indicator to be defined. For ordinal continuous categorical variables, where the frequency associated to one of extreme categories assuming high levels, Filippone *et al*. (2001) recommend normalised membership fuzzy sets function[19] as defined in equation 12.

$$\mu_x = \begin{cases} 1 & \text{if } 0 < yij < y\text{min},j \\ \dfrac{yij - y\text{min}}{y\text{max},\ j - y\text{min},\ j} & \text{if } y_{\text{min},j} < y_i < y_{\text{max},\ j} \\ 0 & \text{if } yij > y\text{max},\ j \end{cases} \qquad (12)$$

Where y_{min} and y_{max} stand for the minimum and maximum thresholds that were considered[20].

[18] This approach of Cheli and Lemmi (1995) is seen to be "relative" inasmuch as the cut-offs and the way in which membership of the set of the poor varies with an indicator depends on the sampling distribution of the indicator. Further Qizilbash (2001) identifies a high level of multi-dimensionality in the framework.

[19] We admit here that even though the estimated poverty results of equation 8 unlike equation 6 violate the two core axioms of Sen (1976), namely the monotonicity and the transfer axioms, they nonetheless characterise poverty better than the headcount index (in one or many dimensional context).

[20] By virtue of the fact that there is no ideal way of setting y_{min} and y_{max} without a bit of arbitrariness, we use the estimated mean expenditure as the y_{min} and about 60 percent above the mean as the y_{max}. This apparently gives an adequate fair distribution of the proportion of the population belonging to the poor and non-poor groups, without revealing any partial membership to a subset.

Considering income as a continuous variable, we use a synthetic description of the TFR method to derive the membership function defined as follows

$$\mu(y_i) = \begin{cases} H(y_i) & \text{where the degree of poverty increases with increases in } X_j \\ 1 - H(y_i) & \text{otherwise} \end{cases} \quad (13)$$

where (y_i) is the equivalent income of household i, $H(y_i)$ is the income distribution function and X_j are attributes included in X. This specification derives its theoretical underpinning from the Totally Fuzzy and Relative (TFR) approach developed by Cheli and Lemmi (1995) and is coherent with a relative concept of poverty. It also has an empirical foundation as $H(y_i)$ or the income distribution is estimated based on the sample (Cheli 1995). The above function may assume a linearity if the income indicator is categorised, but takes on a non-linear or quadratic membership functional form if it is not categorised because of multiple factors and parameters in such function. An example is the Dagum model (Dagum and Lemmi 1989), which uses maximum likelihood function to estimate the parameters. Theoretically the membership function $\mu(y_i)$ has the expectation $E[y_i] = 0.5$, therefore $E[1-(y_i)]$ is also 0.5. This is a limitation to the model, since it seems to imply that the proportion of the deprived in the subset of household i would always be equal to at least half of the total population or equivalent to the proportion of those who are not deprived. Cheli (1995) therefore recommends attaching an exponential weight, α, to measure the relative weight of the more deprived with respect to the less deprived. This modified version of the membership function is defined in equation 14.

$$\mu(y_i)=[1 - (Hy_i)]^{\alpha}, \qquad \alpha \geq 1 \quad (14)$$

The introduction of α exponent essentially serves to obtain poverty indices of the pseudo cardinal type like the head count ratio and the average poverty gap (Betti and Cheli 1998). In practice, equation 14 estimates the individual deprivation index of each household, and aggregating all these values using equation 15 we can obtain a composite index of the overall population.

$$P = \mathrm{E}[\mu(y)] = (1/n)\sum\mu(y_i) \quad (15)$$

4. Data Source

The methodology described above was applied to the data obtained from the third (1991-1992) and fourth (1998-1999) rounds of the Ghana Living Standards Survey (GLSS3 and GLSS4). This is a series of nation-wide household surveys which were conducted by the Ghana Statistical Service with technical assistance from the World Bank. This data source was used due to the lack of a continuous panel or longitudinal data set in Ghana, which should have been the appropriate data source for such a study of poverty dynamics. Ghana currently possesses four rounds of such surveys, which span the period between 1987 and 1999 and which have gained some high measure of reliability over time. The GLSS4 (1999) survey, for instance, includes data collected from about 5,998 households and some 25,000 household members in all the regions of Ghana. The survey contains detailed information on socio-economic and demographic characteristics of every household, including incomes and household expenditure patterns, education, occupational and employment characteristics,

assets and household durable goods, health, and other determinants of household welfare (Glewwe and Twum-Baah, 1991).

Since our study intends to take advantage of the multidimensionality of poverty measures that not only take into account the material situation of individuals but also capture their general living conditions, we shall combine various aspects of poverty as reflected in the above-mentioned socio-economic and demographic characteristics, which give a picture of poverty in the Ghanaian society. Our choice of indicators is based on a so-called *welfarist* understanding of standard of living, which is based solely on individual preferences or utility. Given the fundamental economic assumption that consumers purchase the best bundle of goods they can afford, the level of expenditure (or consumption) has emerged as a preferred indicator of living standards. But as we know, the expenditure measure of economic welfare ignores such items as non-market goods and non-material human conditions whose value is not translated into consumption behaviour, thus ignoring life-cycle issues (Essama-Nssah 1999). We therefore consider additional non-welfarist indicators such as primary goods (Rawls 1971), resources (Dworkin 1981), opportunities for welfare (Arneson 1989), access to advantage (Cohen 1989, 1990), and capabilities (Sen 1995).

From the numerous variables we select a small set of material and non-material indicators whose changes are assumed to impact on poverty. We classify these indicators, along the lines of Miceli (1998), into categories of indicators comprising the following: housing conditions, living conditions household durable goods, health, economic resources, and capabilities. We reiterate here that the choice of indicators was made by taking into consideration factors such as: i) cultural dependence of indicators, ii) temporal dependence, iii) presence of objective elements, and iv)balance between qualitative and quantitative items. A list of the selected indicators is presented in table 2.

Table 2: Categories of Indicators of Deprivation

Housing Conditions	**Household Durables (Livestock)**	**Living Conditions**
Floor	Draught	Cooking Fuel
Cement	Cattle	Electricity
Fibre-glass	Sheep	Gas
Stone	Goats	Kerosene
Wood	Chicken	Charcoal
Mud	Pigs	Wood
Other	Others	Other
Roof Materials	**Household Durables**	***Light***
Asbestos	Furniture	Electricity
Cement	Refrigerator	Generator
Iron	Radio and Recorder	Kerosene
Wood	TV-Video	Candles
Thatch	Electric Iron	Other
Other	Car	***Type of Water***
House Wall	***Living Comfort***	Indoor plumbing
Cement	Number of Rooms	Inside standpipe
Stone	***Economic Resources***	Water vendor
Corrugated Iron	Occupation Status	Water truck/tanker service
Wood	Equivalent Income	Neighbouring household
Mud	Equivalent Expenditure (Welfare)	Private outside standpipe/tap
Other	Food	Public standpipe

Capabilities	Clothing	Well with pump
Education	Footwear	Well without pump
None	Leisure, culture and Hotels	River, lake, spring, pond
Primary	***Toilet Facilities***	Rainwater
Secondary	Flush toilet	Other
Tertiary	Pit latrine	***Water Fetching Comfort***
Health	Pan/bucket	Water distance
Immunisation	KVIP	
	No toilet	

A look at table 2 reveals that the selected indicators are mixed categories of dichotomous and continuous types. While most of the household durables are dichotomous variables, equivalent income and expenditure as well as health and distance to water sources are of the continuous type. Education is a discrete categorical variable with a tertiary category being assigned the least deprivation and no education going for the maximum deprivation. The quality of the house occupied by the household as well as living comfort is paramount to the welfare of the members. In this regard poverty ratios related to the type of dwelling, number of rooms and room space, utilities and amenities, as well as the physical characteristics of the dwelling are estimated. The housing conditions are all dichotomous variables, arranged in ascending order of deprivation. Accordingly, households living in houses with mud walls and floors, or with thatch roofing, are assumed to face higher deprivation, while those living in houses with a cement floor and walls, and asbestos roofing are supposed to face lesser deprivation.

The same logic applies to living conditions. Households with electric light are assumed here to face a lesser degree of deprivation than those with candles. Similarly, those enjoying access to water from indoor plumbing are regarded as less deprived than those depending on rivers, ponds, or rainwater as their source of drinking water. In many studies (Miceli 1998; Filippone *et al*. 2001; Ghellini *et al*. 1995) size of living space has been used to measure living conditions. In this study, we use the number of rooms available to the household, since rural dwellers can be observed to have large sizes of living space as compared with urban dwellers, but with limited individual comfort. The number of rooms is ranked in ascending order of deprivation with the maximum number of eight rooms being assigned to the less deprived and the minimum number of one room assigned to the deprived in the society.

For the categorisation of the indicators we adapt the suggested approach of Qizilbash (2003). This approach is based on the following plausible (if questionable) method of classification: if there are ***n*** classes in terms of which people or degrees of deprivation are ordered, ***1*** is the rank order of the class in which everyone is non-poor, and ***n*** is the rank order of the class in which everyone is definitely poor. This method of classification means that only the worst off category in each dimension is definitely poor. In the case of education, for instance, someone in the fourth category with no education is definitely poor, while someone in the highest ranked class - i.e. rank order 1 - with a tertiary qualification is non-poor. In the case of distance to water sources, for instance, a household which is less than 5 metres from water has a rank order of 1, and is non-poor, while one which is 500 metres away or more from a water source has rank 5 or 6 respectively and is definitely poor.

Income - represented by the expenditure equivalent proxy - as a measure of deprivation of a decent quality of life rather than the deprivation in the quality of life itself is included in the composite index. Here the continuous indicators of deprivation, income and expenditure (as seen in Table 2) are categorised into three groups in descending order of deprivation[21].

5. Results

The results of the estimation of the membership functions depicting the levels of deprivation for the various categories of deprivation indicators, together with the weights, are presented in table 3. Using data from the latest round of the Ghana Living Standards Survey (1998/99) our study estimates a composite deprivation degree of 0.2137 for the whole country, as compared to the uni-dimensional head count index of 0.395. This means that of Ghanaian households, 21 percent on average registered deprivation on the various wellbeing indicators. It must, however, be noted that the estimated fuzzy normalised proportion of the population suffering deprivation cannot be compared with the head count index of 0.395. Indeed there is no basis for such a comparison since the fuzzy result compensates deprivation in one area from the other. This means that the inability to get certain goods, facilities and opportunities, which are usual in the household environment, can be compensated for with the ability to get others (Pérez-Mayo 2003), whereas the head count is usually based on a single deprivation indicator.

Table 3: Fuzzy deprivation indices (membership functions) for Ghana

	1992/93			1998/99			
DEPRIVATION INDICATOR	**MF= μ_j**	**Weight= $\ln(1/\mu_j)$**	**MF*Weight**	**MF=μ_j**	**Weight= $\ln(1/\mu_j)$**	**MF*Weight**	**DIFFERENCE**
HOUSING CONDITIONS							
Roofing Materials	0.1672	1.7883	0.2991	0.1661	1.7953	0.2982	
Flooring Materials	0.0330	3.4120	0.1125	0.0250	3.6872	0.0923	
Wall Materials	0.1086	2.2199	0.2411	0.0901	2.4073	0.2168	
Total		7.4201	0.6527		7.8898	0.6073	
SECTORAL MF	**0.0880**	**2.4308**	**0.2138**	**0.0770**	**2.5643**	**0.1974**	**-0.0110**
LIVING CONDITIONS							
Cooking Fuel	0.1754	1.7407	0.3053	0.1718	1.7613	0.3026	
Light	0.2067	1.5764	0.3259	0.1340	2.0101	0.2693	
Water distance	0.1478	1.9120	0.2826	0.1831	1.6978	0.3108	
Type of Water	0.0852	2.4633	0.2098	0.0862	2.4506	0.2113	
Nr of Rooms	0.2682	1.3162	0.3529	0.3150	1.1550	0.3639	
Toilet	0.2342	1.4515	0.3400	0.2351	1.4476	0.3404	
Total		10.4601	1.8164		10.5224	1.7984	
SECTORAL MF	**0.1737**	**1.7507**	**0.3040**	**0.1709**	**1.7666**	**0.3019**	**-0.0027**
CAPABILITY							
Education	0.3021	1.1970	0.3616	0.3163	1.1511	0.3641	
Health	0.3965	0.9251	0.3668	0.4585	0.7799	0.3575	

[21] For the related equivalent expenditure it was simply decided to fix the minimum category at about 64 percent of the mean, the second category at the mean, and the third at about 159 percent.

Total		2.1221	0.7284		1.9310	0.7216	
SECTORAL MF	**0.3433**	**1.0693**	**0.3670**	**0.3737**	**0.9843**	**0.3678**	**0.0305**
HOUSEHOLD ASSETS							
Household Durables	0.6142	0.4875	0.2994	0.6807	0.3847	0.2618	
Livestock	0.7229	0.3245	0.2346	0.7976	0.2261	0.1803	
Total		0.8119	0.5340		0.6107	0.4422	
SECTORAL MF	**0.6576**	**0.4191**	**0.2756**	**0.7240**	**0.3230**	**0.2338**	**0.0663**
HOUSEHOLD EXPENDITURE / WELFARE							
Food Expenditure	0.2483	1.3933	0.3459	0.2626	1.3373	0.3511	
Non-Food Expenditure	0.2371	1.4391	0.3413	0.3481	1.0553	0.3673	
Total		2.8324	0.6872		2.3926	0.7185	
SECTORAL MF	**0.2426**	**1.4163**	**0.3436**	**0.3003**	**1.2030**	**0.3612**	**0.0577**
COMPOSITE MEMBERSHIP INDEX*	**0.2123**			**0.2137**			**0.0015**

* The composite membership index is obtained by first adding the various ***sectoral MF*Weights*** and dividing this by the sum of ***sectoral weights***.

The levels of deprivation as reflected in the degrees of membership function differ widely from deprivation characteristic to characteristic, with 0.0770 and 0.7240 as the minimum and maximum respectively, considering quality of housing conditions and household durables as indicator characteristics of deprivation. For example, table 3 reveals a very low average degree of deprivation for floor quality (0.0330). However, this should come as no surprise, given that more than 85 percent of the sampled population of houses has cement floors. On the other hand the table reveals high membership deprivation degrees with respect to household durable goods ranging from 0.6807 to 0.7976 for household durable items and agricultural livestock, respectively.

These high deprivation measures (see Table 4) reflect the fact that seemingly “non-essential” household items such as televisions, refrigerators, electric irons, sewing machines, cars, video machines, and others are not so widespread in Ghana. On the average less than about 20 percent of the population were estimated to possess these durable goods. For example, almost 56 percent of the surveyed Ghanaians do not possess household durables assets such as television (57%), radio (52%), refrigerator (65%), fan (54%), car (63%), sewing machine (43%), etc. This evidence, however, stands in sharp contrast with the situation prevailing in most European countries, where these items are regarded as necessities. In his fuzzy poverty study of Switzerland, for example, Miceli (1998) found that a very low proportion (2.5%) of Swiss households was deprived of these items. A little surprising is the high deprivation membership measures for agricultural livestock. Since Ghana, as a developing country, is highly dependent on agriculture, it should be expected to have a lot of livestock. As can be seen in table 4 however, it appears that a sizeable portion of Ghanaians do not keep household farm animals such as sheep, cattle, pigs, etc.

A close look at the degrees of deprivation as reflected in the various membership functions for the various poverty indicators shows a lifestyle among Ghanaians geared toward fulfilling basic necessities. This is manifested in the low deprivation degrees for housing, food, clothing and living conditions. As far as living conditions are concerned, it appears that

Ghanaians have little problem with potable water, since only about 8.6 percent of households do not seem to possess potable water. However, the distance to water sources seems to pose some problems for households. About 18 percent seem to travel long distances to fetch water, and indeed the survey data indicates that over 50 percent of the population travel at least about half a kilometre to fetch potable water.

Table 4: Membership Functions of Durable Goods Generated from GLSS4 Data

Items	Membership Functions		Membership Functions
Household Durables			
Furniture	0.4692	Video	0.9628
Sewing Machine	0.6982	TV	0.7859
Refrigerator	0.8478	Electric Iron	0.7773
Radio	0.8630	Bicycle	0.8239
Radio Cassette	0.5979	Car	0.9777
Recorder	0.9787	House	0.7022
3 in 1 music system	0.9657	Land	0.7683
Agricultural Livestock			
Draught	0.9815	Goats	0.8004
Cattle	0.9567	Chicken	0.7137
Sheep	0.8766	Pigs	0.9587

With regard to indicators related to equivalent income and expenditure Miceli (1998) cautions on the interpretation of the fuzzy proportion of poor households. Here the membership function is considered along the lines of the average position of households in relation to two extremes, the most deprived and that of the well to do. A look at table 3 above shows that equivalent expenditure was, on average, closer to the bottom end of the distribution in 1998/99. It appears that, while intensity of deprivation seemed to be lower for food expenditures, non-food expenditure was quite high over the same period.

6. Deprivation Trends

In this section we attempt to present poverty patterns and trends using estimates of fuzzy sets theoretic membership functions. We compare GLSS4 data from the 1998/ 1999 survey with that from the previous round (GLSS3) in 1991/1992, which provides an opportunity to trace trends in household deprivation levels or well being over the decade. Even though this study attempts to compare deprivation measures derived from the fourth round with those from the third round and thereby reveal variations in living conditions in the 1990s, we must sound a note of caution that the results reported here are not strictly comparable. This is partly because the use of cross sectional data sets for the analysis gives little insight to poverty dynamics in Ghana[22], i.e. investigating the welfare movements of particular households or individuals over time. Moreover, analysis of trends in certain household indicator characteristics is complicated by the fact that the questionnaires for the two surveys are not totally the same. While it was possible to adjust for some of these inconsistencies, it was not possible to correct all of them. Caution therefore has to be exercised in interpreting the trend data.

This constraint notwithstanding, a cursory comparison of the results from the last two rounds of the GLSS, as presented in table 3 above, indicates that deprivation trends have witnessed scarcely any change in Ghana. The results even suggest a slight deterioration in the deprivation trends from 0.2123 in 1991/1992 to 0.2137 in 1998/1999. This appears contrary to the findings of the Ghana Statistical Service, which reports, on the basis of a uni-dimensional income poverty analysis, an overall broadly favourable trend in poverty in Ghana during the 1990s (GSS 2000).

However, there are some differences in the degree of the membership functions or deprivation over time with respect to the various household characteristics. During the nineties, for instance, our results show an improvement in the membership functions with respect to membership functions for household housing characteristics. The respective proportions of the households assumed to be deprived, given certain housing characteristics like roofing, floor and wall materials declined, showed an overall decline in the sectoral membership function from 0.088 in 1991/1992 to 0.077 in 1998/1999. A similar decline can also be observed for living conditions, albeit slight, during the same period (see Table 3). The membership function for light, i.e., the proportion of the population regarded as deprived of electricity, for instance, declined from 0.2067 in 1991/1992 to 0.1340 in 1998/1999.

These findings seem to be confirmed by other survey reports covering the same period. For instance, apart from the GLSS4 report (2000), the GDHS (2004), also reports a 40 percent increase in the use of electricity during the second half of the nineties. On the other hand the trend of the membership functions for household conditions covering capability, assets, and expenditure characteristics experienced various degrees of deterioration. The membership function for the capability characteristic, i.e. the proportion of households deprived of proper health and education, for instance, increased from 0.3433 in 1991/1992 to 0.3737 in 1998/1999, whereas that of household durable assets and expenditure characteristics increased from 0.6576 to 0.7240 and 0.2426 to 0.3003 respectively during the same period. In the case of health the increase in the deprivation levels in Ghana seems to be confirmed by the latest round of data from the Ghana Demographic and Health Survey (GDHS 2004), which reports a decline in vaccination ratios, indicators used as proxy for the health characteristic for the study.

Information on the trends of membership functions or proportion of households owning different consumer durable characteristics in 1991-1992 and 1998-1999 is presented in figures 1 and 2 according to geographical location. We observe in both periods that membership functions are substantially higher in rural areas than urban areas, thus supporting the widely held view that poverty in Ghana is disproportionately a rural phenomenon. We also observe from both figures 1 and 2 that the urban centres seem to have suffered increasing deprivation trends in almost all the identified characteristics as compared to the rural areas, this being especially noticeable for housing and living characteristics. For instance, during the nineties the rural areas seem to have experienced an improvement in housing and living characteristics, while the urban areas seem to have shown a decline with respect to these characteristics.

[22] See Appiah-Kubi and others (2004) for attempts at using cross sectional data sets to analyse poverty dynamics or transitory and permanent poverty in Ghana.

Fig. 1 Trends of Membership Functions Urban

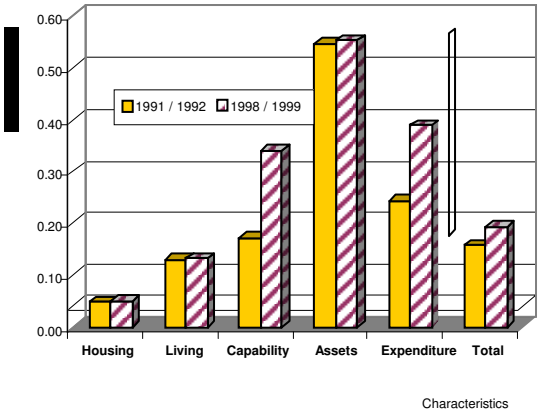
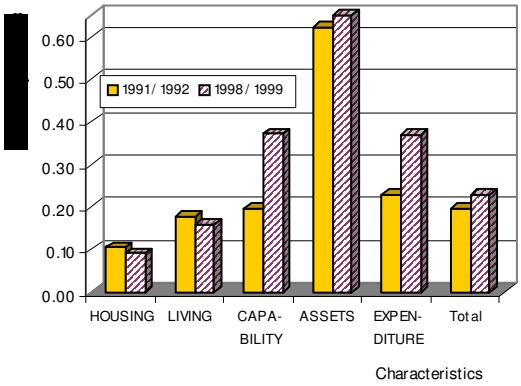


Fig. 2 Trends of Membership Functions, Rural



In the case of education and health characteristics, which are often labelled "basic needs" and hence seen as complementary to the consumption-based welfare (expenditure) indicator, a close look at figures 1 and 2 reveal sharp increases in the membership functions of the urban population with respect to these basic needs welfare (expenditure) characteristics. This thus indicates a deterioration in living standards of the urban households during the nineties. This finding also stands in contrast to the findings of the GLSS 4, which reports of slight gains in the basic need characteristics of all households in Ghana.

On the other hand it appears that the rural population seems to have made some improvements in their housing and living conditions during the nineties. This is reflected in the decline in the trend membership functions between 1991/1992 and 1998/1999. The results also seem to corroborate that of the GLSS4 (2004) report that the rural areas appear to have experienced a much bigger change in their housing and living conditions. This change is reflected in the increase in the proportion of households with access to improved housing facilities, water, adequate toilet facilities, electricity, etc., during the nineties. The rural areas, however, appear to have experienced an increase in the membership functions or deterioration in welfare with regard to their ownership of various assets and durables.

Regional Decomposition of Results

In this section we present some decomposition of deprivation levels with respect to geographical zones in Ghana, which seem to harbour varying degrees of poverty in the various geographical zones. In table 5 we decompose the above-mentioned deprivation levels computed using the 1998/99 round of GLSS according to the administrative regions of Ghana as well as the country's urban-rural dichotomy. Of all the administrative demarcations in Ghana, the Greater Accra Region has the smallest class of deprived households (about 15.18% of its total households). As would be expected, it ranks first followed by Ashanti Region with a deprivation index of 17.97 percent, while the Upper East Region ranks last as the administrative region with the largest proportion of its households suffering some kind of deprivation. The picture about the regional levels of deprivation is, however, different if one considers the individual categories of deprivation characteristics. With respect to household durables, for instance, the situation concerning the degrees of deprivation is totally the reverse of the usual known order. The three supposedly relatively poor Northern Regions have less proportion of their population living in deprivation as opposed to the other supposedly relatively

non-poor Southern Regions, including Greater Accra and Ashanti Regions (see Table 5). A similar picture emerges with respect to the 'capabilities (education and health)' category as a proxy for poverty. The Western Region attains the first position, with the least proportion of its households (about 19.5%) under deprivation, whereas the Eastern Region has as much as almost 40.76 percent of its people under deprivation and so occupies the last position.

Table 5: Decomposition of Fuzzy Deprivation Levels by Administrative Regions Using GLSS4 Data

Regions	All	Housing conditions	Living Conditions	Capabilities	Household Assets	Household Expenditure
Western	0.1881	0.1243	0.1553	0.1949	0.9119	0.2790
Central	0.1910	0.0943	0.1577	0.3200	0.8817	0.2291
Greater Accra	0.1518	0.0419	0.1275	0.2695	0.9202	0.3021
Eastern	0.2195	0.0918	0.1596	0.4076	0.8851	0.3978
Volta	0.1877	0.0884	0.1641	0.3151	0.8997	0.2291
Ashanti	0.1797	0.0761	0.1479	0.2692	0.9071	0.2935
Brong Ahafo	0.1802	0.0675	0.1566	0.3857	0.9021	0.2334
Northern	0.2577	0.1474	0.1845	0.3968	0.8538	0.3705
Upper West	0.2417	0.1888	0.2632	0.2528	0.8329	0.2017
Upper East	0.2708	0.2120	0.1996	0.3078	0.8537	0.3346
Urban	**0.1944**	**0.0512**	**0.1319**	**0.3394**	**0.5517**	**0.3875**
Rural	**0.2287**	**0.0901**	**0.1586**	**0.3716**	**0.6521**	**0.3691**
All	**0.2137**	**0.0770**	**0.1709**	**0.3737**	**0.7240**	**0.3003**

With regard to the urban-rural divide, the results of our study seem to confirm the widely held view that poverty and deprivation are more prevalent in rural Ghana than in the urban areas. Our study estimates that slightly below 20 percent of the households in the urban areas are under deprivation, while about 23 percent of the rural households are estimated to suffer the same fate. A similar picture runs through the various categories of deprivation indicators. The only exception is the household's 'expenditure' category, where a greater proportion of the urban population (39%) can be seen to be more deprived than the rural population (37%), considering household expenditure characteristics. However, this result is contrary to that of the uni-dimensional headcount index, which shows lower expenditure poverty in urban areas. This contradiction can be attributed to the choice of a single poverty line for both urban and rural areas. Since most urban dwellers have higher expenditure (income) levels than rural dwellers, one single poverty line for both is likely to capture lesser urban dwellers under expenditure poverty than rural dwellers.

It has been pointed out earlier that there is no basis of comparison between the fuzzy deprivation indices and the headcount indices. Nevertheless, table 6 seeks to rank the regions according to how they fare on the multi-dimensional deprivation scale and compare this with the rankings that result from the headcount indices. This is done principally because the headcount index rankings have been the only recent poverty rankings. As can be seen in table 6, the fuzzy deprivation indices for all the regions reveal relatively a smaller fraction of their respective proportions of the population under poverty as compared to the results from head count analysis. The exception is the Greater Accra Region, where the fuzzy deprivation index of 0.1518 is higher than the head count index of 0.05. This presupposes that the group in the Greater Accra Region that is identified to be income or expenditure poor in a uni-dimensional

sense may not necessarily be the same group, which may seem to be fuzzy poor in a multi-dimensional sense[23].

The reason does not lie only in the lesser degrees of fuzzy deprivation as opposed to poverty head count indices, but also in the different regional rankings as revealed by the results of the two poverty approaches (see Table 6). Another interesting finding is that, while the poverty head count shows wide variations among the regions, the regional differences in poverty as reflected in the fuzzy deprivation indices are very small. Using the poverty head count index the proportion of the regional population in poverty varies between 5 percent in Greater Accra to 88 percent in the Upper East Region. In other words the prevalence of poverty in the Upper East Region is almost 18 times as huge as that in the Greater Accra Region. In the case of the fuzzy degrees of deprivation, the prevalence of poverty among the regions varies from just 15 percent in the Greater Accra Region to only about 27 percent of the total population of the Upper East Region.

Table 6: Comparison of Fuzzy Multi-Dimensional Deprivation Index and Income Head Count Index (GLSS4)

	Fuzzy Deprivation Index	Ranking	Poverty Incidence Index	Ranking
Western	0.1881	5	0.27	2
Central	0.1910	6	0.48	7
Greater Accra	0.1518	1	0.05	1
Eastern	0.2195	7	0.44	6
Volta	0.1877	4	0.38	5
Ashanti	0.1797	2	0.28	3
Brong-Ahafo	0.1802	3	0.36	4
Northern	0.2577	9	0.70	8
Upper East	0.2417	8	0.88	10
Upper West	0.2708	10	0.84	9
Urban	**0.1944**		**0.194**	
Rural	**0.2287**		**0.495**	
All	**0.2137**		**0.395**	

However, when analysing the fuzzy deprivation results computed from GLSS4 and decomposed according to regions and deprivation indicator categories (see Table 7) it becomes apparent on the one hand that the Greater Accra Region enjoys the best housing predicates. On the other hand the region seems to be more deprived than the Upper East with regard to the health predicate, where only about 21 percent of the population (under 7-year olds) seem to be health deprived as compared to 23 percent in the Greater Accra Region. Similarly the Greater Accra Region does not fare well at all comparatively in terms of household durables. Over 90 percent of its households are deprived of the household durables. If we disaggregate the results into regions with respect to various deprivation characteristics, we also observe some marked contrasts among them with regard to membership functions (Table 7).

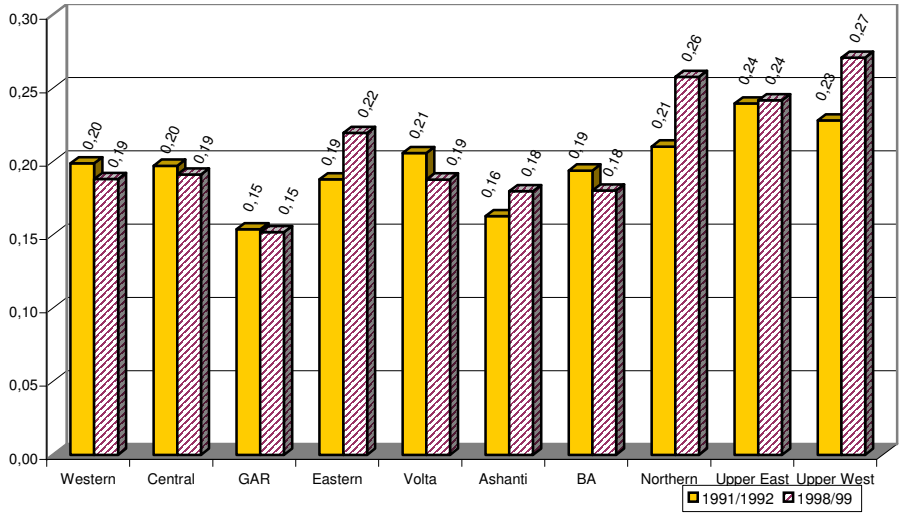
[23] That the use of a multi-dimensional framework might actually alter the particular set of people who otherwise are identified as poor under uni-dimensional sense, seems to be corroborated by the position of Qizilbash (2003) for South Africa.

Considering housing conditions, for instance, the Upper East seems to experience favourable trends during the decade by reducing the proportion of its population deprived of proper housing (floor, and roofing) materials from 21.55 percent in 1991/1992 to 18.88 percent in 1998/1999. They however, perform badly with respect to other characteristics like household assets, capability characteristics, and living conditions. On the whole it can be discerned from table 7 that all the three regions in the north, comprising Northern, Upper East and Upper West suffered deterioration in their living conditions during the nineties as can be seen in the sharp increases in their respective composite membership functions or “poverty” index. All other regions, with the exception of the Eastern and Ashanti Region also witnessed slight declines in living conditions as reflected in increases in their respective regional composite membership functions (see Figure 3). Finally, there is a slight contrast when comparing our findings with that of the GLSS4.

Table 7: Trends in Regional Decomposition of Deprivation Indices (GLSS3 and 4)

Regions / Characteristics	Western		Central		Greater Accra		Eastern		Volta		Ashanti		Brong Ahafo		Northern		Upper East		Upper West	
	1992/93	1998/99	1992/93	1998/99	1992/93	1998/99	1992/93	1998/99	1992/93	1998/99	1992/93	1998/99	1992/93	1998/99	1992/93	1998/99	1992/93	1998/99	1992/93	1998/99
HOUSING CONDITIONS																				
Roofing Materials	0.1685	0.1586	0.1626	0.1480	0.1131	0.1373	0.1786	0.1644	0.1639	0.1765	0.1772	0.1881	0.1605	0.1172	0.1761	0.2279	0.2370	0.1836	0.1696	0.1823
Flooring Materials	0.0392	0.0932	0.0234	0.0418	0.0126	0.0070	0.0375	0.0381	0.0408	0.0314	0.0160	0.0136	0.0400	0.0253	0.0375	0.0569	0.3818	0.1750	0.0889	0.1489
Wall Materials	0.1146	0.1296	0.0928	0.1251	0.0465	0.0371	0.1086	0.1122	0.1020	0.1081	0.0898	0.1132	0.1180	0.0876	0.1243	0.2485	0.1240	0.9583	0.1675	0.3966
Sectoral MF	0.0940	0.1243	0.0759	0.0943	0.0462	0.0419	0.0930	0.0918	0.0905	0.0884	0.0712	0.0761	0.0939	0.0675	0.0968	0.1474	0.2155	0.1888	0.1363	0.2120
LIVING CONDITIONS																				
Cooking Fuel	0.1568	0.1703	0.1548	0.2240	0.1845	0.1867	0.1623	0.1555	0.1497	0.1619	0.1681	0.1666	0.1525	0.1311	0.1469	0.1538	0.1943	0.4237	0.2591	0.2105
Light	0.1963	0.2014	0.2104	0.1863	0.0579	0.0553	0.2143	0.2528	0.4487	0.1977	0.1683	0.1537	0.2442	0.2700	0.2614	0.2583	0.2530	0.3343	0.2667	0.2142
Water distance	0.1557	0.1272	0.1078	0.1902	0.1359	0.2227	0.1677	0.1669	0.1505	0.1862	0.1627	0.1858	0.1181	0.1831	0.0875	0.1706	0.2153	0.1803	0.1442	0.1827
Type of Water	0.0823	0.0893	0.0839	0.0838	0.0805	0.0905	0.0838	0.0883	0.0769	0.0922	0.0837	0.0937	0.0798	0.0901	0.0801	0.1047	0.0790	0.1384	0.2063	0.1537
Nr of Rooms	0.2431	0.1506	0.3961	0.0978	0.2440	0.1108	0.2371	0.2157	0.2543	0.1463	0.2325	0.1003	0.2485	0.1070	0.2762	0.2591	0.2837	0.2774	0.2832	0.2711
Toilet	0.2458	0.2452	0.2444	0.2433	0.1726	0.1818	0.2462	0.1364	0.2484	0.2492	0.2327	0.2380	0.2529	0.2500	0.2252	0.2259	0.1976	0.4673	0.1436	0.1887
Sectoral MF	0.1684	0.1553	0.1697	0.1577	0.1308	0.1275	0.1738	0.1596	0.1835	0.1641	0.1653	0.1479	0.1659	0.1566	0.1581	0.1845	0.1881	0.2632	0.2070	0.1996
CAPABILITY																				
Education	0.2939	0.3088	0.2893	0.2978	0.3082	0.3184	0.2942	0.3171	0.2902	0.3111	0.2966	0.3063	0.2850	0.3121	0.2734	0.3049	0.2580	0.3102	0.2511	0.3186
Health	0.0889	0.1294	0.1774	0.3452	0.0657	0.2312	0.1191	0.7069	0.1848	0.3193	0.0625	0.2386	0.1295	0.5145	0.2713	0.6848	0.0910	0.2098	0.1855	0.2976
Sectoral MF	0.1577	0.1949	0.2241	0.3200	0.1389	0.2695	0.1830	0.4076	0.2293	0.3151	0.1339	0.2692	0.1887	0.3857	0.2724	0.3968	0.1513	0.2528	0.2151	0.3078
HOUSEHOLD ASSETS CHARACTERSTICS																				
Household Durables	0.5199	0.8944	0.5181	0.8589	0.4836	0.9041	0.5207	0.8799	0.3464	0.8854	0.6718	0.8885	0.6838	0.8910	0.7648	0.8490	0.7828	0.8099	0.8635	0.8256
Livestock	0.7558	0.9500	0.7081	0.9278	0.9756	0.9616	0.7050	0.8910	0.6625	0.9210	0.7389	0.9494	0.6145	0.9847	0.5598	0.8590	0.4453	0.9636	0.2486	0.9390
Sectoral MF	0.5906	0.9119	0.5835	0.8817	0.4998	0.9202	0.5850	0.8851	0.4348	0.8997	0.7008	0.9071	0.6449	0.9021	0.6246	0.8538	0.5237	0.8329	0.3072	0.8537
HOUSEHOLD EXPENDITURE / WELFARE																				
Food Expenditure	0.3906	0.2372	0.2353	0.2291	0.2492	0.2754	0.2225	0.3978	0.2232	0.2291	0.2332	0.2606	0.3565	0.2334	0.2247	0.3705	0.3364	0.2017	0.3712	0.3346
Non-food Expenditure	0.3561	0.3339	0.3621	1.0000	0.2306	0.3334	0.2132	1.0000	0.3482	1.0000	0.2360	0.3336	0.2087	1.0000	0.3489	1.0000	1.0000	1.0000	1.0000	1.0000
Sectoral MF	0.3726	0.2790	0.2876	0.2291	0.2876	0.3021	0.2178	0.3978	0.2748	0.2291	0.2346	0.2935	0.2673	0.2334	0.2761	0.3705	0.3364	0.2017	0.3712	0.3346
COMPOSITE MEMBERSHIP INDEX	0.1988	0.1881	0.1971	0.1910	0.1537	0.1518	0.1879	0.2195	0.2058	0.1877	0.1627	0.1797	0.1938	0.1802	0.2102	0.2577	0.2395	0.2417	0.2279	0.2708

Figure 3: Trend Composite Membership Functions According to Regions, 1991/1992



While the GLSS4, using a uni-dimensional poverty index, reports a fall in overall poverty in Ghana during the 1990s, with some regions (particularly the better off ones) benefiting more from the gains than the poorest regions, our multi-dimensional poverty study finds overall poverty remaining almost unchanged in Ghana. However, just like the GLSS4 report some regions experienced slight declines in poverty levels in a multi-dimensional sense, while others - notably the poorest regions in the savannah - registered increases in poverty.

Factor Analysis Procedure

In our attempt to assess whether a different methodology gives a better explanation of the poverty situation in Ghana, we employ a parametric technique such as the factor analysis, which is a data reduction technique that seeks to discover simple patterns in the relationships among variables under consideration (Ferro-Luzzi *et al.* 2006) We employ this technique to discover whether the observed variables can be explained largely or entirely in terms of a much smaller number of variables called *factors,* whose number has been reduced by a data reduction technique (See Appendix A for a detailed explanation of the underlying econometric model). Table 8 compares deprivation indices derived from factor and fuzzy analyses using GLSS4 data. In the first place the results constructed via both factor analysis and fuzzy sets theory exhibit some similarity as they seem to offer equivalent pictures of the Ghanaian's living standard, emphasizing in particular the sensible deprivation on most dimensions.

In the case of factor analysis, factors generated were used to compute deprivation indices for the various deprivation indicators. The deprivation indices for education and health are the same for both analyses principally because these indicators did not lend themselves to data reduction technique, hence, the similarity in the deprivation indices. The overall deprivation index (composite membership index) is about 25 percent under the factor analysis procedure, compared to 21 percent in the fuzzy approach. It is also clear from table 8 that the factor analysis procedure tends to smoothen out the volatilities in the deprivation indices. However, the composite index generated from the factor analysis is only about 4 percentage points above that of the fuzzy approach. Thus, on the whole the fuzzy deprivation indices could be taken as satisfactory indices relative to indices generated from other multi-dimensional poverty analytic procedures.

Table 8: Comparison of Membership Functions Derived From Factor and Fuzzy Analysis (GLSS4)

Indicators	Factor Analysis	Fuzzy Analysis
Housing Materials	0.2449	0.0770
Living Conditions	0.2380	0.1709
Household Assets	0.2214	0.7240
Livestock	0.2041	0.7240
Education	0.3163	0.3163
Health	0.4585	0.4585
Food Expenditure	0.2152	0.2626
Non-Food Expenditure	0.1953	0.3481
Composite Membership Index (Over Sectors)	0.2460	0.2137

7. Summary and Conclusion

This paper studies multi-dimensional aspects of the phenomenon of poverty and living conditions in Ghana and reveals some new insights about the poverty situation in the country, which contrasts with the results available from traditional poverty analysis. The results of the estimation of the membership functions, depicting the deprivation levels for the various categories of deprivation indicators, show a composite deprivation degree of 0.2137 for the whole country, which is considerably lower than that of the head count index of 0.39524. Considering the various deprivation characteristics the results show high deprivation degrees for seemingly 'non-essential' household items such as televisions, refrigerators, electric irons, sewing machines, cars, video machines, and other luxurious durables, compared with other 'essential' household items such as water, shelter, education, health, food, etc. This suggests that the Ghanaian lifestyle is geared toward fulfilling basic necessities of life. Furthermore, a close look at the fuzzy-set results shows deprivation indices for all the regions as being relatively smaller than the indices from the results of head count analysis. However, the Greater Accra Region is the exception, with the fuzzy-set deprivation index of 0.1518 being higher than the head count index of 0.05. This presupposes that the group in the Greater Accra Region that is identified to be income or expenditure poor in a uni-dimensional sense is not necessarily the same group, which may seem to be fuzzy poor in a multi-dimensional sense.

Anti-poverty programmes often seek to improve their impact by targeting households for assistance according to one or more criteria. In Ghana the criterion for identifying the poor has been the arbitrarily-set poverty line, (i.e. those who are not able to meet some basic needs, for both food and non-food consumption). On the basis of such a single poverty characteristic geo-graphical areas have been selected for attention and policy recommendations designed for them, which formed the basis of Ghana's Poverty Reduction Strategy (GPRS). Underlying this strategy is a strong emphasis on enhancing the financial capacity of the poor through micro-credit via the creation of a Poverty Alleviation Fund and Women Relief Fund, and a social investment fund to facilitate the poor's access to some basic social services. Inherent in the use of such a single criterion for target selection is the likelihood of targeting errors in the drastic differentiation between the poor and the non-poor, in particular between those in similar circumstances but who just happen to lie on opposite sides of a poverty line.

On the other hand, income-based poverty indices from traditional analysis suggest policy

[24] As argued earlier these two indices are different in nature, so that the may not be directly comparable. What matters here is that the two approaches do not show the same trend of poverty during 1990s, even though both approaches yield the almost similar ordinal rankings.

recommendations that only plead for transfer policies to alleviate poverty in the short term, this despite the fact that multi-dimensional indices can provide us with information for implementing socioeconomic policies to address poverty in the long term. This lies in the fact that people (as in the case of Ghana) may not only be relatively income poor but also be more relatively deprived in other multi-dimensional characteristics of social welfare. For instance, the Upper East and West Regions have been selected by the Ghana Poverty Strategy as income poor for poverty alleviation focus. But our decomposed multi-dimensional poverty analysis shows that while these regions seem to have experienced favourable trends in their food-expenditure poverty status during the 1990s - probably as a result of financial transfers such as micro-credit - their health and educational poverty characteristics seem to have witnessed substantial deterioration. At the same time their non-food expenditure poverty status seems to have scarcely changed over time. This evidence brings into question the effectiveness and efficacy of Ghana's one-size-fits-all income based poverty reduction programme.

From our multi-dimensional analytic results, a more appropriate policy recommendation for tackling poverty in the above mentioned Upper East and West Regions would probably involve a multi-faceted approach, which, in addition to improving the income earning power, upgrades the capabilities (i.e. health and education) of the poor. On the other hand a look at the membership functions reveals that household food consumption and non-food expenditure indicators as determinants of poverty in Ashanti, Northern, Greater Accra, Eastern and Brong Ahafo Regions have deteriorated. This could probably be attributed to the deterioration in the ownership of households' assets, which seem to be strong predictors of poverty in a multi-dimensional sense. Therefore policymakers should emphasize building up the assets of the poor in these regions so as to enable them to diversify their income-generating activities. Because the ownership of these assets can help households to reduce the variability of their consumption, thus lowering their vulnerability to future poverty. Such interventions should particularly target regions like the Western Region, which has a large rural population but a high assets (livestock) deprivation index. For the Eastern Region, for instance, which possesses a very high deprivation index in terms of capability characteristics, a strategic emphasis on improving health and education may be crucial to avoid the inter-generational transmission of poverty.

In conclusion we must point out that the fuzzy-set analysis needs further refinements, among others, with regard to the choice of variables and the number of variables to be included in the estimation of the membership functions. Nevertheless, the theory can produce multi-dimensional poverty results that can be used for effective cross section and inter-temporal poverty comparisons, and for geographical poverty mappings. We believe that the fuzzy-set results, if produced from a purposeful well structured data set, can be used to rank geographical areas of a country according to their level of welfare for better policy targeting, and thus achieve results better than that from uni-dimensional results. For a proper trend analysis, however, we believe that a better result can be obtained if the fuzzy-set theoretical framework is used to analyse panel data sets, which allow proper tracking of household's behavioural trends.

Appendix A

Factor Analysis Model

Following Lelli (2001) we adopt the factor model in the equation 1) which assumes that the observed variables are linear combinations of some common underlying dimensions or characteristics. The main task of the factor analysis procedure is to determine the extent to which each known variable is explained by each dimension:

$$y_1 = \alpha_{11}x_1 + \alpha_{12}x_2 + \ldots + \alpha_{1m}x_m + e_1$$

$$y_2 = \alpha_{21}x_1 + \alpha_{22}x_2 + \ldots + \alpha_{2m}x_m + e_2$$

$$y_3 = \alpha_{31}x_1 + \alpha_{32}x_2 + \ldots + \alpha_{3m}x_m + e_3 \qquad (1)$$

$$y_n = \alpha_{n1}x_1 + \alpha_{n2}x_2 + \ldots + \alpha_{nm}x_m + e_n$$

Where:

y = a variable with known data

α = a constant (factor loading)

x = a variable, which is a function of some unknown variables.

e = a residual term

By application to the known data on the **y** variables, factor analysis defines the unknown **x** variables. The loadings emerging from a factor analysis are the constants. The factors are the **x** variables. The size of each loading for each factor measures how much that specific variable is related to **y** (Rummel 1970).

In a matrix notation, model 1 reduces to:

$$Y = AX + U \qquad (2)$$

Where:

Y = a vector of known variables under consideration

A = a matrix of factor loadings

X = a matrix of variables

U = a vector of residuals

The factor analysis procedure begins by first determining the elements of matrix A. This matrix can be thought of as containing the optimal linear weights used in predicting the variables from the factors. The traditional regression technique postulates that while the dependent variables are observable, the factors are hypothetical constructs that can only be estimated from the data. Thus, the factor loadings indicate the degree of correspondence between each known variable and the unknown variable, with a higher loading making the known variable more representative of the unknown variable (Lelli 2001). The determination of common dimensions and subsequent computation of factor loadings is done by first computing

the correlation matrix which determines which sets of variables cluster together.

The computed correlation matrix is then used to compute factors, which must be identified and interpreted. The identification of factors possesses a rotation problem. Rotation serves to make the output more understandable and is usually necessary to facilitate the interpretation of factors. The sum of eigenvalues is not affected by rotation, but rotation will alter the eigenvalues of particular factors and will change the factor loadings. Since multiple rotations may explain the same variance (have the same total eigenvalue) but have different factor loadings, and since factor loadings are used to give intuitive meaning of factors, this means that different meanings may be ascribed to the factors depending on the rotation. To overcome the problem of multiple interpretation of a factor, varimax rotation is usually adopted. Varimax rotation is an orthogonal rotation of the factor axes to maximize the variance of the squared loadings of a factor (column) on all the variables (rows) in a factor matrix, which has the effect of differentiating the original variables by extracted factor. That is, it minimizes the number of variables which have high loadings on any one given factor. Each factor will tend to have either large or small loadings of particular variables on it. A varimax solution yields results which make it as easy as possible to identify each variable with a single factor. This is the most common rotation option.

After computing and interpreting the factor loadings, a transformation matrix which indicates the correlation of the factors before and after rotation is constructed. This transformation matrix is then used to generate factor scores under a linear regression which scores every case in the analysis according to its values on the variables as they load on each of the rotated factors. These factor scores become the reduced set of variables to be used for the estimation of the poverty / deprivation index.

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