CHAPTER ONE

INTRODUCTION TO POVERTY

1.1 INTRODUCTION

The 2006 Nobel Peace laureate Muhammad Yunus argues that poverty should not be part of any civilized society. In a speech delivered on the occasion of receiving an Honorary Doctorate from the University of Venda in May 2006, he commented:

> Poverty deserves only to be in the museums, where small children can see it in the future and be shocked how we allowed such an inhuman condition to exist for so many people for so long (Yunus 2006:1).

He indicated that he was very excited when the United Nations announced the Millennium Development Goals at the United Nations Summit in New York in 2000. The central objective of the Millennium Goals, which 149 countries agreed to, is halving poverty by 2015. Yunus (2006) believes that creating a world free from poverty is possible, as many poor people can get themselves out of poverty if they are given the same opportunities as those afforded to people who are not poor.

In theory, a healthy human being born in South Africa is fully equipped, not only to take care of himself or herself, but also to contribute to the development and well-being of the country as a whole. Unfortunately, in reality, 40% of the population in South Africa are classified as being in extreme poverty and over 60% of black South Africans live in underdeveloped rural areas (UNDP 2000).

The first democratically elected government in South Africa in 1994 inherited one of the most unequal societies in the world. One of the consequences of the legislation of the past, especially of laws such as the Group Areas Act, was that it created townships located on the outskirts of the cities, far from white residential and business areas. The Job Reservation Act restricted black people's income, irrespective of their ability and educational qualifications. As a result, developed white areas enjoyed a per capita income comparable to that of an upper middle income in a developed country, while the majority of the population experienced extreme poverty in terms of their income and

expenditure, and they were deprived of basic services, health facilities, educational opportunities and the right to lead the kind of life that everyone has a right to.

Poverty is a complex phenomenon. Consequently, a holistic approach is needed to develop poverty reduction strategies and programmes. The development of effective policies and programmes to deal with the various dimensions of poverty, especially given the limited resources available, has become a challenging task for South Africa.

If the Millennium Development Goals are to be achieved, progress in all major areas related to the well-being of the people is essential, including poverty reduction and improvements in education, health, gender equality and the environment, with the eradication of extreme poverty and hunger at the forefront. In the last few decades, the progress on living up to the commitment to poverty reduction as a core objective of international development policies has been very slow. The world is not on track to achieving the Millennium Development Goals in most regions and countries (UNDP 2003). This inadequate rate of progress raises important questions about the policies and strategies that have been adopted to achieve poverty reduction so far.

This tardy progress raises important questions about the concept and understanding of poverty and deprivation. Perspectives on poverty have evolved significantly, with widespread acceptance of the multi-dimensional nature of poverty and of the importance of considering the depth and severity of poverty. However, progress in recognizing and responding to the persistence of much poverty over time has been slow (Clark and Hulme 2005).

Of the world's 6 billion people, 2.8 billion, almost half, live on less than $2 a day; and 1.2 billion, one fifth, live on less than $1 per day (UNDP 2006).

In South Africa, the African National Congress-led government has initiated a comprehensive anti-poverty policy and has placed the eradication of poverty and

inequality high on its development agenda. South Africa is one of 23 countries that have had their national anti-poverty plans assessed by the UNDP to identify the obstacles to reaching the target and to highlight successful actions. South Africa has set the target date of 2020 for reducing extreme poverty to 0%.

Unfortunately, South Africa, unlike some other countries, has no viable poverty monitoring system yet (UNDP 2000). Morocco is an example of a country that has used a sophisticated system of indicators to determine the poorest provinces and then to identify the most deprived communities within these provinces (UNDP 2000).

The measurement and analysis of poverty, deprivation, inequality and vulnerability are crucial for several reasons. Firstly, for cognitive purposes, it is vital to know what the situation is, in other words, who is poor and where are the poor located in the country? Secondly, for analytical purposes, it is helpful to understand the underlying factors contributing to poverty. Thirdly, for policy-making purposes, it is important to be able to measure and analyse the situation in order to be able to assist the relevant parties in introducing interventions to improve the quality of life of the individuals and households that are affected by poverty. Finally, for monitoring and evaluation purposes, measurement and analysis are needed to assess the effectiveness of the chosen policies in eradicating poverty.

The aim of this study is to develop multi-dimensional techniques to identify the most deprived households and communities. The methods that countries use to determine income poverty tend to differ across countries and this makes comparisons difficult. The method of comparison developed in this study will help to measure the effectiveness of poverty alleviation programmes and strategies in poor communities.

1.2   DEFINITION OF POVERTY

The definition of poverty is very complex. A definition is difficult to formulate because poverty means different things to different people. Some people may define poverty as a lack of income resulting in the absence of a car or refrigerator, while others may describe it as a lack of formal housing, basic services or opportunities for training and employment. According to the *Oxford English Dictionary* (1989), the adjective "poor" means "lacking adequate money or means to live comfortably". The noun "poverty" is defined as "the state of being poor" and as a "want of the necessities of life". Other definitions for poverty and being poor include expressions such as having a "deficiency in", "lacking of", "scantiness", "inferiority", "want of", "leanness or feebleness", and many more.

Historically, the idea that some people are trapped in poverty while others have short spells in poverty was a central element of poverty analysis. Social commentators in eighteenth-century France distinguished between the *pauvre* and the *indigent* (Hulme and Mckay 2005). The *pauvre* experienced spells in poverty, such as seasonal poverty when crops failed or the demand for casual agricultural labour was low. The *indigent* was trapped in poverty and continued to remain permanently poor because of ill health (physical and mental), the results of an accident, age or alcoholism. The central aim of the policy was to support the *pauvre* in ways that would stop a person from becoming *indigent*.

From the above it is clear, firstly, that poverty and the poor are associated with a state of want and deprivation and, secondly, that such deprivation is related to the necessities of life. Thus, the term "poverty", in its daily use, implies a comparison between the condition of a household or person on the one hand and the perception of the person who speaks or writes about what is necessary to sustain life on the other.

Experiences of poverty differ from person to person, from one area to another, and across time. Poverty in India differs from the poverty experienced in England, and poverty in England today is different from the poverty experienced in England 50 years ago. Qizilbash (2002) believes that poverty is a vague concept without a single definition.

One way of trying to find a proper definition is by asking individuals to define poverty to get an idea of what constitutes poverty. This is what the South African Participatory Poverty Assessment (SA-PPA) did. In their survey, conducted in 1998, the SA-PPA found that the definitions of poverty given by the poor differ from those given by people who are not poor. The poor characterize poverty as isolation from the community, a lack of security, low wages, a lack of employment opportunities, poor nutrition, poor access to water, having too many children, poor education opportunities and the misuse of resources. People who are not poor see poverty as a lack of income and a result of bad choices by the poor. It is therefore not easy to get a precise definition of poverty that will suit every situation (May 1998).

Godard (1892:5-6) defines poverty as follows:

> Roughly, we may define poverty as 'An insufficiency of necessaries';
> or more fully, as 'An insufficient supply of those things which are
> requisite for an individual to maintain himself and those dependent
> upon him in health and vigour'.

There are several definitions of poverty. There could be considerable debate as to whether poverty should be regarded as absolute or relative; or whether it should be measured as necessities or capabilities or functions; or whether it is only a monetary phenomenon. The measurement of poverty has now become multi-dimensional. This is clearly expressed by the following definition of poverty given by the World Bank (2002):

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

The World Bank definition of poverty has not changed much from the definition of poverty by Godard (1892) in the nineteenth century.

In the current study, poverty is regarded as the measurement of well-being and deprivation, that is, the more deprived a household is, the poorer the household.

1.2.1 Horizontal and Vertical Vagueness of Poverty

In multi-dimensional poverty studies, there is no consensus as to what the dimensions of poverty should be or how many dimensions are adequate. The following are some examples of dimensions of poverty: a lack of nutrition, housing, safety, clothing and health, income, education, literacy, sanitation and clean drinking water.

Some dimensions contribute more to poverty than others, depending on the time and place, and this is referred to as the horizontal vagueness of poverty (Qizilbash 2002).

There is no consensus on where or how to distinguish between the poor and those who are not poor in each dimension. So, for example, individuals differ in their nutritional requirements, depending on their age, sex, height and weight. This implies that there is no clear threshold where nutritional poverty starts or where it ends.

There is also no consensus as to which level of education is acceptable, since the requirements of society may differ from place to place. Qizilbash (2002) refers to this as

the vertical vagueness of poverty. This vagueness of poverty contributed to a large extent to the debate on and difficulty of measuring poverty.

1.2.2 Income Poverty and Human Poverty

The poverty report of the United Nations Development Programme (UNDP 2000) distinguishes between income poverty and human poverty. Income poverty can be divided further into extreme poverty and overall poverty. Extreme poverty or absolute poverty is the lack of income necessary to satisfy basic food needs, usually defined on the basis of minimum calorie requirements.

Figure 1.2.1: Income inequality in South Africa in 2007
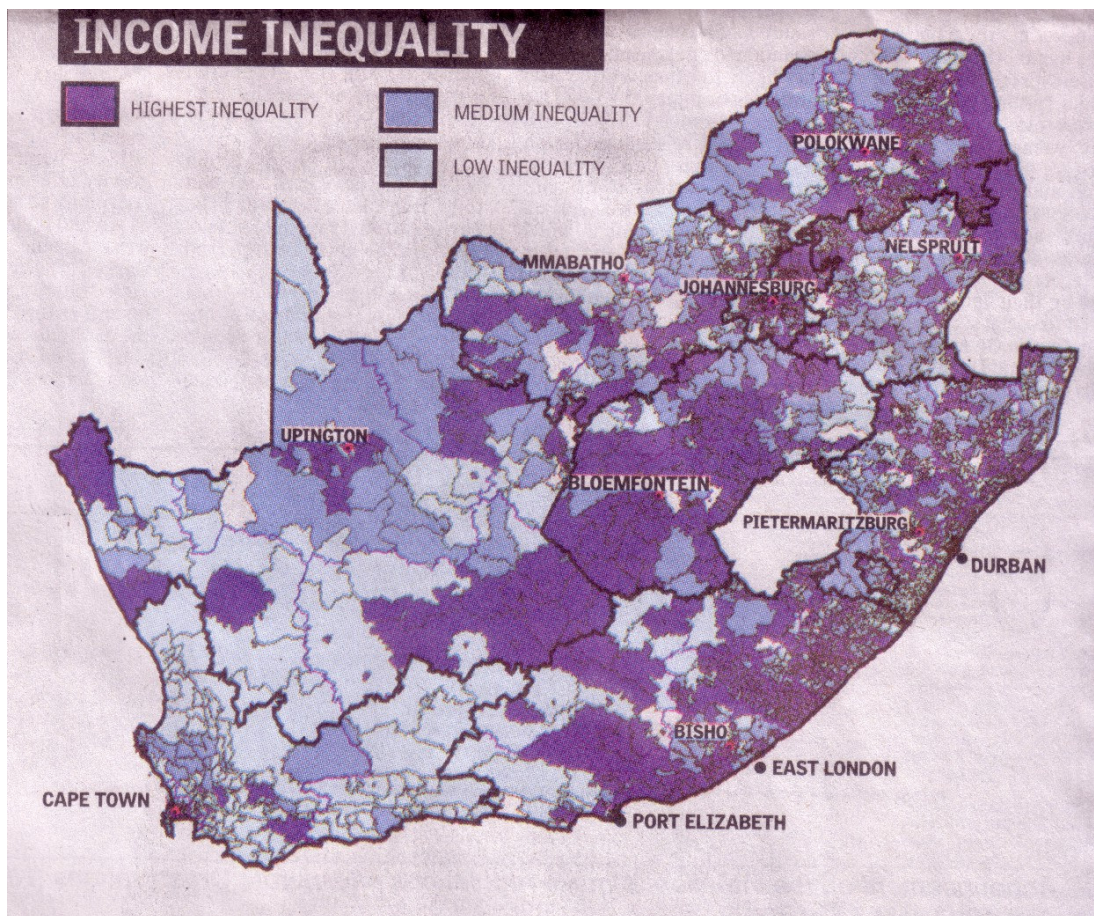
Source: Sunday Times (2007)

Overall poverty or relative poverty is the lack of income necessary to satisfy essential non-food needs, such as clothing, energy and housing needs. In this regard, the income inequalities in South Africa, as shown in Figure 1.2.1, are striking.

Human poverty refers to a lack of basic human capabilities, relating to a lack of literacy, malnutrition, a shortened life span, and poor health. Indirect measures are the lack of access to goods, services and infrastructure, electricity, sanitation and drinking water, the telephone and education.

Because of the uncertainty of what exactly constitutes poverty, policy prescriptions for tackling the problem can vary, depending on how poverty is defined. Everyone agrees that there is a need for poverty reduction, but few agree on what this means. The brief discussion of the concept of poverty and some of its possible meanings set out above will assist in understanding the issues discussed later in this study.

1.2.3 Different Approaches to Poverty Measurement

Ruggeri-Laderchi *et al.* (2003) focused on the four approaches listed below. Theoretically, if all the approaches identify the same people as being poor, any one of these approaches can be used to measure poverty. However, empirical evidence shows that poverty rates in countries differ significantly, depending on which approach is adopted.

The four approaches are the following:

- the monetary approach,

- the capability approach,

- the social exclusion approach, and

- the participatory approach.

The monetary approach is the one most frequently used to define and measure poverty. A poverty line is defined in terms of the monetary income sufficient for a person to attain a minimal standard of living. A person whose income falls below the poverty line is considered to be poor. The World Bank estimate for the poverty line is $2 per person per day for developing countries. In South Africa, the poverty line for households was set at R800 per household per month in 1996 prices.

The capabilities approach pioneered by Amartya Sen emphasizes that income is only valuable in so far as it increases the capabilities of individuals and thereby permits them to function in their society. According to the capabilities approach, poverty is pronounced to be a deprivation in well-being. Many poor people in South Africa live without the fundamental freedoms of action and choice that more affluent people take for granted. The poor often lack adequate food and shelter, education and health, deprivations that keep them from leading the kind of life that everyone values. They are extremely vulnerable to ill health and natural disasters such as floods and fires. Many of them are ill-treated by institutions of state and society and are powerless to influence key decisions affecting their lives. These issues are all dimensions of poverty. The experience of multiple deprivations is intense and painful and many believe that it is impossible to escape poverty.

All these forms of deprivation severely restrict what Sen (1976) calls the "capabilities that a person has, that is, the substantive freedoms he or she enjoys to lead the kind of life he or she values". The ultimate objective is to have capabilities such as the ability to lead a long life, to function without chronic morbidity, to be capable of reading, writing and performing numerical tasks and to be able to move from place to place. According to this approach, a person whose capabilities or functioning falls below a minimum acceptable standard is poor. The resources required to achieve the same capabilities can vary from person to person. A capability poor person may not necessarily be income poor. The capability approach is much broader and addresses the neglect of social goods in the monetary approach.

The social exclusion approach emphasizes relations between individuals. Social exclusion occurs when individuals or groups are unable to participate fully in the society in which they live. As a result of exclusion, the income capabilities or other characteristics of the poor become unacceptably distant from the norms of their community. In terms of the exclusion approach, poverty is a social construct and has little to do with the fulfilment of the individual's minimum needs. This is often a characteristic of groups rather than individuals, for example, of women, the aged, and the handicapped or particular racial or ethnic categories. In South Africa the cities and towns are well developed with the local municipalities able to provide basic services to the majority of households. Unfortunately, in the rural communities several households are severely deprived of educational opportunities, housing and basic services.

A participatory approach takes into account the views of poor people themselves. The people themselves decide what it means to be poor and that determines the magnitude of poverty. Van Praag (1978) introduced this approach to the measurement of poverty based on sample surveys about the perception of poverty of the people interviewed for his study. The study conducted by the South African Participatory Poverty Assessment is a good example of a participatory approach. This approach leads to perceived relative personal welfare rather than to a perceived poverty index and is therefore not discussed in more detail in this study.

1.3   LITERATURE REVIEW ON POVERTY

Several studies on poverty have been conducted in nearly every country in the world. For the sake of brevity, in this section, only the studies that promote the development of the different poverty measures are discussed. The relevant developments are listed chronologically.

The concept of poverty was first introduced, over a century ago, by Booth (1892) and Rowntree (1901).

The social exclusion approach was first introduced in 1974 by Rene Lenoir, the French Minister of Social Welfare (Dagum 2002).

Zadeh (1965) first developed the theory of fuzzy sets on the basis of the idea that certain classes of objects may not be defined by very precise criteria of membership and he introduced a class with a continuum of grades of membership.

Sen (1976) was the first to move away from the traditional approach to poverty measurement: he introduced the axiomatic approach to poverty measurement. This approach gave rise to a number of mathematically sophisticated indicators based on income or expenditure. Sen (1980) also introduced the functioning and capability approach in an attempt to show a more comprehensive view of poverty using several dimensions or attributes of poverty. The first application of Sen (1985), using data from 1980 to 1982, showed that a ranking of countries based on Gross National Product (GNP) per capita is quite different from a ranking based on the selected functioning. The GNP per capita of Brazil and Mexico are more than seven times the GNP per capita of India, China and Sri Lanka, but the performances in life expectancy, infant mortality and child death rates were better in Sri Lanka and China than in Mexico and Brazil.

Sen's (1985) second application examined sex bias in India and found evidence of gender differences. Females have poorer achievements than males for a number of areas of functioning, like age-specific mortality rates, malnutrition and morbidity. This type of quantitative application based on aggregated data has become widespread, especially in development studies, resulting in the concept of human development, which has its theoretical basis in the capability approach.

The fuzzy set approach to the analysis and measurement of poverty was developed further by Cerioli and Zani (1990). Their approach is called the Totally Fuzzy Approach, and it takes into account a whole series of variables that are supposed to measure a

particular aspect of poverty. This approach is applicable to dichotomous variables, polytomous variables and continuous variables.

Schokkaert and Van Ootegem (1990) were the first to operationalize the capability approach using micro data. They applied the capability approach on 1979 data on the unemployed in Belgium. They showed that material factors are almost irrelevant in the determination of the well-being of the unemployed, thus providing support for a broad concept of well-being.

Slottje (1991) used 20 indicators to compute a well-being index for 126 countries. The study showed that the world rankings of the quality of life index vary when the information from several economic well-being indicators is aggregated into one summary index.

Smeeding *et al*. (1993) compared the incidence of poverty among Organization for Economic Cooperation and Development (OECD) countries by assigning a monetary value for each of the welfare attributes of housing, education and healthcare. Estimating the per capita cost of primary, secondary and university education and allocating these costs to each individual in a household that completed a certain level of education allowed them to obtain the distribution across households of education services.

Ellman (1994) studied the sharp decline in living standards after the collapse of the USSR and argued that there were severe negative effects on mortality and morbidity over the period from 1987 to 1993.

Cheli and Lemmi (1995) modified the Totally Fuzzy Approach suggested by Cerioli and Zani (1990) and named their proposed method the Totally Fuzzy and Relative Approach. This approach has the advantage of taking a relative approach to poverty according to some dimension, where one is usually poor in respect of some other individual.

Balestrino (1996) analysed whether a sample of officially poor people indicated that they were functioning poor, income poor or both. Of the 281 Italian households in his sample, 73 households were pure functioning poor (in other words, they lacked education, nutrition or suffered some health failure), 71 were pure income poor and 137 were both. The analysis suggested that a sizeable portion of the poor in affluent societies is actually not income poor.

Ruggeri-Laderchi (1997) tested to what extent an income indicator can capture some of the most essential functioning (education, health and child nutrition). He used 1992 Chilean data. The test concluded that the income variable appears to be an insignificant determinant for the shortfall in the three selected functioning areas. Hence, poverty analysis is highly dependent on the indicators chosen and thus "the approach should be kept as broad as possible in order to more fully capture the multi-dimensional nature of such a complex phenomenon" (Ruggeri-Laderchi 1997:345).

Vero and Werquin (1997) suggested a further fuzzy approach to poverty measurement. Their method adjusts for certain indicators that may be highly correlated in the multi-dimensional measure of poverty.

The UNDP (1997) introduced the Human Poverty Index (HPI) as an example of a multi-dimensional index of poverty in terms of functioning failure. The HPI aggregates the country level deprivations into the living standards of a population for the basic dimensions of life, namely, decent living standards, educational attainment rate and life expectancy at birth.

Brandolini and D'Alessio (1998) used the Bank of Italy's 1995 household survey, which covered six functioning areas (health, education, employment, housing, social relationships and economic resources). This exercise provided an interesting picture of the distribution of the achievements and deprivation of functioning. They also

investigated and discussed a number of techniques which may be used, like sequential dominance analysis and multi-dimensional poverty indices.

Phipps (1999) compared the well-being of children from birth up to the age of 11 years in Canada, Norway and the USA, using equivalent household incomes and ten specific areas of functioning (low birth weight, asthma, accidents, activity limitation, trouble concentrating, disobedience at school, bullying, anxiety, lying and hyperactivity). The study confirmed that while the measurement of functioning and incomes gives complementary information, the respective rankings are not the same.

Chiappero-Martinetti (2000) used the 1994 Italian household survey to promote the methodological development of the fuzzy set theory to measure well-being in the functioning and capabilities space. The study measured five areas of functioning (health, education, knowledge, social interaction and psychological conditions), at three levels of aggregation. This study found that elderly women living alone, housewives and blue-collar workers have lower functioning achievements.

Pradhan and Ravallion (2000) created a subjective poverty line for micro data from Nepal and Jamaica. They asked each household what income level the members of the household considered to be absolute minimum income they needed to make ends meet. For each attribute in the multi-dimensional analysis, a global subjective line was defined as the least amount of expenditure required for an individual to be able to acquire the minimum of each attribute. An individual is considered poor when his or her income falls below the subjective poverty line.

Klasen (2000) measured and compared expenditure poverty and functioning poverty in South Africa. He used data from the Project for Statistics on Living Standards and Development, constructed an aggregated deprivation index comprised of 14 areas of functioning (education, income, wealth, housing, water, sanitation, energy, employment, transport, financial services, nutrition, health care, safety and perceived well-being).

Adams and Page (2001) compared the performances recorded for each welfare indicator for several countries in the Middle East and North America using aggregate data from the World Bank. The comparison observed no clear relationship between a reduction in monetary poverty and an improvement in other welfare indicators.

Balestrino and Sciclone (2001) tested the strength of the correlation between income and functioning on a regional comparison of well-being in Italy. Their study showed that the functioning-based ranking and income-based rankings are strongly positively correlated.

Lelli (2001) did an empirical test on the Panel Study of Belgian Households, and found that an analysis with fuzzy sets or factor analysis makes little difference if the same variables are selected.

Robeyns (2003) assessed gender inequality in Western societies in terms of functioning and capabilities using the British Household Panel Study to make a quantitative empirical application. This study found that women are disadvantaged on more dimensions than men, but enjoy better social relations than men.

Qizilbash (2002) used fuzzy set theoretic measures to rank South African provinces in terms of financial and human poverty. The human poverty criterion contained some capability-like dimensions, and some resources that served as proxies for capabilities. He showed that the provinces' ranking changed considerably, depending on whether one focuses on household expenditure or on the capability-related multi-dimensional poverty measure. The study concluded that the picture obtained from looking at household expenditures alone can be highly misleading.

Table 1.3.1 summarizes the poverty research conducted in South Africa since the first democratically elected government came into power in 1994. The techniques and data sets used in the different studies are listed.

Table 1.3.1: Poverty studies in South Africa (1994-2006)

Author	Techniques	Data sets used	Comments
Klasen (1997)	Income based analysis	SALDRU 1993	Kwa Zulu Natal
McIntyre *et al.* (2000)	General index of deprivation using principal component analysis	Census 1996	Magisterial level
Hirschowitz *et al.* (2000)	Household infrastructure index using factor analysis	Census 1996, using 11 indicators	South African provinces
Klasen (2000)	Composite deprivation index	SALDRU 1993, using 14 indicators	9000 households in South Africa
Ngwane *et al.* (2001)	CHAID Analysis	OHS 1995	South African provinces
Qizilbash (2002)	Borda score, Human poverty index	Census 1996	South African provinces
Ngwane *et al.* (2003)	Head count index, Watts measure	OHS 1995	South African provinces
UNDP (2003)	Service deprivation index	Census 2001	Nationally by province, race and gender
Bhorat *et al.* (2004)	Asset and service deprivation	Census 1996, Census 2001	South African provinces
Van der Walt (2004)	TFA, TFR	Census 1996	Districts of the Eastern Cape
Oosthuizen and Nieuwould (2002)	FGT poverty indices	OHS 1995	Western Cape
Keller (2004)	Heckprobit analysis	OHS 1995, IES 1995	African males in South Africa
May *et al.* (2004)	Micawber threshold, Asset index	KIDS 1998	Kwa Zulu Natal
Leibbrandt and Woolard (1999)	FGT poverty indices	LSDS 1993, IES 1995	South African provinces
Naidoo *et al.* (2005)	TFR	Census 1996, Census 2001	South African provinces
Woolard (2005)	Shorrocks rigidity index, Gini index	PSLSD 1993, KIDS1998	Kwa Zulu Natal
Noble *et al.* (2006)	Provincial indices of multiple deprivation	Census 2001	South African provinces

1.4 ONE-DIMENSIONAL MEASUREMENT OF POVERTY

In a one-dimensional measurement of poverty, the poverty line is chosen in such a way that any household whose income (expenditure) falls below this line is considered to be poor. The poverty line defines the level of income (expenditure) needed for a household to escape poverty. The poverty line could be relative to the population, for example, defining all households below the 40th percentile of income in the population as poor. An absolute poverty line is fixed in terms of the standard of living and does not change from year to year. The World Bank has fixed the absolute poverty line at $1 per day and the poverty line at $2 per day in terms of 1985 prices.

The headcount index is one of the most widely used poverty measures and it simply measures the proportion of the population that is counted as poor. The headcount index is simple to construct and easy to understand; unfortunately it has some limitations. The first limitation of the headcount index is that it does not take the intensity of poverty into account. The headcount index does not show how poor the poor are and it does not change if a household below the poverty line becomes poorer.

The poverty gap index sums up the extent to which individuals fall below the poverty line and expresses it as a percentage of the poverty line. The poverty gap can be defined as the difference between the poverty line and the actual income for poor persons, with the understanding that the gap for non-poor persons is considered as zero. The poverty gap index is a measure of the mean proportionate poverty gap in the population.

One-dimensional measures of poverty are not discussed any further in this study.

1.5 MULTI-DIMENSIONAL MEASURES OF POVERTY

The study of poverty is commonly oversimplified, because the manifestation of poverty is perceived as dichotomous. Poverty is conventionally analysed by splitting the households in a population into two groups: poor and non-poor, defined in relation to the poverty line.

Poverty should be regarded as a multi-dimensional phenomenon of which income is only one aspect. The study of poverty should be supplemented by a number of sets of non-monetary indicators of deprivation which can then be used to understand the different types of hardship experienced by households. The multi-dimensionality of poverty is now internationally recognized, as is clear from the World Bank's (2001) report on poverty and the adoption of social indicators by the European Union.

Deutsch and Silber (2005) detail a systemic comparison of the following four approaches to multi-dimensional poverty analysis:

- a fuzzy set approach,

- a distance function approach,

- an information theory approach, and

- axiomatic derivations of multi-dimensional poverty indices.

The current study introduces the neural network approach to poverty measurement using self-organising maps. The Kohonen vector quantization method, the Kohonen self-organizing maps and the Batch self-organizing maps are discussed.

1.5.1 The Fuzzy Set Approach to Poverty Analysis

Zadeh (1965) introduced the theory of fuzzy sets on the basis of the idea that certain classes of objects may not be defined by precise criteria of membership, such as cases where one is unable to determine which elements belong to a given set and which do not. He characterized a fuzzy set as a class with a continuum of grades of membership.

The fuzzy set approach may be easily applied to the concept of poverty. Some households are in such a state of deprivation that they should certainly be considered poor, while others have such a level of welfare that they should certainly not be classified as poor. There are some households where it is not clear whether the household is poor or not. This is especially true when one takes a multi-dimensional approach to poverty measurement, where, according to some criteria, one would define the household as poor, whereas, according to other criteria, one should not regard the household as poor. Such a fuzzy approach to the study of poverty has taken various forms in the literature.

Cerioli and Zani (1990) applied the concept of fuzzy sets to the measurement of poverty. Their approach is called the Totally Fuzzy Approach. The idea is to take into account a whole series of variables that are supposed to measure a particular aspect of poverty. In the analysis of poverty there are several qualitative variables that may take more than two values. In such cases, the first step is to assume that one may rearrange these values by increasing order, where higher values denote a higher risk of poverty. They defined membership functions for three categories of variables: dichotomous variables, polytomous variables and continuous variables. When the membership function takes the value of one, it indicates a condition of absolute deprivation, while a membership value of zero indicates the absence of deprivation.

Cheli and Lemmi (1995) suggested the Totally Fuzzy and Relative Approach as a modification of the Totally Fuzzy Approach. This method takes a relative approach to

poverty according to which one is poor in respect of some other households. The approach stresses that when the risk of poverty is very low, a high proportion of individuals will not be considered poor, because the value taken by the indicator of poverty in the Totally Fuzzy Approach may be too high for those who turn out not to be poor. The cumulative distribution function of the attribute is used to determine the membership function. This formulation is less arbitrary than the Totally Fuzzy Approach for polytomous and continuous variables, because in both cases one has to define critical threshold values. The Totally Fuzzy and Relative Approach has the advantage of taking a relative approach to poverty, as adopted in most developed countries, according to which one is usually poor compared to some other individuals.

The next step in the Totally Fuzzy and Relative Approach is to decide how to aggregate the various deprivation indicators. The deprivation index is calculated by taking a weighted average of the membership functions for each dimension of poverty. The different approaches have proposed various methods of obtaining the weights. The weights are an inverse function of the average degree of deprivation in the population according to the deprivation indicator. Thus, the lower the frequency of poverty according to a given deprivation indicator, the greater the weight this indicator will receive.

Vero and Werquin (1997) suggested another fuzzy approach to poverty measurement. They noted that one of the serious problems one faces when taking a multi-dimensional approach to poverty measurement, such as the fuzzy approach, is that some of the indicators one uses may be highly correlated. They therefore employed a logarithmic approach in determining the membership function.

The fuzzy approach to poverty measurement is discussed in greater detail in Chapter Two.

1.5.2 The Distance Function Approach

The distance function is a concept widely used in Efficiency Analysis (Coelli *et al.* 1998). It has, however, only rarely been applied to the analysis of household behaviour. Lovell *et al*. (1994) were the first to make such an attempt using the input and output distance functions.

By definition, the distance function is always equal to or greater than one and it indicates by how much an individual's resources must be scaled down to reach the resource frontier. In the current study, the input distance function is used to compare households and rank household in terms of the severity of poverty and deprivation.

Cluster analysis is also referred to as data segmentation. It has a variety of goals which all relate to grouping or segmenting a collection of households into subsets or clusters in such a way that the households in each cluster are more closely related to one another than to households assigned to other clusters. A household can be described by a set of attributes. Central to all the goals of cluster analysis is the notion of the degree of similarity or dissimilarity between the individual households that are being clustered. A clustering method attempts to group the households on the basis of the definition of similarity applied to it.

In the average method, the distance between two clusters is the average distance between pairs of observations, one in each cluster. In the centroid method, the distance between two clusters is defined as the Euclidean distance between their centroids or means. The distance between two clusters in the Ward method is the ANOVA sum of squares for all the variables.

The distance function approach is discussed in greater detail in Chapter Three.

1.5.3 The Information Theory Approach

Engineers in the field of communication originally developed information theory. Maasoumi (1986) was the first to use concepts from information theory to define multi-dimensional measures of poverty and inequality. He proposed that in the first step a procedure be defined to aggregate the various indicators of poverty. In the second step an equality index would be selected to estimate the degree of multi-dimensional equality.

Maasoumi (1986) proposed to replace the information on the values of different indicators for the various households by a composite index by selecting an appropriate aggregation function. This approach reduces multi-dimensional poverty to a scalar measurement. This approach is not discussed in any further detail in this study.

1.5.4 Axiomatic Derivations of Multi-Dimensional Poverty Indices

Sen (1976) criticized the head count ratio and the poverty gap indices because of their insensitivity to a redistribution of income among the poor. He suggested a more sophisticated index of poverty using an axiomatic approach. This stimulated interest in the derivation of axiomatic multi-dimensional indices of poverty. Tsui (2002) recently made such an attempt, on axiomatic derivations of multi-dimensional inequality indices, but it seems that Chakravarty *et al*. (1998) were the first to publish an article on the axiomatic derivation of multi-dimensional poverty indices. Bourguignon and Chakrtavarty (2003) introduced a poverty line for each dimension of poverty and considered a household as poor if it fell below at least one of the various lines. They explored how to combine the various poverty lines into a multi-dimensional poverty measure.

A multi-dimensional poverty index is a non-constant function that gives the extent of poverty associated with the various attributes of poverty.

1.5.5 The Neural Network Self-Organizing Map

Computer technology has developed rapidly in the past years and now allows researchers to carry out data analysis with very complex and multivariate data sets. Traditional data analysis and visualization techniques are useful, but they are insufficient to carry out such tasks. The self-organizing map is a modern data analysis tool that researchers have found useful in analysing high dimensional multivariate data sets. It is often used for such data analysis because of its multi-dimensional scaling and topological mapping capabilities (Takatsuka 2002).

The self-organizing map is presented as a clustering method. It includes the Kohonen vector quantization, the Kohonen self-organizing map and the Batch self-organizing map. Kohonen vector quantization is a clustering method.

The self-organizing map was developed by Kohonen (2001) and is mostly used for the visualization of nonlinear relations of multi-dimensional data, providing a topological mapping from the input space to the clusters.

The neural network self-organizing map approach is discussed in greater detail in Chapter Four.

1.6   TECHNIQUES

Any thesis in the discipline of Statistics has to be either research in new methodology or applied statistical research using a complex data set. This study is novel in the sense that various complex datasets are analysed in each chapter. In addition, several statistical techniques are applied to poverty research for the first time, since the use of fuzzy set membership functions has converted binary categorical data into interval or continuous data. In most of the poverty studies, dimensions of poverty are measured as a binary variable, in other words, poor or not poor in respect of any specific dimension.

The conversion of poverty dimension data from binary to interval data lends itself to complex statistical analysis like k-means clustering and neural network self-organizing maps. Several studies in multi-dimensional measurement of poverty use membership functions, but all of them use the weighted mean for aggregation of the different dimensions and eventually arrive at a single value as the measure of multi-dimensional poverty.

This study focuses on applied statistics, with different new models analysed for different complex data sets. The study also investigates different statistical techniques for the aggregation of multi-dimensions of poverty.

The Euclidean distance measure aggregates the dimensions for each household and allows the households to be ranked from the most deprived to the least deprived. The cluster analysis segments all households in the population into groups.

The neural network self-organizing map reduces the many dimensions of poverty and maps the households onto a two-dimensional grid, thus allowing the households to be categorised into the various grades and shades of poverty.

The clustering methods and self-organizing maps are ideal techniques to monitor the effectiveness of poverty reduction strategies on a group of households.

1.7   SCOPE OF THE STUDY

Chapter One is introductory in nature. It provides a general introduction of poverty in the world and South Africa, and it discusses the definition and techniques of poverty measurement. Recent studies on poverty are then listed. The various one-dimensional and multi-dimensional measures are briefly explored in the next sections. The various multivariate techniques used in this research are also presented.

Chapter Two discusses the fuzzy approach to poverty and these methods are applied in an empirical analysis using data from the South African censuses of 1999 and 2001.

Chapter Three discusses the distance function approach, using the Euclidean distance measure and the k-means clustering on the South African census of 2001 10% sample data.

Chapter Four views poverty measurement from a data mining point of view, using neural networks. The techniques discussed are Kohonen vector quantization, Kohonen self-organizing maps and Batch self-organizing maps. The analysis is performed on the South African census 10% sample data.

Chapter Five contains the conclusion and a comparison of some of the results.