Where are the Poor? Mapping Out A GIS-Multidimensional Non-Monetary Poverty Index Approach for Ghana*

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Abstract

Governments all over the world especially in developing countries continue to emphasise poverty alleviation and eradication as their overarching goals. A number of international organisations also recognise the need for the reduction of poverty incidence within the next decade, making poverty reduction one of the greatest concerns worldwide. During the past three decades, the government of Ghana has developed and subsequently implemented several development policy frameworks as part of its poverty reduction programmes. One of the parameters that play a key role in reduction and alleviation of poverty is statistics on poverty. However, in many developing countries such as Ghana such statistics do not exist, making poverty alleviation intervention a bit scattered and untargeted. Due to this, there exists a major problem of reaching the poor to address their specific needs. In response to this challenge, there is the need to produce poverty map to assist policy makers. This research therefore sought to use GIS to map out poverty endemic areas by displaying the spatial dimensions of poverty and identifying the poverty pockets across the country adopting a Multi-dimensional (Non-Monetary) Poverty Index approach. Ten indicators which were categories under three dimensions were used. Results of the study showed that across Ghana, a considerable percentage of households are deprived in a number of non-monetary poverty indicators. Analysis of these indicators revealed wide disparities by region.

Keywords: GIS, Multi-dimensional Poverty Index, Indicator

1 Introduction

Governments all over the world especially in developing countries continue to emphasise poverty alleviation and eradication as one of their overarching goals. A number of international organisations also recognise the need for the reduction of poverty incidence within the next decade (Estrella, 2003). No wonder, one of the goals of the Millennium Development Goals (MDG) was to reduce extreme poverty by half in target countries, especially developing countries in Africa and Asia.

In addressing poverty reduction, one of the parameters that play a key role is statistics on poverty. Correct, precise and accurate poverty statistics provide a very good platform for the planning and implementation of poverty alleviation programmes. This is because such statistics give an indication of where the poor are located and the condition of the poor among several factors. In many developing countries such as Ghana such statistics do not exist, thus making poverty alleviation intervention a bit scattered and untargeted (Anon., 2011). Reaching the poor to address their needs also becomes a problem.

In response to these challenges, there is the need to produce poverty map to assist policy makers. During the past three decades, the governments of Ghana has developed and subsequently implemented several development policy frameworks as part of its poverty reduction programmes.

These programmes or interventions include, the Ghana Poverty Reduction Strategy (GPRS I) which is a development policy framework developed and implemented from 2002 to 2004. After the GPRS I, the Growth and Poverty Reduction Strategy (GPRS II), 2005 to 2009 was also implemented as a medium term development policy framework. Within the last five years, another medium term development policy framework, the Ghana Shared Growth and Development Agenda (GSGDA) which focuses on accelerated economic growth with the ultimate aim of reducing poverty just like the GPRS I and II is being implemented. All these strategies were government's interventions targeted at reducing poverty, which to some extent have yielded appreciable results (Anon., 2002; Anon., 2005; Anon., 2009; Owusu *et al.*, 2013; Alkire *et al.*, 2010; Alkire *et al.*, 2011).

The Ghana Living Standards Survey (GLSS) is a periodic survey conducted across the country by the Ghana Statistical Services (GSS) to determine the poverty incidence across various socio-economic groups and localities within the country. In these surveys, expenditure-based poverty measurement is applied to determine a poverty line which shows the level of living standard measure at which minimum consumption ought to be met (Anon., 2007; Owusu *et al.*, 2013). Even though there have been several poverty reports prepared by

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the GSS, the most recent of them indicates that there is a declining level of poverty across the overall nation; indeed, the absolute number of the poor have lowered from 7.6 million in 1991 to about 6.2 million in 2006 (Anon., 2007; Owusu *et al.*, 2013).

The definition and measurement of poverty have been of interest to researchers and policy-makers in recent time (Owusu *et al.*, 2013). Several researchers have given their assertions on what needs to be considered during the definition of poverty. Additionally, a careful consideration has also been given to the indicators that need to be taken into account when measuring poverty. Traditionally, poverty is defined either in monetary or non-monetary terms and its measurement also done likewise (Owusu *et al.*, 2007). Owusu and Yankson (2007) measuring and defining poverty noted that the methods used to measure and define poverty are very significant and critical as they have an enormous impact on the strategies that policy makers in a country can adopt to reduce poverty.

In many developing countries such as Ghana, the definition of poverty remains rooted in questionable assumptions about what poverty is and the actual or real need of the poor. Satterthwaite (2004) noted that, the use of income as determinant of the poverty line within the context of the widely accepted view of poverty as being multi-dimensional is problematic since it does not provide a full picture of the "command of resources" that an individual or household possesses (Boarini and d'Ercole 2006).

Income measures tend to neglect the ability of individuals and households to borrow, draw from accumulated savings, and benefit from help provided by family and friends, as well as consumption of public services such as education, health and housing. As a result of the criticisms of the monetary poverty measurements, non-income indicators such as access to health, education, housing and other social services are increasingly considered in the measurement of poverty (Boarini *et al.*, 2006).

Even though the use of poverty line is still widely used and prevalent in Ghana, Owusu and Mensah (2013) adopted the multidimensional poverty index developed by Alkire and Foster (2007) to carry out a non-monetary poverty studies in the country using data obtained from the results of the 2010 Population and Housing Census (PHC). In their research, they used data derived from the 2010 PHC from the GSS without incorporating both poverty statistics and geographically referenced household and community levels data to generate poverty maps.

Geographic Information Systems (GIS) technology provides a flexible environment for entering, analysing and displaying digital data from various sources necessary for poverty mapping, identification of the poor and database development. These make GIS a more useful tool for poverty mapping projects. Some studies (Estrella, 2003; Arshad, 2005 and Hassaan, 2007) have highlighted the potential to measure poverty incidence at household level by applying various indicators of poverty measurement, using GIS techniques to develop a poverty map. Such a map can contribute to regional planning efforts as it will point out spatial variations in poverty levels between various parts of the geographic area and also display different dimensions of poverty.

The focus of this paper is to develop a GIS-based Multidimensional (Non-monetary) Poverty Index (MPI) map by the use of empirical data from the 2010 PHC to map out poverty endemic areas in Ghana. Such a novel map will display the spatial dimensions of poverty and identify the poverty pockets across Ghana so as to channel resources to alleviate poverty in particularly affected enclaves. The map will also give a broader framework to city authorities and other development actors to assess conditions of the population at the community level and provide a solid basis for recommendations about how best to reduce poverty and improve living conditions of the poor.

2 Materials and Methods Used

2.1 Study Area

This research was carried out in the entire nation of Ghana. Ghana is a West African country which lies within latitude 04˚30' N and 11˚10' N and longitude 03˚10' W and 01˚10' E. The country is bounded to the north by Burkina Faso, to the south by the Gulf of Guinea, to the east by Ivory Coast and to the west by Togo. There are ten regions each with a regional capital. Accra which is the national capital is located at the southern part of the country and is the most populated city in the country. Fig. 1 is a map of the study area showing all the regions with their respective regional capital.

2.2 Materials

The study made use of two types of data; spatial data and statistical data. The statistical data was derived from the 2010 PHC data obtained from the GSS and a report prepared by Owusu and Mensah (2013). Spatial data in the form of shapefile were also obtained and used for all the spatial analysis.

2.3 Methods

This study adopted the method developed by Alkire and Foster (2007) to estimate multi-dimensional non-monetary poverty in Ghana. The method also attempted to study and analyse the spatial pattern and distribution of the non-monetary poverty. In most developing countries, literature on poverty confirms that income deprivation should not be considered the only dimension of poverty (Owusu and Mensah, 2013).

Deprivation in other non-monetary dimensions like access to drinking water, access to electricity, education and availability of room in the house are also significant in both urban and rural areas and not necessarily related to deprivation in income (Alkire *et al.*, 2010). Even though, multidimensional poverty is mainly a rural problem in Ghana ((Anon, 2007), this research adopted this non-monetary multidimensional method of poverty estimation because according 2010 PHC about 49.1% of Ghanaians still live in rural area, meaning, almost about half of Ghana's population is rural.

Multi-dimensional Poverty Index (MPI) is an index of acute multi-dimensional poverty and therefore reflects deprivation in very rudimentary services and core human functions (Alkire *et al.*, 2010). According to Alkire *et al.* (2010), MPI also discloses the combination of deprivations that enhance the status of a household at the same time. Alkire and Santos (2010) also note that a household is therefore identified as a multi-dimensionally poor, if and only if, it is deprived in some combination of indicators whose weighted sum exceeds 30% of total deprivations. Thus the MPI identifies a person as deprived or not deprived using any available information for a household member (Owusu and Mensah, 2013).

2.3.1 Dimensions and Indicators Used

The computation of the MPI uses ten indicators belonging to three dimensions namely, Education, Health and Living Standards. Out of these ten indicators, two each belong to both health and education while the remaining six belong to standard of living. The indicators used for this study is a little different from that proposed by Alkire and Santos (2010); this was due to some restrictions in data availability.

However, the selection of the indicators for the three dimensions was guided by the eight Millennium Development Goals (MDGs). Generally, the MPI indicators are identical to the MDGs indicators, making the selected deprivation cut-offs for each indicator backed by some international consensus (Owusu and Mensah 2013). Table 1 provides a summary of the dimensions, indicators, threshold and weight used in the MPI. Using the threshold as shown in Table 1, the total number of both deprived and not deprived households was determined for each region for each of the ten indicators.

2.3.2 Computation of MPI

In determining the MPI which is a product of multi-dimension headcount ratio (H) and Intensity of Poverty (A), the three dimensions of education, health and living standards shown in Table 1 were weighted equally with each dimension receiving a total weight of 1/3 according to Alkire and Santos (2010). The indicators within each dimension were also weighted equally using Equation (1).

$$\text{Weight} = \left(\frac{\text{Total Weight of Dimension}}{\text{No. of Indicators in that Dimension}} \right) \quad (1)$$

From Equation (1), the indicators within education and health were weighted as 1/6 whereas living standard indicators had a weight of 1/18.

The next step was the estimation of a deprivation score for each of the households in Table 1 using Equation 2. This was computed by considering the weighted sum (Equation 1) of the deprivations encountered so that each household's deprivation score lies within 0 and 1; where 0 indicates that a household is not deprived of any of the ten indicators and 1 indicates otherwise. This means the deprivation score (C) decreases as the number of deprivations in a household decreases and vice versa.

$$C_i = w_1 I_1 + w_2 I_2 + \ldots + w_d I_d \quad (2)$$

where, C is the deprivation score, w is the weight and I is a person deprived in a particular indicator.

The third step was the determination and identification the multi-dimensionally poor based on a poverty cut-off. This poverty cut-off is the share of deprivations a household must have in order to be considered poor, and this was denoted by p in this study. A household was therefore considered poor if its deprivation score (C) is greater than or equal to the poverty cut-off (p) (if $c_i \geq p$). Again, before a household could be considered as multi-dimensionally poor, the deprivation of the household must be at least a third of the weighted indicators. Any deprivation score below the poverty score was replaced with zero even if it is non-zero and any existing deprivations are not considered. This process is referred to as censoring the deprivations of the non-poor (Alkire *et al.*, 2011). In order to distinguish the original deprivation score from the censored one, the

notation c_i *(p)* was used to denote the censored deprivation score. Therefore, when $c_i \geq p$, *then* c_i *(p)* = c_i *but* $c_i < p$, *then* c_i *(p) = 0.*

The fourth step was the estimation of multi-dimensional headcount ratio (H) using Equation 3

$$H = \frac{N_p}{n} \tag{3}$$

where N_p is the number of people who are multi-dimensionally poor and n is the total population.

The fifth step is the estimation of the intensity of poverty (A) and it was computed using Equation 4.

$$A = \frac{\sum_{i=1}^{n} c_i(p)}{N_p} \tag{4}$$

where c_i *(p)* is the censored deprivation scores of individual i and N_p is the number of people who are

multi-dimensionally poor. Finally, the MPI was computed as the product of Equation 4 and Equation 5 as:

$$MPI = H \times A \tag{5}$$

2.3.3 GIS Analysis

Several GIS tools such as the raster calculator, interpolation and weighted overlay were used to carry out a GIS analysis of the various indicators and the overall MPI that was computed based on Equations 1 to 5. This assisted in determining the spatial trend, pattern and distribution of deprivation of each indicator and the MPI. A Map that shows the deprivation status of each indicator in terms of percentage was obtained to show the spatial pattern of household deprivation of each indicator and dimension using the Inverse Distance Weighted (IDW) technique. Additionally, maps were also generated using Equations 3 and 4 for each of the two components, H and A that were used to compute the MPI. Using the raster calculator, the map of H and A were multiplied to generate a map of MPI for the study area.

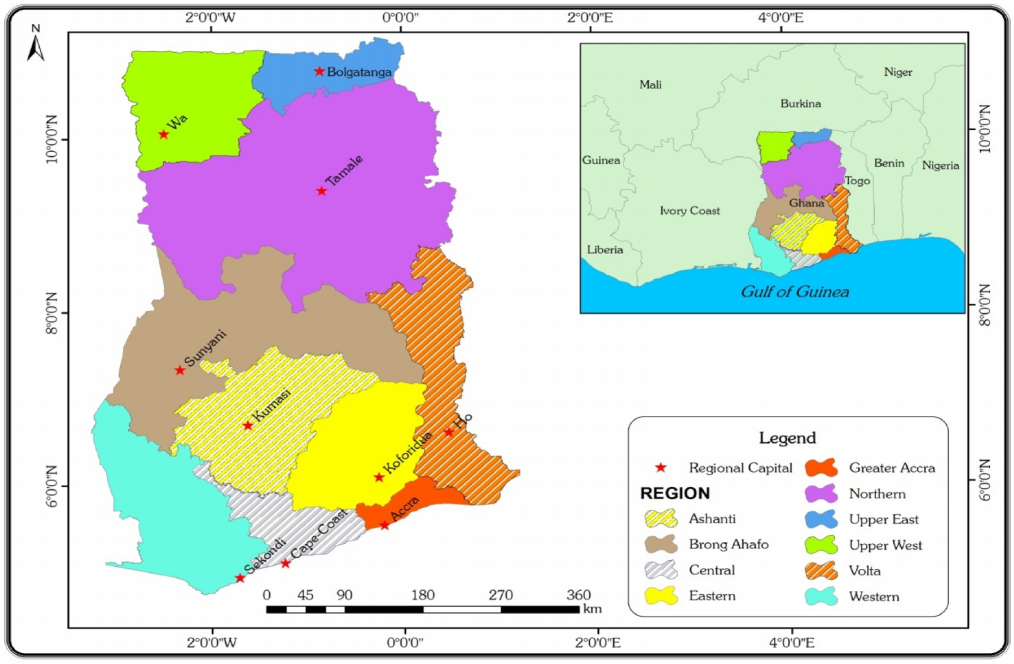

Fig. 1 Regional Map of Ghana

Table 1 The Dimensions, Indicators, Deprivation Thresholds and Weights of MPI

Dimension	Indicator		Household Deprived if	Weight
Education	Years of Schooling		No household member has completed 5 years of education	1/6
	Child School Attendant		Any school-aged child not attending school up to class 8 (*i.e.* from Kindergarten to Primary 6)	1/6
Health	Maternal Mortality		A female household member died while pregnant, during delivery, or within 6 weeks after the end of a pregnancy or child birth in past 12 months	1/6
	Child Mortality		Any under-5 year old child died in the household during past 12 months preceding census	1/6
Living Standard	Safe Drinking Water		The household's water source is not any of the following piped water: public tap, borehole or pump, protected well, protected spring or rainwater	1/18
	Improved Sanitation		The household's sanitation facility is not improved (improved includes flash toilet, pit latrine, ventilated improved pit), or it is improved but shared with other households.	1/18
	Flooring		The household has an earth, mud or dung floor	1/18
	Electricity		The household has no electricity (*i.e.* the household is not connected to the national grid)	1/18
	Cooking Fuel		The household cooks with wood, charcoal, crop residue, saw dust or animal waste	1/18
	Overcrowding		At least 3 people per room	1/18

3 Results and Discussion

3.1 Results

3.1.1 Deprivation by Dimension and Indicator

Maps that show the percentage of household deprived in each indicator and dimension were generated. These maps are shown in Figs. 2, 3 and 4. Fig. 2 shows the spatial distribution of the percentage of household deprived in the education dimension consisting of the years of schooling and child school attendance indicators. From the figure, it can be seen that the lowest and highest deprivation in years of schooling is 21.8% and 87.1% respectively while the highest and lowest deprivation in child school attendance is 2.7% and 30.7% respectively. This depicts that for the education dimension, more households are deprived in years of schooling than child school attendance.

From Fig. 3, it can be observed that the lowest and highest deprivation in maternal mortality is 0.332% and 1.125% respectively while the lowest and highest deprivation in child mortality is 0.485% and 1.898% respectively. This further depicts that for the health dimension, more households are deprived in child mortality and maternal mortality.

3.1.2 Headcount Ratio and Intensity of Poverty

Fig. 5 shows the result of the multi-dimensional headcount ratio and the intensity of poverty. From the result it can be seen that the intensity of poverty (A) is higher than multi-dimensional headcount ratio across the entire country. The lowest and highest multidimensional headcount ratio of 0.387 and 0.459 respectively were recorded while 0.185 and 0.809 were recorded as the lowest and highest respectively for the intensity of poverty.

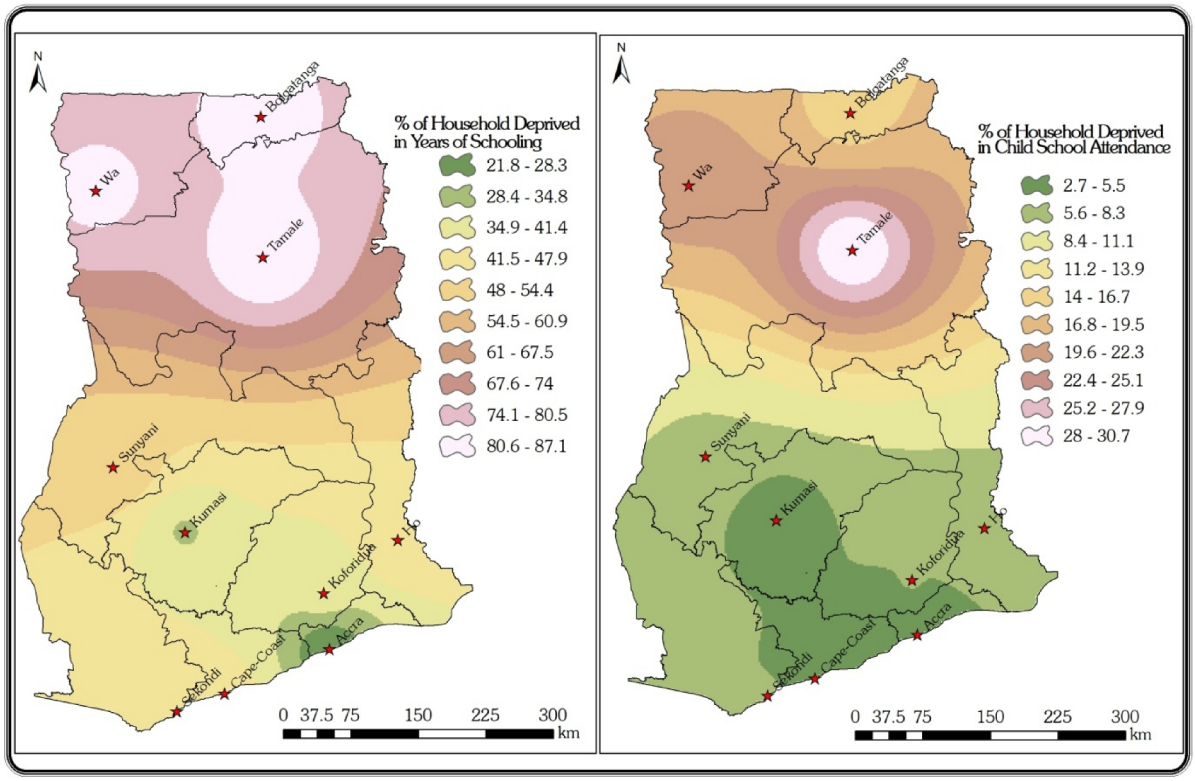

Fig. 2: Percentage of Deprivation by each Indicator for the Education Dimension

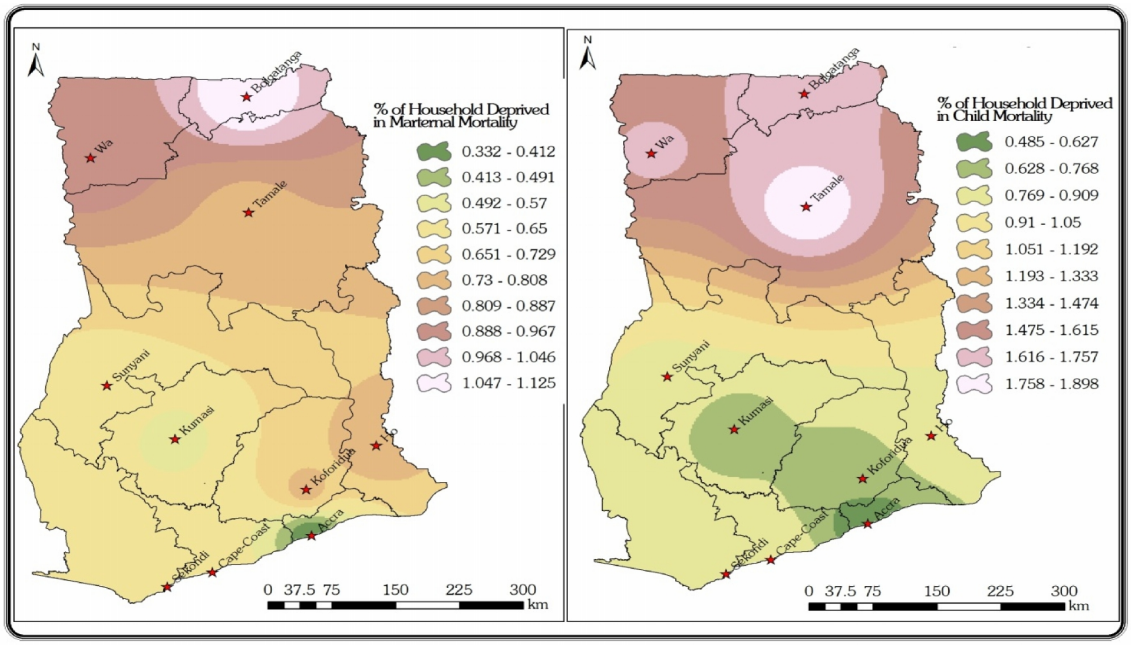

Fig. 3. Percentage of Deprivation by each Indicator for the Health Dimension

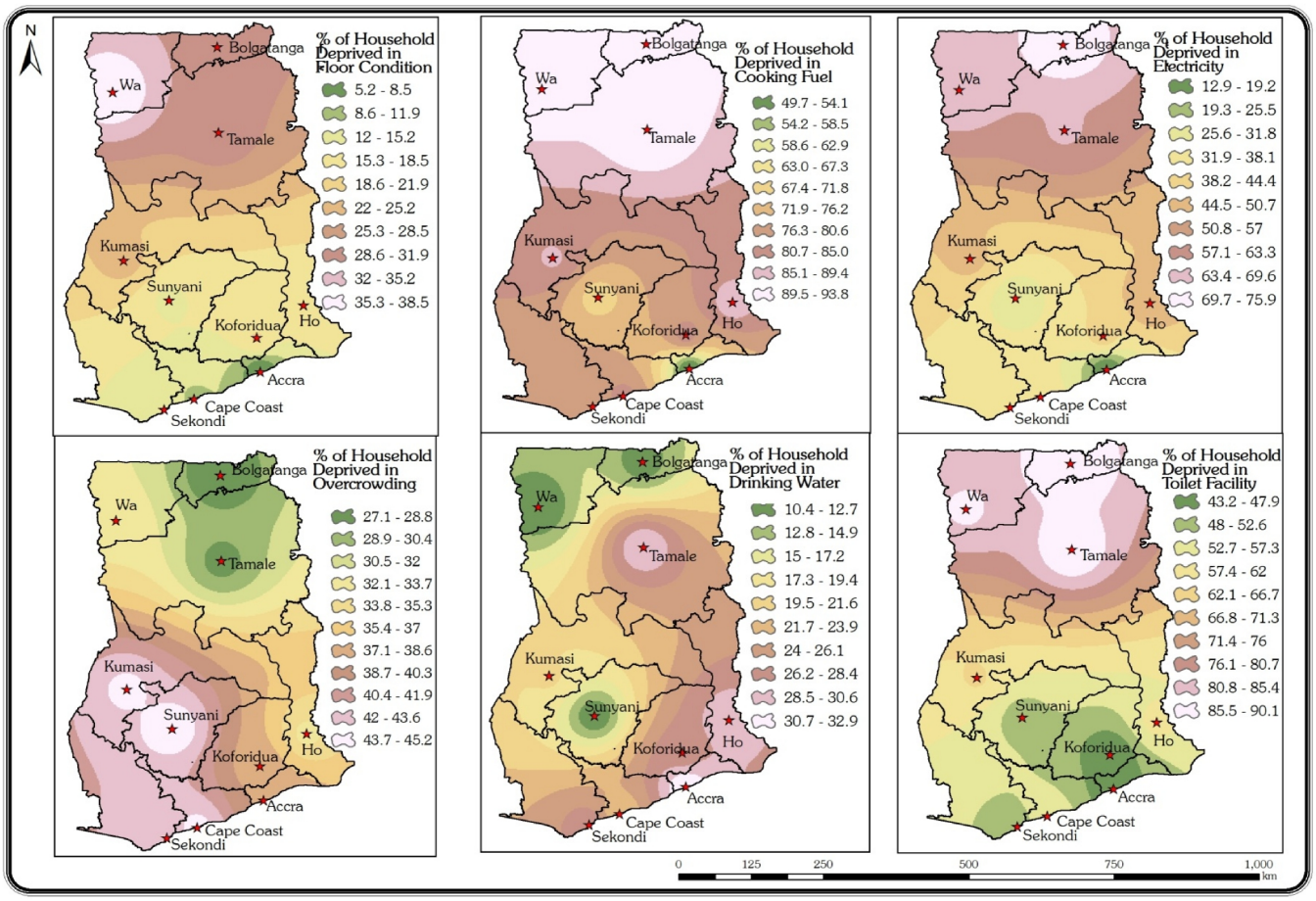

Fig. 4. Percentage of Deprivation by each Indicator for the Health Dimension

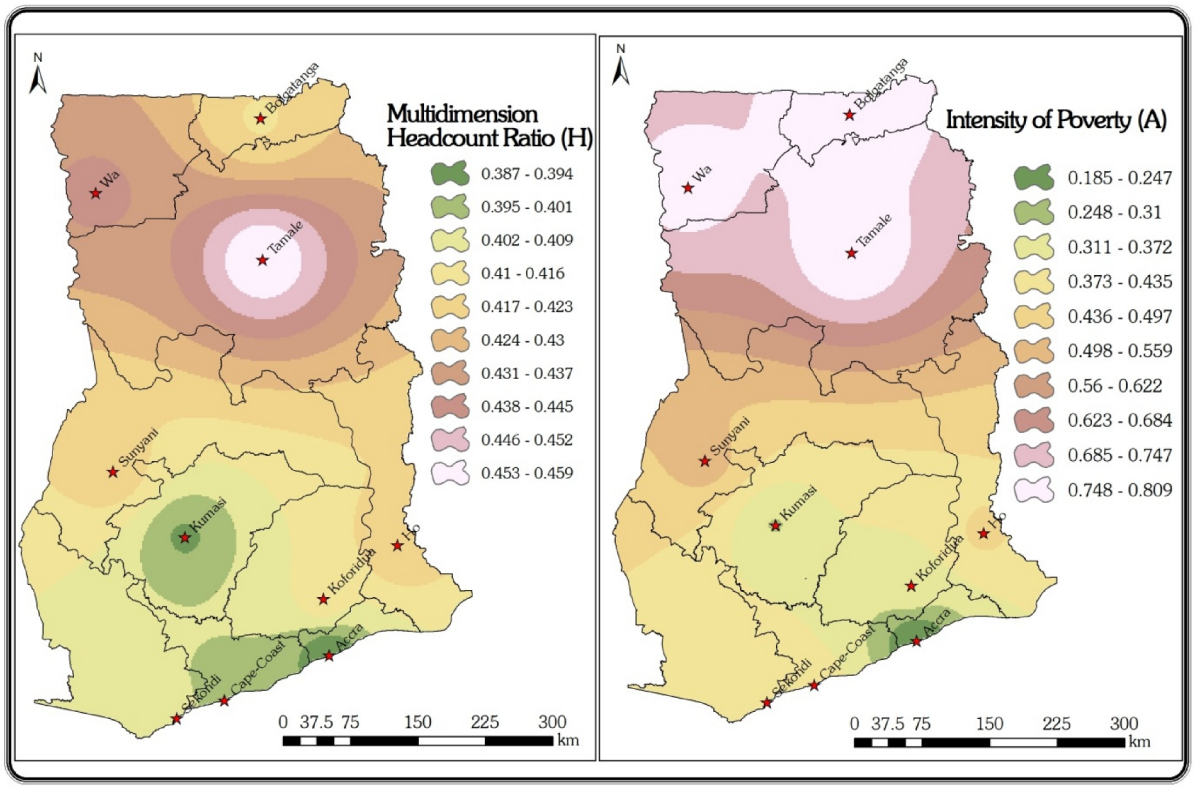

Fig. 5. Map Showing the Multi-dimensional Headcount Ratio (H) and the Intensity of Poverty (A)

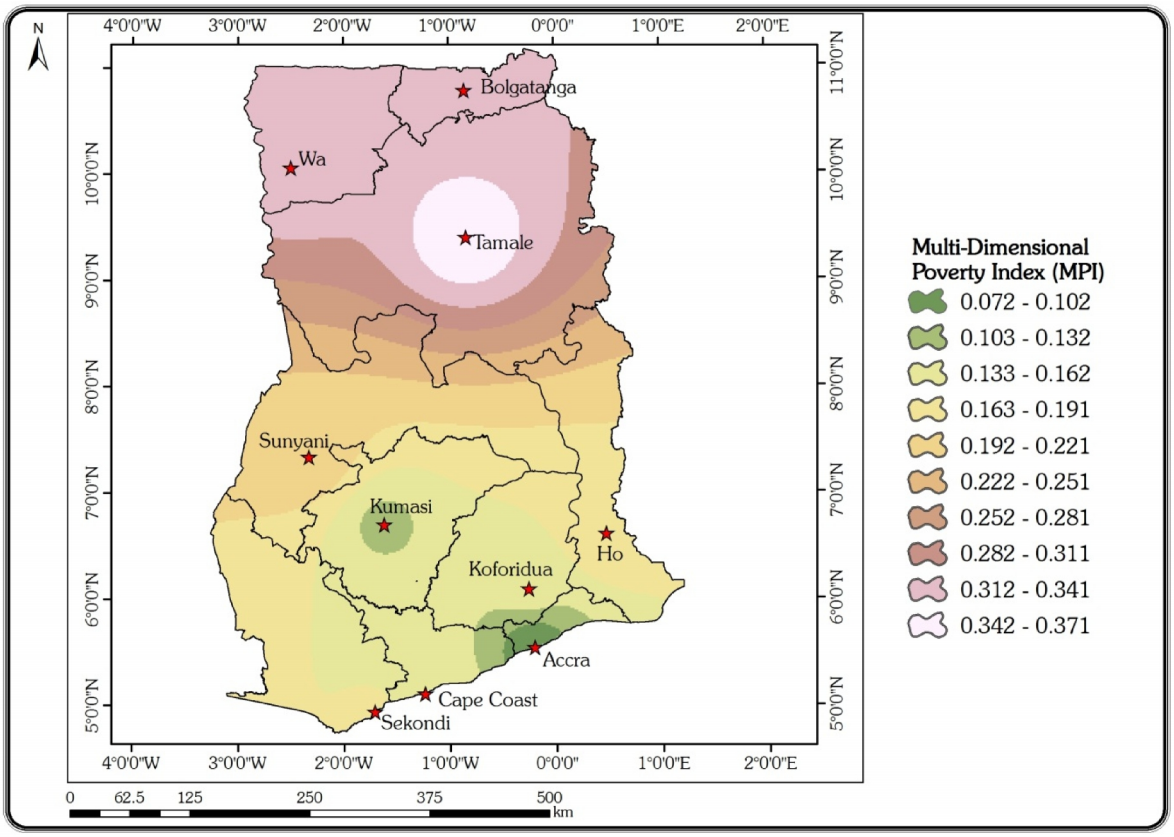

Fig. 6. Map Showing the Multi-dimensional Poverty Index (MPI) of Ghana

3.1.3 Results of MPI

As earlier noted, the MPI is the product of two components: the headcount or the proportion of the population who are MPI-poor (incidence) and the average proportion of weighted indicators in which the MPI-poor persons are deprived (intensity). Fig. 6 shows the spatial distribution of the MPI across the entire study area.

The figure presents the estimate of the MPI for the whole of the country based on regional data. From this index, other estimates such as the proportion of the population vulnerable (or at risk) to poverty (including severe poverty), number and proportion of MPI-poor households and the overall MPI ranking of regions of Ghana were estimated.

The results of the percentage deprivation by indicator show that even though households experience some deprivation, there was no 100% deprivation in the entire study area. For the indicators in the education dimension, percentage deprivation increases as you move up to the north of the country. For the years of schooling indicator, the highest deprivation of 80.6-87.1 % was recorded in the Upper West, Upper East and Northern Regions while the lowest deprivation of 21.8-28.3% was recorded in the Greater Accra Region.

For the child school attendance indicator, the highest deprivation of 28.0-30.7% was recorded at the Northern Region whiles the lowest deprivation of 2.7-5.5% was also recorded at the Western, Central, Eastern and Ashanti Regions.

The same trend is observed in the health dimension; the percentage of deprivation by indicator reduces from the north to the south of the country. For the maternal mortality indicator, the lowest deprivation of 0.323- 0.412% was observed in the Greater Accra Region while the highest deprivation of 1.047-1.125% was recorded in the Upper East Region. For the child morality indicator, the highest deprivation of 1.758-1.898% was observed in the Northern Region while Greater Accra recorded the lowest deprivation of 0.485-0.627%.

Except for the overcrowding and the drinking water indicators, all the other four indicators in the living standards show the same spatial trend and distribution. Just like the indicators in the education and health dimensions, the percentage deprivation reduces from north to south. However, it is worth to note that for the overcrowding and the drinking water indicators, Greater Accra and Ashanti Region are the most deprived while the Upper East, Upper West and Northern Regions are the less deprived.

3.2 Discussion

Education has been identified as one of the important tools in providing people with the basic knowledge, skills and the competencies to improve their quality of life at all levels of development. There have been several studies to suggest that education positively affects the welfare of a household in terms of health care, improved life expectancy and nutritional status (Psacharopoulos, 1991; Owusu and Mensah, 2007; Aryeetey *et al.,* 2007; Alkire and Santos, 2010; Alkire *et al.*, 2011). It was observed that the percentage of household deprived in education is generally high especially in the years of schooling or primary school completion. The illiteracy rate in the country is generally high and subsequently the knowledge of the populace is low and needs to be improved since there is a direct relation between education and the health outcome of a household (Psacharopoulos, 1991). The mechanism of the relation between education and health outcome of a household is that, education can help determine both the level of knowledge about how to combat diseases as well as the mode of transmission and thereby improve health. This will require a policy direction to decrease the deprivation in the education status. The low percentage deprivation in the child school attendant is consistent with some government interventions which have been put in place over the past ten years to increase the enrolment of children. Existing indicators, namely, Gross Enrolment Ratio (GER) (this measures the number of pupils at a given level of education, regardless of age, as a proportion of the number of children in the relevant age group) and the Net Enrolment Rate (NER) (which also measures the number of appropriately aged pupils enrolled in school as a proportion of children in the relevant age group) – all show improvement in child school attendance or participation in the education system over the last decade (Anon, 2007; Anon, 2009; Owusu and Mensah, 2013). According to Owusu and Mensah (2013), this improvement is attributable to a number of interventions introduced into the educational sector including the Free Compulsory Universal Basic Education (FCUBE) and School Feeding Programme (SFP).

A country's quality of life, long life and productivity level is to a large extent determined by the health of its populace and this invariably is linked directly to the country's state of development. The health status of the two most vulnerable groups, children and women is a good indicator of the general health status of the populace. This makes child and maternal mortality a key determinant of a country's health status.

The MPI reflects the number of deprivations poor households experience at the same time, but at varying degrees of intensity. Although households experiencing deprivation in all ten indicators of the three dimensions of education, health and standard of living can be described as extremely poor, the same cannot be said of households deprived in only one or two of the indicators. Thus, the MPI map allows policy makers to observe the varying degrees of deprivation and poverty across households.

From the Multi-dimensional Poverty Index as depicted in Fig. 6, Greater Accra Region has the least MPI score of 0.072 which is far below the national average of 0.179. This MPI of the Greater Accra Region as the well-developed or least deprived region in Ghana is consistent with some income poverty measurement such as the Ghana Statistical Service's GLSS (Anon, 2007). The Upper East, Upper West and Northern Regions happen to have recorded the highest MPI score which is also in line with the Ghana Statistical Service's GLSS.

4 Conclusions

The study used statistical data and several GIS techniques to analyse the poverty situation of Ghana through the use of a multi-dimensional non-monetary poverty index. The use of the GIS techniques provided an effective and efficient approach to obtain the spatial distribution of non-monetary poverty across the entire country.

The study has revealed that across Ghana, a considerable percentage of households are deprived in a number of non-monetary poverty indicators. Analysis of these indicators revealed wide disparities by region. Generally, wide disparities exist between the proportion of households deprived in northern Ghana and in southern Ghana. This reinforces a widely shared view of the inequality in the level of development between northern and southern Ghana.

Analyses of the proportion of Ghanaian households who are experiencing multiple deprivations as well as the intensity of deprivation across the country on regional levels were studied. It was observed that living standard and education contributed largely to the overall poverty. Specifically, non-completion of school (primary education) was observed to be the most significant contributor to deprivation. This is quite alarming because it raises critical issues on access to primary education in the country.

It was subsequently observed that the Upper East, Upper West and Northern Regions are the poorest while the Greater Accra Region (Accra) was the least poor region.

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