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

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Summary

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 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. In order to reduce and alleviate poverty, one of the parameters that play a key role is statistics on poverty. However, in many developing countries such as Ghana such statistics do not exist thus it makes poverty alleviation intervention a bit scattered and untargeted. Due to this, there exist a major problem presently; that is reaching the poor to address their specific needs. In response to this challenge, there is therefore 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 identify the poverty pockets across the country adopting a Multidimensional (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 household 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 the three northern regions and their counterparts in southern Ghana.

1 Introduction

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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).

It is actually out of this that one of the goals or aims of the Millennium Development Goals (MDG) were to reduce extreme poverty by half in target countries, especially, developing countries in Africa and Asia. This makes poverty reduction one of the greatest concerns worldwide.

This worldwide concern to reduce and alleviate poverty, 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).

As a result of the lack of poverty statistics in developing countries, there exist a major problem presently; that is reaching the poor to address their specific needs. In response to this challenge, there is therefore 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 includes, the Ghana Poverty Reduction Strategy (GPRS I) which is a development policy framework developed and implemented during 2002-2004. After the GPRS I, the Growth and Poverty Reduction Strategy (GPRS II), 2005-2009 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 and to some level 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. According to 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 has been several poverty report prepared by the GSS, the most recent of them indicates that there is a declining level of poverty across the overall

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nation; where 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, who the poor are and the methods used to measure and defined 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.

According to them, the measurement and definition of poverty are the foundation on which the analyses of the poor are fixed. 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). 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 a multi-dimensional is problematic.

Additionally, Boarini and d'Ercole (2006) also indicate that, income measures do not provide a full picture of the "command of resources" that an individual or household possesses. They further add that, income measures tend to neglect the ability of individuals and households to borrow, to draw from accumulated savings, and to benefit from help provided by family and friends, as well as consumption of public services such as education, health and housing. Therefore, in the light 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.

Poverty maps incorporate both poverty statistics and geographically referenced data disaggregated to the household and community levels. As a result of this, a poverty map provides a snapshot of the poverty situation of an area, therefore, enabling a course of action to implement a pro-poor development agenda.

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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. Estrella (2003) produced a poverty map for Philippines using a GIS approach. In his research he used both monetary and non-monetary indicators to measure poverty in some selected provinces of the Phillipines. Hassaan (2007) measured poverty incidence at household level by applying various indicators of poverty measurement using GIS techniques to develop a poverty map. He indicated that, his research which was based in on an empirical study for Rosetta area can contribute largely to regional planning efforts as it highlights geographic variations in poverty levels between various parts of the study area and displays different dimensions of poverty.

The research also highlights the potentials and issues associated with employing various indicators to measure poverty in reality. Arshad, (2005) also carried out a research on GIS poverty mapping for Pakistan. In his research, poverty mapping using GIS was carried out using two datasets namely; Pakistan Socio-economic Survey 2001 and Population Census 1998. Therefore, two sets of maps were produced using predictors from the above mentioned datasets. The objectives of his research was to map poverty incidence and its indicators at district level to compare the similarities and differences between the two datasets. The indicators which were all non-monetary were; family size, dependency ratio (young, old and total), population density, literacy, formal education, work status, occupational and industrial choice, access to credit, region (urban/rural), asset ownership, housing quality, and access to facilities like water, electricity, gas and sanitation.

It is evident that poverty maps are important for channelling resources to alleviate poverty in particularly affected enclaves. The maps 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. This research therefore sought to use GIS to map out poverty endemic areas by displaying the spatial dimensions of poverty and identify the poverty pockets across the country adopting a Multidimensional (Non-Monetary) Poverty Index (MPI).

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 in

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the country. Accra which is the national capital is located almost at the southern part of the country and is the populated city in the country. Figure 1 is a map of the study area showing all the regions with their respective regional capital.
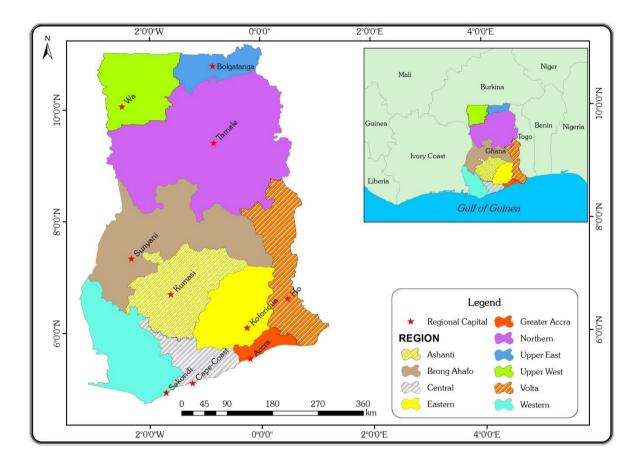

Figure 1 Regional Map of Ghana

2.2 Materials

This study used 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 forms 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 multidimensional non-monetary poverty in Ghana. The method also attempted to study and analyse the spatial pattern and distribution of the non-monetary poverty as well. In most

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developing countries, literature on poverty confirms that income deprivation should not be considered the only dimension of poverty (Owusu *et al.*, 2013).

However, 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.

Multidimensional 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 enhances 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 *et al.*, 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 whiles 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 *et al.*, 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 and is as shown in Table 1.

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

Dimension	Indicator	Household Deprived if	Weight
Education	Year 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	Death of female household members 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

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	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

2.3.2 Determination and Computation of Poverty Cut-off

In determining the MPI, the three dimensions of education, health and living standards are weighted equally; hence each dimension receives a weight of 1/3 according to Alkire and Santos (2010). Additionally the indicators within each dimension were also weighted equally according to the following equation:

$$Weight\ of\ Indicator = \frac{Total\ Weight\ of\ Dimension}{Number\ of\ Indicators\ in\ that\ Dimension} \tag{1}$$

Therefore each indicator within the living standards dimension received a weight of 1/18 while each of the two indicators within the education and health dimensions received a weight of 1/6. Each of the household was given a deprivation score (c) in accordance to its deprivation in the component indicator. This deprivation score was computed by considering the weighted sum 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 in any of the ten indicators and 1 indicates otherwise. This means that, the deprivation score (c) decreases as the number of deprivations in a household decreases and vice versa. Equation 2 shows the computation of the deprivation score.

$$c_i = w_1 I_1 + w_2 I_2 + ... + w_d I_d \tag{2}$$

According to the MPI method developed by Alkire and Foster, a second poverty cut-off referred to as poverty cut-off is used to determine and identify the multi-dimensionally poor. According to them 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. A household was therefore considered poor if its deprivation (c) is greater than or equal to the poverty cut-off (p) (if $c_i \geq p$). Furthermore, according to Alkire-Foster methodology, before a household can be considered as multi-dimensionally poor, the deprivation of the household must be at least a third of the weighted

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indicators. Any deprivation score below the poverty score would have to be replaced by 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.*

2.3.3 Computation of the MPI

Adopting the structure of the Adjusted Headcount measure of Alkire and Foster (2011), the computation of the MPI combines two components. The first component which is referred to as the multidimensional headcount ratio (H) is computed using equation 3

$$H = \frac{N_p}{n} \qquad (3)$$

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

The second component is called the intensity of poverty (A) and is computed using equation 4.

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

Where c_i *(p)* is the censored deprivation score of individual *i* and N_p is the number of people who are multi-dimensionally poor. Therefore, MPI is the product of these two components as shown in the following equation.

$$MPI = H \times A \qquad (5)$$

2.3.4 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. 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 component, 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.

3 Results and Discussions

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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 Figures 2, 3 and 4. Figure 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 whiles the highest and lowest deprivation in child school attendance is 2.7% and 30.7% respectively. This depict that for the education dimension, more household are deprived in years of schooling than child school attendance.
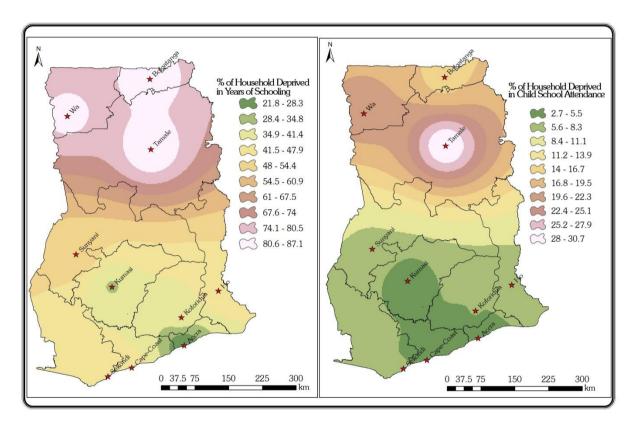

Figure 2: Percentage of Deprivation by each indicator for the Education Dimension

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

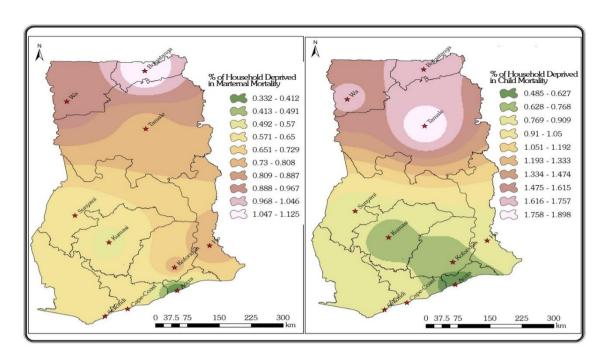Where Are the Poor? A GIS-Multidimensional Non-Monetary Poverty Index Approach for Ghana (11906)
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Figure 3: Percentage of Deprivation by each indicator for the Health Dimension

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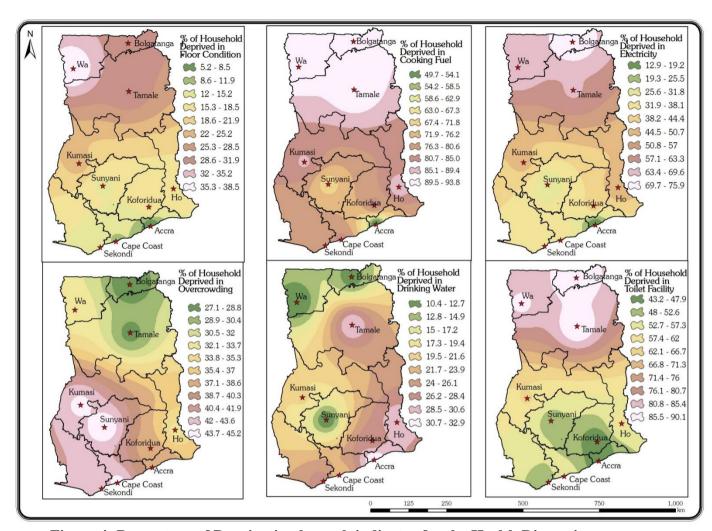Orlando, Florida, USA, 28 May–1 June 2023

Figure 4: Percentage of Deprivation by each indicator for the Health Dimension

3.1.2 Headcount Ratio and Intensity of Poverty

Figure 5 shows the result of the multidimensional headcount ratio and the intensity of poverty. From the result it can be seen that, the intensity of poverty (A) is higher than multidimensional 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 recorded as the lowest and highest respectively for the intensity of poverty.

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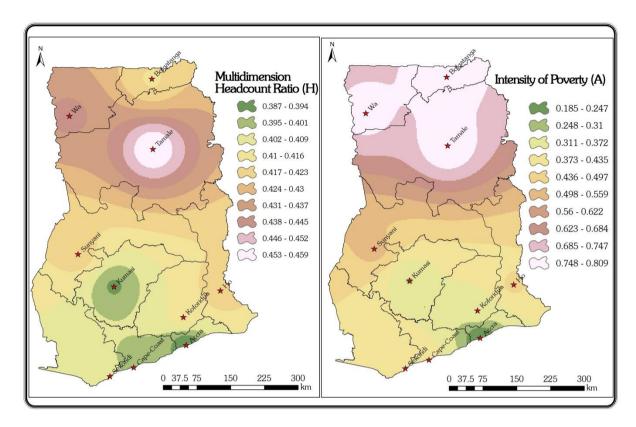Orlando, Florida, USA, 28 May–1 June 2023

Figure 5: Map Showing the Multidimensional Headcount Ratio (H) and the Intensity of Poverty (A)

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). Figure 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 can be calculated (Owusu *et al.*, 2013).

The results of the percentage deprivation by indicator show that even though household 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

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% was recorded in the three northern regions of Upper West, Upper East and Northern whiles 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 as well, the percentage of deprivation by indicator reduces from the north of the country 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 whiles 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 whiles Greater Accra recorded the lowest deprivation of 0.485 – 0.627%. It is also worth noting that all the two indicators in the health dimension recorded the lowest percentage deprivation among all the other eight indicators.
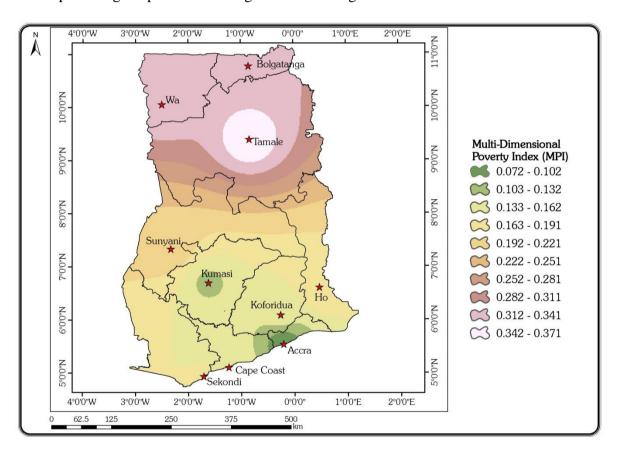

Figure 6: Map Showing the Multidimensional Poverty Index (MPI) of Ghana

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

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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 most deprived whiles the three Northern Regions are the less deprived.

3.2 Discussion

Education has been identified as one of the important tool 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). It was observed that the percentage of household deprived in education is generally high especially in the years of schooling or primary school completion. This shows that generally the illiteracy rate in the country is generally high and subsequently the knowledge of the populace is low generally. There is therefore the need to improve this because, according to Psacharopoulos (1991), there is a relationship between education and the health outcome of a household. According to him, the mechanism of the relationship 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 producing better health outcomes in terms of preventive measures. As a result of this there must be a policy direction to decrease the deprivation status in the education status especially in the three northern regions, even though over the years various indicators in the educational sector have revealed a consistent improvement in school attendance and completion (Owusu *et al.*, 2013). 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 *et al.*, 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 it populace and this invariable 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.

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According to Alkire *et al.* (2010), the MPI reflects the number of deprivations poor households experience at the same time, but at varying degrees of intensity and breadth. 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 one or two of the indicators. Thus, the MPI allow us to observe the varying degrees of deprivation and poverty across households (Owusu *et al.*, 2013).

From the Multidimensional Poverty Index as depicted in Figure 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 three Northern Regions happens 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 multidimensional non-monetary poverty index. The data statistical data that was used were the regional averages. 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 household 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 the three northern regions and their counterparts in southern Ghana. This reinforces a widely shared view of the inequality in the level of development between northern and southern Ghana (Aryeetey *et al.*, 2009).

The study also analysed the proportion of Ghanaian household who are experiencing multiple deprivation as well as the intensity of deprivation across the country on regional levels. 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.

It was subsequently observed that the three Northern Regions (Upper East, Upper West and Northern with Bolgatanga, Wa and Tamale being the respective regional capital) are the poorest whiles the Greater Accra Region (Accra) was the least poor region.

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