A Geographic Information System Base Spatial Decision Support Systems for Poverty Analysis and Management in Adamawa State, Nigeria

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ABSTRACT

Poverty is a multidimensional, multifaceted, and complex, poverty can manifest in the social, political, economic, environmental and any sector of human existence. In Nigeria pervious government and present administration have adopted many poverty alleviations programs but most of them did not yield any positive result due to lack of spatial Geodatabase. Therefore, this article uses the concept of spatial decision support system and Geographic Information System in assessing the spatial distribution of poverty in Adamawa State as a model for decision making. Spatial decision making are multi-facetted challenges that needs technical requirement because they contain economic, social, environmental, and political dimension. Solving theses complex issues requires integrating and using information systems such as Geographic Information System and Spatial Decision Support Systems. The pragmatic approach was used as the methodology for collecting spatial information and for making inquiries into the complex phenomena. The geographic disparities theory was used as a lens to provide answers to the research questions. The Poverty situation in Adamawa State was measured using the Fosre, Greer and Thorbecke (FGT) index to determine the incidence of poverty in the state. A GIS base spatial decision support system model was design for decision making on how to alleviate poverty in disadvantage areas of the state.

Keywords: Geographic Information System (GIS), Poverty, Spatial Decision Support System, Geodatabase, decision making. Poverty maps.

INTRODUCTION

Poverty is a threat to humanity all over the world. Poverty is multidimensional, multifaceted, and complex, poverty can manifest in the social, political, economic, environmental and any sector of human existence [18] Poverty in a nutshell is referred to as the pronounced deprivation of individuals' economic and social wellbeing and has become a global problem that attracted renewed interests by governments and international agencies [4]. The components of wellbeing of individuals are measured in terms of income and consumption, access to health care, nutrition, education, good sanitation; others are access to good drinking water, quality housing and capability to function in a society among others [34].

Several poverty reductions programs have been adopted to alleviate or reduce poverty in Nigeria [27], notable poverty reduction programs pursued by previous administration in Nigeria include; operation feed the nation, free and compulsory primary education, green revolution, low-cost housing, river basin development authority, national agricultural land development etc.[2],[7],[18],[20] gave many reasons why poverty alleviation programs and initiatives in Nigeria failed. Some of the reasons given are poor design and implementation, poor funding and corruption, policy inconsistencies and discontinuity, political differences,

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lack of comprehensive Geodatabase and use of information system for planning, design, implementation, and monitoring. Almost all these programs happen somewhere on a spatial location in Nigeria and all these programs need spatial decision making models for them to be effective.

Spatial decision making is a routine activity that is common to individuals and to organizations [32]. Spatial decision making are multi-facetted challenges that needs technical requirement because they contain economic, social, environmental, and political dimension. Solving these complex issues requires integrating and using information systems such as geographic information system and spatial decision support systems.

Geographic information system (GIS) is one of the most widely used decision aids, especially for solving complex spatial problems [30]. [13] define Geographic information system (GIS) as a computer-based information system that enable capture, modelling, storage, retrieval, sharing, manipulating, analysis and presentation of geographically referenced data. Spatial decision support system in the other hand is an interactive computer-based system designed to support a user or group of users in achieving highest effectiveness of decision making while solving a semi- structured spatial decision problem [33].

Geographic information system Poverty mapping is a relatively new concept. It describes the methodology for providing a detailed description of the spatial distribution of poverty and inequality within a state, region, or country [5], she further state that, it combines individual and household (micro) survey data and population (macro) census data with the objective of estimating welfare indicators for specific geographic area as small as a village or hamlet.

There is no consensus in the definition of poverty; poverty definition varies from place to place. But there are four major classes of poverty assessment measures identified based on data sources, assumptions, and the statistical routine utilized [4]. These are econometric, social, demographic, and vulnerability-based measures [7].

Econometrics poverty indicators are current consumption expenditures, income and wealth, social indicators are nutrition, water, health and education, demographic measures use gender, health, and household age structure indicators while vulnerability measures are level of household exposure to shocks, environmental challenges, physical insecurity, political changes etc.

Geographic Information System Poverty maps are useful in devising policy for tackling poverty [31]. These maps show the spatial distribution of poverty, which can be used to quantify regional disparities in living standards and identify areas falling behind in economic development [22]. Geographic Information System Poverty maps are used for various purposes, ranging from identifying and understanding the causes of poverty, assisting in program development and policy formulation, guiding allocation of anti-poverty investments and expenditures to areas of greatest need.

A poverty map is a map which provides a detailed description information of the spatial distribution of poverty and inequality within a country or state. Geographically disaggregated poverty data are important for better understanding development issues and ensuring development efforts are directed to the places where they are most needed. Poverty maps allow for the visualization of poverty estimate and spread in a country or state, poverty maps are also helpful in the context of evaluation, allowing evaluators to examine the effects of intervention on the incidence and magnitude of poverty, including changes over time.

Geographic Information System poverty maps are needed to show that certain areas are disadvantaged and to rapidly assess options for emergency interventions and for better decision making for poverty alleviation. Geographic Information System poverty mapping techniques use composite indexes as the poverty measure rely on the direct aggregation of census data to display the poverty indicator for the chosen geographic area. Composite indexes used for this spatial decision support system and Geographic Information System

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poverty mapping include United Nations Development Program's well-known Human Development Index (HDI) and various basic needs measures. These include life expectancy, education (literacy), income, access to water, access to sanitation, access to health services and quality of housing. All these components are weighted equally.[34]

Choosing an indicator or indicators of poverty is a very important step in developing spatial decision support systems and Geographic Information System poverty map model production. The selected indicator may be a monetary or non-monetary variable. For example, the proportion of households below a certain income level etc.

Recent advances in Geographic Information System (GIS), data base and computer aided software engineering has made Geographic Information System poverty mapping possible, where data can be presented in the form of maps and overlaying interfaces for cross-comparisons as spatial decision support system for decision making by relevant organizations. Geographic Information System Poverty maps are not a panacea for understanding or solving poverty problems; they are only one tool among many for investigating the complex phenomenon of poverty. They should be used in conjunction with other information such as spatial decision support (SDSS) and analysis that provide context and ground trotting within communities.

Despite all the poverty alleviation and reduction programs embark by previous and present governments in Nigeria, most of the populations are still under the poverty line. Adamawa state as one the state in Nigeria is not exempted from this problem. Therefore, this paper is aimed at using Geographic Information System mapping techniques in assessing the geospatial poverty spread in the state to design a spatial decision support system model for better decision making on poverty reduction and management.

This paper contributes to knowledge by providing geospatial information on the geographical distribution of poverty in Adamawa State.

The paper seeks to answer the following research question. RQ1. What are the main courses of poverty in Adamawa State? RQ2 what is the geographical spread of poverty in Adamawa state? RQ3. How can Geographic Information System and spatial decision support system be integrated to a model for decision making?

To explore or rather answer these questions, we use a pragmatic approach which draws heavily on the inductive and deductive reasoning [28]. This is because, to fully analyse a phenomenon, it is vital and necessary to support the inductive approach with deductive thinking to enable it to tackle a real-world problem such as in the case of this paper [33]

The pragmatic approach provides for the use of both qualitative and quantitative research methodology to collect information and make inquiry into complex phenomenon of social and natural context [16], [24]. Therefore, the pragmatic research philosophy provides for the adoption of mixed methods as the data collection method which opens the opportunity to be objective and subjective in analysing the points of view of the participants.

The pragmatic approach helps to provide a grounding where the research avoids engaging in issues of insignificance rather than issues of truth and reality and as such is intuitively appealing [16],[23].

The Concept of Poverty

[26] affirmed that there is no standard definition of poverty despite enormous literatures on poverty and its universality. But distinctions have been made by scholars between absolute and relative poverty [30].

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Absolute poverty is a situation where household are unable to meet its basic needs such as shelter, food, clothing, transportation, and education [25]. Absolute poverty is also viewed as a situation of low income and consumption which are the parameters and yard stick for measuring the minimum and maximum standard of living. While relative poverty, is a situation where an individual or household income falls below the average income of the population of the society being considered.

The World Bank adopted that people are considered poor if they earn less than $1 per day [34]. This paper adopts the later concept in mapping and assessing poverty spread in Adamawa state. Other methods that are also used by scholars and researchers in measuring poverty are head count/incidence of poverty, poverty gap/income shortfall, disparity of income distribution, composite poverty measures, physical quality of life index (PQLI), augmented physical quality of life index (APQLI), and the human development index.[3]

Poverty Theories

Poverty has attracted the interest of many scholars and researchers all over the world. Poverty reduction programmes are normally designed based on theories that justify such interventions. There are many poverty theories that can be use or applied in different poverty research and alleviation programmes such as the culture of poverty theory developed by Oscar Lewis an American anthropologist, others are the individual deficiency theory, the progressive social theory, the geographical disparities theory, the cyclical interdependence theory, poverty individualization theory and the theory of social exclusion/cumulative disadvantage [26].

This paper adopts the geographical disparities theory as the research lens. This theory focuses on poverty in geographical perspective such as ghetto poverty, rural poverty, southern or northern poverty, third world poverty etc. The theory emphasis that people in certain geographical areas lack basic to wealth creation opportunities [5]. This theory is adopted in this paper because it is applicable in the Nigerian context whereby poverty is prevalent in some geographical locations for example rural areas, slums areas prone to floods, draught, desert encroachment and disasters. Mostly economic activities in those areas are very low leading to unemployment and poverty. The theory also indicates that the neglect of government in the provision of social amenities and empowerment opportunities are the causes of these imbalance in most of these areas that are geographically disadvantaged.

LITERATURE REVIEW

Many studies have been carried out by researchers on poverty and its effects on human bean. [6] relate poverty to social exclusion in both developed and developing countries,[13] discuss and analyses children poverty and its effects on children wellbeing. [30] also analyses the effects of poverty in most advanced countries in Europe.

Poverty is a very significant topic of discuss and research in Africa, researchers such as [11] have also contributed on the effects of poverty in Africa. Other topics of discuss on poverty are the link of poverty to climate vulnerability [24], poverty and social protection [9]. Poverty and gender issue [12]. [29] listed poverty as one of the risk factors in health challenges. Combining poverty indicators with geo-spatial referenced datasets help to highlight where poverty overlaps with socio-economic and environmental challenges [10]. Geographic information system and spatial decision system are important tools and technology in combining and analysing poverty indicators and geo-spatial referenced dataset [3]. She also acknowledged the role Geographic Information System plays in poverty assessment and mapping which has increased in importance, as a means of explaining variables because of its data integration and spatial analysis capabilities.

As spatial determinants are increasingly important in understanding poverty, the consistent use of spatial

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datasets in developing poverty reduction strategies is a growing requirement [5]. Data modelling is required to better convey the components, processes and meaning of poverty assessment as with other geographic phenomenon and translating the knowledge into a geographic information system [23]. [23] emphasized that spatial decision support modelling is also another means of poverty assessment for making decision on poverty reduction and alleviation.[23] and [19] identify four classes of Geographic Information System poverty mapping measures based on data sources, assumptions, and statistical routine utilization. These are econometrics, social, demographic, and vulnerability-based measures, and therefore this paper based its assessment on econometric poverty indicators which are current consumption, expenditure, income, and wealth of the people in Adamawa state.

Study Site

Adamawa state is located at the north-eastern part of Nigeria, it lies between latitude 7º and 11º N of the equator and between longitude 11º and 14º E of the Greenwich meridian. It shares boundary with Taraba state in the south and west, Gombe State in its Northwest and Borno state to the north. Adamawa state has an international boundary with the Cameroon republic along its eastern border. The state covers a land area of about 38,741 km with a population of 3,675,750 People according to the 2006 census and a population density 115.1km2. Adamawa state is divided into 21 local government areas. This article covers 20 local government areas out of the 21 local government areas of Adamawa State,

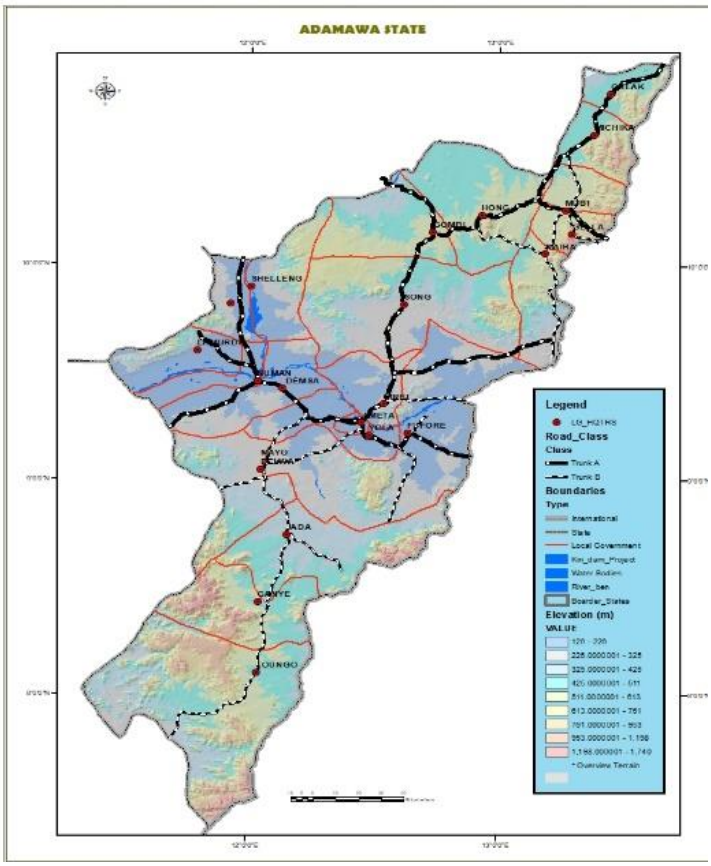

Fig.1. Study Area

Research Design

There are many research design alternatives that can be applied in research study such as experiments, survey, case study, action research, grounded theory, ethnography, and archival research. Therefore, we combine both case study and survey research. Case study is an empirical inquiry that investigates a

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contemporary phenomenon within its real –life context especially when the boundaries between the phenomenon and context are not clear [28].

Case study research according to [29] are analysis of a person, event, decision, periods, projects, policies, institution, or other systems that are studied holistically by one or more method. While survey research is the collection of information's from a sample of individuals through their responses to question (check & Schutt, 2012, p. 160). They further added that "this type of research allows for a variety of methods to recruit participants, collect data and utilize various methods of instrumentation".

MATERIALS AND METHODS

This paper adopts the mixed method research methodology which combines the quantitative and qualitative research methods which is underpin by the pragmatic research philosophy. A quantitative research approach is an investigation based on testing a theory composed of variables, measured with numbers and analysis with numerical procedures, to determine whether the prognostic generalization of the hypothesis holds true [16]. For the mixed method approach, it employs both quantitative and qualitative approaches in a research work for the purpose of breadth and depth of understanding and partnership [17]. They added that the use of both quantitative and qualitative in mixed method design would provide better understanding of the research problem than the use of either one method along in a study.

In this paper we used the concept of geographic information system poverty mapping to produce a poverty map of Adamawa state. Community and household data from twenty (20) out of twenty-one (21) Local Government Areas of Adamawa State cutting across the 226 political wards both in the urban, semi-urban and rural communities with their geographical positioning obtained from the baseline information and the data were used in constructing the poverty map of the State. Data were then aggregated to derive estimates at both the community and Local Government levels. The sample size was 30 household questionnaires and 5 community-based questionnaires in each sampled community. The communities were selected using stratified sampling for the survey from each of the 20 LGAs covered.

The overall objective of the model is to provide a detailed description of the spatial distribution of poverty and inequality in all the communities in 20 LGAs of the State. It combines individual and household (micro) survey data and population (macro) data with the objective of estimating welfare indicators for specific geographic area as small as village or hamlet. It is thus, a very good tool of targeting mechanisms.

The traditional approach of a poverty index is based on headcount of poor individuals below the specified cut-off point, i.e., the proportion of the population whose standard of living is less than the poverty line to the number of individual or households [35]. The poverty line is the level of welfare that distinguishes poor households from the non-poor households.

For the purpose of this study, the poverty line was determined by categorizing households with less than \$1.00 per capita income or consumption to current naira value purchasing power parity (i.e., ≤ ₦1,500) per day as poor and households with \$1.00 and above per capita income or consumption to current naira value purchasing power parity (> ₦1,500) per day as non-poor. This was used to categorize the households into poor or non-poor. Household income was divided by the number of people in the household to establish income per person.

The poverty situation in Adamawa state was measured using Foster, Greer and Thorbecke (FGT) Index [21] to determine the incidence and depth of poverty in the State. This method subsumes the Headcount Ratio and the poverty gap measurements [6]. It also allows for the decomposition of poverty levels among the various categories of a population. It is generally given as:

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$$P\alpha = \frac{1}{N} \Sigma \left[\frac{Z - Yi}{Z} \right]^{\alpha} \quad (1)$$

Where:

a = Foster, Greer and Thorbecke Index

$(0 \leq P \geq 1)$

N = Total number of respondents

Z = Poverty line

Yi = Income of the respondents (The sum is taken only on the poor)

q = Number of respondents below the poverty line

a = FGT ≥ 0. The 'a' takes a value of 0, 1, and 2 with different implications:

'P_0'= When a = 0; it measures poverty incidence (the index of people that are impoverished).

'P_1' = When a = 1; it measures poverty depth or gap, that is, the proportion of the poverty line that the average poor will require to attain to poverty line. That is, the value obtained will give an indication of the amount of money that would make the poor people to cross the threshold of poverty [2].

'P_2' = When a = 2; it measures the severity of poverty, giving more weight to the poorest.

The closer the FGT index is to 1, the greater the poverty level. The FGT index had been widely used to determine the level of poverty by various studies [35], [8].

The Headcount Ratio (HR) measures the percentage of the population below the poverty line. It is given as:

$$HR = q / N \quad (2)$$

Where:

HR = Headcount Ratio with value ranging from 0 to 1. The higher and closer the value is to 1, the higher the proportion of people below the poverty line [1].

q = Number of households below the poverty line

N = Total number of households in the population

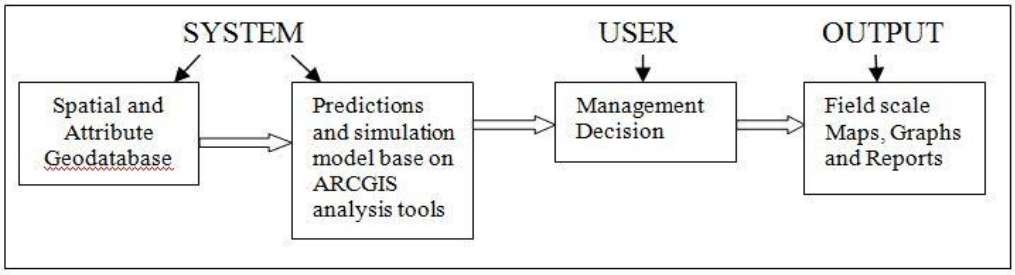

Fig. 2. Schematic model of the GIS based spatial decision support system for poverty assessment

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Description of the Model

System: the system section is divided into two sub sections the first sub section is the spatial data collected from the field such as the geographical coordinate of communities, names of communities and location of the 20 local government areas of the state, other data in the first sub-section are attribute data such as numbers of household, total number of respondents, income of respondents, population of the communities, poverty line and head count ratio. The second sub- section is where predictions and simulation of the model based of ARCGIS, and analysis tools are stored; this sub-section helps in the production of different types of models and database management system that can be used for decision making.

User: the user section is linked to the system section where information (data) and models in the system section can be used by the management for decision making.

Output: this section of the model can also be referred to as the graphic user interface (GUI) where tables, maps and reports are presented in for of graphic for easy analysis and decision making. The model is a conceptual model of the GIS base spatial decision support system for poverty mapping, it can be expanded and be used for real situation and decision making by the government of Adamawa State for poverty assessment and alleviation.

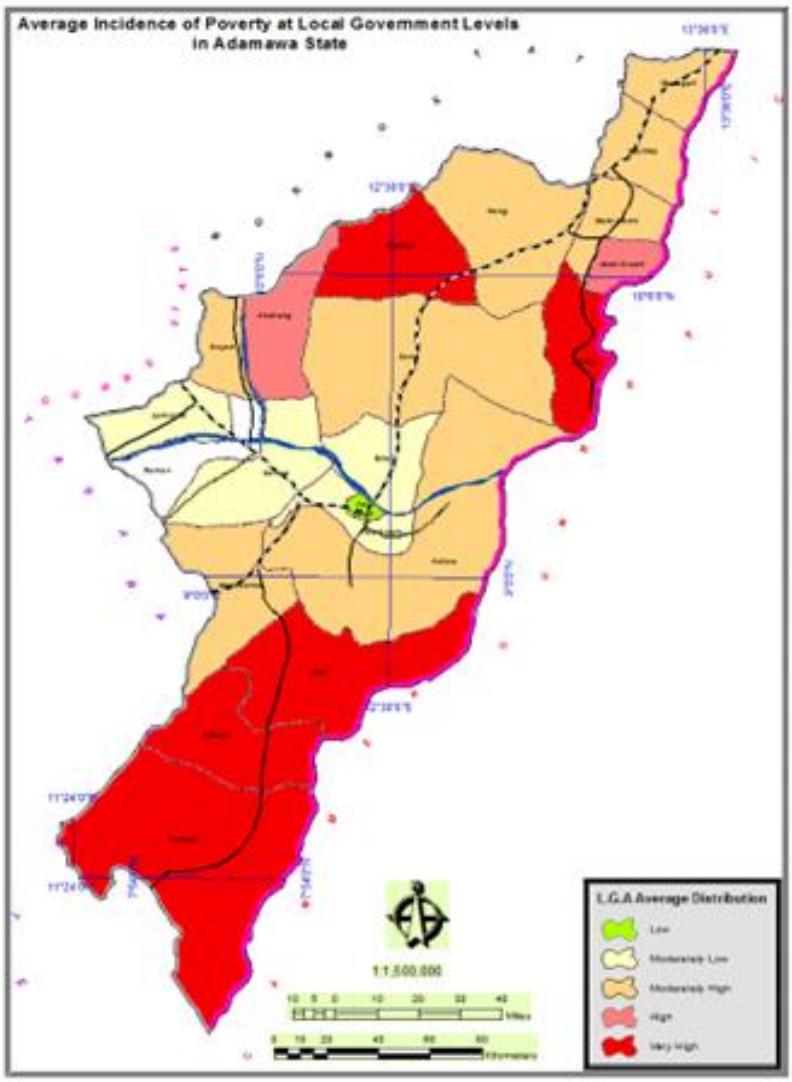

Fig. 3. Average incidence of poverty.

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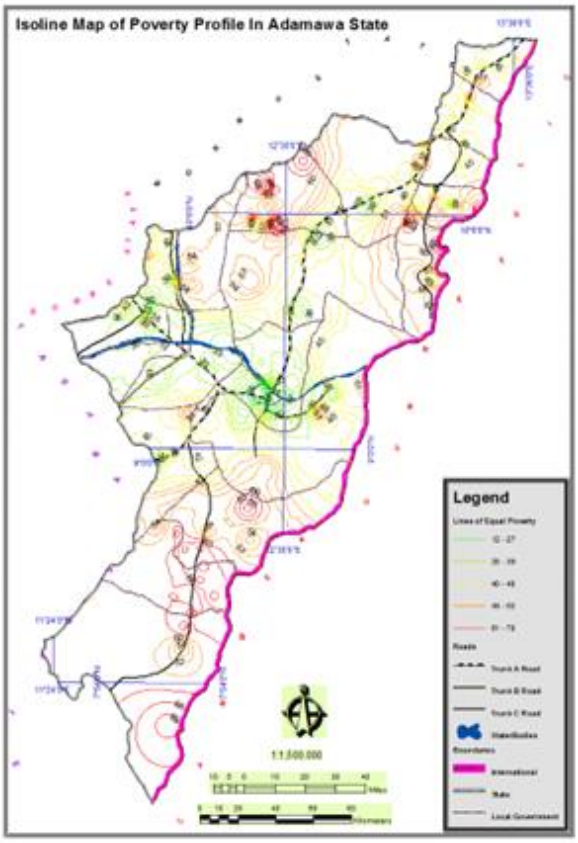

Fig .4. Isoline map of poverty profile

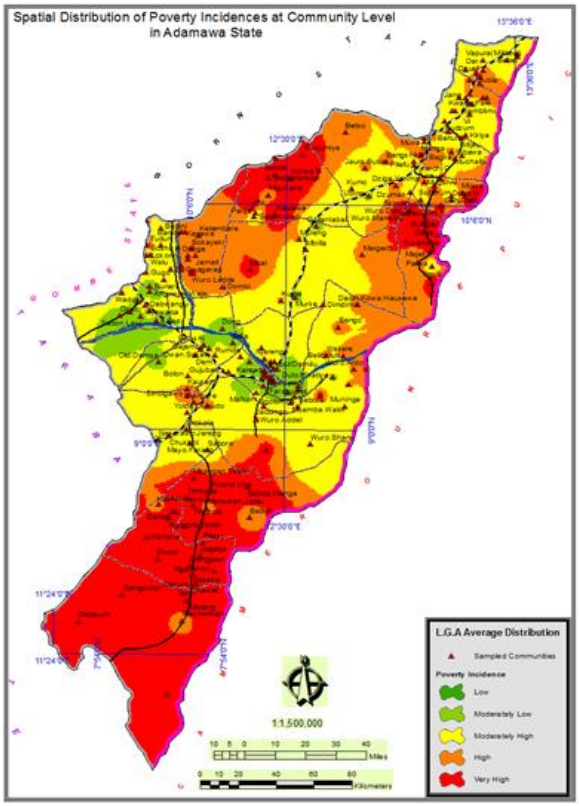

Fig. 5. poverty incidence at community level

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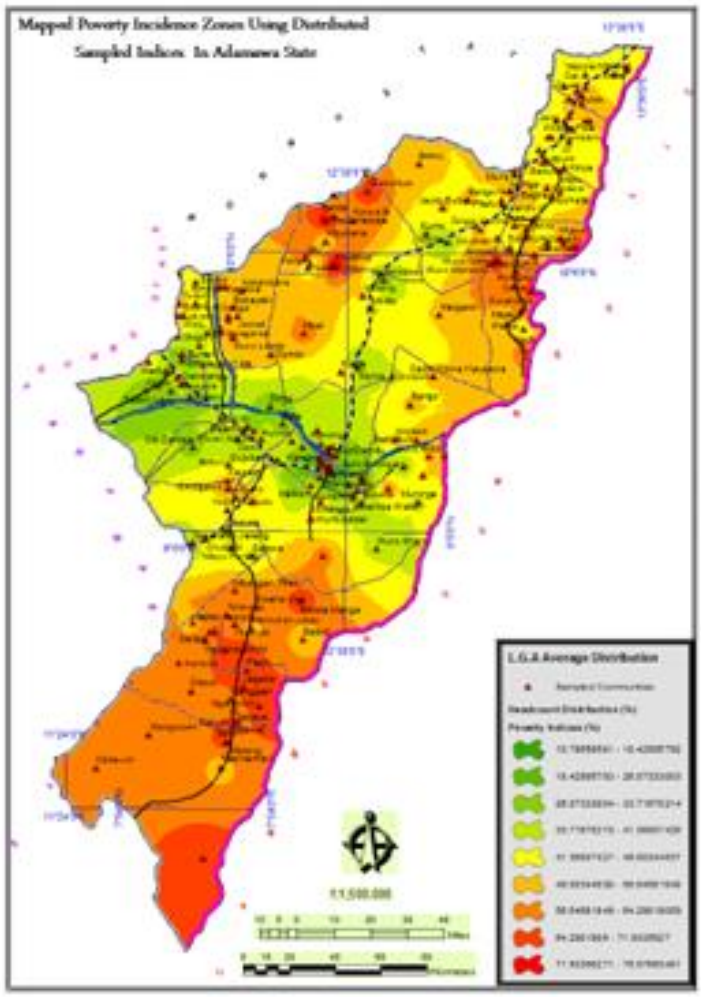

Fig. 6. poverty incidence zones

RESULTS AND DISCUSSION

The different colours on the maps signify the spatial heterogeneity of poverty across the state. The Local Government areas and communities coloured green indicates low incidences of poverty with poverty rate of 11-26%. Lemon and yellow colours indicate moderately high incidences of poverty with poverty rate of 34-49%. The brown and red colours indicate high to very high incidences of poverty with poverty rate of 49-80%. It is evident from the map that many communities in the southern part of the state, particularly around Toungo and Ganye local government areas have fallen within the brown and red colours indicating that the poverty level is high in those local government areas. Also, communities around Maiha, Mubi south and Gombi local government areas falls within the zone of high poverty level. These communities are disadvantaged in the provision of basic social amenities. However, communities within the central and northern parts of the state appear to have low to moderately high incidences of poverty. The isocline map tries to link communities with equal levels of poverty.

The characteristic feature of most of the communities in the state, particularly those that have fallen within the moderately high and very high incidences of poverty is the near complete absence of basic amenities especially good quality drinking water, road network, health facilities, electricity, and educational facilities. In places where some of these facilities exist, they are either in complete state of dilapidation or are not easily accessible. People had to trek long distances to access some of these facilities. Additionally, there are

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many cases of water borne diseases, high maternal and infant mortality, high school drop-out among children and loss of self-esteem among community members.

The poverty indicators in the state are presented in Table 1. It shows that poverty in the rural areas of the state is higher than that in the semi-urban and urban areas of the state. About 66% of the population in the rural areas of the state lives below the poverty line. This is as opposed to 52.78% and 31.27% in the semi-urban and urban communities respectively. This is an indication that poverty incidence in Adamawa state is high despite the many interventions by government and the private sector.

On poverty gap as shown in the table, rural income most increase by 44% to get the population to poverty line. Consequently, incomes most increase by 37% and 24% to get the semi-urban and urban communities respectively to poverty line. Alternatively, the expenditure pattern of the rural, semi-urban and urban population most increase by 44%, 37% and 24% respectively to move them to the line of poverty threshold. This indicates that the poverty gap in the state is large. The population must be able to engage in other income generating activities outside their primary occupation to sufficiently move them to the line of poverty so as not to be classified as poor in the context of incidence of poverty.

On the severity of poverty, the table also shows that, of the people classified as poor in the rural communities, 26% are severely affected by poverty. This also applies to semi-urban and urban communities where 15% and 12% respectively are severely affected by poverty. These analyses show that poverty is a serious problem in the State. The places that may be seen as having low incidences of poverty are in the real sense also poor if other indicators outside income and expenditure are considered.

Table 1: Poverty Indicators in Adamawa state

Poverty incidence (%)			**Poverty depth**			**Poverty**		
Urban	Semi-Urban	Rural	Urban	Semi-Urban	Rural	Urban	Semi-Urban	Rural
31.27	52.78	66.23	0.25	0.37	0.44	0.12	0.15	0.26

Source: field survey 2021-2023

SUMMARY

The concept of GIS-base spatial decision support system for poverty assessment is very significant in poverty reduction and alleviation. Several poverty reduction and programs have been adopted in Nigeria over the years, but most of these programs lack a comprehensive geo-database such as the one design in this paper. GIS mapping helps in visualizing the impact of poverty in communities affected.

Poverty maps are useful in devising policy for tackling poverty [31]. These maps show the spatial distribution of poverty, which can be used to quantify regional disparities in living standards and identify areas falling behind in economic development [22] Poverty maps are used for various purposes, ranging from identifying and understanding the causes of poverty, to assisting in program development and policy formulation, to guiding allocation of anti-poverty investments and expenditures to areas of greatest need. Maps may be needed to show that certain areas are disadvantaged and to rapidly assess options for emergency interventions.

CONCLUSION AND FURTHER RESEARCH

Geographic Information System Poverty mapping is a relatively new concept. It describes the methodology for providing a detailed description of the spatial distribution of poverty and inequality within a state,

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region, or country. Three research question RQ1. What are the main courses of poverty in Adamawa State? RQ2 what is the geographical spread of poverty in Adamawa State, RQ3 how can GIS and spatial decision support system be integrated to a model for decision making by the government. The questions were answered using the geographical disparities theory that was adopted as the lens to guide the paper findings. The main courses of poverty in Adamawa State are that; communities are disadvantaged in the provision of basic social amenities. The characteristic feature of most of the communities in the state, particularly those that have fallen within the moderately high and very high incidences of poverty is the near complete absence of basic amenities especially good quality drinking water, road network, health facilities, electricity, and educational facilities due to their geographical nearness to the centre of administration. In places where some of these facilities exist, they are either in complete state of dilapidation or are not easily accessible. People had to trek long distances to access some of these facilities. Additionally, there are many cases of water borne diseases, high maternal and infant mortality, high school drop-out among children and loss of self-esteem among community members. On what is the geographical spread of poverty in Adamawa State, the communities in the semi-urban and urban areas of the state have lower incidence of poverty compared to communities that are in rural area with high incidence of poverty. The government can use the GIS base spatial decision support system model as a lens that will guide its decision making on poverty alleviation, distribution of social amenities etc.

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