Analysis and Depiction of Accessibility Levels of Water Supply Schemes in Rural Akwa Ibom State, Nigeria

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ABSTRACT
This study analyzed and depicted accessibility levels of water schemes in rural areas of Akwa Ibom State, Nigeria. Data on rural water schemes, population data as well as a community map of the study area were utilized. GIS technique was employed in creating a database of water schemes and the spatial distribution of the water schemes displayed on the map of the study area. Based on the criteria stipulated in the National Water Supply and Sanitation Policy for Nigeria, percentage rural water accessibility map was computed and analysed using ArcMap extension. Findings revealed the discrepancies in the sitting of water facilities and gradual phasing out of handpump boreholes to mini water schemes. Lack of community boundary map is a setback to rural water scheme implementation. Percentage access to safe water supply was found to be very low. It is recommended that the state government should set up Water Supply Technical Committee to regulate water supply programmes with the mandate of redesigning water schemes in line with the national policy standard.

Keywords: Rural Water Schemes, Accessibility Levels, Analysis, Depiction, Akwa Ibom State

INTRODUCTION
Water is one of the essential needs of man. Securing access to potable water supply is a central issue of concern not only in urban areas but much more in rural areas. The importance of water supply for domestic uses cannot be compromised not only because of its social and economic values, but also because water based sources of livelihoods have become critical to the survival and health of most rural households, providing valuable contributions to rural livelihoods [1]. Water is therefore a very strategic socio-economic asset especially in poor economies where wealth and survival are measured by the level of access to water. The concept and meaning of rural water accessibility have generated a lot of debates in many fora. In some cases, the term is used synonymous with water coverage in an interchangeably manner, whereas the same term may have different meanings for different practitioners [2]. According to UNICEF/WHO [3] water coverage refers to the proportion of the population using improved sources of drinking water. It is based on the principle that an improved source of water is designed to deliver water to a certain number of people. Rural water coverage is often calculated by multiplying the number of each safe water point by the number of people who should be served by those water points [3]. However, coverage may not give an accurate estimate of access due to functionality and distance to the water source(s). For example, it could be assumed that the water point can serve a particular number of people but the number actually having access could be very different [4].

The Ministry of Local Government and Housing, Zambia defined access to water in rural areas based on the ability of people to collect at least a minimum of 25 litres of water per person per day for domestic purposes all year round, and also walk less than 500 meters to the water point [5, 6]. This could be a good definition, but some raised the issue that queuing at the water point can sometimes take time. For instance, in Mozambique, 30 minutes round trip which included going to the water point, queuing, fetching the water, and returning home were added as additional criteria for water access to be made. UNICEF/WHO [3] broadly defined rural water access as the availability of at least 20 liters per person per day from an improved source within one kilometer of user's dwelling. The standard for Nigeria according to National Water Supply and Sanitation Policy (NWSSP) [7] is that access to rural water supply should guarantee minimum level of service, 30 liters per capita per day within 250 meters of the community of 150 to 5000 people, serving about 250-500 persons per point.

Rural water accessibility is very fundamental for equitable and sustainable distribution of water supply schemes in our rural communities. Although, the population of a place is very fundamental when the issue of water coverage is to be addressed, water accessibility looks beyond population issue. Where water schemes are actually sited is also of paramount importance. This implies that for equitable distribution of safe water schemes for our rural populace, accessibility should be seen to satisfy the tenets of equitability and sustainability. Compromise of these tenets could likely result in underutilization, mismanagement and neglect of the facility.

Nigeria has water policy and rural water programmes should be implemented to guarantee accessibility to safe water delivery to the rural communities nationwide. In Akwa Ibom State of Nigeria, preliminary investigation shows that in the present dispensation, this does not seem to be the case in rural communities and this development makes one wonder if the policy is sacrificed on the altar of political patronage. This observed poor access to rural water supply schemes could be attributable to the fact that many of our planners and other decision makers may not have considered the national water policy in the implementation of water projects; the attendant effect of which is the result of inequitable distribution of water facilities against the backdrop of accessibility criteria stipulated in the water policy. This could be one of the possible reasons why some of the water facilities are underutilized to the detriment of some communities that have none and have to drink from a very inhumanly unimproved source. The situation has been of great concern which has necessitated the present research to investigate the number and location of water schemes in rural Akwa Ibom State and examine the accessibility levels of water schemes in rural areas of the State.

Nyoike [8] in an attempt to analyze factors affecting vegetation change in Southern Samburu, Kenya came up with spatial distribution of water points in the area as one of the factors affecting vegetation change in the area. This was made possible by taking coordinates of the water points in the area which was later plotted into the digitized land use map of the area to assess the effect on the vegetation change. The result was the production of digitized map showing lands for grazing exclusively during the dry periods, wet season, settlement areas and areas prone to insecurity (cattle rustling). Vancalcar [9] also applied the same technique to create map showing spatial distribution of safe water points in Northern Region of Ghana as part of the effort to track progress and success of borehole projects carried out by Rural Water and Sanitation Agency (RWSA) as well as the Semi-Autonomous Community Water and Sanitation Agency (CWSA) to aid in decision support for the implementation of household water treatment and safe storage technology for the region. Data was obtained from borehole mapping done by World Vision, CWSA and RWSA. To cross check the accuracy of the dataset, global positioning system (GPS) receiver was used to mark some selected data points. Some boreholes, rivers and roads were also marked. ArcView 3.2 was used to store, analyze and display all the Geographic Information System (GIS) data with the aid of scanned and georeferenced map of the Northern Region of Ghana.

Atser and Udoh applied four spatial factors of total length of road infrastructure in the local government area, total area in square kilometers, poverty index, and rural population to investigate their influence on the number of safe water points among the Local Government Areas. All the four independent variables are surrogate to rural development. However, the result showed that only the rural population factor highly significant correlated with the number of safe water points in the state ($r = 0.678$; $r^2 = 46\%$), implying that about 46% of variance in number of safe water points is explained by rural population[10].

UNICEF/CRS RUWATSSA [11] created a database for all safe water facilities in Obubra Local Government Area (LGA) of Cross River State in Nigeria. This was carried out by taking inventory and spatial locations of all the safe water facilities including their state of functionality. The data were later entered into the computer through a pre-designed excel template which was analyzed using Statistical Package for Services Solution (SPSS) software. Communities map of Obubra LGA was scanned and georeferenced in ArcMap environment. Shapefile of safe water facilities and communities were created as point while the Local Government boundary was created as polygon. At the end two maps were produced showings spatial distribution of functional and non functional safe water facilities respectively. Findings revealed that thirty four out of sixty seven communities did not have safe water facilities and 45.5% of the safe water supply facilities in Obubra LGA were not in use. Also, most of the water facilities skewed and were concentrated in one direction without regard to population density and settlement centers. Sharma [12] mapped and showed spatial distribution of drinking water schemes in Nepal while developing a national level database for drinking water in a GIS platform. The database components considered in the work included ward level data on piped water projects (project characteristics, coverage and status), number of tube wells, drinking water profile (number of households having drinking water by source of drinking water) and toilet facility. Data source was mainly from National Surveys Commission. Relational database management system, oracle MS-Access and ArcGIS respectively were adopted for data entry, storage, management, analysis, query and presentation of output maps and tables. This information was very helpful in planning new schemes and rehabilitation/improvement of older ones. MacDonald, Dochartaigh and Welle [13] conducted a study to reveal factors contributing to high handpump driven borehole failures and used ArcGIS capabilities to come up with spatial distribution of water points in the three Woredas, Benishangul-Gumuz in Ethiopia which was subsequently overlaid on vectorized hydro-geological map of the region. The exercise clearly revealed that hand pumps failures in this region were that of the reduced yield of the aquifer and deep seated water level during the dry season. The study also informed the planners of the need to channel more funds for the maintenance of the schemes in the affected areas.

MATERIALS AND METHODS

This study is confined to the rural areas of Akwa Ibom State of Nigeria. The state is comprised of 31 Local Government Areas (LGAs) out of which 11 LGAs are adjudged to be 100 percent rural based on the 2006 National Population Census. The 11 LGAs classified as rural are Eastern Obolo, Ibiono Ibom, Ika, Ikono, Ini, Mbo, Nsit Atai, Obot Akara, Oruk Anam, Udung Uko, and Urue Offong Oruko. The State is located in the south-east corner of Nigeria, lying between Latitudes 40 001 and 50 451 North and Longitudes 70 251 and 80 251East and spanning a total of 8,412 square kilometers. To the east, it is bordered by Cross River State and on the West by Rivers State and Abia State and to the South by the Atlantic Ocean. The State is characterized by two seasons, the wet or rainy season, which lasts for 7 to 8 months and a short dry season during which the State is covered by dry dust harmattan winds. Rainfall is expected to be very heavy, ranging from over 3000mm along the coast to 2000mm on the northern fringe. Temperatures are uniformly high throughout the year with a slight variation between 26^0 and 28^0C. Groundwater potential of Akwa Ibom State is very high due to general high permeability, considerable thicknesses of the aquifers and high recharge potentials. The lithology of the State is more than 80% sands and sandstones which are very favorable for the storage and exploitation of groundwater. Fig 1 shows the study area at a glance.

The Coastal Plain Sands or Benin Formation is the main aquifer in the State. The dominant grain sizes range from fine to coarse grained and sometimes grades into gravelly sands with clay intercalations. The clay intercalations and clay lenses occurring in some horizons sometimes act as cap rocks which could give rise to confined aquifers. The intensity of confinement could be very high resulting in artesian aquifers especially around Etinan [14]. Akwa Ibom State has immense fresh water potentials. State is washed by Atlantic Ocean and rivers such as the Cross River, Qua Iboe River, and Ikpa River. These rivers and other streams, in addition to high annual rainfall, catchment area and relatively less complex geology, guarantee continuous recharge of existing prolific aquifer. This underscores sustainable groundwater delivery option adopted in the State, an off shoot of the concept of the water cycle which is a framework for which water resources of a place can be assessed to guarantee access to the rural communities. It therefore means that the water cycle guarantees enough water for human uses but it might not be readily available where it is needed in a sustainable way. With this understanding, what is required is how best to harness this inexhaustible natural asset to the benefit of humanity which is what water access are all about.

According to the 2006 population census result, the State has a population of 3,920,208 persons; a density of 466 people per square km. State population forms about 3 percent of the national population. About 11.79% of the population of the State is urban, 15.55% is small towns while the remaining 72.66% is rural [15]. Datasets for the study were both from primary and secondary sources. These include political map of Akwa Ibom State showing 31 Local Government Areas and their Headquarters, community map of Akwa Ibom State, population data of the State, location and types of safe water schemes in the study area. All the data on safe water points obtained from statutory government agencies and multinational companies for this research had only non-spatial attributes and it was therefore imperative to assign coordinates to these points for intended analysis in GIS domain. The reason for considering these water points as safe is because the data were from statutory government agencies and multinational companies. These bodies have track records and integrity of strict compliance to standards for safe water. The use of georeferenced community map of Akwa Ibom State to assign coordinates to the water points was considered and ground truthing was undertaken to establish the accurateness of the coordinates on ten randomly selected safe water points with GPS to map the coordinates of the water points. The names and types of rural water schemes cover all rural schemes in the eleven 100% Rural Local Government Areas of Akwa Ibom State of Nigeria and are categorized into mini water and hand pump. Each mini water scheme is designed to supply water to 10 public stand posts/water points all year round while hand pump driven borehole stands for 1 water point. A water point is deemed to service 500 people. With the rural water data in conjunction with the population data and political map of Akwa Ibom State, ArcMap capabilities were employed to show water access in rural areas of the State. Ten water points of mini water were considered as single water point in terms of access because the water points are constructed within the water head works and shared the same 250m allowed for maximum distance adopted for rural water access.

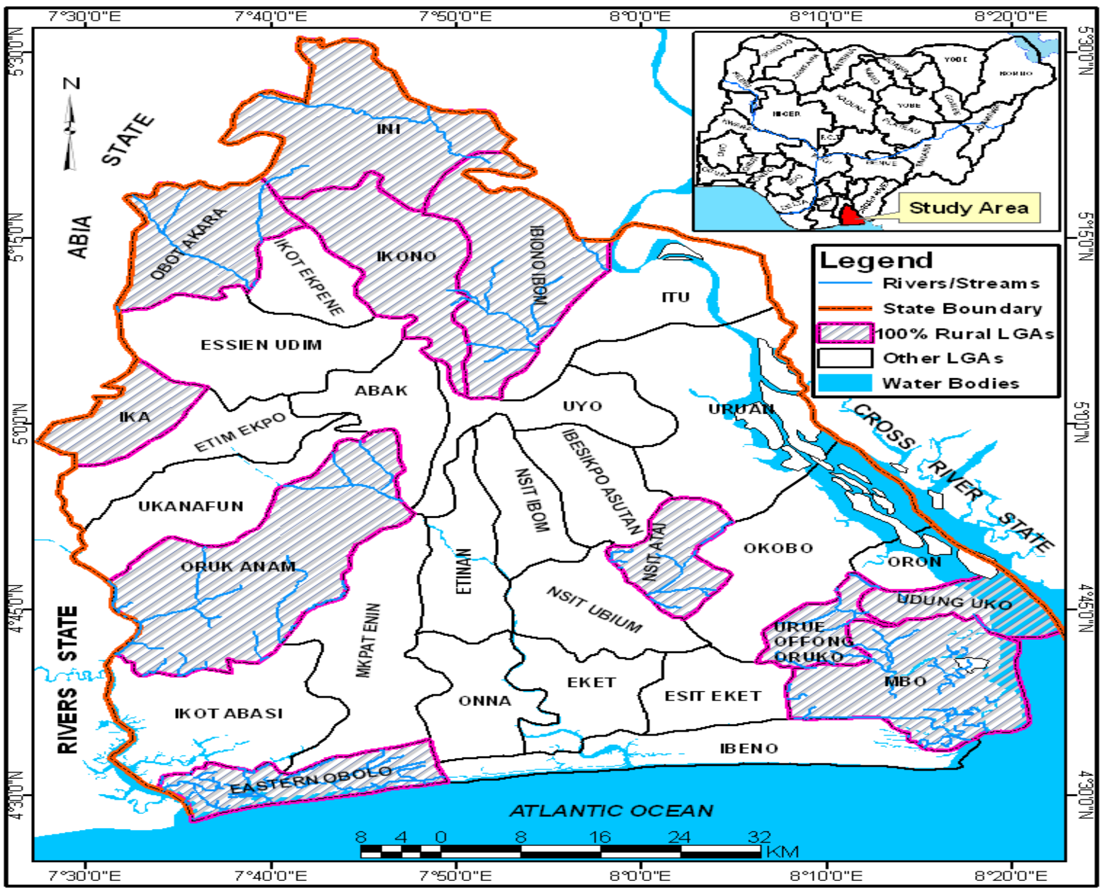

Fig. 1. Map of Akwa Ibom State of Nigeria showing the rural Local Government Areas

For rural water access analysis only eleven Local Government Areas adjudged by the National Population Commission to be 100% rural were considered. The rest of the Local Government Areas with urban and peri-urban settlements was not considered due to absence of boundary demarcation between urban and peri-urban centers with the rural communities. Also in computing rural water access, population density as a criterion was not applied because the distance criterion adopted by National Water Supply and Sanitation Policy is at variance with the population density criterion. The reason being that population is not likely to be evenly distributed in space and could be very difficult to come by satellite images of high resolution capable of showing spatial distribution of settlements in most of our rural communities [16]. This limitation was overcome by using average community population figures within the respective Local Government Areas as surrogate data in the computation of percentage of rural water access. Baber [17] applied housing density data as a surrogate to overcome the challenge posed by lack of population density data. To be able to apply this option, all the communities within the Local Government Area were ranked to be equal in terms of population size. This might not have been the truth but since there are no community boundaries and the smallest areal boundary unit is Local Government Area, whatever imbalances that could have arisen in the approximated average population of individual communities would have been seen to balance up when the sum total of the entire Local Government Area's population is computed. The idea of averaging the community approximate population was to enable application of 250–500 persons service standard per safe water point so as to arrive at required number of points for the respective communities which is to be used in calculating the number of points required in a particular Local Government Area. With this the percentage access was then calculated by finding the number of water points within a community against the number of community in the Local Government Area. Table 1 shows data on rural water schemes for the eleven rural Local Government Areas of Akwa Ibom while Table 2 shows analysis of percentage rural water access. Edem [14] in an attempt to examine rural water coverage and access developed four formulae and applied same in the computation of the percentage rural water access for each of the eleven rural Local Government Areas as showed on Table 2. The basic assumption is that each safe water point is expected to service a maximum of 500 people within maximum distance of 250metre radius.

i. ***Ppc = Pp./Nc;*** where Ppc = Average community population in a LGA, Pp = LGA population and Nc = Number of communities per LGA.
ii. ***WPrc = Ppc/Nc;*** where WPrc = Required water points per community in LGA
iii. ***WPrl = WPrc x Nc;*** where WPrl = Required water points in LGA
iv. ***Percentage access = NSWP/WPrl x 100%;*** where NSWP = Total number of safe water points found in LGAs

After the computation of the percentage access table, the next step was the application of GIS technique for further analysis. In this regards ArcMap was launched and ArcCatalog opened for creation of shapefile of eleven 100% Rural LGAs as polygon. The shapefile created was then displayed in the same view with the georeferenced image for the eleven 100% Rural LGAs to be digitized with corresponding attribute table opened and displayed for the creation of the fields. While the image was still on display, the layer name was double clicked to display layer properties for symbology and classification of percentages of water access. Percentage access was later reclassified into five classes. Thus, this model was deployed and applied to analyses safe water point's access across the communities. The rationale behind it was to critically evaluate how far or close a community is from safe water points. The layers used for this analysis were hand pump boreholes and mini water scheme projects across the eleven 100% Rural LGAs of the State.

RESULTS

From Table 1, summary of safe water database, the total number of safe water points in the eleven rural Local Government Areas (LGAs) of Akwa Ibom State and the population are indicated. Out of this number 912 safe water points, 92 (10.1%) is contributed by hand pump boreholes while the balance of 820 representing 89.9% is through mini water schemes. Ikono Local Government Area (165) has the highest number of safe water points followed by Ibiono Ibom LGA with 154 number water points. Eastern Obolo LGA has the least number (24) of safe water points followed by Mbo LGA (47). Database also revealed that hand pump boreholes are gradually phasing out to give way to mini water schemes which might be indicative of socio- economic status of Akwa Ibom State vis-à-vis the local communities. But sadly the database failed to reveal certain salient features like well hydraulics and the geology which could have aided in the subsequent implementation of similar projects in terms of design and cost. In terms of spread, Fig. 2 shows the spatial distribution of safe water points in 11 LGAs under consideration. There were cases of overlapping of the water points in addition to skewness of the water points to a particular direction to the detriment of other sections in dire need of water. The distribution pattern also showed gaps and areas that needed urgent attention at a glance for possible intervention, even to draw support from donor Agencies and multi-national companies in the implementation of rural water programmes. One of the important significant of spatial distribution also was that fact that communities and other features like road network, settlement and rivers/streams could be placed side by side as showed in the map for decision support in project sitting.

Table 1: Summary of safe water database in the eleven Rural LGAs of Akwa Ibom State

S/N	Local Govt. Area	Population	Hand pump Boreholes	Mini Water Schemes	Total No. of Points
1	**Eastern Obolo**	24,509	4	2 (20)	24
2	**Ibiono Ibom**	182,264	4	15 (150)	154
3	**Ika**	79,294	3	8 (80)	83
4	**Ikono**	162,012	5	16 (160)	165
5	**Ini**	125,608	8	7 (70)	78
6	**Mbo**	118,578	7	4 (40)	47
7	**Nsit Atai**	78,965	11	6 (60)	71
8	**Obot Akara**	114,155	17	7 (70)	87
9	**Oruk Anam**	223,276	19	7 (70)	89
10	**Udung Uko**	40,813	5	5 (50)	55
11	**Urueoffong/Oruk**	54,150	9	5 (50)	59
	Total		**92 (10.1%)**	**820 (89.9%)**	**912**

Table 2: Percentage rural water accessibility analysis for the eleven rural LGAs

S/N	Name of LGA	Pp	NC	Ppc	WPrc	WPrl	NWPP	% ac
1.	Eastern Obolo	24,509	17	1442	3	51	6	11.76
2.	Ibiono Ibom	182,264	161	1132	3	483	19	3.93
3.	Ika	79,294	54	1468	3	164	11	6.71
4.	Ikono	162,012	79	2051	5	395	21	5.32
5.	Ini	125,608	79	1590	4	316	15	4.75
6.	Mbo	118,578	78	1520	4	312	11	3.53
7.	Nsit Atai	78,965	49	1612	4	196	17	8.67
8.	Obot Akara	114,155	61	1871	4	244	24	9.84
9.	Oruk Anam	223,276	108	2067	5	540	26	4.82
10.	Udung Uko	40,813	25	1633	4	100	10	10.00
11.	Urue Offong Oruko	54,150	37	1464	3	111	14	12.61

Source: Authors' field survey

To enhance data analysis of percentage safe water access, the percentage access column on Table 2 was used to form the Attribute Table for the compilation of percentage safe water points access map (Fig. 3). As shown in Fig. 3, percentage access was extremely very low. Mbo LGA had the least (3.53%). This is closely followed by Ibiono Ibom LGA (3.93%), Ini LGA (4.75%), and Oruk Anam (4.82%) while Urue Offong Oruko (12.61%) and Eastern Obolo (11.76%) had the highest levels of access. This result implies that there is very poor water distribution network.

In more specific term, the result of this study reveals that not all the communities have access to safe water point. For instance, in Ibiono LGA, only fifteen communities had mini water schemes sited in their locality while four communities benefitted from hand pump boreholes. In Eastern Obolo LGA, two communities had mini water schemes sited in their locality while four communities had access to hand pump boreholes. This inequality and several of such disparity abound in all other LGAs thereby creating water access gap in these LGAs in particular and the State in general. The GIS database also revealed that each of the mini water schemes had 10 safe water points expected to service a maximum 5000 person within the locality given the right access of not more than 250m away from people's abode. Similarly, hand pump borehole had a single water point meant to serve a maximum population of 500 people. According to the database, agencies and organizations engaged in the implementation and execution of these water schemes include Akwa Ibom State government, Cross River Basin Development Authority, ExxonMobil, the Petroleum Trust Fund, UNICEF and the Directorate of Food, Road, Rural Infrastructure. This therefore calls for other agencies, organized private sector, non-governmental organizations, community-based organizations, and religious/faith-based groups to see it as a challenge and embrace the provision of safe water to their operational localities as one of their corporate social responsibilities.

Another fascinating aspect of this research was the display of these water points on the map of Akwa Ibom State. The prime motivation of this study was to show their spatial distribution. This therefore revealed a chaotic nature in the distribution of safe water points across the State. It was found that some of the facilities are clustered in some parts of the LGAs (e.g. Nsit Ibom, Onna, Urue Offong Oruko etc.) while others are sparsely sited in various parts of the LGAs (e.g. Ini, Ikono, Ibiono

Ibom, and Oruk Anam among others). This is an indication of inequity in the location of projects. The distribution however does not conform to the NWSSP which clearly spelt out criteria for sitting of water schemes in our rural communities. With this distribution gap created by such chaotic pattern, it is apt to say that redistribution and reallocation are essential, most especially in the areas that have not benefited from such projects. This is where the expertise of GIS can be harnessed and applied, starting from the phase of selecting suitable site to the post project monitoring and evaluation phases. The result of poor access revealed in this study should be a good pointer to policy makers and various stakeholders to reflect in the design and implementation of mini water schemes. Consideration should be given to water distribution. This informed the development of safe water access model as a decision support mechanism to aid our policy makers and stakeholders in rural water implementation.

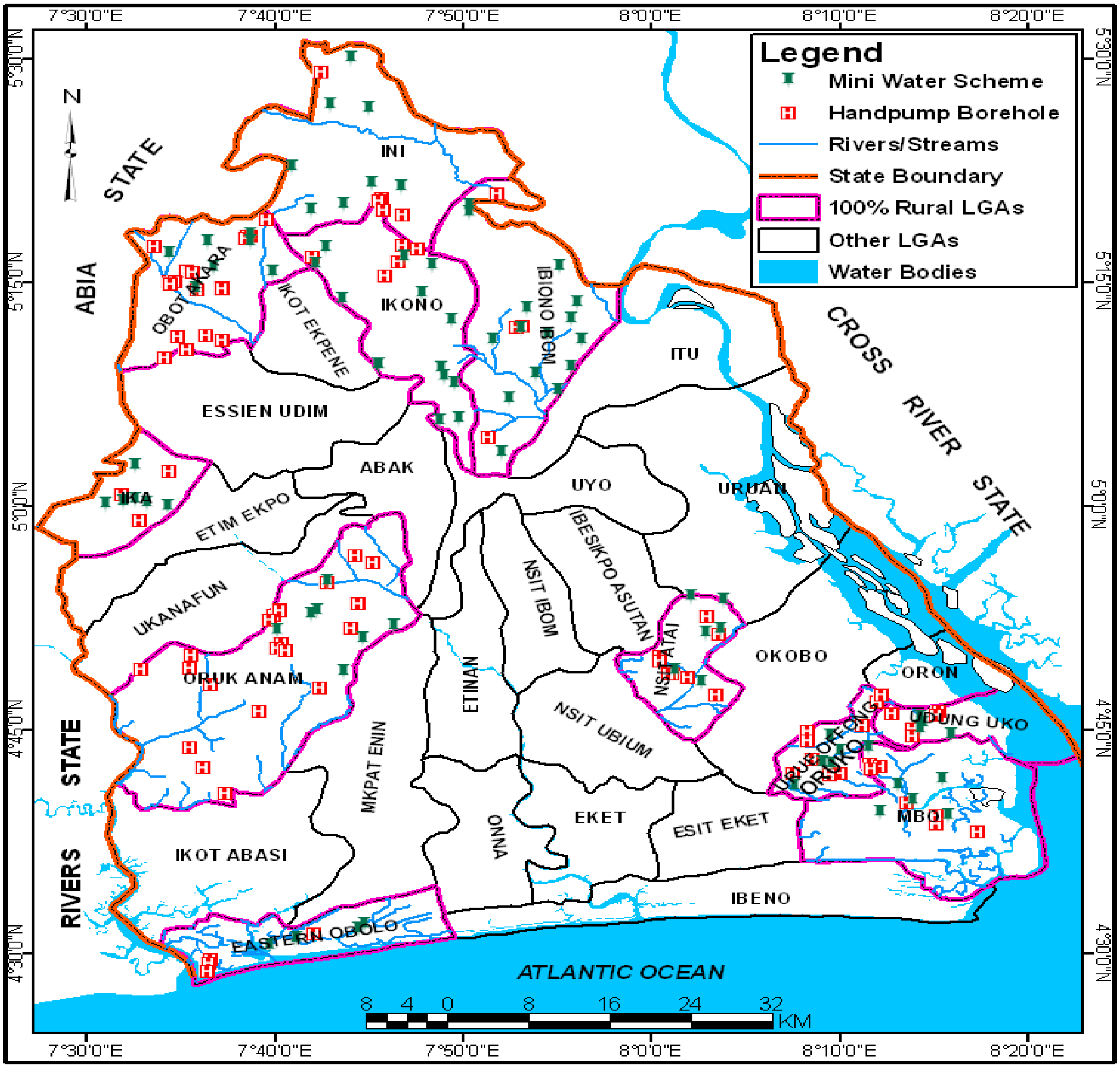

Fig. 2: Spatial distribution of safe water points in rural Local Government Areas of Akwa Ibom State, Nigeria.

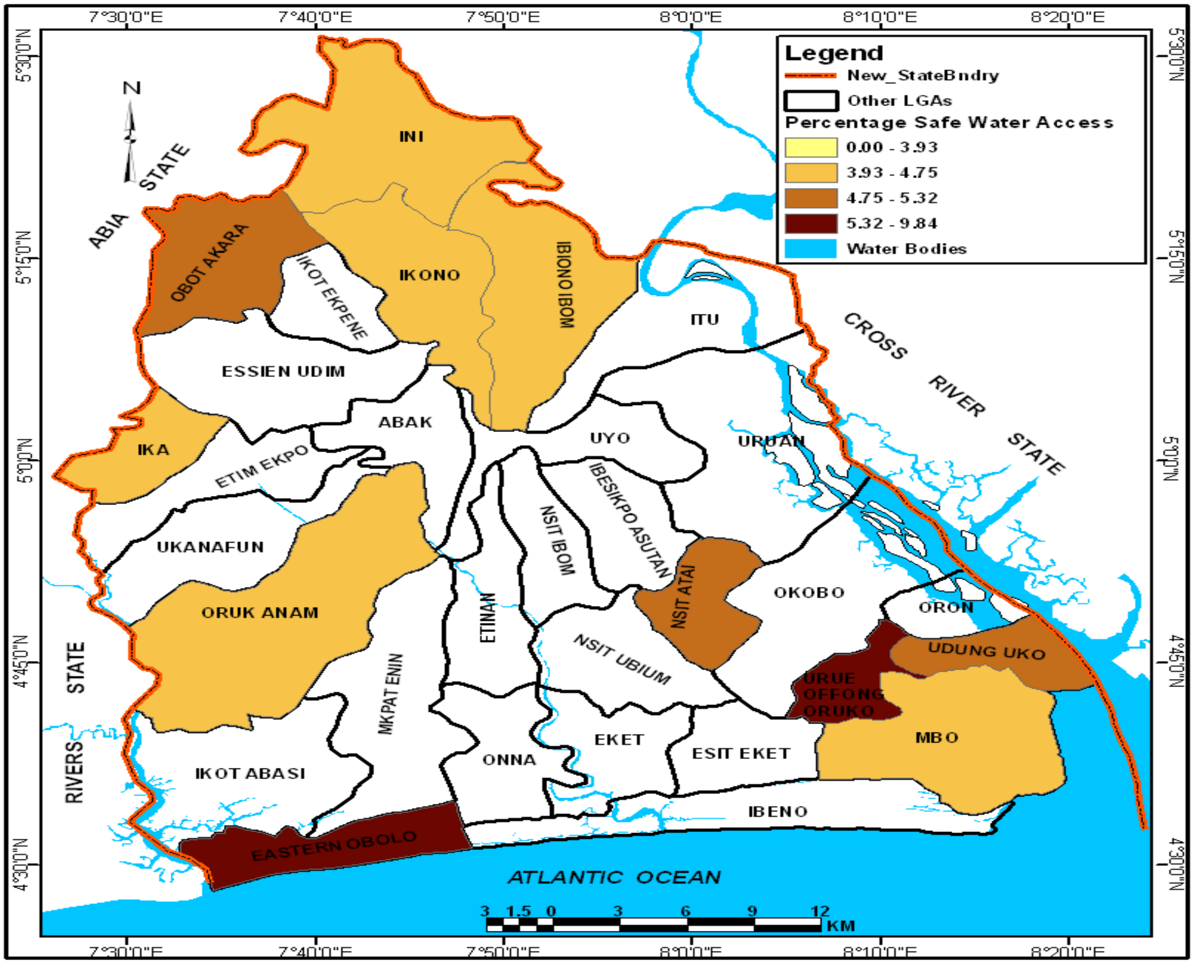

Fig. 3: Percentage Safe Water Points Accessibility of eleven 100% Rural LGAs of AKS

Source: Authors' field survey

CONCLUTION

The need for equitable and sustainable access to rural water schemes for Akwa Ibom State cannot be overemphasized. Thus, for rural water access to be sustainable, creation and maintenance of efficient and up-to-date database containing vital information is essential. The national policy on water supply provides criteria for solving the problem of inequity in resource allocation when portrayed spatially as seen in this work. In some areas, safe water points are poorly distributed or accessed. This invariably means that there is poor access level to rural water supply and by implication indicates that there is need for adequate measures to distribute rural water schemes based on the national water policy criteria for Nigeria. On the basis of the findings of this study, there is a dire need for the statutory government organs to interface with stakeholders involved in rural water programs to maintain a robust spatial database which amongst other things should include hydrologic parameters of all their rural water programs. This will aid in the design, costing and execution of rural water projects. Akwa Ibom State Government as a matter of great concern should liaise with relevant bodies to produce community boundary map of the State to allow for efficient and effective implementation of rural water programmes and any other community based programmes in the State. This will help in proper sitting of projects. A situation where safe water points are over lapping as seen in the spatial distribution map and buffer map of safe water points could be reduced and facility channeled to other areas. More so sustainability of the facility will be enhanced as it will be based on the capability and needs of the community. It is recommended that the state government should set up Water Supply Technical Committee to regulate water supply programmes with the mandate of redesigning water schemes in line with the national policy standard.

ETHICAL ISSUES

The ethical issues involved in scientific research were considered and observed during the conduct of the study. Proper permission was obtained from village heads and elders of the communities before the field work was embarked on. Participation in the study was not by force but on the willingness of respondents to participate. Anonymity of respondents was respected. During the field work, all forms of identification including names, addresses and telephone numbers of respondents were avoided. This research report has not been published anywhere and it is in its original form.

CONFLICT OF INTEREST

Conflict of interest is not envisaged as all the authors contributed towards the conduct of the study in terms of human, materials and financial resources without external funding and support. The authors therefore declare that they have no competing interest relating to this work.

AUTHORS' CONTRIBUTIONS

The authors of this paper have made sufficiently substantial intellectual contributions from concept, design, acquisition and analysis of data to interpretation of data and subsequent drafting as well as revision of the manuscript for publication. Conflict of interest is not envisaged as all the authors contributed towards the conduct of the study in terms of human, materials and financial resources without external funding and support. The authors therefore declare that they have no competing interest relating to this work.

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