Savanna volume 23, Number 1, June, 2016

Spatial Mapping of Renewable Energy Potentials in Zaria, Kaduna State, Nigeria

Muhammad Isma'il
Department of Geography & Environmental Management,
Ahmadu Bello University, Zaria
mgeogjameel@yahoo.com

ABSTRACT

This study analyzed the renewable energy potentials (solar energy, wind energy and hydropower) in Zaria using Geographic Information system (GIS). Three types of data were used for this study namely; solar radiation data, wind speed data and hydrological data. Twenty two (22) year monthly average of solar radiation and 10 year monthly average of wind speed data (at an altitude of 50m) of each political ward in the study area were obtained from the National Aeronautics and Space Administration (NASA). These are the available solar radiation and wind speed data on the NASA website. These data were used to map the solar and wind energy potentials in ArcGIS 10.3 software. The hydropower potential was determined by digitizing the water bodies in the study area in ArcGIS environment. Findings revealed that the amount of solar radiation received in the study area ranges from 5.52 to 5.78kWh/m^2/day. It was found that the wind speed in the study area ranges from 3.20 to 4.50m/s. Three sites have been identified that can be used for generating hydropower in the study area. These are, Ahmadu Bello University (A.B.U.)/Kubanni dam, Shika dam, and River Galma. It was observed that the solar energy potential in the area is enormous while the wind energy potential is moderate but significant for generating electricity in the area. Also, each of the dams identified in the area has small scale hydropower potentials which can be harnessed to increase the energy supply mix in the area.

Keywords: Spatial Mapping; GIS; Renewable Energy; Potentials.

1. INTRODUCTION

Nigeria is endowed with abundant renewable energy resources, but the country is mostly dependent on fuelwood and fossil fuels as sources of energy for industrial and household activities (Vincent-Akpu, 2012). Only about 40% of households in Nigeria are connected to the national electricity grid, provision of electricity for commercial, industrial and household activities is largely supplemented by private producers or the use of fossil fuel powered generators (Omokaro, 2008). This unsustainable energy situation can be reversed by developing the renewable energy resources in Nigeria. Renewable energy resources are those that can be easily regenerated after they have been used, examples are solar energy, hydropower, geothermal energy, biomass and wind. Nigeria has all of these renewable resources distributed across different parts of the country.

Nigeria is endowed with an annual average daily sunshine of 6.25 hours, ranging from 3.5 hours at the coastal areas in the south to 9.0 hours at the far northern boundary, which can be exploited to reduce dependence on fossil fuels in the country (Oji et al., 2012). The country has an annual average daily solar radiation of about 5.25kW/m^2/day at the coastal area and 7.0kWh/m^2/day at the northern boundary, with an average daily incident solar energy of 4.85×10^{12}kWh and annual 1.804×10^{15}kWh. This implies that, only about 37% of Nigeria's land area is required annually to harness the amount of solar energy equivalent to the conventional energy reserve in the country (Chendo, 2002).

Also, Nigeria has enormous wind energy resources which can be used to generate electricity. This is because wind speed in Nigeria ranges from 1.4 to 3.0m/s in the southern part of the country and 4.0 to 5.12m/s in the extreme north (Idris et al., 2012). Wind energy has been used for rural electrification in Northern Nigeria as it has also been used to pump water from open well for domestic and irrigation purposes (Agbetuyi et al., 2013).

Hydropower is one of the major sources of renewable energy in Nigeria; the country is endowed with a lot of rivers, river basins, streams and some few natural waterfalls. Some of the rivers maintain minimum discharges throughout the year. The Nigerian government has installed eight small hydropower stations with aggregate capacity of 37.0MW (Okafor and Uzuegbu, 2010). Moreover, Nigeria has enormous hydropower potentials along the numerous river systems, where a total of 70 micro dams, 126 mini dams and 86 small sites have been identified (Oyeneye, 2004). Also, in a study carried out in twelve states and four river basins in the country, over 278 unexploited small hydropower sites with total potentials of 734.3MW were identified (Aliyu and Elegba, 2015). Nevertheless, hydropower currently accounts for about 29% of the total electrical power supply in Nigeria (Abiodun, 2012), and the total technically exploitable hydropower potential based on the country's river system is estimated to be about 11,000MW of which only 19% is currently being developed (Okafor and Uzuegbu, 2010).

Studies have been carried out to assess renewable energy potentials in different parts of Nigeria. For instance, Otun et al. (2012) evaluated the hydropower potentials of the Kangimi reservoir in Kaduna state and found that the reservoir can potentially generate 1.109MW and 0.692MW if the Kangimi reservoir dam axis is respectively placed at 612m and 604m above mean sea level. This hydro electric power potential of the reservoir can adequately meet the 872.566KW total estimated energy needs of the communities neighboring the Kangimi reservoir. Hassan and Onimisi (2013) assessed the global solar radiation at the Afaka site of the Nigerian Defence Academy (NDA) in Kaduna State within the period of March to May; their study found that although the global solar radiation in the area exhibits monthly variation, the mean values of all the months is significantly above the benchmark of good average radiation level required for solar energy application. Eke (2013) investigated the optimum angle of inclination for flat plate solar collector in Zaria, he found that an annual increment of about 4% of solar intensity will be achieved when a flat surface is located at a predicted optimum angle of inclination for each month of the year.

Nigeria has a lot of renewable energy potentials in form of solar energy, wind energy and hydropower which have remained largely untapped. A very critical step in renewable resource exploitation is to identify the magnitude of the renewable energy potentials across geographical locations in the country. However, little attention has been given to this area of research in Nigeria.

Several methods are used to analyze renewable the renewable energy potentials in an area or region. The methods include statistical modeling, geostatistical approach and the use of Geographical Information System (GIS) techniques. Akpootu and Sulu (2015) employed twelve different

Angstrom-Prescott based empirical models to estimate the monthly average daily global solar radiation on a horizontal surface at Zaria in North-Western, Nigeria. They observed a noticeable underestimation of diffuse solar radiation by all the models in the months from February to April. An alternative to this method is the application of GIS to anlyze solar energy potentials in the area. GIS is as a powerful set of computer tools for collecting, storing, managing, retrieving at will, transforming, and displaying geographic data from the real world in order to achieve a particular objective (Burrough and McDonnell, 1998). Ramachandra (2007) employed GIS to map and analyze spatial variation in solar potential in Karnataka state of India, based on global solar radiation data. Ismaila (2006) analyzed the potential hydropower sites in Nigeria using GIS. Olatunji and Sanusi (2013) analyzed the wind energy potential in Zaria metropolis using GIS. They found that the maximum average wind speed of 3 m/s at a height of 10m is usually experienced from the month of January through July and low average wind speed period observed from August to December. The aim of this study is to analyze the renewable energy potentials of Zaria using GIS with a view to assess the solar energy, wind energy and hydropower potentials in the area.

1.1 The Study Area

Zaria is located between latitudes 11°00′-11°10′ North of the Equator and longitudes 7°36′ - 7°45′ East of the Greenwich Meridian as shown in Figure 1. It is bounded to the north by Makarfi, to the south by Igabi, to the east by soba and to the west by Giwa Local Government Areas (LGAs) of Kaduna State. The area constitutes two LGAs (Zaria and Sabon-Gari) with the population of 408,198 and 286,871 respectively (National Population Commission, 2006). The projected populations of Zaria and Sabon-Gari in 2016 are 546,985 and 384,407 respectively.

Zaria is located on a monotonous rolling to gently undulating plains between 600m and 800m above sea level. It forms part of giant high plains of Northern Nigeria (Mortimore, 1970). The area is underlain by undifferentiated Precambrian basement complex formations comprising of both igneous and metamorphic rocks. The area has a combination of older granite and undifferentiated older alluvial and younger laterite (Wright and McCurry, 1970).

The climate of Zaria area is described as tropical continental, characterized by two distinct seasons, wet and dry season. The mean annual rainfall is about 1099.3mm. The climate of the area is influenced by the tropical continental air mass from the Sahara desert and the tropical maritime airmass from the Atlantic Ocean (Shehu, 2010). The natural vegetation of the study area is the northern guinea savannah type (Jackson, 1970). The River Galma forms the main focus of the drainage system in Zaria and its tributeries are Kubanni, Shika and Saye.

Zaria is inhabited by civil servants, traders and a larger population in the rural areas engaged in subsistence farming .The economy of Zaria is agricultural supplemented by various non-agricultural traditional industries. Some of the main agricultural crops cultivated in the area are yam, cassava, cocoyam, maize, cowpea, guinea corn and millet, cotton, ginger, ground nut, and soya beans. The study area is endowed with a number of flourishing markets where people from far and near conduct business transactions daily (Usman, 2013). Industrial areas found in Zaria include Muchiya, Cikaji and Dambo-Dakaci industrial layouts.

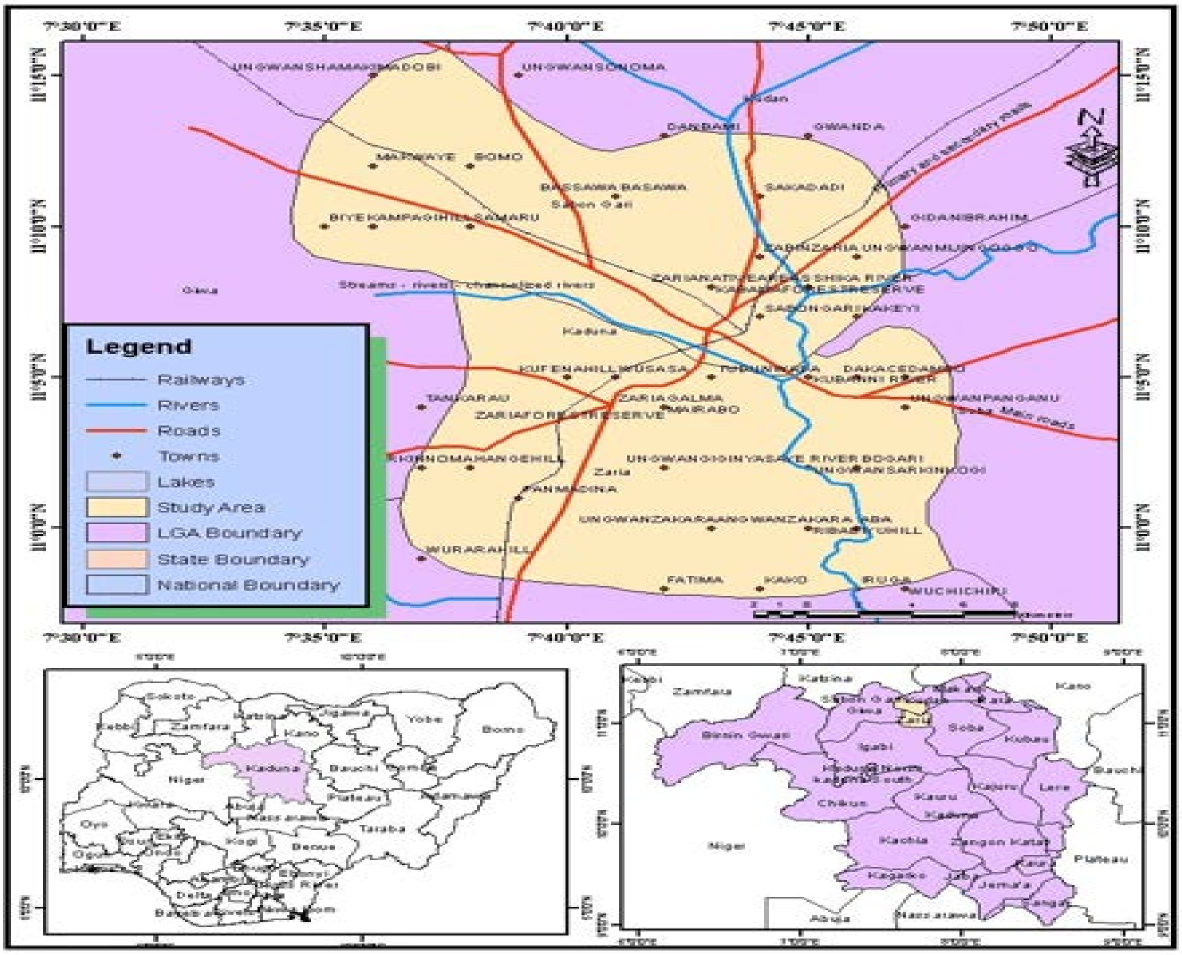


Figure 1: The Study Area
Source: Adapted from the Administrative Map of Kaduna State

2. MATERIALS AND METHODS

2.1 Types and Sources of Data

Three types of data were used for this study namely; solar radiation data, wind speed data and hydrological data. Twenty two (22) year monthly average of solar radiation and 10 year monthly average of wind speed (at an altitude of 50m) of each political ward in the study area were obtained from National Aeronautics and Space Administration (NASAwww.eosweb.larc.nasa.gov/sse/). These are the available solar radiation and wind speed data on the NASA website. The hydropower potential was determined by digitizing the water bodies in the study area in ArcGIS 10.3 software.

2.2 Data Analysis

The solar energy potential map of the study area was generated in ArcMap using the solar radiation data of the various wards in the study area. ArcMap is an application in ArcGIS software for mapping spatial data. The wind potential map of the study area was also generated in ArcMap using wind speed data. The hydropower potential was estimated by georeferencing and digitizing the water bodies (dams) on the Google map of the study area in ArcMap.

3. RESULTS AND DISCUSSION

3.1 Solar Energy Potentials in Zaria

Renewable energy maps serve as veritable tools for visualizing spatial distribution and variations in renewable energy potentials, which will guide policy formulation and investment in renewable energy development. The solar energy potential map of the study area is presented in Figure 2. It was found that the amount of solar radiation received in the study area ranges from 5.52 to 5.78kWh/m^2/day. This is more than the minimum solar radiation value of 5kWh/m^2/day required in an area for developing solar power technologies (The United State Department of Agriculture and Forest Service- USFS, 2005). It was also observed that the maximum annual mean solar radiation of 5.96kWh/m^2/day is received in Bomo ward, while the minimum annual mean solar radiation of 5.6kWh/m^2/day is received in Zabi ward. Though, most of the wards in the area receive average solar radiation of 5.74kWh/m^2/day which is quite good for installing solar energy technologies to harness solar energy in the area.

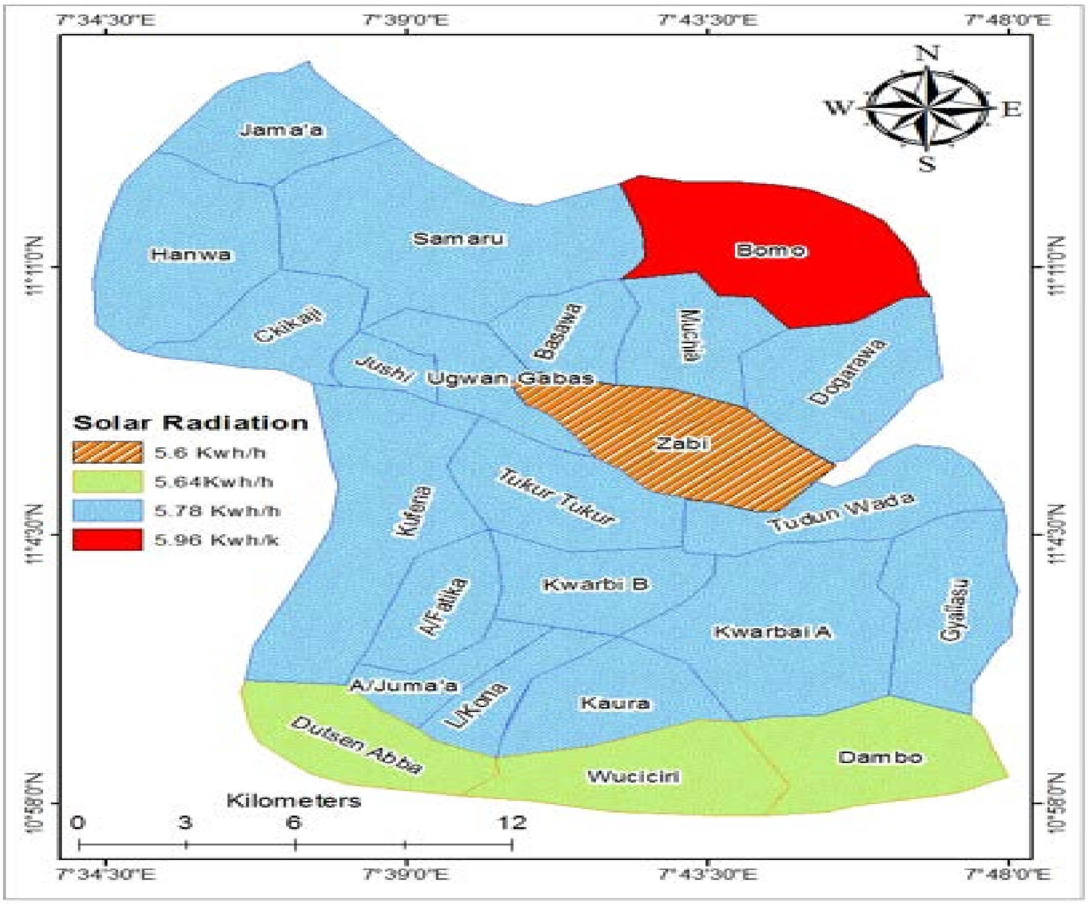


Figure 2: Solar Energy Potentials in Zaria

3.2 Wind Energy Potentials in Zaria

The wind energy potential map is presented in Figure 3. It was found that Bomo ward has the highest annual average wind speed of about 4.53m/s at a height of 50m above sea level, while Dutsen Abba, Wuciciri and Danbo wards have the lowest average wind speed of about 3.19 m/s as shown in Figure 3. Hence, the best place for siting wind farm in the study area is Bomo ward. Also, spatial variability in wind potential across the political wards in the study area can be observed from Figure 3. It can be observed that the wind speed in the study area ranges from 3.20 to 4.50m/s. This is not an overestimation in view of the fact that Aidan and Ododo (2010) predicted the wind speed of Zaria in Northwestern Nigeria using Weibull distribution function and found that at height of 50m, the minimum wind speed in the area is 2.35m/s and the maximum is 10.65m/s. Likewise, Lehmeyer (2005) reported that the measured mean wind speed at 30 m height in Northwestern Nigeria could reach up to 4.9m/s.

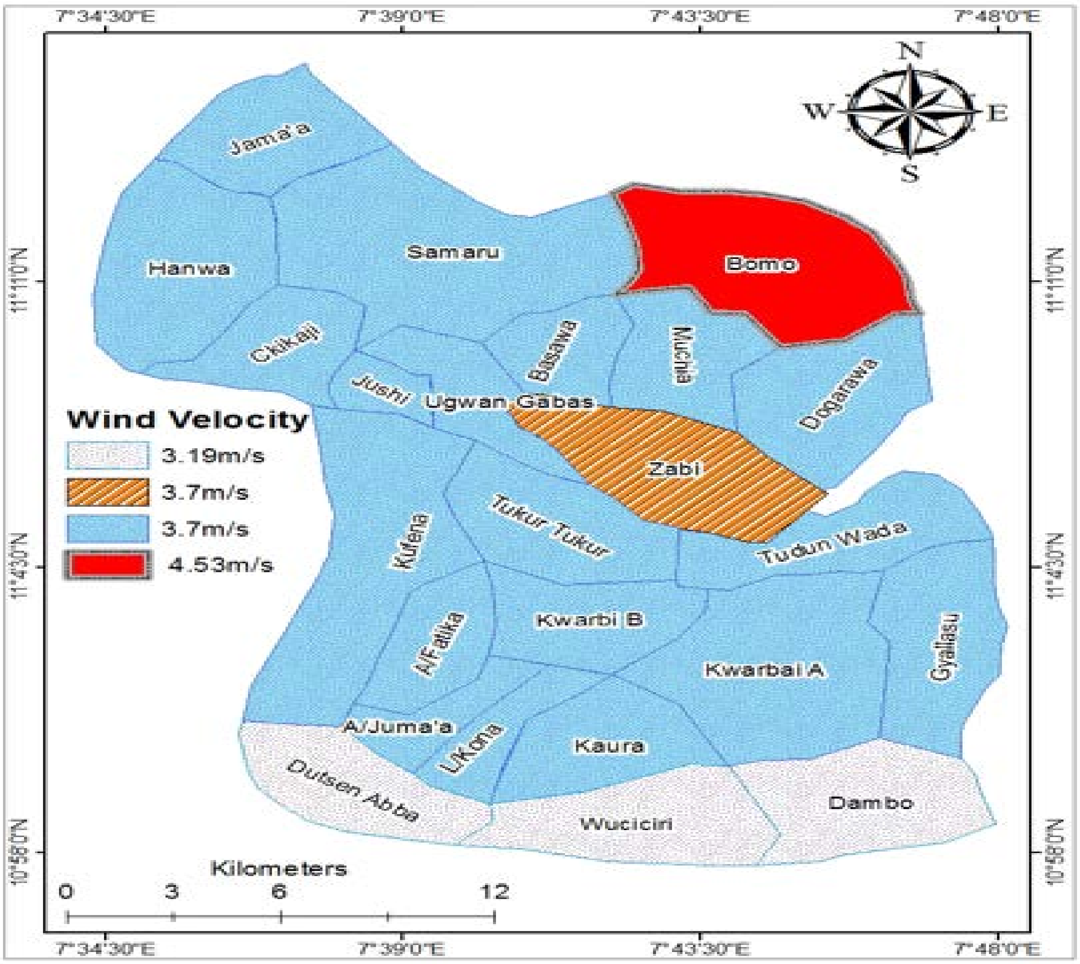


Figure 3: Wind Energy Potentials in Zaria

In addition, it was found that wind speed increases with height above sea level and the average extractable wind power per unit area of Zaria was estimated at 9w/m^2 (Olatunji and Sanusi, 2013). Similarly, the mean wind speed at 25m height in Zaria was estimated at 2.89m/s, also, the monthly and annual mean wind energy in the area is estimated at 5.32kWh and 63.88kWh respectively (Agbetuyi et al., 2012). This suggests that Zaria has reasonable wind power potentials that can be exploited as an alternative renewable source of energy in the area.

Analysis of the wind speed data revealed an average wind speed of 3.85m/s across the wards in the study area. Therefore, the area is considered of significant potential for harnessing wind energy. Although the potential for wind power in the area is not as huge as the solar energy potentials, the wind projects installed in Kano and Katsina states can be replicated in areas with relatively high wind velocity within the study area.

3.3 Hydropower Potentials in Zaria

The hydropower potential map of the study area is presented in Figure 4. Three sites have been identified that can be used for generating small hydropower in the study area. These are, Ahmadu Bello University (A.B.U.)/Kubanni dam, Shika dam, and River Galma. Each of these water sources has small scale hydropower potentials. Shika dam has a length of 900 meters and a designed reservoir storage capacity of 349,911 m^3, while A.B.U. dam has a length of 84.4 meters and the storage reservoir capacity of 30,331 m^3. The Shika and A.B.U. dams have the capacity to generate 2.7 megawatts and 0.47 megawatts of hydroelectric power respectively.

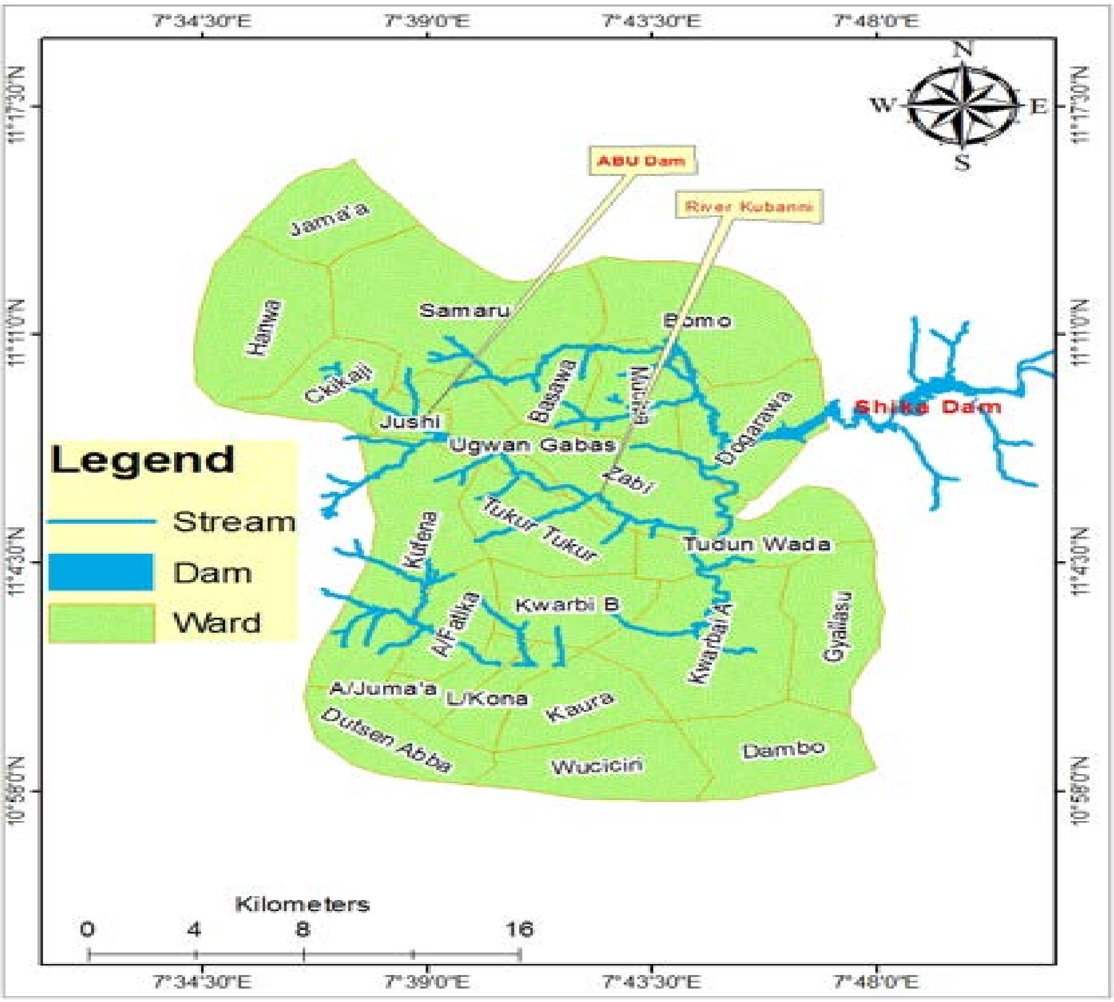


Figure 4: Hydropower Potentials in Zaria

This study has discovered reasonable hydropower potential in the study area. However, there is the need to develop and conserve the hydropower potentials in the area in view of the fact that the annual loss of storage in A.B.U./Kubanni reservoir is estimated at about 1.16% (A.B.U. Committee on Protection of the Kubanni Dam Drainage Basin, 2008). Similarly, it was discovered in another study that the sediment yield into Kubanni reservoir was 20387000Kg/year and the rate of siltation in the reservoir was 30,331m^3/year (Otun and Adeogun, 2010). While the rate of shika dam reservoirs loss might exceed 1.72 % annually (McCully, 1996). The rate of loss of these reservoirs due to siltation is colossal and needs to be checked in order to maximally exploit the hydropower potentials of the dams.

4. CONCLUSION AND RECOMMENDATION

Geographic Information system (GIS) was used to analyze renewable energy potentials in Zaria. It was found that the area has enormous solar energy and significant wind energy potentials with mean values of 5.65kWh/m^2/day and 3.85m/s respectively. Also, there are reservoirs identified in the area which have small scale hydropower potentials. Although, there is spatial variation in terms of the renewable energy potentials over the study area, Zaria provides a condusive environment for harnessing solar energy, wind energy and hydropower which can be exploited to increase the energy supply mix in the area. In order to maximally exploit the renewable energy potentials in the area, there is the need to consider the spatial variations in terms of the potentials with a view to identify the most suitable locations for the development of hydropower, wind energy or solar energy technologies.

REFERENCES

Abiodun, O. (2012). Review of Renewable Energy Sources in Nigeria: Security and Challenges. *International Journal of Advanced Renewable Energy Research*, 1(1): 71-77.

A.B.U. Committee on Protection of the Kubanni Dam Drainage Basin (2008). *Report on Protection of the Kubanni Dam Drainage Basin.* Ahmadu Bello University, Zaria.

Agbetuyi et al. (2012). Wind Energy Potential in Nigeria. *International Electrical Engineering Journal,* 3(1): 59.

Agbetuyi, A.F., Odigwe, I.A., Awelewa, A.A. and Awosope, C.O.A. (2013). Wind power potential and integration in Africa. *International Journal of Development and Sustainability,* 2(1): 232-239.

Aidan, J. and Ododo, J. C. (2010). Wind Speed Distributions and Power Densities of Some Cities in Northern Nigeria. *Journal of Engineering and Applied Sciences,* 5(6): 420-426.

Akpootu, D. O. and Sulu, H. T. (2015). A Comparative Study of Various Sunshine Based Models for Estimating Global Solar Radiation in Zaria, North-Western, Nigeria. *International Journal of Technology Enhancements and Emerging Engineering Research*, 3(12): 1-5.

Aliyu, U.O. and Elegba, S.B. (2015). Prospects for small Hydro-power Development for Rural Application in Nigeria. *Nigerian Journal of Renewable Energy*, 1, 74-86.

Chendo (2002). “Renewable energy resources in Nigeria Energy potentials for Nigeria renewable energy". *National Conference of the Nigeria Society of Engineering* (Electrical Division), October 6th to 7th, Pp.1-15.

Eke, A. B. (2013). Prediction of optimum angle of inclination for flat plate solar collector in Zaria, Nigeria. *Agricultural Engineering International,* 13(4): 1-11.

Hassan, I. and Onimisi M. Y. (2013). Assessment of the Global Solar Energy Potential at Nigerian Defence Academy (NDA) Permanent Site Afaka Kaduna, Nigeria. *American Chemical Science Journal,* 3(3): 232-246.

Idris, N.A., Lamin, H.S., Ladan, M.J. and Yusuf, B.H. (2012). Nigeria's Wind Energy Potentials: the Path to a Diversified Electricity Generation-Mix. *International Journal of Modern Engineering Research,* 2(4): 2434-2437.

Ismaila, H. (2006). "Potential Hydro Power Sites"*.* Being a country position paper presented at *2nd Conference International Centre on Small Hydro Power*, Hangzhou, China.

Jackson, G. (1970). "Vegetation around the city and nearby villages of Zaria". In: Mortimore, M. J. (1970). *Zaria and its Region* (Ed.), Occasional Paper No.4 Department of Geography. A.B.U, Zaria. Pp. 191.

Lehmeyer (2005). *Report on Nigeria wind power mapping projects*. Federal Ministry of Science and Technology, Nigeria, pp. 37-51.

Mahmood, K. (1987). *"Reservoir Sedimentation: Impact, Extent, Mitigation".* World Bank Technical Report No. 71, Washington, D.C.

McCully, P. (1996). *Sedimentation Problems with Dams. Excerpt from Silenced Rivers: The Ecology and Politics of Large Dams*. Zed Books, London. https://www.internationalrivers.org/sedimentation-problems-with-dams

Mortimore, M.J. (1970). *Zaria and its regions: A Nigerian Savannah City and its environment*. Ahmadu Bello University, Zaria.

National Population Commission (NPC, 2006). *Nigeria Census Results.* National Population Commission, Abuja, Nigeria.

Oji, J. O., Idusuyi, N., Aliu, T. O., Petinrin, M. O., Odejobi, O. A., Adetunji, A. R. (2012). Utilization of Solar Energy for Power Generation in Nigeria. *International Journal of Energy Engineering*, 2(2): 54-59.

Okafor, E.N.C. and Uzuegbu, J. (2010).Challenges to development of renewable energy for electricity power sector in Nigeria. *International Journal of Academic Research*, 2(2): 211-216.

Olatunji, S. and Sanusi, Y. (2013). *Evaluation of wind energy potential in Zaria metropolis. Global Journal of Science Frontier Research Physics and Space Science,* 13(1): 18-27.

Omokaro, O. (2008). "Energy Development in a Fossil Fuel Economy: The Nigeria Experience". *One-day Conference/Workshop of West African Quaternary Research Scientists*, City of Ibadan, Nigeria. pp.8. www.credcentre.org

Otun, J.A. and Adeogun, B.K. (2010). Analysis of Fluvial Sediment Discharges into Kubanni Reservoir. *Nigerian Journal of Technology*, 29(2).

Otuna, J.A., Onemano, J.I. and Alayande, A.W. (2012). Assessment of the hydropower potential of Kangimi reservoir in Kaduna State, Nigeria. *Nigerian Journal of Technology*, 31(3): 300-307.

Oyeneye, O. O. (2004). "Socio-economic influence on policies of Power Deregulation". *Proc 20th National Conference of the Nigeria Society of Engineering* (Electrical Division), October 6th to 7th, Pp.1-15.

Ramachandra, T.V. Shruthi, B.V. (2007). *Spatial mapping of renewable energy potential*. Renewable and Sustainable Energy Review, 11, 1460–1480.

Shehu, S. (2010). "The foundation of Kassar Zazzau". Paper presented at the *1st Zazzau Conference*, at Arewa House, Kaduna State, Nigeria. pp. 3-4.

The United States Department of Agriculture, Forest Service (USFS) (2005). *Assessing the Potential for Renewable Energy on National Forest System Lands,* USDA Forest Service and NREL, United States.

Usman, M. (2000). *Assessing the impact of small scale industries in Zaria*. An unpublished B.Sc Thesis. Department of Geography, Ahmadu Bello University, Zaria.

Vincent-Akpu, I. (2012). "Renewable energy potentials in Nigeria". *'IAIA12 Conference Proceedings' Energy Future: The Role of Impact Assessment. 32nd Annual Meeting of the International Association for Impact Assessment.* Centro de Congresso da Alfândega, Porto-Portugal.

Wright, J. B. and McCurry, P. (1970). "Geology of Zaria". In: Mortimore, M.J. (ed), *Zaria and its Regions*. Occasional Paper 4, Department of Geography, A.B.U., Zaria.

Savanna volume 23, Number 1, June, 2016

Geospatial Analysis of Solar Energy Potentials in Kaduna State, Nigeria

Muhammad Isma'il[1]*, Ibrahim Musa Jaro[1], Aminu Lawal Ahmed[2], Ali Ibrahim Naibbi[3]
[1]*Department of Geography & Environmental Management, Ahmadu Bello University, Zaria*
[2]*Department of Physics, Ahmadu Bello University, Zaria*
[3]*Department of Geography, Northwest University, Kano*
*mgeogjameel@yahoo.com

ABSTARCT

This study analyzed spatially solar energy potential in Kaduna State with a view to identifying the optimum sites for harnessing solar energy in the area. Geospatial techniques were applied to map solar energy potentials using the ground measured and the satellite solar radiation data of the study area. Specifically, the Inverse Distance Weighted (IDW) interpolation was applied to generate the solar radiation map using the Spatial Analyst tool in ArcGIS software. In order to identify solar energy potential sites in the area, the Digital Elevation Model (DEM) of the area was obtained from the Shuttle Radar Topographic Mapper (SRTM) data in ArcGIS environment. Then, the slope and aspect maps of the area were generated from the DEM. Then, the solar radiation map, the DEM, the slope and aspect maps were ranked based on the Analytic Hierarchy Process (AHP). Finally, the solar radiation map, the DEM, the slope and aspect maps were integrated using weighted overlay to produce the map of solar energy potential sites in the area. Based on the satellite data, the minimum and maximum insolation values recorded in Kaduna State were found to be 4.47kWh/m^2/day in August and 6.32kWh/m^2/day in March/ April respectively. Based on the ground data, the minimum and maximum insolation values recorded in the state were found to be 4.92kWh/m^2/day in August and 7.00kWh/m^2/day in March respectively. Correlation between the ground and the satellite insolation data was found to be positive. Analysis showed that Kaduna State can be divided into three classes in terms of solar energy potentials namely; areas of very high, high and moderate solar energy potentials, which are spread across the 23 Local Government Areas of the state. The maximum insolation values are found during the months of March, April and May in the study area. Therefore, these are the optimum times for harnessing solar energy in the area.

Keywords: Geospatial Analysis; GIS; Solar Energy; Potentials.

1. INTRODUCTION

Solar energy can be considered as the most abundant renewable source of energy on the Earth's surface. Nigeria has enormous solar energy potentials but the contribution of solar in the energy mix of the country is insignificant because the potentials have not been fully developed or neglected (Omokoro, 2008). Nigeria's energy scenario is characterized by a supply dependent on fossil fuels and fuelwood (Vincent-Akpu, 2012) and energy demand far outweighing the supply which is epileptic in nature (Oji et al., 2012). This represents the picture of a country having vast renewable energy potentials but lacking energy security. With an average solar radiation of 19.8MJm^2/day and average sunshine hours of 6 hours per day, Nigeria has enormous solar energy potentials (Vincent-Akpu, 2012). Also, the amount of solar energy received in the country is estimated at 4.851x 10^{12} kWh per day (Oghogho et al., 2014).

The geographical location of Nigeria in the tropical climate offers the country suitable locations especially in the Northern region for harnessing solar energy where 7-9 daily sunshine hours are experienced. Therefore, there is the need to study the abundant solar energy potentials in different parts of the country with a view to facilitating solar energy development in Nigeria, which has the capacity to increase the energy supply mix to meet the demand for energy in the country.

In Nigeria, researchers have assessed solar energy potentials in different parts of the country. For instance, Augustine and Nnabuchi (2010) used the monthly mean daily global solar radiation, sunshine hours, maximum temperature, cloudiness index and relative humidity data for some selected cities, Owerri and Enugu in southeastern Nigeria, Warri and Calabar in southsouthern Nigeria, to assess solar energy in these cities. Sanusi and Abisoye (2011) evaluated the behaviour of three empirical models based on the difference between maximum and minimum temperatures to analyze solar radiation in Ibadan city of southwestern Nigeria. Gana et al. (2014) assessed the potentials for solar energy development in Kebbi town of Northwestern Nigeria using ground measurement for the period of fifteen years. Their results showed variation of direct and diffuse components of solar radiation in summer and winter months. Also, Innocent et al. (2015) used Angstrom-Prescott model to estimate the global solar radiation based on the monthly mean sunshine hours recorded for six years in Gusau town of Northwestern Nigeria. They found that the values of global solar radiation for the town ranged from 16.17 to 21.65MJ/m^2/day over the period of study with mean value of 18.80MJ/m^2/day, which was found to be sufficient for exploiting solar energy in the area.

In addition, Okoye et al. (2016) modeled the solar potentials of some Nigerian cities using synthetic hourly meteorological data for a complete year. They found that on an annual basis, the average daily global horizontal solar radiation in Kano state was 6.08kWhm^{-2} which is quite significant for solar energy development and utilization. Likewise, Sulaiman and Umar (2017) compared different empirical models based on Angstrom-Prescott model to estimate the monthly average daily global solar radiation on a horizontal surface for Sokoto State in Northwestern Nigeria, using sunshine duration, relative humidity and temperature. The selected models were compared on the basis of the statistical error tests. Based on the statistical results, a new linear model based on modified Angstrom model was recommended to estimate monthly average daily global solar radiation for Sokoto State and areas with similar climatic conditions where the radiation data is unavailable.

A review of the above mentioned studies showed that they employed various statistical techniques to model solar radiation directly from insolation data, or, indirectly from other climatic variables. However, an alternative approach to solar radiation modeling is the application of geospatial techniques to analyze solar energy potentials in an area or region. Geospatial analysis comprises of spatial analysis and associated modeling techniques that are provided within the Geographic Information Systems (GIS) and associated software for the analysis of geospatial data (De Smith et al., 2015). Ramachandra and Shruthi (2007) and Ramachandra (2007) demonstrated the application of GIS as an alternative method in analyzing spatial variation in solar energy potentials in Karnataka State of India, and its ability in determining the most suitable locations for harnessing solar energy in an area or region. Basir et al. (2013) employed Remote Sensing and GIS techniques in identifying the areas with maximum solar energy potentials in Pakistan. Also, Hermann et al. (2014) used a GIS-based approach to estimate the renewable energy potential in Africa. Their findings revealed that solar energy resources have significant potentials in large parts of the continent but with remarkable differences when applied through different solar technologies.

The aim of this study is to analyze solar radiation in Kaduna State of Northwestern Nigeria using geospatial techniques with a view to reveal the solar energy potentials in the state which can be used as an alternative renewable energy source to facilitate socioeconomic development in the area. The objectives of this study are to:

i. analyze spatially solar energy potential in Kaduna State using both ground measurement and satellite solar radiation data.
ii. compare and contrast between ground measured and satellite solar radiation data.
iii. identify the optimum solar energy potential sites for solar energy development in the area.

1.1 The Study Area

Kaduna State is located on the "High Plains of Northern Nigeria" which lies on altitude of between 450 to 745m above sea level (Udo, 1970). It is located between Latitudes 9°01′ to 11°34′ North of the Equator and Longitudes 6°11′ and 8°49′ East of the Greenwich Meridian as shown in Figure 1.

Figure 1: Nigeria Showing Kaduna State

The area is underlain by the Precambrian Basement Complex Rocks. The climate of the area is described as Aw (tropical continental) based on Koppen's classification, characterized by alternating wet and dry seasons. The rainy season is heavily influenced by the Tropical Maritime airmass from the Atlantic Ocean, while the dry season is accompanied by a dust laden wind from the Sahara desert, known as Harmattan, which is brought by the Tropical Continental airmass (Eludoyin, 2011). The Harmattan greatly reduces the amount of solar radiation received in the area. The Northern Nigeria is generally characterized by a northward increase in temperature extending from July to September before a reverse in trend in the month of October (Adefolalu, 2007). The mean monthly temperature in the area is about 27°C but higher between the months of March and May, representing the hot dry season. The mean annual rainfall in the area is 1187.5 mm (Obot et al., 2010).

The area is characterized by leached ferruginous tropical soil and hydromorphic soils (*Fadama*) (Federal Fertilizer Department, 2012). The natural vegetation of the study area is the north guinea savannah type (Jackson, 1970). The common tree species found in the area include *Acacia senegalensis, Adansonia digitata, Isoberlinia doka, Pekia bigloboza*.

Kaduna State comprises of 23 Local Government Areas (LGAs) with an estimated population 6,066,562 according to the National Population Commission (NPC, 2006). The projected population of the state in 2017 is 8,359,668. There are several economic activities engaged by people in the area which include civil service, agriculture, business activities, technical, as well as craft industries in the area. There is a large population in the rural areas engaged in subsistence agriculture. Agriculture remains one of the major economic activities in the area because the area is blessed with vast fertile agricultural land for the production of different varieties of crops like rice, maize, millet, guinea corn sorghum and wheat. In addition, there are several animal species found in the area. The study area is endowed with a number of flourishing markets, several commercial banks, industrial estates and several textile industries (Ministry of lands and survey, 1996). However, most of these industries have grounded due to lack of stable electricity in the area.

2. MATERIALS AND METHODS

2.1 Types and Sources of Data

The study used both ground measurements of solar radiation obtained from the Nigerian Meteorological Agency (NIMET) and satellite solar radiation data obtained from National Aeronautics and Space Administration Surface Meteorology and Solar Energy (NASA SSE). The ground-measured solar radiation data were obtained in millijoule per meter square per day ($MJ/m^2/day$) which were converted into kilowatt hour per meter square per day ($kWh/m^2/day$) using the International Energy Agency (IEA) General Converter for Energy to achieve uniformity with the satellite data.

2.2 Methods of Data Analysis

Geospatial techniques were applied to map solar energy potentials using the ground-measured and the satellite data of the study area. Specifically, the Inverse Distance Weighted (IDW) interpolation was used to generate the solar radiation map. This was achieved using the Spatial Analyst tool in ArcGIS software. The solar radiation data were arranged in Microsoft Excel, saved as coma separated values (csv) and imported into the ArcGIS environment as points, using these points, the interpolation was carried out to produce the solar radiation map.

In order to identify the solar energy potential sites, the map of the study area was used to delineate the Digital Elevation Model (DEM) of the area from Shuttle Radar Topographic Mapper (SRTM) data in ArcGIS environment. Then the maps were georeferenced based on the WGS 1984 Geographic coordinate system. Then, the slope and aspect maps of the area were generated from the DEM. Then, the solar radiation map, the DEM, the slope and aspect maps were ranked based on the Analytic Hierarchy Process (AHP). Finally, the solar radiation map, the DEM, the slope and aspect maps were integrated using weighted overlay to produce the map of solar energy potential sites in the area. In order to determine the amount of exploitable power in the study area, the following formula was used: Cross sectional area X the average power intercepted at any time (Electropaedia, 2016).

3. RESULTS AND DISCUSSION

3.1 Pattern of Solar Radiation in Kaduna State

Comprehensive knowledge of the spatiotemporal pattern of monthly mean daily values of global solar radiation reaching the Earth's surface is required in the design and development of solar conversion devices (Rehman and Ghori, 2000). Table 1 shows the pattern of monthly mean solar radiation in Kaduna State based on the ground measurement and the satellite data. This is because satellite data is presently one of the major sources of solar radiation data.

Table 1: Ground-measured and Satellite Monthly Mean Daily Values of Global Solar Radiation (kWh/m²/day) in Kaduna State for 1986-2015

Source	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	De
Ground	6.08	6.53	7.00	6.73	6.25	5.94	5.33	4.92	5.81	6.37	6.48	6.1
Satellite	5.76	6.1	6.32	6.3	5.94	5.4	4.8	4.47	5.11	5.63	6.11	5.7

Source: NIMET and NASA SSE (2015).

It can be observed from Table 1 that a maximum monthly mean solar radiation value of 7.00kWh/m^2/day was recorded in March based on the ground measurement. It is also observed from Table 1 that the maximum solar radiation values were constantly recorded between March and April in Kaduna State. This can be attributed to the fact that the months of March, April and May fall within the period of longer days and shorter nights experienced in the northern hemisphere. A longer day implies longer sunshine hours per day. Under normal conditions, the longer the period of sunshine and shorter the night, the greater the amount of solar radiation received in an area (Rajan, 2017). Results also showed that based on the ground measurements of solar radiation in the study area as presented in Table 1, a minimum monthly mean solar radiation value of 4.92kWh/m^2/day was recorded in the month of August.

Analysis of the satellite-derived solar radiation in the study area as shown in Table 1 revealed that the minimum insolation of 4.47kWh/m^2/day was also recorded in the month of August. It is also observed that in Kaduna State, the insolation remains high during the months of February, March and April. This can be accounted for the increasing sunshine hours observed from the winter solstice (December 22) till the summer solstice (June 21) in the northern hemisphere.

Findings revealed that even the minimum solar radiation of between 4.47-4.92 kWh/m^2/day received in Kaduna State during the months of July and August is significant for harnessing solar energy in the area. The minimum solar radiation value is attributed to the effect of cloud during the rainy season in the area. The maximum solar radiation value of 7kWh/m^2/day recorded in March is an evidence of high solar energy potentials in the area.

3.2 Comparison between Ground Measured and Satellite Solar Radiation Data

Based on the two sources of data (ground-measured and satellite-derived), the minimum insolation values in Kaduna were recorded during the month of August as shown in Table 1. The minimum ground-measured insolation value was found to be 4.92kWh/m^2/day while the corresponding satellite-derived value was 4.47kWh/m^2/day. It is observed that the difference between the minimum ground-measured and the corresponding satellite-derived solar radiation value is about 0.45kWh/m^2/day.

Analysis of the differences between the ground insolation data and the satellite insolation data showed that in Kaduna State, the minimum differences of 0.32 and 0.31kWh/m^2/day were recorded in May and January respectively, while the maximum differences of 0.70 and 0.74kWh/m^2/day were found in September and October respectively (derived from Table 1).

Comparison of the two sources of solar radiation data as presented in Figure 2 suggests some level of correlation between the satellite-derived and the ground-measured solar radiation data. This correlation was tested using scatter plots in Figures 3, the correlation was found to be positive suggesting that the relationship between the ground-measured and the satellite-derived solar radiation data is strong. This implies that in the absence of one source of solar radiation data, the other source can reliably serve as an alternative.

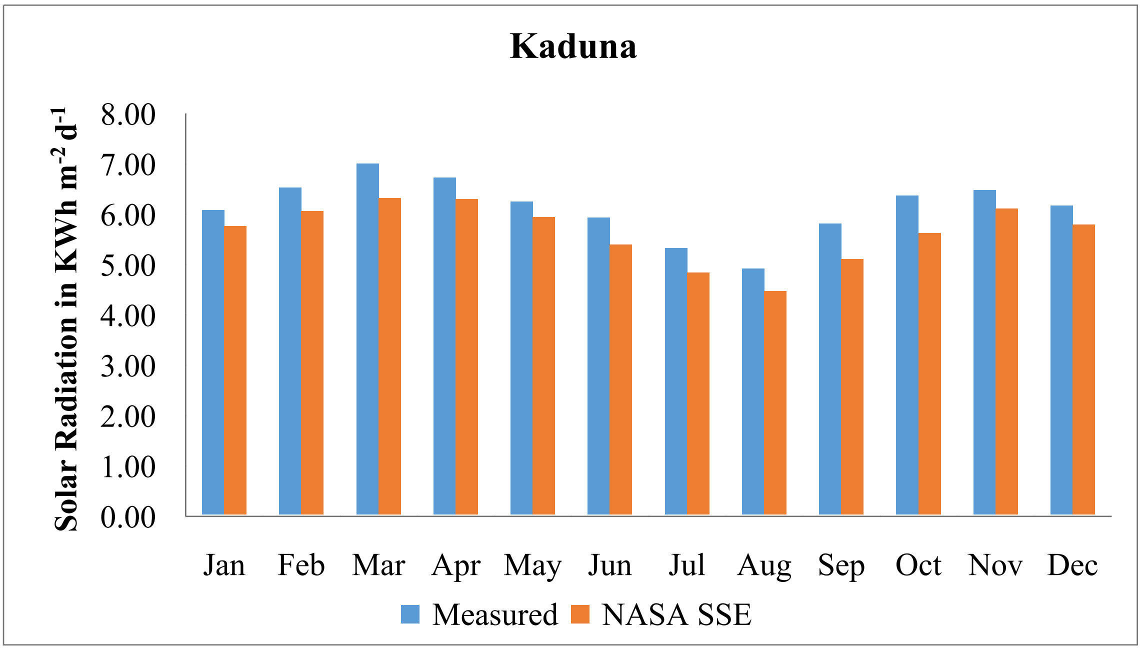
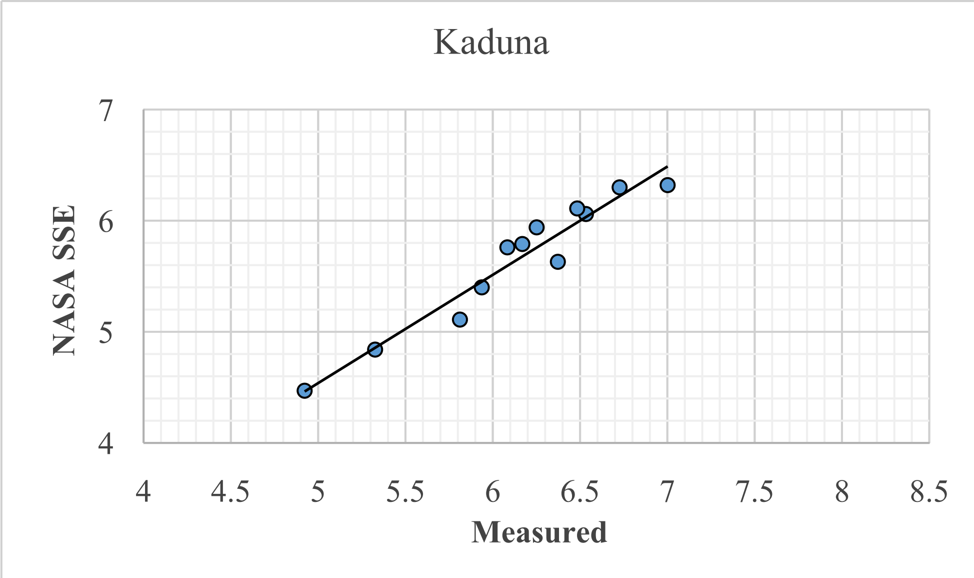


Figure 2: Monthly Mean Daily Values of Global Solar Radiation in Kaduna (kWh/m^2/day)



.

Figure 3: Comparison between the Two Sources of Solar Radiation Data in Kaduna State

Although efforts are being made by Kaduna State government to install Photovoltaic (PV) powered street lights, little effort has been made to harness the abundant solar energy potentials in a large scale. The level of solar energy potential across the state as discovered by this study suggests that there is the need to harness solar energy using Photovoltaic solar technology or Concentrating Solar Power on a large scale. This can be used as an alternative source of power in the state and can be privatized to generate revenue for the government.

3.3 Solar Energy Potential Sites in Kaduna State

Figure 4 shows that Kaduna State can be divided into three classes based on solar energy potentials. These are areas with very high solar energy potentials which include Kubau, Lere, Zangon Kataf, Kauru and Ikara Local Government Areas (LGAs). These are the most suitable areas for harvesting solar energy in the state.

Areas with high solar energy potentials which are: Giwa, Igabi, Kaduna South, Kaduna North, Zaria, Soba, Kajuru, Kachia, Kudan, Kaura, Makarfi and Jaba LGAs. Areas with moderate solar energy potentials which are: Birnin Gwari, Chikun, Kagarko, Jama'a and Sanga LGAs. This is an indication that most areas in Kaduna State are good for deploying solar energy technology to harness solar energy.

3.4 Available Solar Power in Kaduna State

Knowledge of the average solar radiation received in an area and the cross sectional area extent is required in order to estimate the available solar power in the area (the average power intercepted at any time). This is illustrated below:

Since Kaduna state's cross sectional area =46,053km^2;

and the average solar radiation in Kaduna = 5.1kWh/m^2/day;

thus, the average power intercepted at any time in the state =46,053X5.1

= 234870.3X 10^6= 234.870 X 10^9 kWh

= 234.870 X 10^6 MWh

= 20,195,184.867 tonne of oil equivalent.

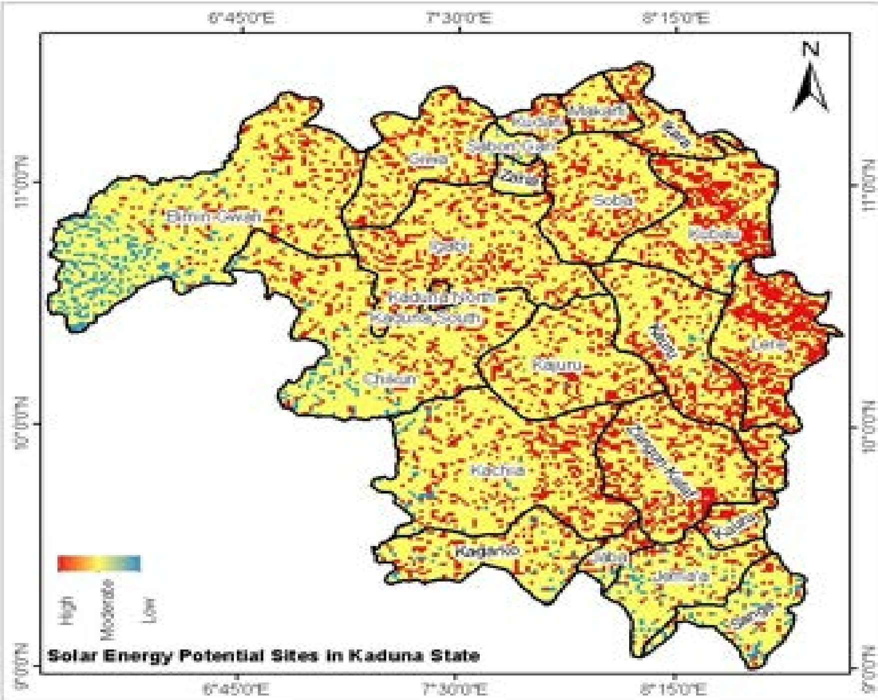


Figure 4: Solar Energy Potential Sites in Kaduna State

4. CONCLUSION

Based on the satellite data, the maximum insolation value recorded in Kaduna State was found to be 6.32kWh/m^2/day in March and April, while the minimum insolation received in in the state was found to be 4.47kWh/m^2/day in August.

Based on the ground measurements, the minimum insolation value recorded in Kaduna State was 4.92kWh/m^2/day in August, while the maximum insolation value recorded in the state was 7.00kWh/m^2/day in March. The correlation between the satellite and the ground insolation data was found to be positive. These suggest that Kaduna has enormous solar energy potentials.

Analysis showed that Kaduna State can be divided into three classes in terms of solar energy potentials which are areas of very high, high and moderate solar energy potentials which are spread across the 23 Local Government Areas of the state. The maximum insolation values in Kaduna State were recorded between March and May. Therefore, the optimum times for harnessing solar energy in the area are the months of March, April and May.

REFERENCES

Adefolalu, D. O. (2007). “Climate change and economic sustainability in Nigeria”, Paper presented at the *International Conference on Climate Change and Economic Sustainability* held at Nnamdi Azikiwe University, Enugu, Nigeria. June, 2007, 1-12.

Augustine, C. and Nnabuchi, M. N. (2009). Relationship between global solar radiation and Sunshine hours for Calabar, Port Harcourt and Enugu, Nigeria. *International Journal of Physical Sciences*, 4(4): 182-188.

Basir, R., Aziz, N., Ahmad, S.S. and Wahid, A. (2013). Satellite remote sensing for identification of solar potential sites in Pakistan. *International Journal of Basic and Applied Sciences*, 2(2): 200-209.

De Smith, M. J., Goodchild, M. F. and Longley, P. A. (2015). *Geospatial Analysis: A Comprehensive Guide to Principles, Techniques and Software Tools*. Fifth Edition. TheWinchelsea Press, Winchelsea, UK.

Electropaedia (2016). *Solar Power (Technology and Economics).* Retrieved on 16/01/2016 from http://www.mpoweruk.com/solar_power.htm

Eludoyin, O. M. (2011). Air Temperature and Relative Humidity Areal Distribution over Nigeria. *Ife Research Publications in Geography,* 10(1): 134-145.

Federal Fertilizer Department. (2012). *Fertilizer Use and Management Practices for Nigeria*. Federal Fertilizer Department, Federal Ministry of Agriculture and Rural Development, Abuja, Nigeria, pp: 1-215.

Gana, N. N., Rai, J. K. and Momoh, M. (2014). Estimation of Global and Diffuse Solar Radiation for Kebbi, North-Western, Nigeria. *International Journal of Scientific & Engineering Research,* 5(1): 1654-1661.

Hermann, S., Miketa, A. and Fichaux, N. (2014). *Estimating the Renewable Energy Potential in Africa, IRENA-KTH working paper*. International Renewable Energy Agency, Abu Dhabi.

Ibrahim, K. and Mohammed, B. M. (2015). Rising Temperature: Evidence of Global Warming in Northern Nigeria. *Journal of Environment and Earth Science*, 5(22): 50- 55.

Innocent, A. J., Jacob, O. E., Chibuzo, G. C., James, I. and Odeh, D. O. (2015). Estimation of Global Solar Radiation in Gusau, Nigeria. *International Journal of Research in Engineering & Technology*, 3(2): 27-32.

Jackson, G. (1970). “Vegetation around the city and nearby villages of Zaria”. In: Mortimore, M. J. (1970). *Zaria and its Region* (Ed.), Occasional Paper No.4 Department of Geography. A.B.U, Zaria. Pp. 191.

NASA SSE (2016). *A renewable energy resource web site (release 6.0)* sponsored by NASA's Applied Science Program in the Science Mission Directorate developed by POWER: Prediction of Worldwide Energy Resource Project. http://eosweb.larc.nasa.gov/sse

Obot, N. I., Chendo, M. A. C., Udo, S. O. and Ewona, I. O. (2010). Evaluation of rainfall trends in Nigeria for 30 years (1978-2007). *International Journal of the Physical Sciences*, 5(14): 2217-2222.

Oghogho, I., Sulaimon, O., Adedayo, B. A., Egbune, D. and Kenechi, A. V. (2014). Solar energy potential and its development for sustainable energy generation in Nigeria: A road map to achieving this feat. *International Journal of Engineering and Management Sciences,* 5(2): 61-67.

Oji, J. O., Idusuyi, N., Aliu, T. O., Petinrin, M. O., Odejobi, O. A., Adetunji, A. R. (2012). Utilization of Solar Energy for Power Generation in Nigeria. *International Journal of Energy Engineering*, 2(2): 54-59.

Okoye, C. O., Taylan, O. and Baker, D. K. (2016). Solar energy potentials in strategically located cities in Nigeria: Review, resource assessment and PV system design. *Renewable and Sustainable Energy Reviews*, 55(C): 550-566.

Omokaro, O. (2008). Energy Development in a Fossil Fuel Economy: The Nigeria Experience. *One-day Conference/Workshop of West African Quaternary Research Scientists*, City of Ibadan, Nigeria. pp.8. www.credcentre.org

Rajan, D. (2017). *What are the factors affecting the distribution of insolation?* Retrieved on 14/04/2017 from http://www.preservearticles.com/2011111217104/what-are-the-factors-affecting-the-distribution-of-insolation.html

Ramachandra, T.V. (2007). Solar energy potential assessment using GIS. *Energy Education Science and Technology*, 18(2): 101-114.

Ramachandra, T.V. andShruthi B.V. (2007). Spatial mapping of renewable energy potential. *Renewable and Sustainable Energy Reviews*, 11, 1460-1480.

Rehman, S. and Ghori, S.G. (2000). Spatial estimation of global solar radiation using geostatistics. *Renewable Energy*, 21, 583-605.

Sanusi, Y. K. and Abisoye S. G. (2011). Estimation of Solar Radiation at Ibadan, Nigeria. *Journal of Emerging Trends in Engineering and Applied Sciences (JETEAS),* 2(4):701- 705.

Sulaiman, M. Y. and Umar, A. B. (2017). A Comparative Analysis of Empirical Models for the Estimation of Monthly Mean Daily Global Solar Radiation Using Different Climate Parameters in Sokoto, Nigeria. *International Journal of Marine, Atmospheric & Earth Sciences*, 5(1): 1-19.

Udo, S.O. (2002). Contribution to the Relationship between Solar Radiation and Sunshine Duration in the Tropics: A Case Study of Experimental Data at Ilorin, Nigeria. *Turk J Phys,* 26, 229-236.

Vincent-Akpu, I. (2012). “Renewable energy potentials in Nigeria”. 'IAIA12 Conference Proceedings' Energy Future: The Role of Impact Assessment. *32nd Annual Meeting of the International Association for Impact Assessment.* Centro de Congresso da Alfândega, Porto-Portugal.

Savanna volume 23, Number 1, June, 2016

Geostatistical Approach to Crime Mapping in Kaduna South of Kaduna State, Nigeria

Hafiz Aminu Umar* and Sadiq Abba Gana
Department of Environmental Management and Toxicology,
Federal University, Dutse
**abdulhafizamin@yahoo.com*

ABSTRACT

In this study, two geostatistical techniques (Getis-Ord Gi* and Kernel Density) were used to determine the spatial distribution and pattern of crime hotspots in Kaduna South Local Government Area in northwestern Nigeria. In addition, the two geostatistical techniques were compared and used to analyze the spatial pattern of crime in the area. The advantages and disadvantages of the two techniques were highlighted; and appropriate locations for siting new police stations in the area were recommended.

Keywords: Crime mapping; Geostatistical techniques; Getis-Ord Gi*; Kernel Density.

1. INTRODUCTION

The central role of government as enshrined in the Nigerian Constitution is to provide maximum security to its citizenry. However, the situation in Nigeria has taken a different dimension as crime is increasing at an alarming rate in spite of the efforts of the law enforcement agencies to address the situation. In fact, the level of insecurity in Nigeria remains an obstacle to the progress and development of the country (Balogun et al., 2014). This is because crimes are committed on the daily basis and offenders are sometimes committing such crimes with impunity in Nigeria (Akhavan, 2001). This cannot be unconnected with the traditional approach used by the various law enforcement agencies to crime detection in Nigeria. However, the advent of computerized crime mapping has become one of the most powerful tools that provide law enforcement agencies with sophisticated tools in fighting crime and devise a means for crime prevention (Santos, 2012). Geographic Information Systems (GIS) provide a powerful tool for representing crimes in an analytical and descriptive way. Basically, the application of GIS in crime analysis is to complement traditional policing goals by allowing law enforcement agencies to choose where to target their efforts and resources appropriately. Crime analysis identifies patterns and trends in crime data (Boba, 2001).

A good understanding of crime data is required for effective crime management (Odumosu, 1999). GIS as a computerized tool for the analysis of geospatial data can be used effectively to study and understand crime data. GIS can be used for crime mapping, crime hotspots identification, and crime analysis which are essential for effective crime management. A crime hotspot is a location within the identifiable boundary that depicts a concentration of criminal activities (Anselin, 1995). Early crime analysis methods frequently involved the aggregation of crime to areal units, while modern crime analysis methods utilize GIS technology to identify risk factors and locations that may attract crime. However, crime mapping implementation is relatively low in Nigeria. Few examples can be used in this context. Bala et al. (2014) used GIS to map out crime zone in Katsina state, their findings revealed that theft and stealing were among the highest crime committed in the study area. Similarly, Onyewuchi (2015) developed a crime map of Imo state and concluded that crime mapping is very effective in crime mitigation and control.

In Kaduna state of northwestern Nigeria, criminal elements pose a serious risk throughout the state. Residents have experienced armed robberies, assaults, burglaries, carjacking, rapes, kidnappings, and extortion (Umar et al., 2015). The Nigeria Security Tracker recorded 454 violence-related deaths in Kaduna between May 2011 and August 2013, while the Armed Conflict Location and Event Data Project (ACLED) recorded 140 separate explicitly political incidents of armed violence in the state between 1997 and August 2013 (Taft and Haken, 2015).

Moreover, in Kaduna south local government, a suburb of Kaduna metropolis which is inhabited by multi-ethnic groups living together, crimes are committed on a daily basis since the area provides the kind of atmosphere needed for crime to take place, and a space for a specialized and organized underworld (Osaghae and Suberu, 2005). Despite the efforts of law enforcement agencies to curb the menace of criminal activities in Kaduna South, crime and criminality are on the increase in the area. In view of this, it is crucial to devise a means whereby law enforcement agencies can find the best alternative approach to crime management which usually starts with crime mapping to visualize the rate at which crime is concentrated in a particular area (Odumosu, 1999). This will go a long way in identifying the crime hotspots, facilitate understanding the pattern of crime in the area for proper crime management.

Although studies have been conducted on crime and criminality in some parts of Kaduna State in Nigeria, the use of geospatial techniques is very rare in spite of its capabilities in crime analysis. In this study, geostatistical techniques which employ the application of Gi* and kernel density estimation to determine the spatial distribution of crime hotspots in the Kaduna South were used, and the two approaches (Gi* and kernel density) were compared with a view to understand the spatial pattern of crime in the area and suggest appropriate locations for siting new police stations in the area.

1.1 Study Area

Kaduna South Local Government area (LGA) is one of the 23 LGAs of Kaduna state in northwestern Nigeria. It is bounded by Kaduna North LGA, Igabi LGA to the west and Chikun LGA to the south and east. It is geographically located between Latitudes 9˚54′ and 10˚29′ North of the Equator and Longitudes 6˚59′ and 8˚09′ East of the Greenwich meridian as shown in Figure 1. According to 2006 census, Kaduna south has a population of 402,390, comprising of 210,486 males and 191, 904 females, while population density in the area stands at 0.02 per km^2. The area has a perimeter of about 6148.607 ha. The area is inhabited by different ethnic and religious groups.

2. MATERIALS AND METHODS

2.1 Types and Sources of Data

The crime data used for this study was obtained from the Nigerian Police Headquarters in Kaduna State. Then the Global Positioning System (GPS) was used in order to obtain the coordinates of crime locations in the area. Kaduna street map was obtained from the GIS Laboratory of Ahmadu Bello University, Zaria.

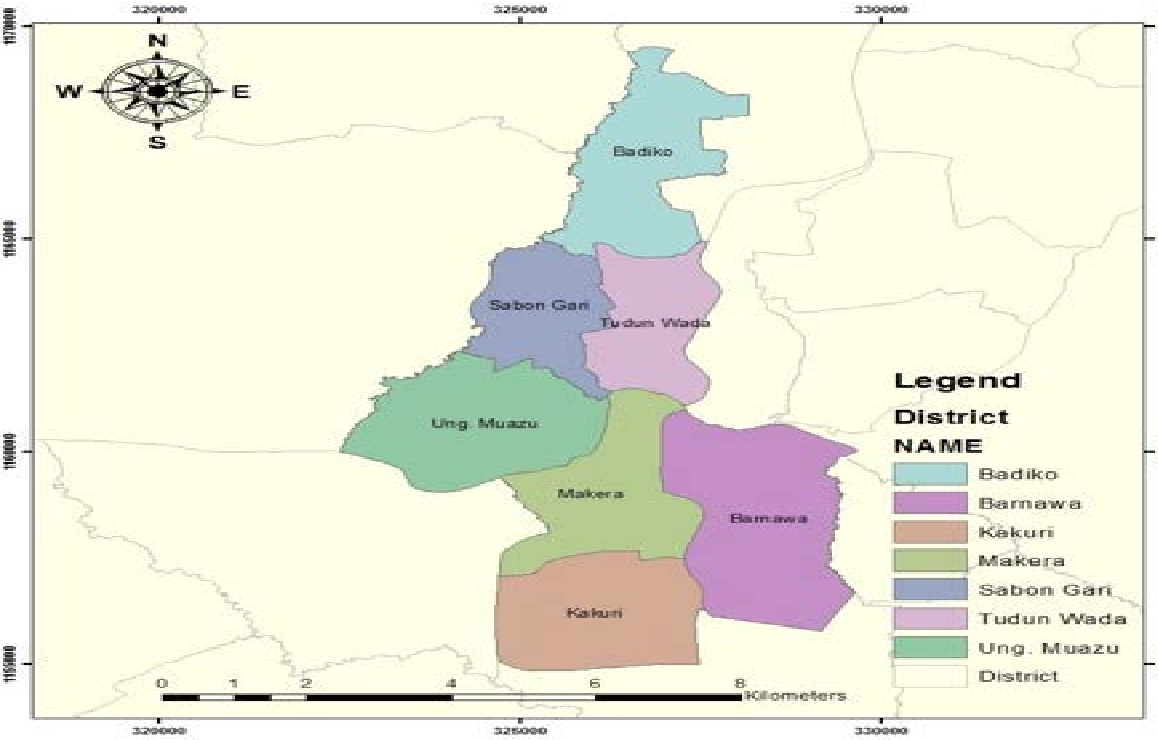


Figure 1: Map of Kaduna South

2.2 Methods of Data Analysis

There are various methods of crime mapping. The choice of which method to employ is guided by the type of data available (incident data, or aggregated data) and the purpose of the map. Common methods of crime mapping include point mapping, ellipse hotspot maps, and Choropleth maps, interpolated or smoothed maps and isoline maps, as well as geostatistical mapping. All of the above methods have advantages and disadvantages. In this study, geostatistical techniques which employ the application of Getis-Ord Gi* and Kernel Density Estimation to determine the spatial distribution and pattern of crime hotspots in the area were used and the two approaches (Gi* and Kernel) were compared to determine the best approach among them. To establish new police stations across the study area, suitability analysis has been carried out using Thiessen polygon and the results show the existing police stations and the proposed ones.

3. RESULTS AND DISCUSSION

3.1 Crime Mapping in Kaduna South

The analysis begins by displaying all the crimes in the study area based on their number of occurrences as can be seen in Figure 2 where seven different types of crimes are shown. The crimes are aggravated assault, car hijacking, grievous harm and wounding, murder, rape, robbery, and terrorism.

Figure 2 represents the percentages of crimes committed in the area. It can be observed that areas around Barnawa, Unguwan Mu'azu and Tudun Wada have dense hotspots of crime indicating a high concentration of hotspots. While areas in Tudun Wada and Sabon Gari have the highest records of crime as it can be observed from the graduation of hotspots from red to yellow in Figure 3. This can be attributed to the higher number of people living in the areas, availability of numerous commercial activities such as banks and markets, as well poverty and high level of illiteracy in the area. As observed by Akintoye (2008) who states that in a country like Nigeria, where poverty and unemployment are endemic, individual citizens are likely to commit one form of crime or the other in order to satisfy their basic needs.

However, the result can be computed statistically (using Z-score statistical significance threshold values) as can be seen below:
90% significant: Gi* z-score > 1.644
955% significant: Gi* z-score >1.960
99% significant: Gi* z-score > 2.576
99.9% significant: Gi* z-score > 3.291.

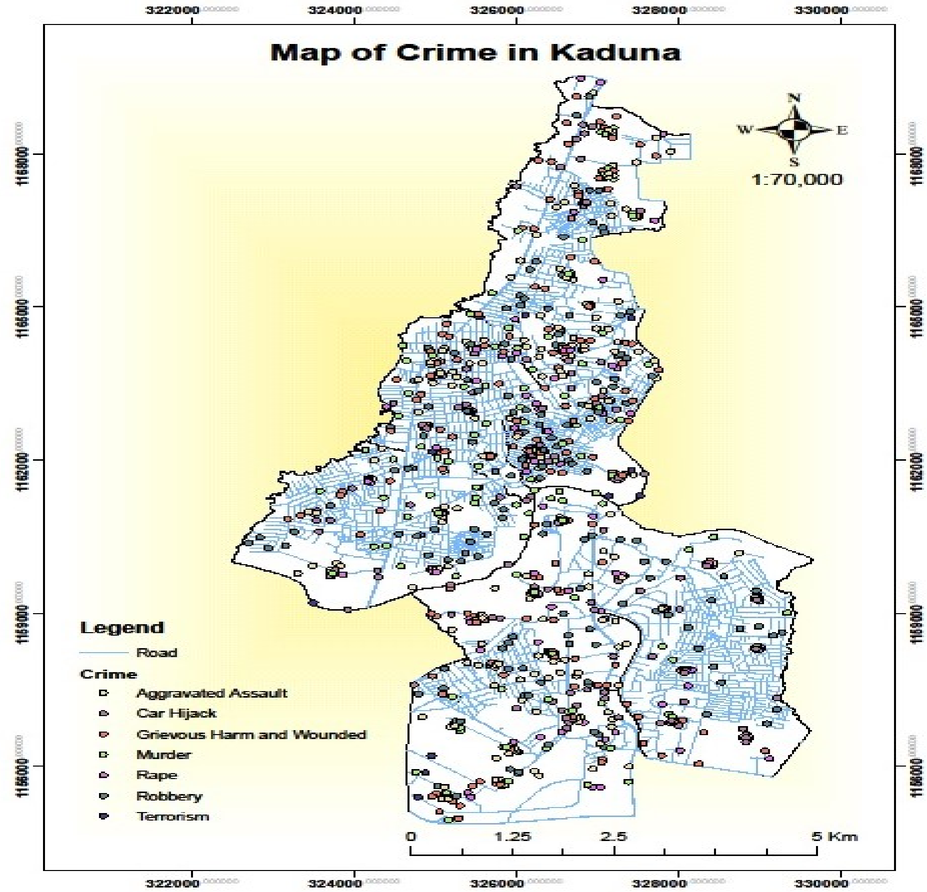


Figure 2: Map of Different Types of Crime in the Study Area

Moreover, it can be observed from the Kernel Density Hotspot Map in Figure 4 that areas around Sabon Gari and Tudun Wada have the highest percentage of crime committed and it reduces towards Unguwan Mu'azu and Barnawa. The graduation of colors shows the density of crime from higher to lower (hotspots to coldspots). Areas with high crimes are considered as "hotspots" while those with low are known as "coldspots".

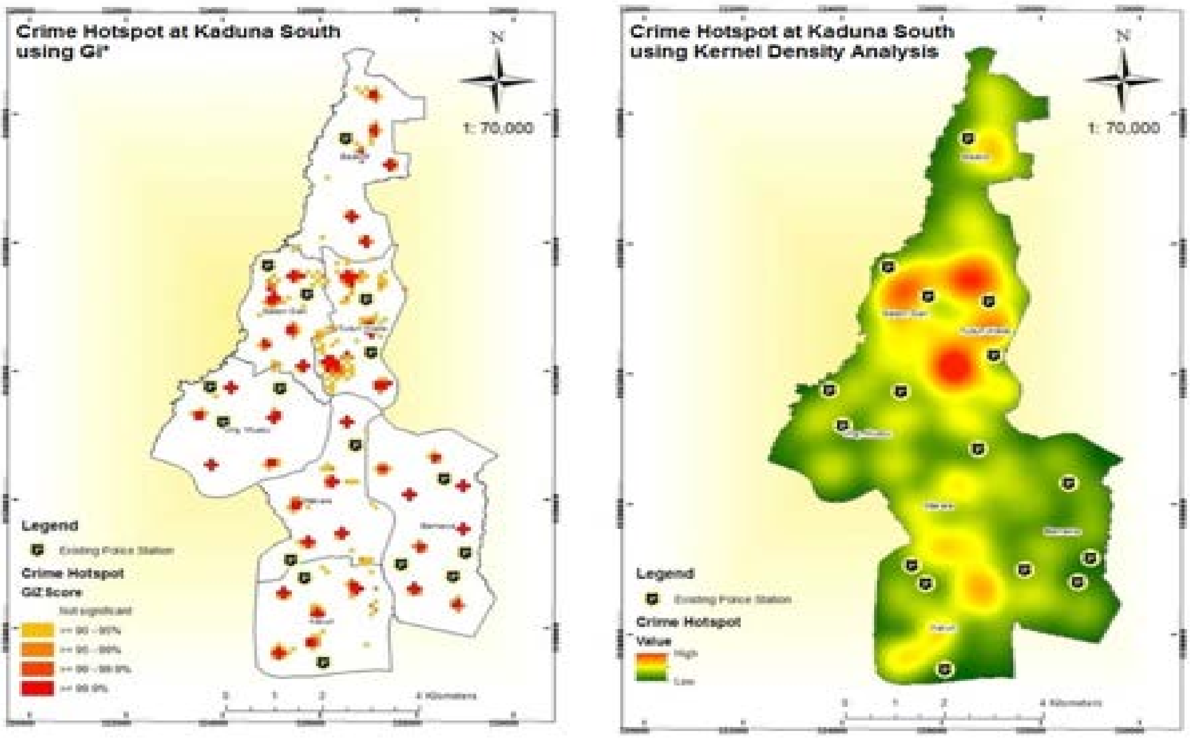


Figure 3: Crime Hotspot Maps

3.2 Comparison between Getis-Ord G* and Kernel Density Estimation

In view of the fact that there are various geostatistical techniques of crime mapping, it is important to compare between them in order to determine the best technique of producing a hotspot map. It was observed that both Gi* and Kernel density can be used to show the density of crime in a particular area, but the problem associated with kernel density (Figure 4) is that in some locations it may smooth across or into areas where there is no record of crime, because it is not constrained to the high detail of underlying geography of crime point distribution. Therefore, crime mappers sometimes have to explain to the police why there is an apparent crime level (shading) in an area where no crime is recorded. On the other hand, Gi* techniques compare local average against global average. But sometimes, where it is impossible for certain crimes to happen (e.g., the incidence of residential burglary in reservoirs, rivers or any area where there is no residential housing) can be identified as the cells cover this area can be extracted from the full grid coverage, so they do not influence the global average.

However, kernel density estimation may smooth away the peaks in areas where large bandwidth aggregated high value with neighbouring low values (see Figure 3). One way of addressing these limitations is to use GIS in suggesting the appropriate locations for new police stations which is presented in the following section.

3.3 Appropriate Locations for Establishing New Police Stations

To suggest the possibility of establishing new police stations across the area starts with the analysis of road network in order to show if there is a need for establishing new police stations across the area. However, the network analysis is used in general concept without considering traffic flow, one way or two ways (FT or TF).

The analysis is meant to show how police can patrol from one location to the other and to see how fast police can reach the crime scene. This will assist in determining the adequacy of the police stations and suggest if there is a need to establish new ones.

3.4 Road Network Analysis

GIS was applied in the production of the road network and composite maps of the study area (Kaduna south local government area) which were used for the network analysis as shown in Figures 5 and 6. The composite map allowed us to see the extent of the survey area along with the landuses and the police stations present. It further revealed that most of the banks are located around Sabon Gari and Barnawa while the markets are mostly situated in Tudun Wada, Makera and Sabon Gari. Also shown on the map is the distribution of various police stations across the study area. It can also be seen that Badikko has the least number of police stations followed by Makera. This calls for the establishment of a more police stations in order to complement the existing ones.

However, the road network map of the study area shown in Figure 5 comprises dual carriage roads as well as major and minor roads. Also, on the map are the names of the busiest roads in the study area. Network analysis is very crucial due to its ability to solve numerous problems, such as finding the most efficient travel routes, generating travel directions, finding the closest facility and defining service areas based on travel time. Prior to network analysis, some operations need to be performed in order to accurately obtain a reliable output, such operations include data cleaning, sometimes referred to as cleaning up bad digitizing, the operation is carried out within ArcGIS software. Most free data contained a lot of geometry problems, therefore, there is a need for thorough cleaning and all the junctions or intersection points also need to be separated in order to allow accessibility.

3.5 Assessing the Sufficiency of Police Stations in the Study Area

From the result of the analysis conducted so far, it is vividly clear that there is a need to increase the number of police stations across the study area in order to complement the effort of the existing ones. Looking at the map, it can be seen that areas around Badikko, Unguwan Mu'azu and Tudun Wada have few police stations, especially Tudun Wada where the population is high. When new police stations are established across the area, it will certainly reduce the magnitude of crime committed and will burst the morals of the officers of Nigeria police stationed across the study area to feel safe and secured in discharging their duties.

Considering the population explosion in Nigeria and the study area, in particular, it will be better if the government employs a large number of people into the Nigerian police so as to complement the effort of the ones presently serving. Security is paramount and it is a foundation for every sustainable development, as both international and local investors will have confidence for investing in a country where peace and stability reign. The suitability map using Theissen polygon in Figure 6 shows the need of establishing new police stations in some areas based on the density of crimes.

Moreover, the Thiessen Polygon in Figure 6 shows the locations of the existing police stations and the proposed new ones. It can be seen from the Figure that areas around Tudun Wada, Barnawa, Makera and Badikko have a high number of crimes, and therefore require the establishment of new police stations across the areas. This would assist in complementing the existing police stations and by so doing, the rate of crime in such areas could be reduced.

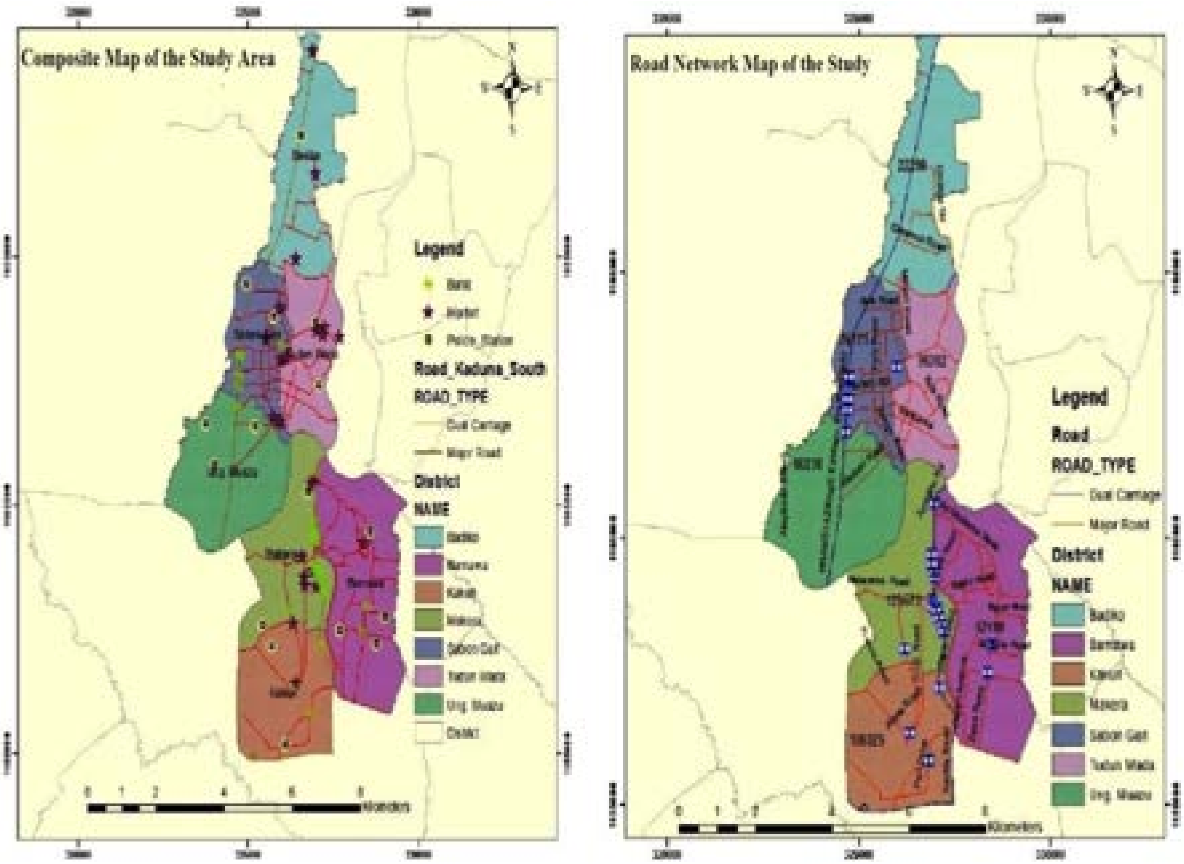


Figure 4: Map of the Study Area

4. CONCLUSIONS

Two geostatistical techniques (Getis-Ord Gi* and Kernel Density) were compared and used for mapping of crime hotspots in Kaduna South. It was observed that both Gi* and Kernel density have the capability to show the aggregate of crime in area of interest, but the drawback of kernel density is that in some locations it may smooth across or into areas where there is no record of crime, because it is not constrained to the high detail of underlying geography of crime point distribution. Therefore, this requires explanation to the police or other map users. While the Gi* techniques compare local average against global average. The disadvantage of Gi* is that it sometimes identifies crime in locations where it is impossible for certain crimes to happen. One way of addressing these limitations is to use GIS in suggesting the appropriate locations for new police stations. Findings revealed that areas around Badikko, Unguwan Mu'azu and Tudun Wada have few police stations. Collectively, Badikko has the least number of police stations followed by Makera. There is therefore the need for more police stations in these areas, especially in Tudun Wada where the population is high.

4.1 Recommendations

It is therefore pertinent for the Nigerian law enforcement agencies to migrate from primitive means of keeping, tracking and analyzing crime data to a more modern digital system by adopting geostatistical techniques and GIS in crime management. In addition, this should be complemented by establishing new police stations across the area, which will certainly reduce the rate of crime committed and will boost the morale of the officers of Nigeria police stationed across the area, to feel safe and secured in discharging their duties.

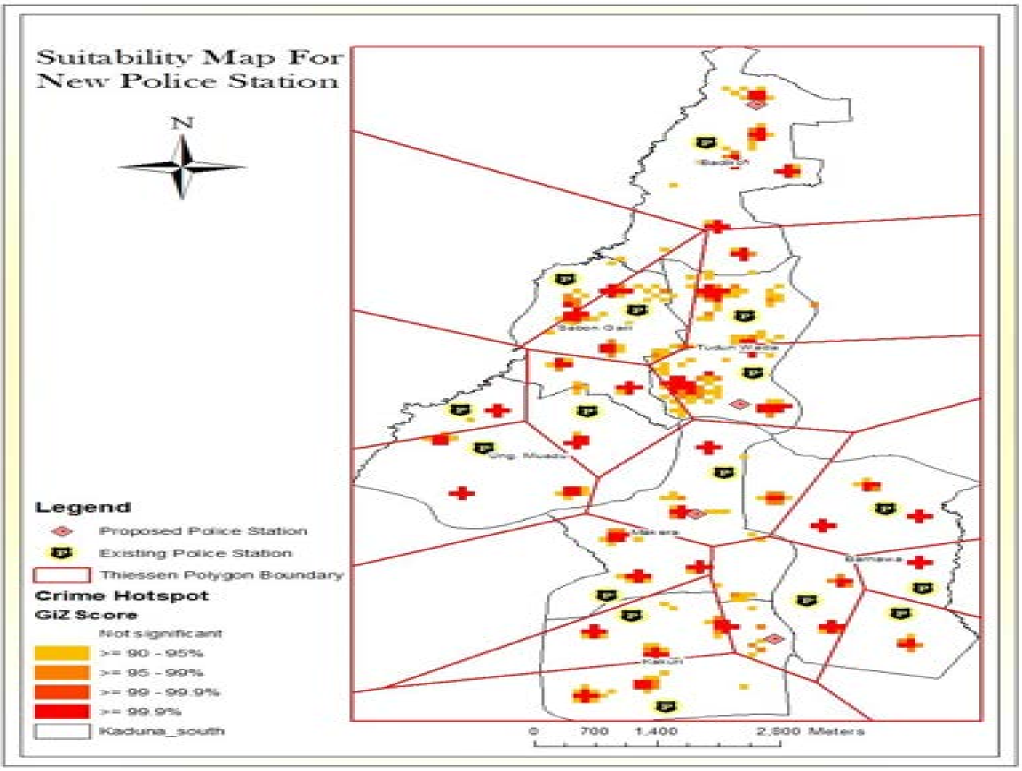


Figure 6: Suitability Map of New Police Stations Using Thiessen Polygon

REFERENCES

Akhavan, P. (2001). Beyond impunity: can international criminal justice prevent future atrocities? *American Journal of International Law*: (2001) 7-31.

Akintoye, I. R. (2008). Reducing unemployment through the informal sector: A case study of Nigeria. *European Journal of Economics, Finance and Administrative Sciences*: (11), 97-106.

Anselin, L. (1995). Local Indicators of Spatial Association - LISA. *Geographical Analysis*: 27(2), 93-115.

Bala, A., Bawa, S. and Lugga, M. (2014). Geospatial Information System for Crime Analysis and Crime Zone Identification - Case Study of Katsina, Nigeria. *Journal of Multidisciplinary Engineering Science and Technology (JMEST)*: 2014, 2(1).

Balogun, T. F., Okeke, H. and Chukwukere, C. I. (2014). Crime Mapping in Nigeria using GIS. *Journal of Geographic Information System*. 2014, 6(14).

Boba, R. (2001). *Introductory guide to crime analysis and mapping*.

Community Oriented Policing Services.U.S.A.

Odumosu, O. F. (1999). Social costs of poverty: The case of crime in Nigeria. *Journal of Social Development in Africa*: 14, 71-86.

Onyewuchi, C. N. (2015). Developing a Crime Mapping GIS System for Law Enforcement: A Case Study of Owerri Metropolis, Nigeria. *International Journal of Computer Applications Technology and Research*: 4(4), 240 - 245.

Osaghae, E. E. and Suberu, R. T. (2005). *A history of identities, violence and stability in Nigeria*. Centre for Research on Inequality, Human Security and Ethnicity, University of Oxford.

Santos, R. B. (2012). *Crime analysis with crime mapping*. Sage.

Taft, P. and Haken, N. (2015). *North Central OverviewViolence in Nigeria* (pp. 51-62), Springer.

Umar, F., Cheshire, J. and Johnson, S. (2015). Understanding the spatial pattern of urban crime: a developing country's perspective.

Savanna volume 23, Number 1, June, 2016

A Geospatial Database for Secondary Schools Facilities in Zaria Education Zone, Kaduna State, Nigeria

Abdulkadir Muhammed Yahaya[1]*, Ibrahim Musa Jaro[2] and Binta Abdulkarim[3]

[1]*Department of Geography, Federal College of Education, Zaria*
[2]*Department of Geography & Environmental Management, Ahmadu Bello University, Zaria*
[3]*Department of Science Education, Ahmadu Bello University, Zaria*
*abdulkadirmuhammed2@gmail.com

ABSTRACT

The National Policy of Education in Nigeria contends that the success of education for all hinged on proper planning and effective location of school facilities with a data management. This paper focused on the creation of geospatial database for effective management of secondary schools facilities in Zaria Education Zone. The aim of the study was achieved through identification of public secondary schools in the study area by means of mapping using their geographic coordinates. The spatial locations of the schools were complemented with the attribute data of some basic facilities in creation of the geospatial database for the schools. Some attribute data were obtained from Zaria Education Zone verified through administration of checklist to the schools heads and completed during field observation. A satellite image of the study area was obtained using Google pro to derive the maps through digitizing process. Finally, a geospatial database was created with the spatial and attribute data encoded; and analysis carried out using ILWIS 3.3 software. The result of the analysis showed a clustered distribution of schools in Zaria and Sabon-Gari parts of the study area, while it was dispersed in Soba Local Lovernment Area. The database also provides the users with a working environment for data management. It was recommended that more schools, classes, facilities and staff should be provided by government in the deficit areas.

Keywords: Geospatial database; GIS; Secondary Schools; Zaria Education Zone.

1. INTRODUCTION

Education in Nigeria is managed by the three tiers of governments (the Local, the State and the Federal). The Federal Ministry of Education takes responsibility for the policy formation and implementation at regional and national levels while state and local governments look after the local level. The education system is divided into Kindergerten or Nursery, Primary Education, Secondary Education and Tertiary Education with hierarchy of systems in operations (Kayode, 2006). A lot of effort has been made to measure universal education in Nigeria, one of them being 4-3-3-6 system, but it was reported that the realization of Education For All (EFA) will remain a dream as long as there is imbalance in the distribution of educational facilities (Kayode, 2006).

The National Policy on Education (2004) posits that the success of education to be achieved by all groups (boys and girls) is hinged on proper planning, efficient administration, adequate planning and effective location/siting (Kamla, 2009). Within this context, the framework of action adopted at the World Education Forum in Dakar in 2000 to the goal of EFA was reaffirmed by Nigeria (Mark and Varghese, 2011).

Ogunsaju (1980) and Asiabaka (2008) reported that the quality of education that students receive bears direct relevance to the availability or lack of physical facilities and overall atmosphere in which learning takes place. These facilities play a pivotal role in the actualization of educational goals and objectives by satisfying the physical and material needs of teaching and learning educational facilities, which were referred to by

Adepoju and Fabiyi (2000), and Amnesty International (2012) as the basic structures necessary for learning. The facilities include school buildings, furniture, laboratories, instructional materials, computer facilities, libraries, sport facilities, etc.

Thompson and Hardin (2000) posited that the quality of planning and decision making process are strongly influenced by the data availability and data completeness and can be influenced by Geographic Information System (GIS). Watanbe (1992) and John (1996) reported that effective use of GIS by educators and planners to establish the location coordinates and distribution pattern of schools with details characteristics of students' enrolment, class sizes, school accessibility and transportation networks that convert and integrate school data into digital for further analysis is highly needed. GIS can be used in school mapping. The most important goal of school mapping is to identify the location and accessibility of the school facility as well as the pattern of schools over space (John, 1999). GIS as a technique has a number of possibilities to improve education at micro planning (DeGrauwe, Anfield, Tamiro and Parolin, 2002).

Students' enrolments into primary, secondary and tertiary institutions in Zaria have increased exponentially overtime. So also the demand for physical structures like classrooms, laboratories, field plots and administrative buildings that put pressure on school resources as well as the space needed for buildings. While the need for space in schools increases, the population increase in urban Zaria has stretched the sanity of locations and physical planning of schools. Commercial buildings have distorted the beauty of educational institutions, made their visibility obscured and complicated location of facilities. The challenges of physical planning are also compounded by the inability of the Kaduna State Ministry of Education to provide the public with the exact spatial extent of her Secondary Schools and the database for the physical facilities. More so, there are no GIS facilities in these schools that would provide the spatial location and the physical database for planning (Abdulkarim, 2004 and 2006). In addition, the available record with the Education Zone is analogue with no provision for modernizing it. This study seeks to create a geospatial database for secondary school facilities in Zaria Education Zone with a view to providing necessary information for effective planning and management.

1.1 The Study Area

The study area is Zaria Education Zone. It is one of the many Education Zones in Kaduna State others include: Giwa Education Zone, Anchau Education Zone, Rigachikun Sabon Tasha Education Zone, Kafanchan Education and others. It is situated between latitude 11°15′ - 11°3′N and longitude 7°3′E - 7°45′E. It extends from Zaria Local Government Area (LGA) to parts of Soba, Sabon Gari and Kudan LGAs. It is bounded to the northwest by Giwa LGA and Katsina State, Igabi LGA to the southwest, Kauru LGA to the south, Kubau LGA to the southeast and Ikara and Makarfi LGAs to the northeast as shown in Figure 1. The study area falls within the Tropical Continental Climate region with pronounced dry and rainy season. It is characterized by hazy to dusty conditions and low temperatures, as low as 10°C at night during dry season. In the afternoons, up to 42°C temperature is sometimes recorded. The rainy season lasts from May to September/October with long-term annual rainfall of 1035 mm in about 90 days (Abaje, Ishaya and Abashiya, 2016).

The vegetation of the study area falls within the guinea savanna zone which is characterized by grassland with scattered trees and woody shrubs vegetation. There are farms, gardens, mangoes trees, silk cotton and baobabs, shrubs and a number of grasses. However, increase in human population with its resultant demands for housing and fuelwood have great impact on the natural vegetation thereby reducing it drastically (Lawal, 2008).

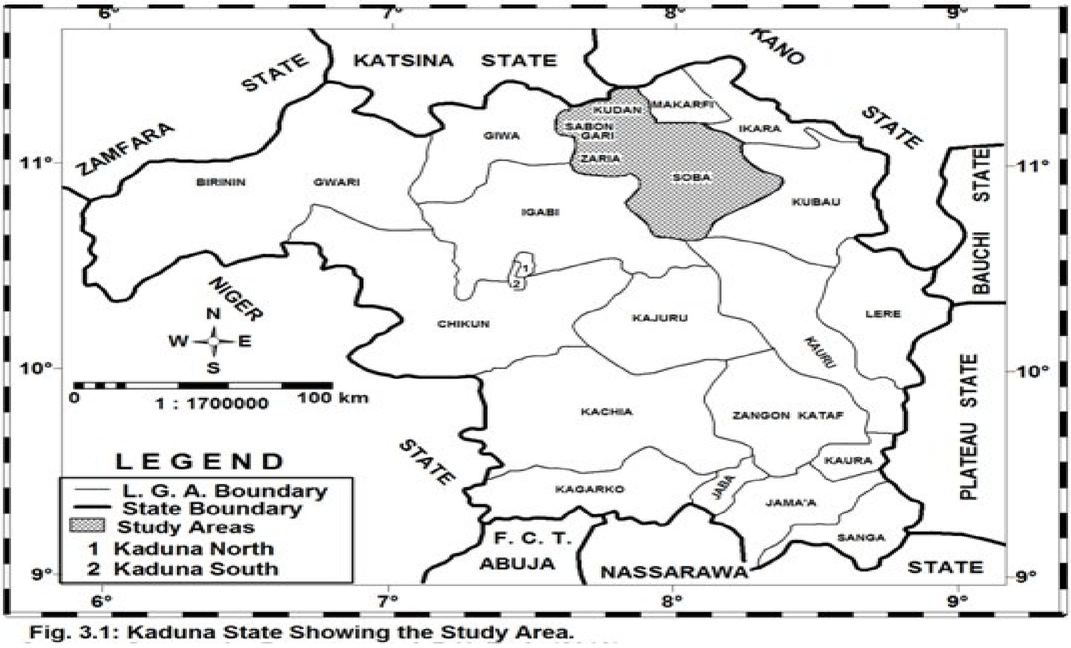


Figure 1: Kaduna State Showing the Study Area

2. MATERIALS AND METHODS

2.1 Types and Sources of Data

The list of schools was sourced from Zaria Education Zone and a checklist was prepared by the researchers. Field survey was carried out to obtain information on location of schools using Handheld Global Positioning System (GPS)-Garmin 75S receiver, and data on number of classrooms, number of teachers, minimum distance to schools, maximum distance to schools, and facilities in schools were verified with the checklist. The checklist provided a platform for comparison with the lists of facilities of Secondary Schools obtained from Zaria Education Zone. Besides, interview was conducted with stakeholders in the area.

2.2 GIS Processing and Database Creation

This involves digitizination process. In digitizing the domain classes, the Google satellite image of the area was used to map the features. The coordinates of the image were acquired, and then the image was georeferenced using Minna Zone 32 before digitizing exercise started by creating the segments, the polygons, the lines and the points. A layout was then created to merge the polygons, the lines and the points in ILWIS 3.3. On-screen digitizing was carried out to collect all relevant vector based data. In addition, kennel density estimation method was used in ArcGIS10.1 software to analyze the spatial distribution of schools in the area. In creating the geodatabase, attribute tables were created using Microsoft Excel and data on number of classrooms, number of teachers, minimum distance to schools, maximum distance to schools, facilities in schools were entered into the tables and then imported into GIS environment to create a geospatial database of the schools.

3. RESULTS AND DISCUSSION

On year of establishment, 11 schools were established in 1990, 9 schools were established in 2004, 2 schools were established in 1989, 4 schools were established in 1981 and the oldest school established in the Education Zone was Alhuda Huda College, established in 1910 as presented on Table 1. The full meanings of the acronyms in Table 1 are presented in Appendices 1 and 2.

Tables 1, 2 and Figures 2, 3 represent the summary of the data collected from the schools. The geographic coordinates showing the exact location for all the schools is presented in Table 2. This can help supervisors and inspectors of education during supervision of schools. The spatial distribution of schools was found to be clustered in Zaria and Sabon Gari Local Government Areas (LGAs) but dispersed in Soba LGA as shown in Figures 2 and 3. Figure 2 shows that concentration of schools in the northwestern part of the area and dispersal in the northeastern part of the area. It is observed from Figure 3 that in some areas, about 4 to 5 schools are found in an area of 2 km^2, which can be described as highly clustered. In some areas, 3 to 4 schools are found, which is considered as clustered; where 2 to 3 schools are present in an area of about 2 km^2, it is regarded as being dispersed; and where 1 to 2 schools are found, it is highly dispersed. This is what was obtainable in Zaria and Sabon-Gari LGAs where schools where public secondary schools were found to be clustered and sometimes even share fences or buildings.

Schools like Alhuda Huda College, GGSS Chindit, GSS Magajiya, etc were divided into Senior and Junior with different heads and staff despite being at the same place. This and other reasons like population of the places brought more Secondary Schools to the neighborhood and increase their concentration.

Findings revealed that the schools were overcrowded in Zaria and Sabon-Gari LGAs as shown in Table 1, where more than 80% of the schools had over 100 students per class against the standard of 40 students per class (UNESCO, 2000). The number of students per class in Soba LGA is not as crowded as in Zaria and Sabon Gari LGAs partly because Soba LGA is semi urban area. Only four schools; Barewa College, Alhuda Huda College, Government Girls Secondary School, Kongo (WTC) and Government Commercial College had computer laboratory as shown on Table 1. Nine schools had library, all poorly equipped. Similarly, 12 schools had laboratory in Biology, Chemistry, Physics and Geography, most poorly equipped except in Barewa College. Thanks to the intervention of her powerful old boys association. In the case of sports, all schools except SIASS had football fields and some like Alhuda Huda, Barewa College, Government Commercial College, and GSS Chindit had multiple sports fields. This is required for achievement of effective extra curricula activities.

Barewa College had the highest number of classes (37) and GSS Aminu had the highest number of students (1660). Sheikh Ibrahim Arab Special Secondary School (SIASS) had the highest number of staff (84). About staff qualifications, 14 teachers had Masters Degree; 2 each from GSS Kofan Kibo, GGSS Pada, GSS Chindit, SIASS and GGSS Dogon Bauchi. In all, 401 teachers had Bachelor's Degrees; and most of the schools were accessible by car, tricycle, motorcycle, bicycle and/or foot as shown in Table 1 with only two schools GJSS MANGI and GJSS Matari having fair in the analysis (the created database for the schools).

4. CONCLUSION AND RECOMMENDATIONS

The distribution of schools in Zaria Education Zone was found to be uneven and inadequate in some areas where in many schools, more than 100 students are overcrowded to receive instructions in a class. This is not conducive for effective learning and against the standard of 40 students per class as stipulated by UNESCO (2000). It was also found that the schools are highly clustered in some areas with some areas grossly underserved with very few schools. So, government should build more schools and or/more classes to decongest the existing ones. In addition, facilities such as laboratories and libraries with standard equipments should be added where they are available but inadequate and provided where they are unavailable. More staff are needed to keep pace with ever increasing students in Zaria Education Zone. Some schools like Government Secondary School Bogari had only four teaching staff and other schools that have good number of staff lack adequate teachers in some basic subjects as found from the interview conducted. Zaria Education Zone should upload the database on its website to make it available to the public so that they can have access and easily decide for their wards.

Table 1: Database Created for Zaria Education Zone Public Secondary Schools

SCH_ID	N_ST	C_L	LIB	S_L	G_L	YR_ES	S_F	N_C	N_S	M_A	DE	HN	NC	OTH	AC
AM S	31	NO	NO	NO	YES	1990	YES	12	1660	0	9	1	10	1	GD
MC S	17	NO	NO	NO	YES	1990	YES	9	556	0	6	1	10	0	GD
DNY	11	NO	NO	NO	YES	2004	YES	9	345	0	2	0	2	0	GD
LKR	13	NO	NO	NO	NO	2004	YES	9	349	0	4	0	8	1	GD
KG	68	NO	YES	YES	NO	1979	YES	30	375	0	3	0	21	1	GD
KR	34	NO	NO	NO	YES	2007	YES	15	198	0	14	1	15	1	GD
KKIB	53	NO	YES	YES	NO	1972	YES	15	1552	2	23	1	5	1	GD
MG S	28	NO	NO	NO	YES	1990	YES	9	233	0	10	1	12	1	GD
P S	28	NO	NO	NO	YES	1990	YES	9	256	2	14	1	9	0	GD
YAK	13	NO	NO	NO	YES	2003	YES	9	221	0	3	0	9	0	GD
BAREW	85	YES	YES	YES	NO	1921	YES	37	849	1	26	5	9	2	GD
GS TS S	15	NO	YES	YES	NO	1982	YES	12	401	0	5	0	7	0	GD
DB S	45	NO	YES	YES	NO	1982	YES	18	1313	0	25	3	10	0	GD
K/KY	30	NO	NO	NO	YES	1989	YES	24	576	0	18	2	23	1	GD
CH S	8	NO	YES	YES	NO	1989	YES	19	1225	2	15	0	9	0	GD
KGU	8	NO	NO	NO	NO	2004	YES	10	1112	0	1	0	3	0	FR
ALHU S	43	YES	YES	YES	NO	1910	YES	18	1110	0	11	2	17	4	GD
ALHU J	40	NO	YES	YES	NO	1910	YES	18	1225	0	9	0	0	0	GD
SIASSS	84	NO	YES	YES	NO	1993	NO	19	1559	2	20	1	15	38	GD

TJK	46	NO	NO	NO	YES	1990	YES	18	1203	0	2	0	17	0	GD
CH S	29	NO	NO	YES	NO	1981	YES	19	1314	0	15	1	11	2	GD
DAK	29	NO	NO	NO	YES	1990	YES	9	1110	0	5	0	11	0	GD
WTC	80	YES	YES	YES	NO	1981	YES	32	1223	0	15	1	13	3	GD
MAT	6	NO	NO	NO	NO	2004	YES	0	257	0	1	0	3	2	FR
R/D	27	NO	NO	NO	NO	2004	YES	9	602	0	2	0	23	1	GD
K/J	28	NO	NO	NO	NO	1990	YES	9	557	0	9	4	16	11	GD
CKJ	24	NO	NO	NO	NO	1999	YES	9	750	0	10	1	11	0	GD
AB	4	NO	NO	NO	N0	2004	YES	0	220	0	1	0	3	0	FR
GYA	23	NO	NO	NO	NO	2004	YES	9	615	0	6	0	14	1	GD
BOG	14	NO	NO	NO	YES	1999	YES	0	360	0	2	0	11	1	FR
MG S	20	NO	NO	NO	YES	1990	YES	9	666	0	0	0	0	0	GD
MG J	26	NO	NO	NO	NO	1990	YES	0	698	1	3	0	19	0	GD
K/DK	40	NO	NO	NO	NO	2004	YES	9	733	1	9	0	29	1	GD
GMB	5	NO	NO	NO	NO	2004	YES	0	330	0	1	0	4	0	GD
MC J	27	NO	NO	NO	NO	1990	YES	9	905	0	8	2	16	1	GD
AW	10	NO	NO	NO	NO	2004	YES	0	268	0	1	0	9	0	GD
CH J	37	NO	NO	NO	NO	1990	YES	19	870	0	10	4	17	4	GD
GGS P J	34	NO	NO	NO	NO	1990	YES	9	556	0	4	0	28	0	GD
GSS TS J	10	NO	YES	NO	NO	1982	YES	0	780	1	3	0	6	0	GD
GG CH J	28	NO	NO	NO	NO	1981	YES	19	603	0	7	1	20	0	GD
GJRCH	4	NO	NO	NO	NO	2004	YES	0	333	0	1	1	2	0	GD
GJSMG	5	NO	NO	NO	NO	2004	YES	0	257	0	2	2	1	0	FR
GJ K/KB	5	NO	NO	NO	NO	2004	YES	9	660	0	2	0	3	0	GD
GG DB J	36	NO	YES	NO	NO	1982	YES	0	790	2	12	1	20	1	GD
AM J	30	NO	NO	NO	NO	1990	YES	9	576	0	0	0	0	0	GD
GSS K/K	45	NO	YES	YES	NO	1972	YES	15	1301	0	15	1	26	3	GD
GJSSTW			NO	NO	NO	2005	YES	12	1200	0	0	0	0	0	GD

SOURCE: Zaria Education Zone, Ministry of Education Kaduna State and Field Survey, 2014.

Table 2. Geographic Coordinates of Schools

SHAPE	EASTHINGS	NORTHINGS	SCH_ NAME
POINT	380469	1215924	GJSS MATARI
POINT	357166	1229284	GJSS R/DOKO
POINT	355582	1222738	GJSS K/JATAU
POINT	359686	1228336	GJSS CHIKAJI
POINT	361796	1211146	GJSS ABA
POINT	360275	1224534	GJSS GYALLESU
POINT	367039	1236573	GSS LIKORO
POINT	390492	1230054	GSS DINYA
POINT	365090	1211833	GJSS BOGARI
POINT	358405	1220763	GJSS MAGAJIYA (JNR)
POINT	357908	1222832	GJSS K/DOKA
POINT	384414	122651	GJSS GIMBA
POINT	362229	1230579	GJSS MUCHIA (JNR)
POINT	356741	1224163	BAREWA COLLEGE
POINT	378892	1222404	GJSS AWAI
POINT	360731	1225953	GSS CHINDIT (JNR)
POINT	358758	1222063	GGSS PADA (JNR)
POINT	381100	1218535	GSS T/SAIBU
POINT	352114	1220681	GSS KUGU
POINT	357662	1223074	ALHUDA HUDA COL
POINT	356808	1224351	SIASSS K/KARAU
POINT	358131	1224886	GSS T/JUKUN
POINT	385165	1232577	GJSS RICHIFA
POINT	384453	122594	GJSS KINKIBA
POINT	356874	1219020	GGSS K/GAYAN

POINT	362829	1227394	GSS DAKACE
POINT	360391	1227394	GSS AMINU S (SNR)
POINT	361076	1229145	GSS MUCHIA (SNR)
POINT	357148	1220250	GSSS KAURA
POINT	357406	1224297	GSS K/KIBO (SNR)
POINT	359839	1223326	GGSS PADA (SNR)
POINT	372624	1220791	GSS YAKASAI
POINT	360104	1226214	GSS D /BAUCHI (SNR)
POINT	360123	1226000	GSS D /BAUCHI (JNR)
POINT	355081	1220660	GGSS K/KUYAMBANA
POINT	360731	1225953	GSS CHINDIT (SNR)
POINT	362829	1223563	GSS DAKACE
POINT	360477	1222343	GJSS MAGAJIYA(SNR)
POINT	385165	1232577	GJSS RICHIFA
POINT	357906	1208688	GJSS MANGI
POINT	356180	12222865	GSS K/ KIBO (JNR)
POINT	362004	1229111	GSS AMINU (JNR)
POINT	357406	1224297	GSS K/KIBO (SNR)
POINT	360553	1223269	GGSS KONGO (WTC)
POINT	362229	1230579	GSS MUCHIA (SNR)
POINT	361070	1229240	COMMERCIAL COL
POINT	355582	1222738	GSS K/JATAU
POINT	360339	1225002	GSS T/WADA
POINT	353155	1223161	SCI SEC SCH KUFENA

Source: Field Survey, 2014

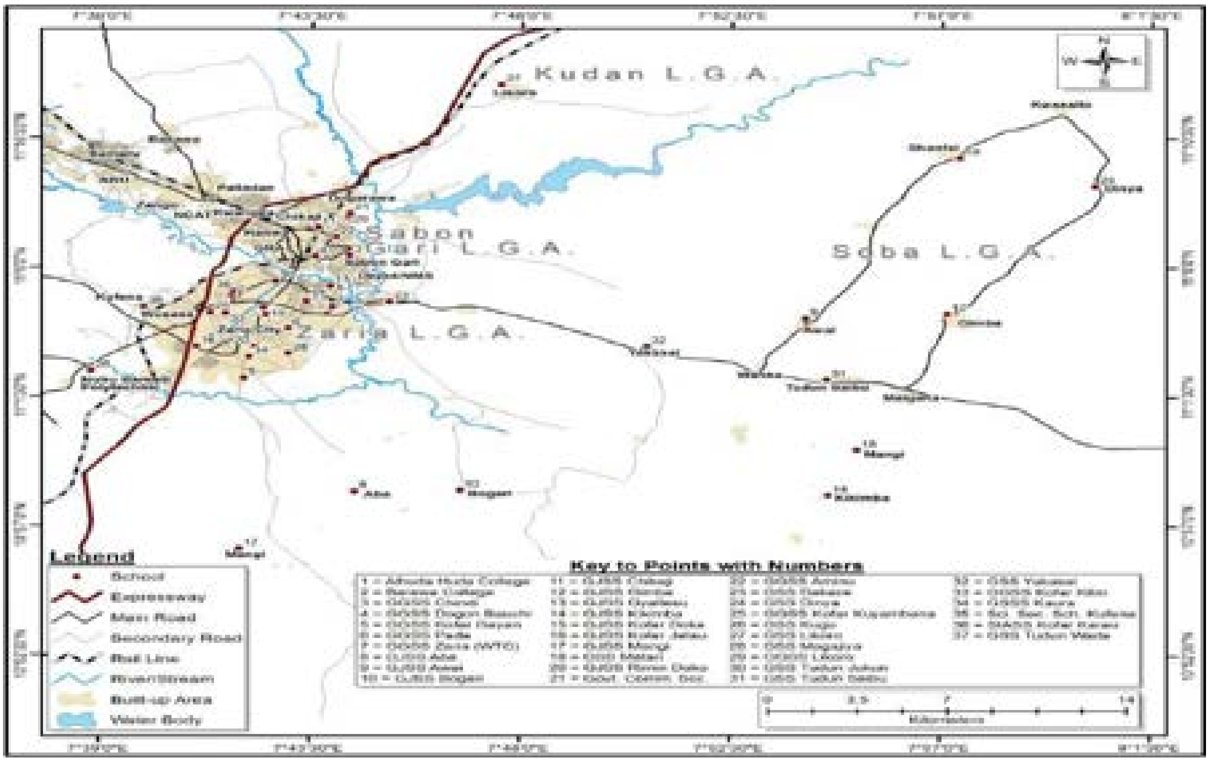


Figure 2: The Spatial Distribution of Secondary Schools in Zaria Education Zone

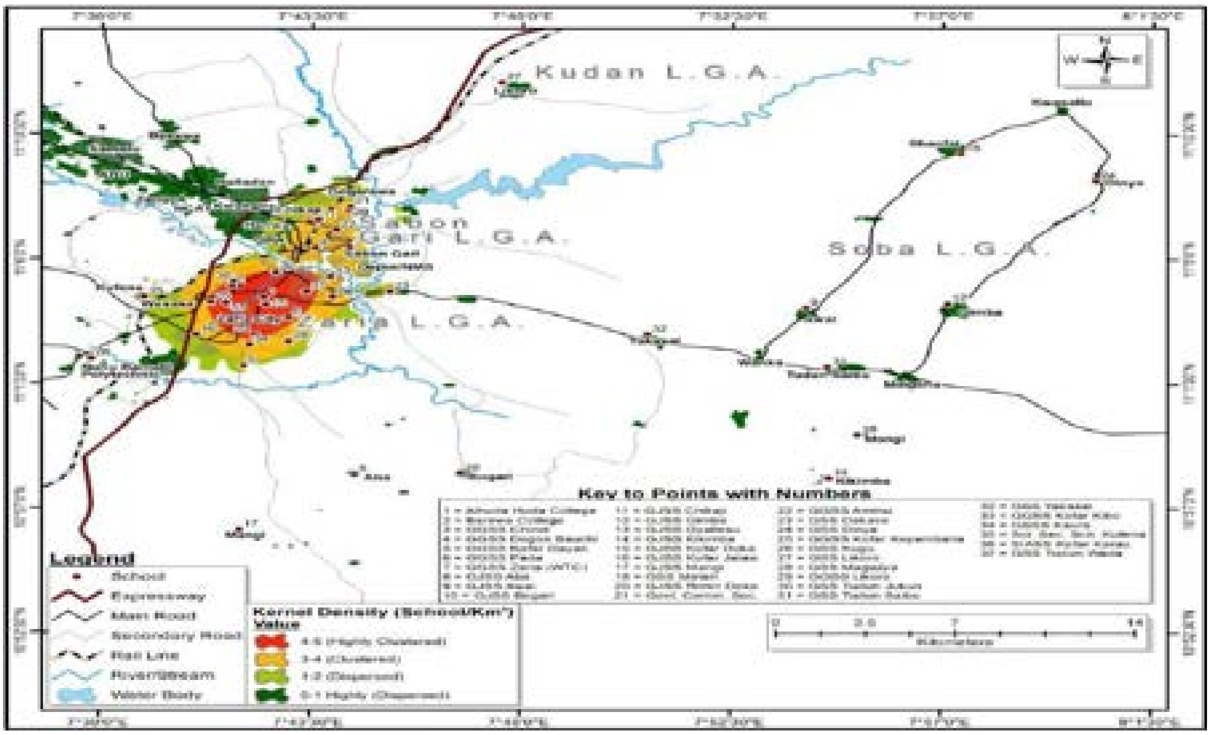


Figure 3 : The Density of Secondary Schools in Zaria Education Zone

REFERENCES

Abaje, I.B. S. Ishaya and M. Abashiya (2016). Evidence of Global warming on Statistical Analysis of temperature Data in Kaduna State. *Nigeria Geographical Journal* 11(1). 125-140.

Abdulkarim, B. (2006). Application of Geographic Information System and Remote Sensing Technology to the Teaching of Map work in Senior Secondary Schools in Zaria Inspectorate Division, Kaduna State, *A Journal of Educational Research and Development*, 1(1): 05-14.

Abdulkarim, B. (2004). The Problems of Teaching Map Reading in Secondary Schools: A Paperpresentation. *In-house workshop for Geography Teachers in Zaria* Inspectorate Division. M.O.E. Zaria Zone.

Adepoju, A. and Fabiyi, A. (2010). *Universal Basic Education in Nigeria: Challenges and Prospects. Planning and Implementation of UBE in Nigerian Education*. Education Industrial Nigeria Ltd, Ibadan.

Amazon (2009). Garmin GPS Map 76S Handheld GPS, Retrieved from, www.Amazon.com, Accessed on 27th December, 2009.

Anmesty International (2002). *Report on Regional Education*. Retrieved on 13th December, 2002, from https://www.amnesty.org

Asiabaka, I.P. (2008). *Facilities Management in Schools*. In: Anukam, I. L, Okunamiri, P.O., Ogbonna, R.N.O (Ed). Owerri: Chinashop Publisher.

DeGrauwe, A.; Anfield, I.; Tamiru M. and Parolin, B. (2002). Improving Microplaning in Education through a Geographical Information System: Studies on Ethiopia and Palastine. School Mapping and Local-Level Planning. *Human Geography, Geografisca Annaler Series B.*

John, M. (1999). *Education Planning and Management and the use of Geographical Information System.* IIEP Paris, France.

John P. "GPS III Operational Control Segmen". Globalsecurity.org. Retrieved 8/12/2009.

Kamla, R. (2009). National Policy on Education, Federal Republic of Nigeria 2004. *Stud Home Comm. Science*, 3(2): 81-86.

Kayode, A. A. (2006). *Let your voice be heard.* Retrieved on 30/03/2007, from University of Jos

Lawal A. (2008). *A history of Tukur Tukur*, Zaria 1903-1960. B.A. Project, History Department, Ahmadu Bello University, Zaria.

Mark, B. and Varghese, N.V. (2001). *Directions in educational planning, International experiences and perspectives* IIEP-UNESCO.

UNESCO (2000). *World Data on Education: Nigeria,* UNESCO-IBE.

Overview of the Nigerian Education System. Retrieved on 16th August, 2011.

Ogunsaju, S. (1980*). Some Aspect of School Managements*, Porist: Ibadan

Thompson, C. and Hardin, P. (2000). Remote Sensing/GIS integration to identify potential low income housing sites cities, (17). 97-109.

Tomlinson, R.F. (1987). Current and potential uses of geographical information systems. The North American experience. *International Journal of Geographical Information Systems*. (4) 2.

Watanbe, S. (1992). *A study on Sub-urbanisation and Urban Development Methodology: With the Focus on Middle Income Group*. PhD Thesis. University of Tokyo, Tokyo Japan.

APPENDIX 1

MAT = GJSS MATARI
R/D = GJSS RIMIN DOKO
K/J = GJSS KOFAR JATAU
CKJ = GJSS CHIKAJI
AB = GJSS ABA
GYA = GJSS GYALLESU
LKR = GSS LIKORO
DNY = GSS DINYA
BOG = GJSS BOGARI
MG S & J = GSS MAGAJIYA (SENIOR) & (JUNIOR)
K/DK = GJSS KOFAR DOKA
GMB = GJSS GIMBA
MC S & J = GSS MUCHIA (SENIOR) & (JUNIOR)
BAREWA = BAREWA COLLEGE
AW = GJSS AWAI
GSS CHINDIT (SENIOR) & (JUNIOR)
P S = GGSS PADA (SENIOR) & (JUNIOR)
GS TS S = GSS TUDUN SAIBU
KG = GSS KUGU
ALHU S & J = ALHUDA HUDA COLLEGE (SENIOR) AND (JUNIOR)
SIASSS = SHEIK IBRAHIM ARAB SPECIAL SECONDARY SCHOOL KARAU-KARAU
TJK= GSS TUDUN JUKUN
GJRCH = GJSS RICHIFA
KKIB = GJSS KINKIBA
K/KY = GGSS KOFAN GAYAN
DAK = GSS DAKACE
AM S & J = GSS AMINU (SENIOR) & (JUNIOR)
MC S & J = GSS MUCHIA (SENIOR) & (JUNIOR)
KR = GSSS KAURA
KKIB = GSS KOFAR KIBO (SENIOR) & (JUNIOR)
DB S & J = GSS DOGON BAUCHI (SENIOR) & (JUNIOR)
GSS K/K= GGSS KOFAR KUYAMBANA
GG CH J CH S = GOVT GIRLS SEC SCH CHINDIT (SENIOR) & (JUNIOR)
GJSMG = GJSS MANGI
GJRCH = GJSS RICHIFA
G K/KB = GSS KOFAR KIBO (SENIOR) & (JUNIOR)
AM S & J = GSS AMINU (SENIOR) & (JUNIOR)
WTC = GGSS KONGO (WTC)
GJSSTW = GSS TUDUN WADA
YAK = GSS YAKASAI

APPENDIX 2
SCH_ID = School Identification
N_ST = Number of Staff
C_L = Computer Laboratory
LIB = Library
S_L = Science Laboratories (Biology, Chemistry and Physics)
G_L = Geography Laboratory
YR_ES = Year of School Establishment
S_F = Sports Facilities
N_C = Number of Classes
N_S = Number of Staff
M_A = Number of Masters Holders and Above
DE = Number of Degree Holders
HD = Number of HND Holders
NC = Number of NCE Holders
OTH = Other Certificates Holders
AC = Accessibility to Schools

Savanna volume 23, Number 1, June, 2016

Analysis of Vacant Land Value Variations in Zaria Urban Area, Nigeria

Shehu Abbas*, Musa, I.J. and Adefila, J.O.
Department of Geography & Environmental Management,
Ahmadu Bello University, Zaria
*abbasshehu55@gmail.com

ABSTRACT

The Zaria urban area in Kaduna State has been a centre for several socioeconomic activities. This has therefore attracted population from far and near. Consequently, the area has witnessed increased demand for land for housing and other purposes, thus, leading to a continuous rise in land value – both over space and time. Using questionnaire administered on estate dealers/agents, this study tried to analyse the spatio-temporal pattern of vacant land value in the area. Findings revealed that lands around areas occupied by the elites, notably the Government Reserve Area (GRA) had higher values than the others, while over time the values have been continuously on the rise, until the period after 2012, when the values went down by an average of -20%, due to the security challenges that bedeviled the area and indeed the country as a whole. It was suggested that the Kaduna State government should start the idea of land banking that would take care of all class or category of people at reasonable rates, so that the housing shortage being witnessed can be ameliorated.

Keywords: Vacant land; Value; Variation; Estate agents; Zaria urban area.

1. INTRODUCTION

The influx of people into urban areas of developing countries is continuously on the rise. Current trends in world urbanisation indicate a growth of about 50 million urbanites each year, roughly a million a week (Rodrigue, Comtois and Slack, 2006). It was reported that more than 90% of that growth occurs in developing countries, and Nigeria being the most populous nation in Africa, would contribute a significant proportion of this. The urban population growth in Africa is mainly determined by two major factors: the migration of mostly young people from rural to urban areas, and a high natural rate of population growth due to high fertility and low mortality rates as well as low median ages. This therefore, affects the need for land for the provision of housing and other services (Ai, 2005). Little wonder that the European Reintegration Support Organisation (2008) has estimated that residential home ownership in Nigeria is less than 25%, compared with the international benchmarks of 75%. It therefore concluded that housing issues would remain one of the primary social focuses in the country for next 20 years or more.

For quite a long time, urban Zaria has been known to pull a large number of people, from far near, as a result of the location of so many activity centres, notably institutions of higher learning. Because of these, it is to be expected that the demand for land would be on the rise. Consequently, there appears to be a significant increase in land value over time as well as a variation in the pattern over space, with some areas exhibiting very high land value while others are not so high. According to Adams (1994), price for land or property is either the amount sought (asking price) or the sum received (price paid); while the value of land or property are price estimates that reflect subjective expectations and perception of worth.

Several studies have attempted to determine the spatial pattern and factors influencing either residential or commercial land value in various cities in Nigeria, to the neglect of vacant land values. The work by Adebayo (2006) is one of them, essentially on the effect of urban infrastructure on property values in Lagos. Also Bello and Ajayi (2010) worked on the effect of waste dumpsites on land value in parts of Lagos metropolis. Oni (2009) studied the effect of arterial roads on commercial property values in Ikeja, Lagos. Unlike what was done by most of the previous studies on the pattern or factors affecting residential land value, this paper tries to analyse the spatio-temporal pattern of vacant land values in the Zaria urban area, Nigeria.

1.1 The Study Area

Zaria is located in the central plain of northern Nigeria, about 950km from the sea, approximately between latitudes 11° 00′ - 11°10′ North of the equator and longitudes 7° 36′ - 7°45′East of the Greenwich Meridian, as shown in Figure 1. It is the second largest town in Kaduna State, after Kaduna town which is the state capital. Zaria and Sabon Gari are the two local government areas (LGAs) that form the study area, with the Kubanni River as the boundary that separates the two areas. The headquarters of Zaria LGA is located in Zaria city, near the Emir's palace, while that of Sabon Gari is located at Dogarawa.

Zaria, being in the heart of the Hausa land is predominantly occupied by the Hausa speaking people, traditionally known as Zage-zagi or Zazzagawa, who largely occupy the old walled city. Outside it however, there are other Hausas, who originally migrated into Zaria from the northern states. These are especially found in Tudun Wada. The non-Hausa in-migrants to the area are predominantly found in areas like Sabon Gari, Palladan and Samaru. According to the 2006 population census, the two LGAs that make up the Zaria urban area have a combined population of 698,348 (with S/Gari having 291,358 and Zaria 406,990). According to Buttler (2015), Zaria is among the top ten most populous urban areas in Nigeria. Indeed it has been ranked 8th, and is the only non-state capital amongst the top ten.

The growth of urban Zaria, though influenced by historic circumstance and political authority it wielded prior to the 19th century, is also the result of deliberate establishment of educational institutions (Bello, 2000). Hence, it has been noted that twelve out of the seventeen tertiary institutions in Kaduna state are located in Zaria, while there are about fourteen manufacturing industries and major commercial establishments. As a result of this and many other developments in the area, Bello (*ibid*) has found that between 1962 and 1992, Zaria as an urban centre has been transformed from an educational centre to a rapidly growing manufacturing industrial city sprawling for more than 25km stretch along Kaduna-Sokoto motor road.

2. MATERIALS AND METHODS

Data for the study was obtained through the administration of questionnaire on estate dealers/agents. To select the estate dealers/agents, snowball sampling technique was adopted. It involved contacting a well-known estate agent and interviewing him/her after which he/she was asked to introduce the researcher to an equally well-established person in the same business. The method is often used to obtain a sample when there is no adequate list which could be used as a sampling frame (Osuala, 2005). The method was adopted because of the difficulty in identifying this type of and entered on the Y axis, while the

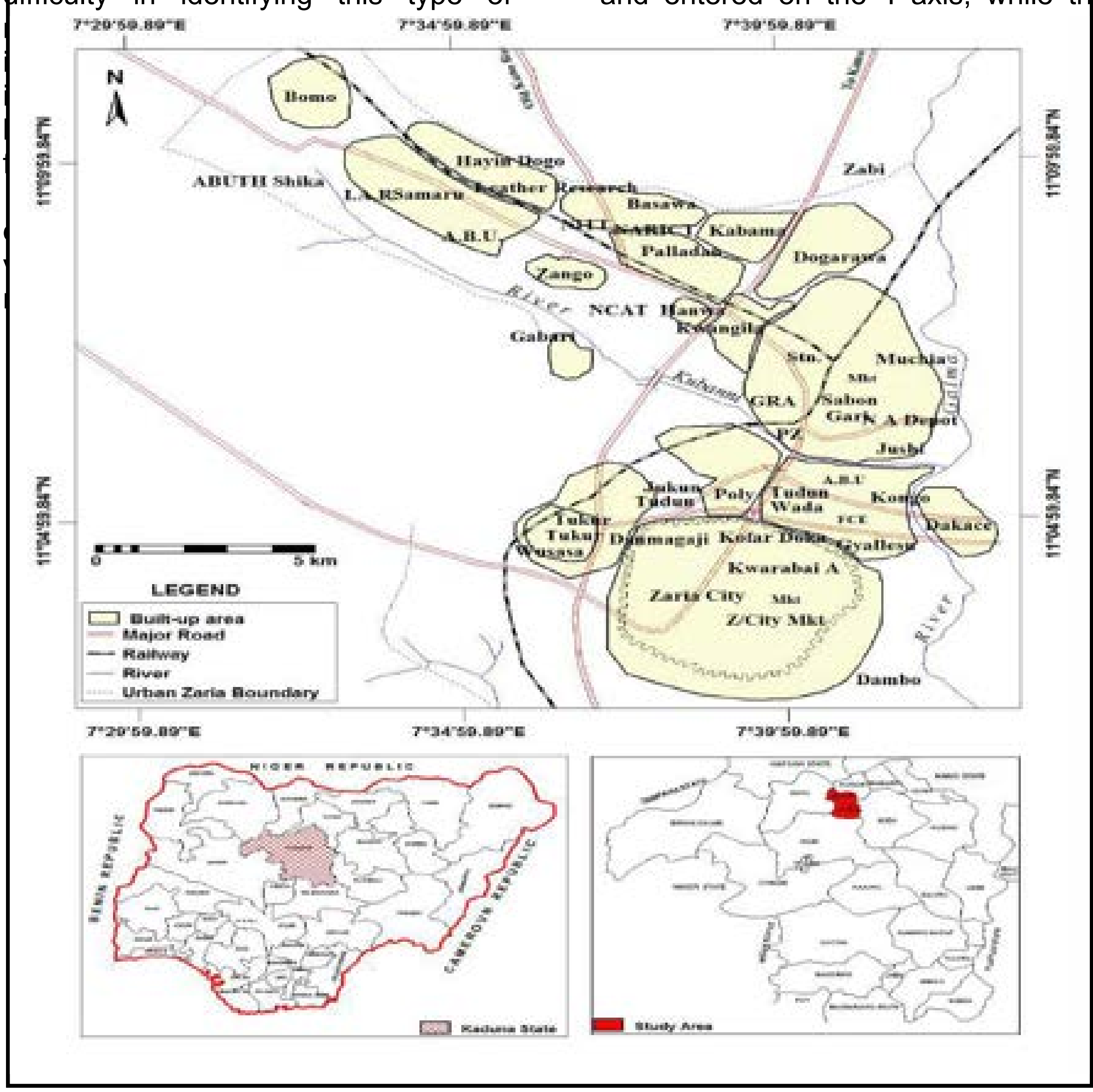


Figure. 1: The Study Area – Urban Zaria
Source: Adapted and Modified From Topographic Map of Zaria Sheet 102 S.W

3. RESULTS AND DISCUSSION

The responses of land dealers, vendors or agents were utilised to obtain the mean vacant land values in the study area. Table 1shows average land value by areas, for the period under study. The GRA had the highest mean value of N8,877/m^2, while Zabi had the least value of N267/m^2.The high values around the GRA could be due to a number of reasons. First, the area is purely a high class residential area, with a serene environment, high quality buildings, large sized plots, well planned and had the initial advantage of being occupied by the colonial masters. Therefore, the area is for the rich and powerful in the society, likewise Hanwa. This is consistent with the findings of Rikko and Dung-Gwom (2006) who noted that Rayfeild in the city of Jos, Nigeria has high land value due to the elite status of the area.

Vacant or undeveloped lands in urban Zaria are largely found in the peripheral areas, as shown in Figure 1. For this reason, the activities of land dealers and agents is more around such sections of the city, where farmlands are easily acquired, subdivided and converted to commercial and residential landuses.

Next is the temporal pattern of vacant land value. Table 1 shows that the year 2012 recorded the highest mean value of N22,222/m^2, while the least N0.6/m^2 was obtained in 1982.Then Figure 2 reveals that the trend for vacant land value was very gentle from 1982 to 1992, with the line graph almost parallel with the horizontal x-axis, especially the minimum value. The steepest trend line was recorded from 2002 till the year 2012. However, for the first time, the value of land nose-dived between 2012 and 2014; that is, it went down by about -20% (see Figures 2 and 3). This was due to the high level of insecurity, as demand for vacant land dropped significantly, largely due to the threat of *Boko Haram* insurgency as well as the apprehension that preceded the outcomes of the 2015 General elections. Many non-indigent members of the population were leaving the area, selling off some of their landed properties in the process. This, therefore, significantly affected property values.

Table 1: Mean Vacant Land Value and its Rate of Change in Urban Zaria (1982-2014)

S N	Location	Average price of a plot (50m x 15m) in Naira/m^2					Mean	% Change between			
		1982 (A)	1992 (B)	2002 (C)	2012 (D)	2014 (E)		(A) & (B)	(B) & (C)	(C) & (D)	(D) & (E)
1	GRA/PZ	55	333	4,000	22,222	17,777	8877	505	1101	455	-20
2	T/wada/Gyales	18	44	667	11,111	8,889	4146	173	1415	1565	-19
3	Gaskiya	15	33	267	6,667	4,444	2285	120	709	2397	-33
4	,, (New L.o)	-	-	778	11,111	8,889	5195	-	-	1328	-19
5	Gonar Ganye	-	-	-	2,889	2,667	2778	-	-	-	-8
6	Ang. Kaya	-	-	222	4,444	3,333	2666	-	-	1901	-25
7	F/Mallawa	-	-	222	4,444	3,556	2741	-	-	1901	-19
8	Nagoyi	-	-	-	1,556	1,333	1445	-	-	-	-14
9	Ban Zazzau	-	-	133	2,667	2,222	1674	-	-	1905	-16
10	Kwangila	-	6.7	444	4,444	4,444	2335	-	6526	900	0
11	Hanwa-Y/goro	2.2	5.6	333	17,777	15,555	6735	154	5846	5238	-13
12	Kabama	-	-	-	4,889	3,333	4111	-	-	-	-31
13	Dogarawa	4.4	5.6	222	3,333	2,667	1246	27	3864	1401	-19
14	Hayin Ojo	1.6	2.2	111	2,667	2,222	1001	37	6837	2302	-16
15	Zabi	0.6	01	33	556	444	267	-	5400	729	-20
16	N. Mopol Bar.	-	-	-	778	444	611	-	-	-	-42
17	Z/Shanu	-	-	444	4,889	3,778	3037	-	-	1001	-22
18	Hayin Mal.	-	-	222	4,444	3,333	2666	-	-	1901	-25
19	Palladan	-	-	222	3,333	2,222	1926	-	-	1401	-33
	Mean	**14**	**54**	**555**	**6,012**	**4,819**	**2292**	**286**	**928**	**983**	**-20**

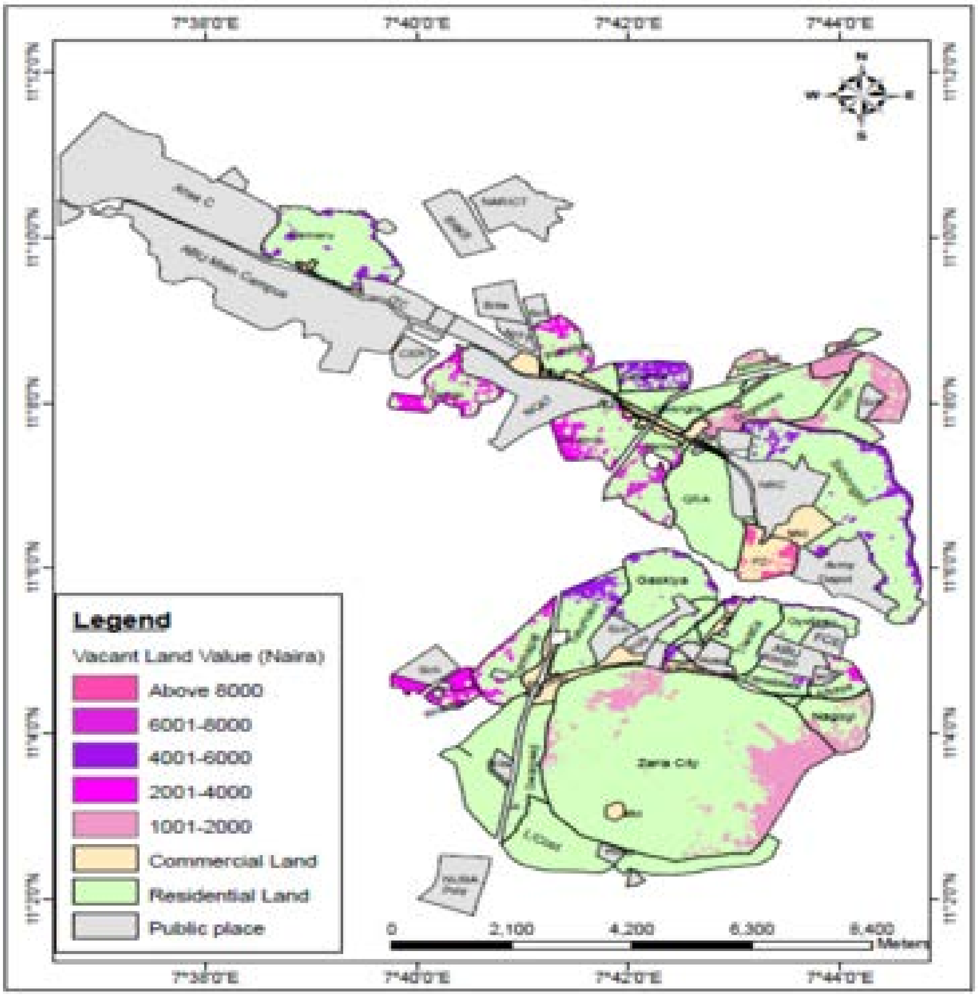


Figure. 2: Pattern of Mean Vacant Land Value in Urban Zaria (1982 – 2014)
Source: Adapted and Modified From Topographic Map of Zaria Sheet 102 S.W

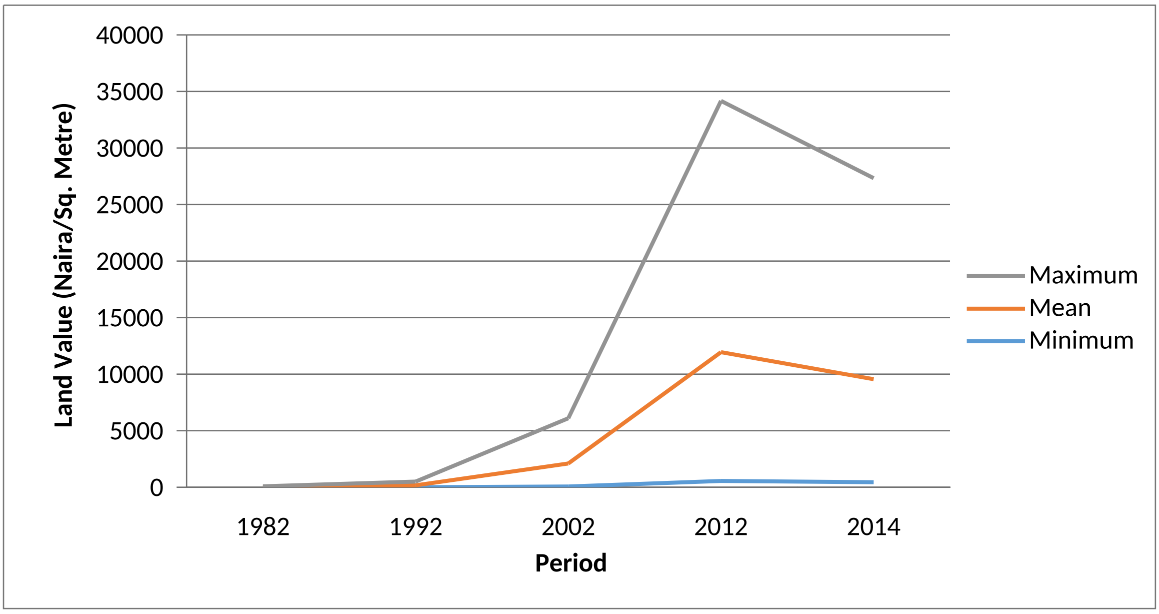


Figure 3: Trends in the Maximum, Minimum and Mean Vacant Land Value in Urban Zaria (1982 – 2014)

4. CONCLUSION

It is evident from the study that the pattern of vacant land value varies both over space and time. The values over space were higher around high-class residential areas that have low density, such as the GRA and Hanwa New extension areas; while the low-class and high density residential areas, such as around the old city and Zabi had lower vacant land values. However, over time, vacant land values have been continuously on the increase from 1982 up till 2012. Thereafter, the values went down due to security challenges that bedeviled the area and indeed the nation as a whole.

Based on the foregoing, it is pertinent to suggest that there is the need for a long range housing development plan for Zaria, due to high demand e.g. by developing land banks with well-articulated development schemes; such that would take care of various classes/categories of the society (low, medium and high density areas) at reasonably affordable rates. This would help to allow the citizenry to have unfettered access to this all important requirement of life. And in this way, the huge gap of housing supply, as earlier noted, can be drastically reduced.

REFERENCES

Adams, D.C. (1994). *Urban planning and the Development process*. London, UCL Press

Ai, P. (2005). *Residential Land Value Modelling- Case Study Hankou, China*. Unpublished M.Sc. thesis submitted to the International Institute for Geo-Information Science, the Nertherlands.

Amenyah, I.D. (2013). Factors Determining Residential Rental Prices.*Asian Economic and Financial Review, 3 (1)* pp. 39 – 50.

Bello, A.L. (2000). Kaduna State. In *Nigeria: A People United, A Future Assured*. Vol.2, Gabumo Press, Esuk Utan, Calabar, Nigeria.

Bello, V.A. and Ajayi, C.A. (2010). Occupants Satisfaction and Rent paid for Residential properties Close to Waste Dumpsites in Nigeria. *Journal of Sustainable Development, 3(1),* March.

Bible, D.S. and Hsieh, C. (1999). Determinants of Vacant Land Values and Implications for Appraisers. *The Appraisal Journal*, July.

Buttler, R.A. (2015). Mongabay.com – City Population. Retrieved 16/10/15 from http://www.mongabay.com

Emoh, F.I., Oni, A.O. and Egolum, C.C. (2013). Prioritizing Residential Land Value Determinants in Onitsha, Nigeria. *International Journal of Academic Research in Business and Social Sciences*; 3(3), pp. 201- 213.

European Reintegration Support Organisation-ERSO (2008).Expert Meeting. Stockholm, 21-22, April

Kabba, V.T.S. and Li, J. (2011).Determinants of Urban Land Price in Freetown, Sierra Leone. *Journal of American Science*, *7(2)* pp. 213-223.

Oni, O.A. (2009). *Arterial Road Network and Commercial property Values in Ikeja, Nigeria.* Unpublished Ph.D. Thesis, Department of Estate Management, Covenant

University, Ota, Ogun State, Nigeria.

Osuala, E.C. (2005). *Introduction to Research Methodology*. Africana-First Publishers Ltd. 3rd edition

Riko, L.S. and Dung-Gwom, J.Y. (2006). Peri-urban Land Values in Jos. *Nigerian Journal of Construction Technology and Management.* pp. 136 – 144.

Rodrigue, J., Comtois, C. and Slack, B. (2006). *The Geography of Transport Systems*. Routledge, London.

Effects of Coal Mining on Landuse/Landcover in Maiganga, Akko Local Government Area, Gombe State, Nigeria

Akut, Y.B.[1]*, Iguisi, E.O.[2], Abdulkarim, B.[3] and Jeb, D.N.[4]

[1]*Department of Geography, Federal College of Education, Zaria*

[2]*Department of Geography & Environmental Management, Ahmadu Bello University, Zaria*

[3]*Departmentt of Science Education, Ahmadu Bello University, Zaria*

[4]*National Center for Remote Sensing, Jos*

*yabqutt@yahoo.com

ABSTRACT

This study examined the effects of coal mining on landuse/landcover in Maiganga, Akko Local Government Area of Gombe State. Landuse/landcover status of the study area in 2007, 2011 and 2016 was acquired using Landsat Enhanced Thematic Mapper Plus (ETM+) of 2007 with a 30 meter spatial resolution; Landsat ETM+ of 2011 with a 30 meter spatial resolution; Landsat 8 image of 2016 with spatial resolution of 28 meters which were obtained from the United States Geological Survey website (February-September, 2016). The datasets were geo-referenced to geographic coordinates. The images were imported into Erdas Imagine 9.2 environment where they were rectified to a common projection (Universal Traverse Mercator). The mining site was subset from each of the larger scenes in Erdas Imagine 9.2 software since the satellite images come in bands and cover large areas. Supervised classification technique was performed using maximum likelihood classification (MLC) algorithm. This technique enabled generation of training classes based on the actual landuse/landcover themes present within the study area and helped in curtailing ambiguity associated with the unsupervised technique of image classification. The result revealed that the dominant landuse type for the period under review (2007-2016) is agricultural (64.65%). Though there is a steady but gradual decrease in percentage - 62.59% in 2011 and 60.52% in 2016. The study concluded that the gradual decrease in percentage is due to the conversion of hitherto agricultural land to mining land and the expansion of settlements. It was recommended that the mining activities should curtail the incidences of coal mine fires which pumps tons of smoke and other pollutants into the atmosphere by providing firefighting equipment and personnel for prompt intervention.

Keywords: Coal mining; landuse/landcover; Remote Sensing; GIS.

1. INTRODUCTION

Mining is a generic term used when resources ranging from biotic and non-biotic are being obtained from the Earth (Abdulkarim, 2013). Mineral excavation is a special mining of resources from rock veins, seams or sub-surfaces. It is carried out in different locations, from the tropics to the polar areas and at different earth substrata. Common among minerals being mined are petroleum, coal, copper, silver, iron ore, gold, uranium and diamond, among others (Priyadarshi, 2012; Arango, 2012).

Mining impacts notable changes on the environment with varying severity depending on the methods of operations, and geological conditions of the mining sites (Mondal, Bandayopadhyay and Chakravatry, 2014). Reduction of forest and biodiversity, gullying, landslide and pollution are among the surface disturbances triggered by open-cast mining (Globalmethane, 2014). Coal is mined through surface (open-cast) and subsurface (underground) techniques. Techniques of surface mining include: open pit mining which consists of recovery of materials from an open pit in the ground; strip mining which consist of stripping surface layers off to reveal coal seams underneath, and mountain top removal commonly associated with coal mining, which involves taking the top of a mountain off to reach coal deposits at depth. Standard practices of open cast mining involve separate removal, handling and storage of top-soil and sub-soils so that these can be re-laid during reclamation (Arango, 2012).

Mining coal globally has resulted to land degradation and loss of bio-diversity. Common among them are loss of vegetation cover and species migration, accelerated siltation of low lying land areas of the mining complexes, landslides in hilly terrains and exposure of fertile agricultural surfaces. In addition to degradation of land on which the dumps are made, they also degrade the surrounding land due to leachate (Abdulkarim, Oladipo and Balarabe, 2015; Prakash and Gupta, 1998).

Mining activities in resource-dependent communities exert considerable impact on the environment, as well as on the lives of the people living within the vicinity. This impact may be positive as well as negative. For instance, mining companies provide employment for indigenous people; build infrastructure such as roads, clinics and schools; and, provide water and electricity when they move to the local communities (Osei, 2012).

Amos (2010) studied the effects of limestone mining on landuse/landcover changes in Ashaka and identified the types of environmental damage relating to mining as including air, land and water pollution, damage to vegetation, ecological disturbance, degradation of natural landscape and geological hazard problems. Musa and Jiya (2011) in their assessment of the impact of mining activities on vegetation in Bukuru concluded that further decrease in vegetation in the area is due to intensive mining as well as extensive cultivation which exposes the soil to adverse erosion and subsequent environmental degradation.

Large scale mining activities and livelihood was studied by Maliganya, Simon and Paul (2013) in Tanzania to the extent that most of the respondents in all surveyed villages reported minimal direct and indirect socio-economic accrued benefits to their livelihood. A study by Yaro (2010) also dealt with the impact of mining on livelihood of locals and concluded that at the local level, communities are saddled with adverse social and environmental problems which have deprived them of their main source of livelihood in Ghana. Yaro’s study was focused on gold and included artisanal mining. Mapping the livelihoods of mining induced communities was done by Mishra and Reddy (2011) in India, noting that mining has a negative impact on wildlife, river systems, tribal livelihoods, tourism and climate.

Although literature abounds on the application of Remote Sensing and Geographic Information System (GIS) tools in assessing the effect of mining activities on landuse/landcover in different parts of the world, limited studies exist on the impact of coal mining on landuse/landcover in the study area. The researcher therefore used remote sensing to map landcover and landuse changes within and around the Maiganga coal mining concession. This study examines the impact of coal mining on the physical landscape (landuse/landcover) in Maiganga from the commencement of coal mining in 2007 to 2016.

1.1 Study Area

The study area is located within longitudes 11°13′E to 11°21′E and latitudes 10°03′N to 10°05′N, some 80 km south of Gombe state in Nigeria as shown in Figures 1 and 2. It has an area of 2,627km^2. The climate is generally warm with the hottest months exceeding 30˚C (March – May) which drops to about 25°C during harmattan and the wet season. The climate is seasonally wet and dry largely due to the influence of the south west trade winds and the north east trade winds respectively. Rainfall averages 850mm annually; it commences in May and lasts till late September.

The study area is part of the cretaceous sedimentary formation. The depression made possible series of marine transgressions and regression which led to the development of cretaceous sedimentary rocks in the area (Ashaka Geological Survey, 1987). The plains are gentle with pockets of hills of sedimentary formations. Sand stone is dominant in some places while in others, shale occurs on higher parts (Adefila, 2004). The dominant soil type of the study area is grey mottled, sand and loams with some grey clay. Hydromorphic soil of riverine and lacustrine type is found along the flood plain of rivers. The vegetation of the area is predominantly wooded scrubland. The grasses are short and overgrazed. Some of the tree species are (*Andonsonia digitat, Amongeisus leiocarpus, sclerocaraya spp. Tamarindus indica and balaniate eygptian*) which grow to a height of 7 to 20m; while some pothers (*combretuin glutuism, Acacia seyal* and other thorny shrubs) are a meager 2 to 6 m.

Figure. 1: Map of Nigeria showing Akko Local Govt. Area
Source: Adapted from Google Earth, 2016

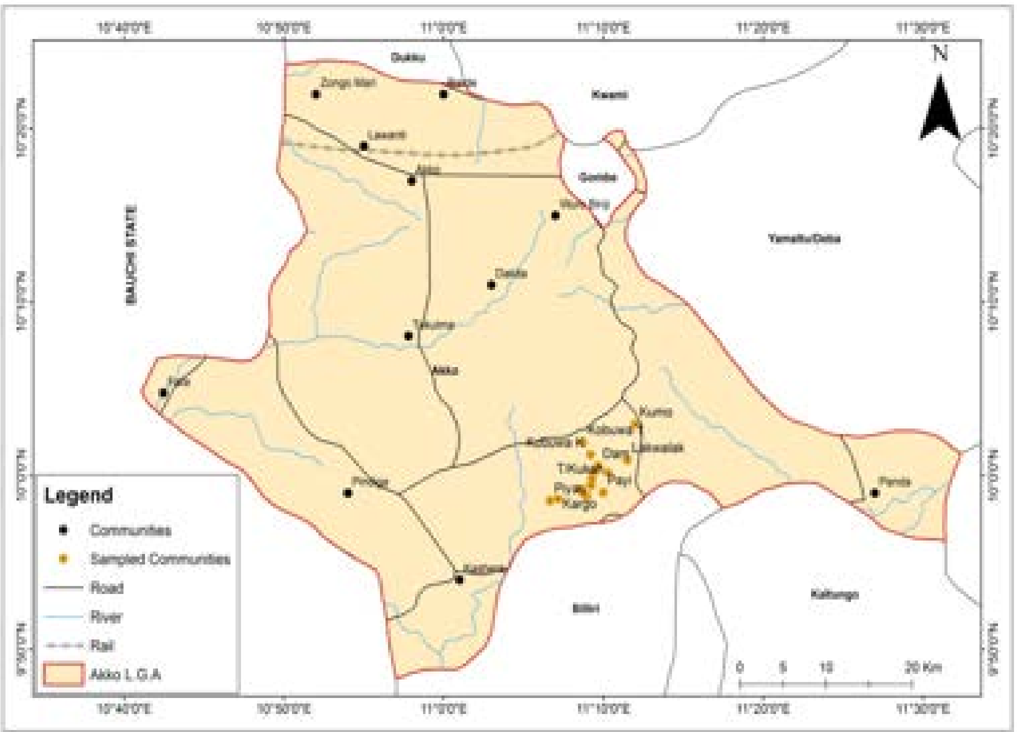


Figure 2: Location of the Study Area
Source: Adapted from Google Earth, 2016

2. MATERIALS AND METHODS

2.1 Reconnaissance Survey

A reconnaissance survey was carried out to acquaint the researcher with the study area. During the exercise, observations guided by a checklist revealed that the land is being extensively degraded as vegetation is being cleared. Also, the hilly terrain is undergoing excavation to the extent of being flattened, resulting in heaps of wastes/overburden dumps and creating bare surfaces and open pits. This has been going on since the commencement of commercial mining in the area in 2007.

2.2 Types and Sources of Data Used

The data used include:

i. Landsat Enhanced Thematic Mapper Plus (ETM+) of 2007 with a 30 meter spatial resolution.
ii. Landsat ETM+ of 2011 with a 30 meter spatial resolution.
iii. Landsat 8 image of 2016 with spatial resolution of 28 meters.

The Satellite imageries were obtained from the United States Geological Survey website (February-September, 2016)

2.3 Methods of Data Analysis

2.3.1 Satellite Image Processing

Landsat ETM+ imageries of 2007 and 2011, as well as Landsat (8) imagery of 2016 were used for the study. The mining site was subset from each of the larger scenes using Erdas Imagine 9.2 software since the satellite images come in bands and cover large area.

Supervised classification technique was performed using maximum likelihood classification (MLC) algorithm. This technique enabled generation of training classes based on the actual landuse/landcover themes present within the study area and helped in curtailing ambiguity associated with the unsupervised technique of image classification according to Liu, Skidmore and Oosten (2002). The MLC is the most widely and commonly used with remotely sensed data, and is proven to yield the best classification result (Jensen, 1996). The attribute and statistics from the classification result were generated and used for post-classification comparison between the years. Based on the prior knowledge of the area and reconnaissance survey carried out, a classification scheme of Anderson, Hardy, Roach and Witmer, (1976) was adapted for the study and is shown in Table 1.

Table1: Landuse classification scheme of Maiganga and environs

Code	Landuse/Landcover Class	Description
1	Build-up land	Landuse for settlement and building of infrastructures such as schools, roads, etc.
2	Vegetated surface	Land covered with natural vegetation such as grasses, shrubs, grass like-plants and natural forest.
3	Agricultural land	Land used as cropland, agricultural farmland etc.
4	Water surface	Rivers, streams, ponds and dams.
5	Bare Ground	Land devoid of vegetation cover and exposed soils.

Source: Adapted from Anderson et al. (1976).

3. RESULTS AND DISCUSSION

3.1 Landuse/Landcover Change in the Study Area

Table 2 summarizes landuse/landcover classes in the study area and reveals that the dominant landuse type for the period under review (2007-2016) is agricultural (64.65%). Though there is a steady but gradual decrease in percentage - 62.59% in 2011 and 60.52% in 2016. This may not be unconnected with the conversion of hitherto agricultural land to mining land and the expansion of settlements. This result contrasts with the finding of Amos (2010) in Ashaka that agricultural land had increased by 3.18%. Other major landuse/landcover classes within the study area include bare land surfaces which have witnessed some measure of increment from 16.75% (2007) to 22.89% (2016) as shown in Figure 3.This result is expected as coal mining requires the clearing of large expanse of land for exploration, excavation, storage and transportation of the mined coal. Another reason for the increase in bare surfaces may not be directly linked to coal mining as there is a large concentration of cattle that graze within the vicinity of the mining concession.

The study area is spotted with pockets of hills/ridges of sedimentary origin. At the commencement of mining in 2007, the area covered by hills was 15.59% which reduced to 15.12% in 2011 and 15.05% in 2016. These figures reveal a gradual decrease from 2007 to 2016. This can be attributed to mining activities as observed by the researcher. Some of the hills have almost been flattened as a result of coal excavation leaving behind heaps of overburden waste.

Settlement is another landuse type that shows a reduction in size from the initial growth in 2011 (2.59%) to a decline (0.53%) in 2016 as shown in Table 2. This agrees with the finding of Nzuda (2013) which reported that settlement has reduced by (14.36%) due to mining in Mboya District of Tanzania. The reasons are not farfetched, and may include the re-settlement of some communities whose lands have either been confiscated or acquired without adequate compensation. There is also the problem of pollution from dust and coal mine fires that periodically affect close communities.

The area covered by vegetation has equally witnessed some decline from 0.56% (2007) to 0.29% and 0.27% for 2011 and 2016 respectively (refer to Table 2). Overgrazing, mining activities and the continuous clearing of land for cultivation could be responsible for the decline in vegetation cover over the study area. A similar case was reported by Nzuda (2013) in Tanzania that the rampart and random clearing of forest areas for mining purposes has resulted into drastic changes and significant reduction of vegetation cover.

Water bodies within the area have equally reduced from 0.155% at the commencement of mining in 2007 to 0.151% in 2016 as revealed in Table 2. Water is being continuously depleted for both domestic and agricultural uses – mainly for irrigation. The large numbers of cattle also rely on same water sources for drinking. Coal mining requires a lot of water particularly for spraying on the normally dust – laden roads and for excavation purposes as well. Consequently, both surface and underground water sources are depleted around the mining concession.

Table 2: Landuse/ Landcover Classes

Landuse/Landcover	2007	%	2011	%	2016	%
Vegetation	0.270	0.558	0.140	0.289	0.130	0.269
Coal Mining Pit	0.122	0.252	0.167	0.345	0.257	0.530
Ridges	7.550	15.596	7.320	15.121	7.290	15.059
Settlement	0.969	2.002	1.258	2.598	0.257	0.530
Bare Land	8.110	16.753	9.140	18.880	11.083	22.894
Agricultural Land	31.300	64.656	30.300	62.590	29.300	60.525
Water body	0.077	0.159	0.074	0.153	0.073	0.151
Mined Coal	0.013	0.026	0.015	0.031	0.021	0.043
Total	**48.41**	**100.0**	**48.41**	**100.0**	**48.41**	**100.0**

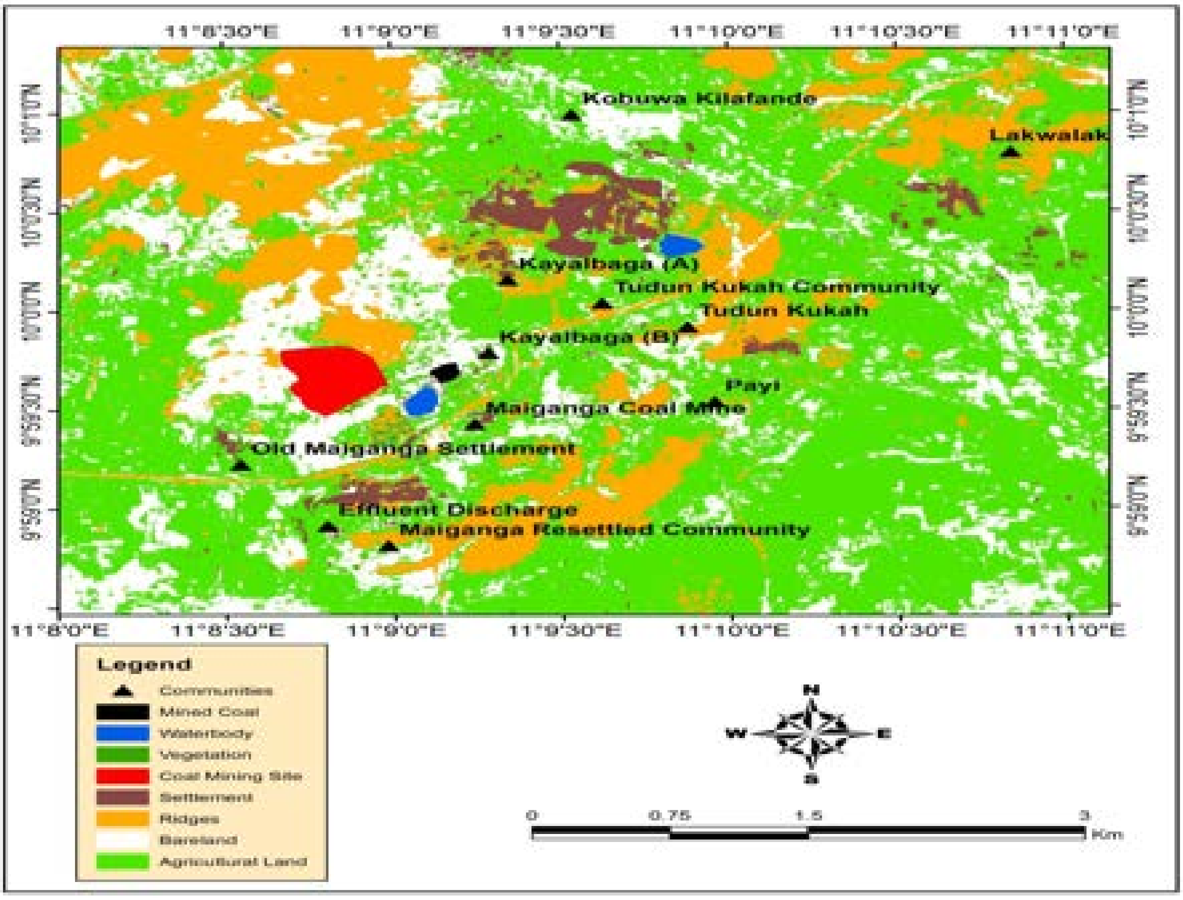


Figure 3: Landuse/Landcover of Maiganga and Environs in 2016

4. CONCLUSION

Analysis of landuse/landcover classes in the study area revealed that the dominant landuse type for the period under review (2007-2016) is agricultural. Though there is a steady but gradual decrease in percentage from 2011 to 2016. This may not be unconnected with the conversion of hitherto agricultural land to mining land and the expansion of settlements. There is also a gradual decrease in the height and number of hills/ridges in the area. The settlements within the area have equally reduced in size from the initial growth in 2011. There is also the problem of pollution from dust and coal mine fires that periodically affects close communities. The area covered by vegetation has equally witnessed some decline from. Overgrazing, mining activities and the continuous clearing of land for cultivation could be responsible for the decline in vegetation cover over the study area. Water bodies within the area have equally reduced.

4.1 Recommendations

- The gradual but steady decrease in agricultural land due to the conversion of hitherto agricultural land to mining land could be controlled by reclaiming already mined areas to be used for cultivation. Bare land surfaces which have witnessed some measure of increment can be reduced by embarking on re-forestation by the mining company.
- The Coal Mine should curtail the incidences of coal mine fires which pumps tons of smoke and other pollutants into the atmosphere by providing firefighting equipment and personal for prompt intervention.
- Range farming can be introduced to forestall the further loss of vegetation in the area. Also, the dusty roads should be built with asphalt to reduce the amount of dust released into the atmosphere which retards vegetation growth. Also, motorized boreholes should be sunk in all the communities in order to avoid a looming human disaster from water borne diseases.

REFERENCES

Abdulkarim, B. Olodipo, E.O and Balarabe, M.L (2015). *Building Resilience*: Adaptive Strategies for Livelihoods most at risk to Climate Change impacts in Desertification prone Areas of Katsina State, Nigeria and a Trans-boundary Community in Niger

Amos, B. B. (2010). *An Assessment of the Effects of Limestone Mining on LULC Changes in Ashaka Area, Gombe State.* An Unpublished Msc. Thesis, Dept of Geog: A.B.U. Zaria.

Anderson, J.R., Hardy, E.E., Roach, J.T. and Witmer, W.E. (1976). A Land-use and Land cover Classification System for Use with Remote Sensing Data. *U.S. Geological Survey Professional Paper964*, Pp.23. Reston, Viginia.

Arango, C.L. (2012). *Re-Used Landscapes.* Milano, Italy.

Ashaka Geological Survey (1987) in: Amos (2010). *An Assessment of the Effects of Limestone Mining on LULC Changes in Ashaka Area, Gombe State*. An Unpublished Msc. Thesis, Dept of Geog: A.B.U. Zaria.

Globalmethane,(2014).*Nigeria: Coal Mine Methane Country Profiles*. https://www.globalmethane.org

Greenpeace, (2016). *About Coal Mining Impacts*. http://www.greenpeace.org

Gupta, S. K. and Nikhil, K. (2016). Ground Water Contamination in Coal Mining Areas: A Critical Review. *International Journal of Engineering and Applied Sciences (IJEAS)* ISSN: 2394-3661, Volume-3, Issue-2, February.

Gutti, B., Aji, M.M., and Magaj, G. (2012). Environmental Impact of Natural Resources Exploitation in Nigeria and the Way Forward. *Journal of Applied Technology in Environmental Sanitation.*Volume 2, Number 2: 95-102, August.

Maliganya, W., Simon, M.S., and Paul,R. (2013). *Large Scale Mining Activities and the Livelihood of Adjacent Communities in Tanzania: A Case of Geita Gold Mine*. Draft Report Presented at REPOA's 18th Annual Research Workshop held at the Kunduchi Beach

Hotel, Dar es Salaam, Tanzania; April 3-4, 2013.

Mishra, P.P., Reddy, M.G. (2011). Threat to Forest Commons: Mapping the Livelihoods of Mining induced Communities in the Eastern Ghats of Andhra Pradesh.

Mondal, S., Bandayopadhyay, J. Chakravatry, D. (2014). Scientific Investigation of the Environmental Impact of Mines Using Geospatial Techniques over a Small Part of Keonjhar District of Orissa. *International Journal of Scientific and Research Publications,4(1):pp 66-68*

Musa, H.D. and Jiya, S.N. (2011). An Assessment of Mining Activities' Impact On Vegetation in Bukuru, Using Normalized Differential Vegetation Index (NDVI). *Journal of Sustainable Development 4(*6) pp 88-92

Nzunda, P.H. (2013). Impacts of Mining Activities on Land Cover and Forest Stock in Mbozi District, Mbeya Region, Tanzania. A Dissertation Submitted in Partial Fulfilment of the Requirements for the Degree of Master of Science in Management of Natural Resources for Sustainable Agriculture of Sokoine University of Agriculture,Morogoro, Tanzania

Osei-Bagyina, A. (2012) Assessment of the Impact of Mining on the Land use Systems and Livelihoods in the Obuasi Municipality. An unpublished M.SC Thesis submitted to the Department of Materials Engineering, Kwame Nkrumah University of Science and Technology, Accra, Ghana.

Prakash, A. and Gupta, R.K. (1998). Land-use mapping and change detection in a coal mining area- a case study in the Jharia Coal field, India. *International Journal of Remote Sensing*.3, 391-410.

Priyadarshi, N. (2012). Effects of Mining on Environment in the State of Jharkhand, India. *Environment and Geology.* Accessed Wednesday, May 12.from: http://nitishpriyadarshi.blogspot.com.ng on 17-11-16.

Yaro, Irene J. (2010). The Impact of Mining on Livelihoods of Local Communities: A Case Study of Newmont Ahafo South Mining Project of Brong Ahafo Region of Ghana. An unpublished Master of Arts Thesis submitted to the Graduate School of Development Studies, International Institute of Social Studies, The Hague, Netherlands.

Savanna volume 23, Number 1, June, 2016

Analysis of Landuse/Landcover Change in Southern Part of Kaduna Metropolis, Kaduna State, Nigeria

Ishaya Goje Musa[1], Benedine Akpu[2*], Innocent Idowu Abbas[3]
[1]*Department of Surveying and Geo-informatics, Nuhu Bamalli Polytechnic, Zaria*
[2]*Department of Geography & Environmental Management, Ahmadu Bello University, Zaria*
[3]*Department of Geography, Kaduna State University, Kaduna*
*Benyb4real@yahoo.com

ABSTRACT

Landuse and landcover change drives changes that limit availability of products and services for human and livestock, and can undermine environmental health as well. This paper analyzed landuse/landcover change (LULCC) in the southern part of Kaduna metropolis. The data used were; Landsat (4) Thematic Mapper (TM) of 1990, Landsat (7) Enhanced Thematic Mapper Plus (ETM +) of 2001 and Landsat (8) ETM + of 2014 all with 30m spatial resolution. Erdas Imagine Software version 9.2 and ArcGIS version 10.1 were used for the analysis. Supervised classification technique with Maximum Likelihood Algorithm was used to classify the data into landuse/lancover classes. An overlay analysis was carried out in order to determine the changes in the landuse/landcover classes. The results revealed an overall change in landuse/landcover status of the area. Urban landuse witnessed an overall increase of 186.29% with an annual expansion rate of 7.76% within the study period (1990-2014). Agricultural land which was the most dominant in 1990, decreased by 25.64% in 2014. Similarly, vegetation and bare surfaces decreased by 48.13% and 18.81% respectively within that period. The study recommends that there should be periodic monitoring and modelling of landuse and landcover changes in the study area for formulating effective environmental policies and management. There is also the need to control urban development by by relevant agencies in the area in order to avoid harphazard developments that may have negative consequences on the environment and the people.

Keywords: Landuse/landcover; GIS; Remote Sensing; Urban development.

1. INTRODUCTION

Human beings have been modifying land to obtain food, shelter and other essentials of life for thousands of years. Current rates, extent and intensities of such modifications are far greater now than ever in history and continue undocumented (Eastman 1999**)**. Landuse and landcover dynamics are widespread and accelerating. It is a significant process driven by human actions but also producing changes that impact humans (Agarwal et al., 2002). These dynamics alter the availability of different biophysical resources including soil, vegetation, water, animal feed among others. Consequently, landuse/landcover changes could lead to a decreased availability of different products and services for human, and livestock as well as damage to the environment.

Landcover according to Campbell (1996) refers to the physical cover of the Earth including natural vegetation, crops, artificial constructions that cover the land surface while landuse describes the use of the land by the people usually with emphasis on the functional role of land on economic activities. Landuse is the actual use of the land which is the purpose for which man exploits the landcover (Omojola, 1997). Landuse change is a locally pervasive and globally significant ecological trend. Clawson, Mari and Stewart (1965) noted that landuse/lancover (LULC) change is one of the well documented global changes.

Drescher (2000) observed that changes in landuse can be due to urban expansion, loss of agricultural land, changes in river regimes, the effect of shifting cultivation, the spread of erosion and desertification among others. However, Oyedele (1977) identified population growth and rapid economic transformation as the leading causes of landuse and landcover change. According to the United Nations World Population Prospects (2012), the current world population of 7.2 billion was projected to increase to 8.1 billion by 2025 and 9.6 billion in 2050. Most of this population growth will occur in developing regions, whose population is expected to increase from 5.9 billion in 2013 to 8.2 billion in 2050 (United Nations World Population Prospects, 2012). The same report pointed out that more than half of global population growth between 2013 and 2050 is expected to occur in Africa. This implies that most of the landuse/landcover changes are occurring in developing countries of the world and Nigeria is not an exception; this explains why southern part of Kaduna metropolis also experiences changes in LULC.

The LULC of southern part of Kaduna Metropolis remained largely unchanged until the last four decades when the area began to assume some dimension of spatial growth due to population growth and rapid economic transformation (Oyedele, 1977). Due to the activities of man, the LULC status of the area has being undergoing modifications. Some of the vegetation cover and agricultural land that were conspicuous in parts of the area have now disappeared as built-up areas appear to be increasing (Akpu, 2012). The findings by Akpu (2012) revealed that built-up area increased from 6,410ha to 19,611ha between 1973 and 2009 at the rate of 5.72% annually. The results also showed that the southern part of the metropolis was growing at a faster rate of 11.24% yearly within that same period. Such trend in LULCC could lead to some adverse effect on the ecosystem and consequently, deterioration of the environment. There is therefore, the need to analyze the changes in LULC of the area. Hence, the aim of this paper is to apply remote sensing and Geographic Information System (GIS) techniques to analyze landuse/landcover changes in the Southern part of Kaduna metropolis with a view to determine the nature, magnitude and rate of change in landuse/landcover of the area between 1990 and 2014.

1.1 The Study Area

Southern part of Kaduna metropolis is found in Kaduna State, Nigeria, located between latitudes 10° 23′30″North-10°29′30″North and Longitudes 7°21′45″East - 7°31′30″East (Figure 1). The area has a total land mass of 319.16km² and bounded by River Kaduna to the north and extends southwards to cover all the settlements south of River Kaduna (Oyedele, 1977). The area lies on an enclosed gentle rolling within the undulating high plains of northern Nigeria (Musa, 1993). The dry season lasts from November to March. The mean annual rainfall is about 1525mm and the length of the rainy season period is about 200 days. The mean monthly temperature reaches 28°C in March and drops to 23.3°C in December (Abaje & Giwa, 2008). Humidity is constantly high (above 60%) at mid-day and close to 100% at night during the rainy season (Ndabula, 2006). The vegetation is shrub savanna interspersed with orchard bush which is an indication of degradation of natural vegetation. The original vegetation which was slightly thick woodland and tall grasses has been modified by intense cultivation, grazing and burning (Jackson, 1958).

The population of southern part of Kaduna metropolis is estimated at 299,451 according to 1991 census figures of localities and is expected to reach 597,280 by the year 2014 as projected by the researchers using the exponential method of population projection. This implies that the population of the area had almost doubled with an increase of about 99.5% and an annual growth rate of about 4.3%. Such population growth is expected to mount great pressure on the land leading to changes in landuse/landcover across the area (Akpu, 2012).

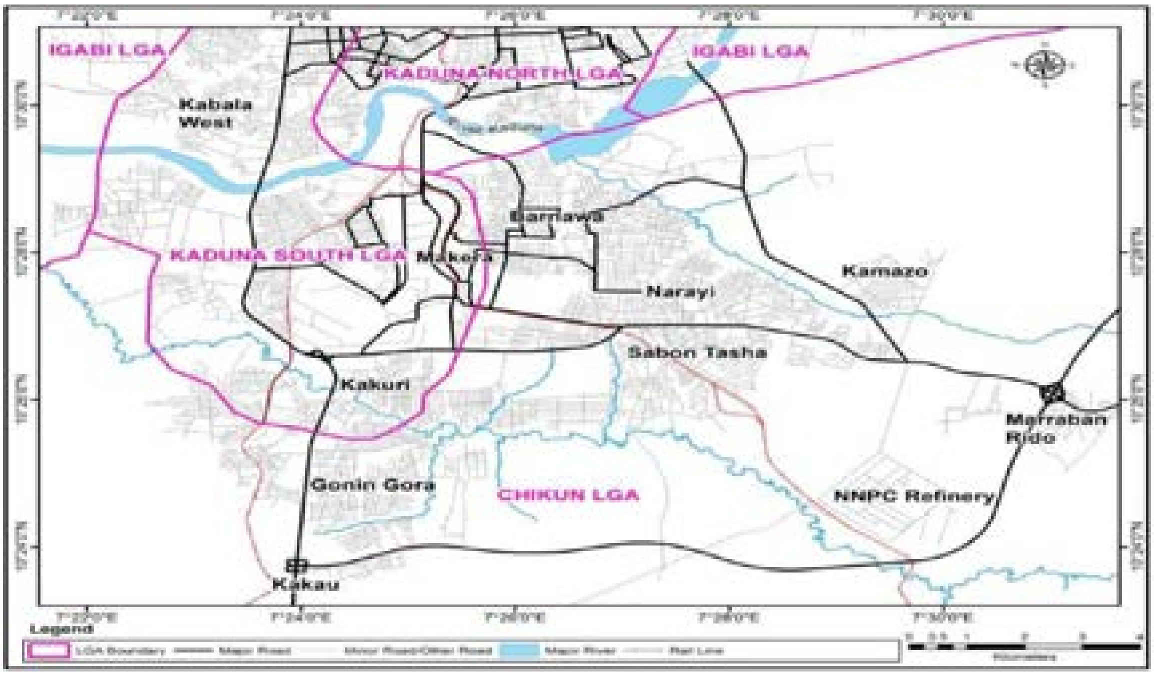


Figure 1: Southern part of Kaduna Metropolis (The study area).
Source: Modified from the Administrative Map of Kaduna State.

2. MATERIALS AND METHODS

A reconnaissance survey was carried out to identify the landuse/landcover types in the area. A hand-held Global Positioning System (GPS) (GARMIN PRO MAP 76 CSX) receiver was used which facilitated navigation and identification of locations of salient points. The main data used were satellite imageries covering the study area which include: Landsat 4 Thematic Mapper (TM) acquired on 27th November 1990, Landsat 7 Enhanced Thematic Mapper Plus (ETM +) obtained on 24th October, 2001 and Landsat 8 ETM + of 23rd February 2014 all with 30m spatial resolution. They were used to generate the landuse/landcover maps of the area. The sub-setting of the Area of Interest (AOI) from the larger scenes was achieved using ERDAS IMAGINE 9.2 software. The datasets were auto-rectified and needed no any geometric and radiometric correction. However, the datasets were geo-referenced in order to conform to a geographic coordinate system. Since the datasets had the same spatial resolution, re-sampling was not necessary because the data were already suitable for overlay analysis and other forms of GIS operations. Supervised classification using maximum likelihood classifier was carried out to sort each of the datasets into landuse/landcover classes. The classes are: built-up land, agricultural land, vegetated land, waterbody and bare surface. The classification scheme was modified from Anderson et al. (1967). The extent and rate of change in landuse/landcover were then calculated. Ground truthingwas carried out in order to ascertain the accuracy assessment of the classification.

An accuracy assessment matrix was generated using the error matrix and Kappa Coefficient. The Kappa Coefficient according to Congalton (1991) expresses the proportional reduction in error generated by a classified process compared with the error of a completely random classification. In order to assess the accuracy of the classification, 25 ground control points were obtained based on the recommendations of Van Genderen and Lock (1977) which states that a minimum sample size of 20 to 30 observations (reference pixels) per class are required for an acceptable classification accuracy assessment. Therefore, the 25 ground control points from each landuse are converted to raster in ArcGIS. A signature tool was used to combine the cells with those of the classified image. This resulted in a Confusion Matrix and the Kappa was calculated. The calculation for the overall accuracy was obtained using Kappa statistic (Congalton, 1991).

$$K = \frac{p_o - p_e}{1 - p_e}$$

Where K = Kappa
Po = Observed Accuracy
Pe = Expected Accuracy

3. RESULTS AND DISCUSSION

The results of the classification of LULC and analysis of the changes that occurred therein between the periods 1990 and 2014 in Southern part of Kaduna metropolis are presented and discussed in this section using maps, charts and Tables.

3.1 Ground Truthing andAccuracy Assessment

Results of the accuracy assessment of the image classification using error matrix and Kappa Coefficient are presented inTable 1. Table 1 shows that built-up areas had a User's accuracy of 68% and Producer's accuracy of 65%. Agricultural land had the highest level of User's and Producer's accuracy with 72% and 69% respectively. The overall User's accuracy was 80% and the kappa coefficient was 0.41 which is said to be fair and good according to Congalton (1991).

3.2 Landuse and Landcover Distribution in Southern part of Kaduna Metropolis

Table 2, Figures 2, 3 and 4 show the landuse/landcover distribution in Southern part of Kaduna metropolis in 1990, 2001 and 2014. Table 2 shows that agricultural landuse was dominant in 1990 occupying about 67.0% of the entire area. This was followed by built-up area which accounted for 12.71% of the total land area. Waterbody had the lowest coverage with only 1.02% of the area. In 2001, agricultural land still had the largest area coverage with about 63.0% while built-up landuse had the second largest area coverage accounting for 19.34%. Waterbody still occupied the lowest area (0.83%).

Table 1: Accuracy assessment of image classification

Landuse	Built-up land	Agriculture land	Vegetated land	Water body	Bare surface	Total	User's Accuracy

Built-up land	**17**	2	3	2	1	25	68%
Agriculture land	2	**18**	2	1	2	25	72%
Vegetated land	4	2	**15**	2	2	25	60%
Water body	2	3	1	**16**	3	25	64%
Bare land	1	1	2	3	**14**	25	56%
Total	26	26	23	24	22	**125**	
Producer's Accuracy	65%	69%	65%	67%	64%		Total 80

Table 2: Landuse/Landcover distribution

	1990		2001		2014	
Landuse/landcover	Km²	%	Km²	%	km²	%
Built-up land	40.56	12.71	61.71	19.34	116.12	36.38
Agricultural Land	213.79	66.99	201.18	63.03	158.98	49.81
Vegetated land	28.07	8.79	22.46	7.04	14.56	4.56
Bare Surface	33.50	10.50	31.17	9.77	27.20	8.52
Water Body	3.25	1.02	2.64	0.83	2.30	0.72
Total	**319.16**	**100.00**	**319.16**	**100.00**	**319.16**	**100.00**

In 2014, though agricultural landuse still covered the largest area, but the proportion drastically reduced to 49.81%. Built-up area still remained the second largest; however, it increased to 36.38% which almost doubled the area it occupied in 2001. The implication is that if build-up area continues to maintain its increase at that alarming rate, it will force agricultural land to continue to shrink and subsequently result in shortage of farmlands for agricultural purposes.

3.3 Magnitude and Rate of Change in Landuse/landcover

The magnitude and annual rate of change in landuse and landcover classes between the periods 1990 - 2001; 2001- 2014 and 1990-2014 are presented in Table 3. The results show that the area coverage of all the landuse/landcover classes with the exception of built-up land decreased at varying proportions between 1990 and 2001. However, built-up or urban landuse increased by 52.15% during that same period. The period between 2001 and 2014 also shows that all the landuse/landcover classes except urban landuse reduced in area extent. Vegetated land and agricultural land were mostly affected as they reduced by 35.17% and 20.98% respectively.

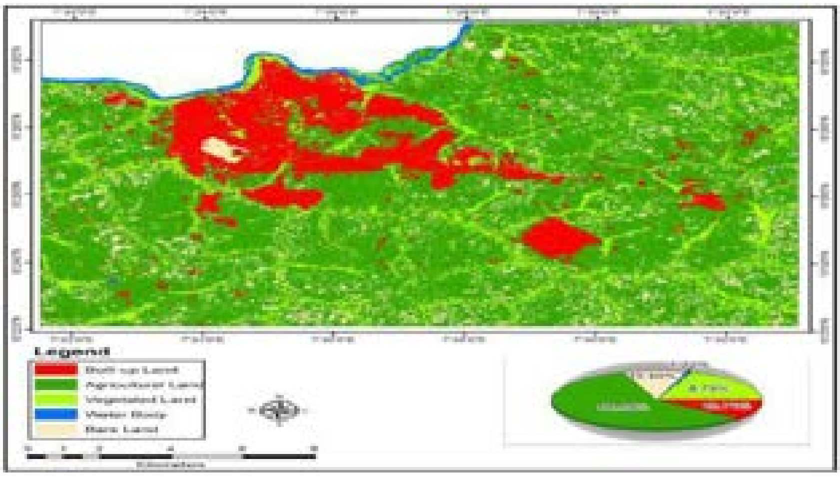


Figure 2: Landuse/landcover distribution in Southern part of Kaduna Metropolis in 1990

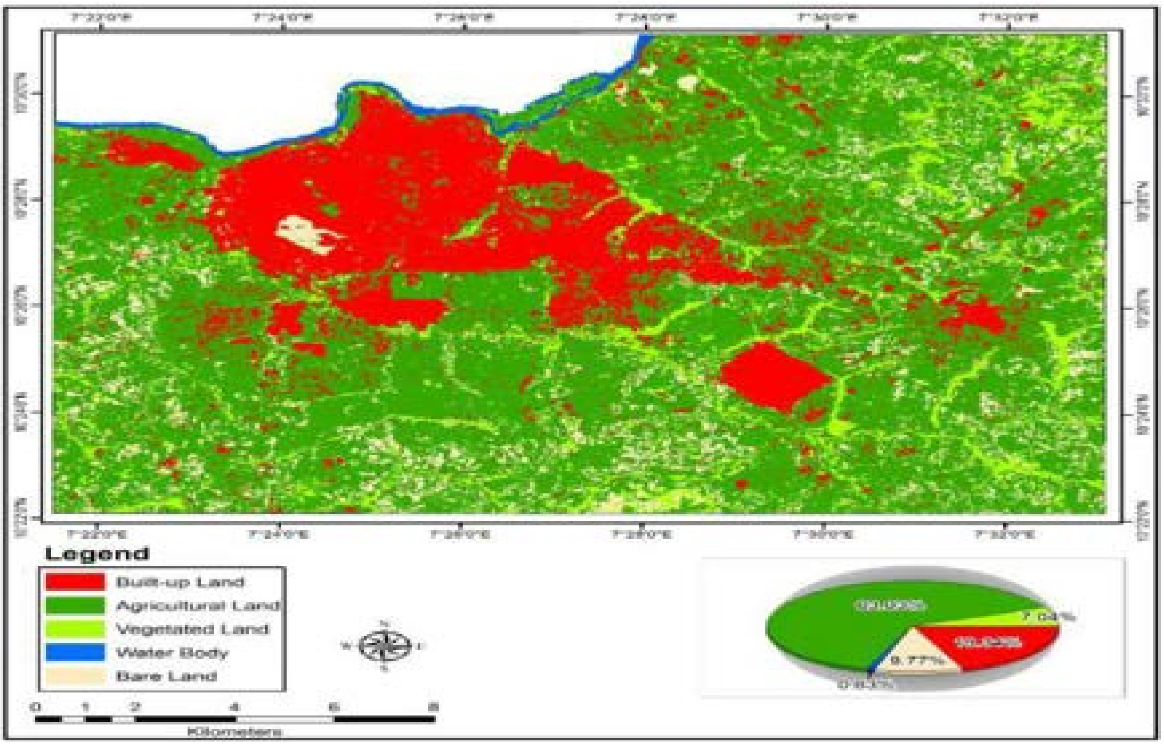


Figure 3: Landuse/landcover distribution in Southern part of Kaduna Metropolis in 2001

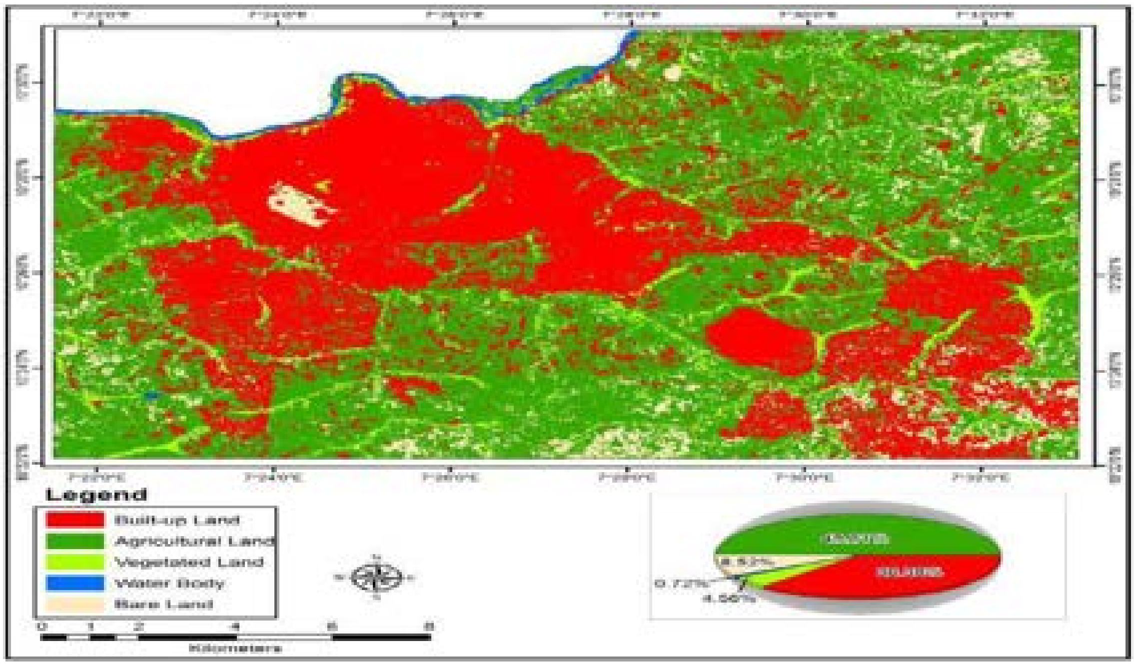


Figure 4: Landuse/landcover distribution in Southern part of Kaduna Metropolis in 2014

Table 3: Magnitude and Rate of Change in Landuse/landcover between 1990 and 2014

Land use	**Magnitude of Change**						**Annual Rate of Change**					
	1990-2001		2001-2014		1990-2014		1990-2001		2001-2014		1990-2014	
	km²	%	km²	%	km²	%	km²	%	km²	%	km²	%
Built-up	21.15	52.15	54.41	88.17	75.57	186.29	1.92	4.74	4.19	6.78	3.15	7.76
Agricultural	-12.61	5.90	-42.20	20.98	-54.81	25.64	-1.15	0.54	-3.25	1.61	-2.28	1.07
Vegetated	-5.61	19.99	-7.90	35.17	-13.51	48.13	-0.51	1.82	-0.61	2.72	-0.56	2.01
Bare surface	-2.33	6.96	-3.97	12.74	-6.30	18.81	-0.21	0.63	-0.31	0.98	-0.26	0.78
Water body	-0.61	18.77	-0.34	12.88	-0.95	29.23	-0.06	1.71	-0.03	1.13	-0.04	1.22

On the other hand, urban land increased by about 88.0% during that period. The entire 25years period (1990-2014) studied shows that urban land experienced rapid increase while other landuses decreased (Figures 2, 3 and 4). The results further revealed that the built-up or urban land was changing at a high rate of 7.76% annually. The implication of such rate of change is encroachment of built-up land on other LULC types in the area. This confirms the assertions of Oyedele (1977) and Drescher (2000) that changes in landuse can be attributed majorly to urban expansion, population growth and economic transformation.

4. CONCLUSION AND RECOMMENDATIONS

This paper demonstrated the ability of GIS and Remote Sensing techniques in analysing landuse/landcover changes. Landuse/landcover change is evident in southern part of Kaduna metropolis as revealed by the analysis. All the landuses in the study area have changed dramatically between 1990 and 2014. Urban landuse increased rapidly by about 186.0% and at the rate of 7.76% annually within the study period (1990-2014). However, other landuse/cover decreased and agricultural and vegetated landuses were mostly affected. Built-up area experienced the highest annual rate of increase (6.78%) between 2001and 2014, while vegetated land and agricultural land had the highest rate of decrease (2.27% and 1.61% respectively) during that period. It was also established that most of the landuse and landcover changes were driven by human actions.

Based on the findings of this research, the following are recommended: there should be periodic monitoring and modelling of landuse and land cover changes in the study area for formulating effective environmental policies and management strategies; the agencies responsible for urban planning should effectively plan, monitor, and control urban development in the area so as to checkmate the harphazard developments that may have negative consequences on the environment and the people.

REFERENCES

Abaje, I.B. & Giwa, P. N. (2008). Urban Flooding and Environmental Safety*:* A Case Study of Kafanchan Town in Kaduna State. In: Mamman, A.B., Chup, C.D. and Mashi, S.A. (Eds.), *Ubanisation,Resource Exploitation and Environmental Stability in Nigeria.* Book of Proceedings of the 49th Annual Conference of the Association of Nigeria Geographers (ANG). Held at Department of Geography, University of Abuja- Nigeria, pp: 582-589.

Agarwal, C., Green, G. M., Grove, J. M., Evans, T. P. & Schweik, C. M., 2002. A Review and Assessment of Land-Use Change Models: Dynamics of Space, Time, and Human Choice. *General Technical Report NE-297*. Newtown Square, Pennsylvania: U.S. Department of Agriculture, Forest Service, Northeastern Research Station. 61 pp.

Akpu, B. (2012). Remote Sensing and GIS-Based Analysis of Urban Expansion and Encroachment on FloodPlain in Kaduna Metropolis, Nigeria. *Zaria Geographer*, 19(1): 150-163.

Ariyo, J. A. (1991). The Policy Challenges of Urban Land Speculation an Ilorin Case*. In*

Olofin, E. A. and Patric, S. eds. *Land Adminitration and Development in Nigeria* pp. 39-47, Zaria: Ahmadu Bello University Press

Ashiya, T. I. (1976). Land and soil characteristics studies in relation to erosion and livelihood with special reference to river basin development, Sagua, V. O: Enabor, E. E; Olmata, G. E. K; Ologe K. E; and Oyebande, L. O. (eds): *Ecological disasters in Nigeria: Soil erosion*, FMST, Lagos pp173.

Batty, M. & Howes, D. (2001). Predicting Temporal Patterns in Urban Development from Remote Imagery. In: Donnay J. P., Barnsley M. J. and Longley P. A.(Hrsg.), *Remote Sensing and Urban Analysis.* PP. 185-204. London. Taylor and Francis.

Cambell, J. B. (1996). *Introduction to Remote Sensing.* The Guilford press.

Clawson, Mari. & Stewart, C. L. (1965). *Land use information. A critical survey of U.S. statistics including possibilities for greater uniformity*: Baltimore, Md., The Johns Hopkins Press for Resources for the Future, Inc., pp 402

Congalton, R. G. (1991). A Review of Assessing the Accuracy of Classification of Remotely Sensing Data, *Remote Sensing of Environment*, 37: 35-46.

Donnay, J. P., Barnsley M. J. and Longley P. A. (2001): *Remote Sensing and Urban Analysis*. London. Taylor and Francis.

Drescher, Axel. (2000). *Urban and Periurban Agriculture and Urban Planning*". University of Freiburg, Germany.

Eastman, R. (1999). *Guide to GIS and Image Processing*. Clark University, Worcester, MA.

Herold, M., Scepan, J., & Clarke, K. C. (2002): The Use of Remote Sensing and Landscape metrics To Describe Structures and Changes in Urban Land Uses. *Environment and Planning.* A(34): 1443-1458.

Musa, I.J. (1993). *Journey to Work Pattern in Zaria Urban Area*. Unpublished M.Sc. Dissertation.Department of Geography, Ahmadu Bello

University, Zaria, Kaduna State 41-53pp.

Ndabula, C. (2006). *Assessment of Landuse/Landcover Changes in Kaduna Metropolitan area using Remote Sensing and Geographic Information System*. Unpublished Msc. Dissertation, Department of Geography, Ahmadu Bello University, Zaria Nigeria

Omojola, A. (1997). *Use of Remote Sensing and Geographic Information Techniques in Land Use and Land cover Inventory and Change Assessment in a Semi-Arid Region of Nigeria.* Unpublished PhD Thesis, University of Lagos.

Oyedele, E. (1977). *The History of the Establishment of Kaduna (1917-1957)* Unpublished B. A. Project, Department of History, Ahmadu Bello University, Zaria.

Ramachandra, T. V.Bharath, H.A. & Sreekantha, S. (2012). Spatial Metrics Based Landscape Structure and Dynamics Assessment for an Emerging India Megapolis. *International Journal of Advanced Research in Artificial Intelligence.*

Unite Nations Press Release, (2013). *EMBARGOED UNTIL 13 JUNE 2013,* 11:00 A.M., EDT.

United Nations World Population Prospects (2012). *World Population Prospects*: The 2012.

Savanna volume 23, Number 1, June, 2016

An Assessment of the Urban Canopy Heat Island (UCHI) of Kano Metropolis During the Dry/Hot Season

Abdulhamed, I. A.[1]*, Kibon, A.U.[2], Usman, S. U.[1], Nduka, I. C.[3]
[1]*Department of Environmental Management and Toxicology, Federal University, Dutse*
[2]*Department of Geography & Environmental Management, Ahmadu Bello University, Zaria*
[3]*Department of Geography, Federal University, Lokoja*
abdulhamidaz@yahoo.com

ABSTRACT

Urbanization has had a profound impact on our local, regional and even global climate, through the modification of the natural environment by replacing it with artificial surfaces, canyons and materials. This study assessed the nature of Urban Canopy Heat Island (UCHI) intensities in Kano metropolis during the hot/dry season. This study involved the measurement of temperature within the period and determination of the UCHI within Kano metropolis. The study measured the temperature data using an automatic temperature data logger and determined the UCHI from the data collected. The different sample stations were determined using the canyon zoning system known as the Urban Climate Zone (UCZ). Temperature and UCHI variation for the study were also determined for two periods that showed its diurnal distribution. The study area was categorized into 13 stations and all the classes of the UCZ fit into the study area. The UCHI characteristics showed a generally warm profile during the day time and night time periods, suggesting that most of the stations had high temperatures. This can be attributed to the season, as it is classified as hot and dry, thereby allowing for high insolation and consequent warming and heat retention capacity of the surface and the overlying atmosphere. The UCHI intensities can be attributed to the nature of the surface materials and characteristics, as well as level of human activities ranging from moderate to high, taking place within the various stations. It is thereby recommended that extensive vegetation of the metropolis be carried out so as to mitigate the effect of the UCHI within the area.

Keywords: Urban Canopy Heat Island; Urban Climate Zone; Hot Season; Kano Metropolis.

1. INTRODUCTION

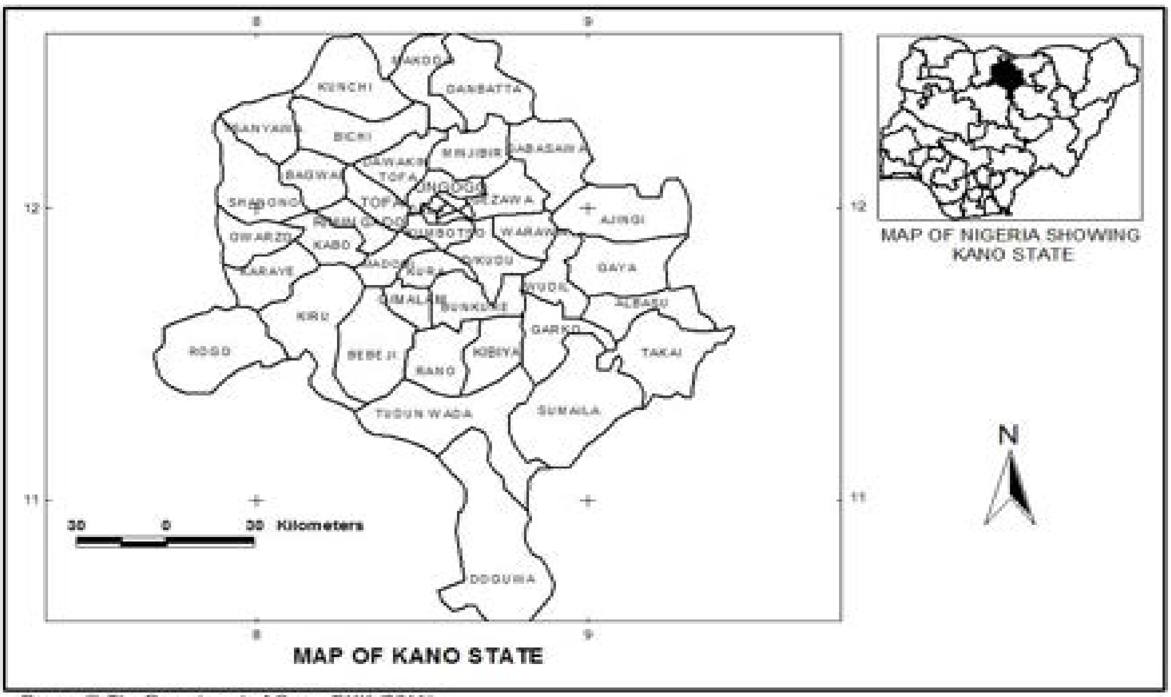
An urban area is perhaps the most complex of the entire earth surface phenomenon; this is due to the multi-facetious nature of its artificial character as promoted by the various activities taking place in such an area. The highly varying temperature characteristics of the urban structures, the artificial injection of heat into the urban system and the presence of aerosols in the atmosphere have led to a considerable urban temperature field (Montávez et al., 2008). Significant and widespread changes in landuse/landcover resulting from urbanization cause changes in climatic conditions of a place. The best known phenomenon resulting from these modifications is the so-called Urban Heat Island (UHI) (Landsberg, 1981 and Montávez et al., 2008). Oke (1987) defined UHI as the temperature differences between the urban area and its rural surroundings, always assuming that the records should be similar if there were no urbanization.

Landsberg (1981) stated that an understanding of the urban heat island is important for a variety of reasons; the radiation absorbed warms the ambient air thus increasing the low-level stability and consequently preventing the pollution dispersal, which will result in an increase in pollution concentration. It also helps in setting up of the recirculation of pollutants thus making the pollution problems more serious with increasing emphasis on planning for healthier and comfortable physical environments in cities. Thus, the need to recognize the role of cities increasing and meeting the challenges posed by climate change has become greater. This paper is aimed at assessing the UCHI of Kano metropolis during the hot/dry season.

1.1 Study Area

Kano Metropolis is one of the nerve centers of commercial activities in northwestern Nigeria. It is located between latitudes 12°25′N and 12°40′N and longitudes 8°35′E and 8°45′E (see Figure 1). The boundary of Kano metropolis keeps on changing with time. The area is presently made up of eight Local Government Areas namely: Kano Municipal, Gwale, Dala, Tarauni, Nassarawa, Ungogo, Kumbotso and Fagge.

The metropolis exhibits the characteristics of a typical African city with cleared vegetation, reclaimed ponds, constructed buildings of various sizes and orientation, criss-cross of roads as well as open spaces like parks, institutions; human activities from transportation, homes, small, medium and large scale industries which serve as sources of pollution and heat generation to a high degree. While the population of the area in 1991was put at 1,364,300 with a population density well over 450/km^{2}, the 2006 census revealed that Kano state had over 9 million persons with more than half living in the metropolis (National Population Comission 2006).



Drown @ The Department of Geog. BUK (2011)

Figure 1: Kano metropolis showing the Local Government Areas

The present climate of Kano is the Tropical wet and dry type, coded as Aw according to Koppen's classification, although climatic changes are believed to have occurred in the past. The mean annual rainfall is about 800mm around metropolitan Kano. Great temporal variation occurs in the amount of rainfall received and no two consecutive years record the same amount. Air temperature characteristics in Kano metropolis as a whole are typical of the West African Savanna climate. Temperature in the area is generally high throughout the year. In Kano, there are seasonal changes, indicating a gradual increase from January to April reaching as high as 43°C. The minimum mean monthly temperature value for the area can be as low as 21°C between December and January. The season found within the metropolis includes; the dry and cool season (mid – November to February), the dry and hot season (March to about mid – May), the wet and warm season (May to Mid September), and dry and warm (September to December) (Olofin, 1987).

2. MATERIALS AND METHODS

The study area was divided into several climate zones or canyon category as defined by Oke (2006). The categorization of the climate zone was done using Urban Climate Zone (UCZ) and it was based on aerial, street view and sky-view photographs, height to width ratio were applicable, surface coverage, nature of surface, nature of building materials and other descriptions given to such categories or zones, which include function of such zones. Thirteen (13) stations were identified, 12 of which were under the urban fields, while 1 was a rural field and served as the control station.

The temperature data was measured using the digital Thermochron from maxim-ic. For details on its durability and reliability see (Hubbart et al., 2005). The device was mounted about 3 meters above the ground and 10 meters from the nearest obstacle (house/tree), except where the measurement is supposed to depict a direct effect of obstacles, as when measuring urban vegetation. The iButton was programmed to log data at every 15 minutes interval for 15:00hrs (day time) and 20:00hrs (night time). The exposure period was 30 days (1 to 30th April) which is the peak of dry season.

The UCHI intensity sought is the multiple heat islands spread across the entire study area and among the various zones of the LULC categorization done for the study. The UCHI intensity is defined for this study as UCHI = $Tu_x - Tr_c$; where:

- T represents temperature of a sample station;
- u represents urban stations;
- r represents rural control site;
- x represents the sites from site 1 to 12 which are in the urban area;
- c represents the control site outside the area.

3. RESULTS AND DISCUSSION

3.1 Temperature Variation

Figure 2 shows the results and temporal patterns of the mean diurnal temperature of each observation sites for the Dry season in the month of April at 15:00hrs local time (3:00pm) and 20:00hrs (8:00pm) respectively. The 15:00hrs profile revealed different values of temperature readings in the various UCZs. LS, GM, SH and TF have the highest diurnal mean temperature value of 46.17°C, 43.67°C, 43.36°C and 43.10°C respectively, while the lowest diurnal mean temperature values were recorded at AP, BK and BR with mean values of 36.32°C, 37.18°C and 38.43°C respectively. It also has a mean temperature range of 10.35°C.

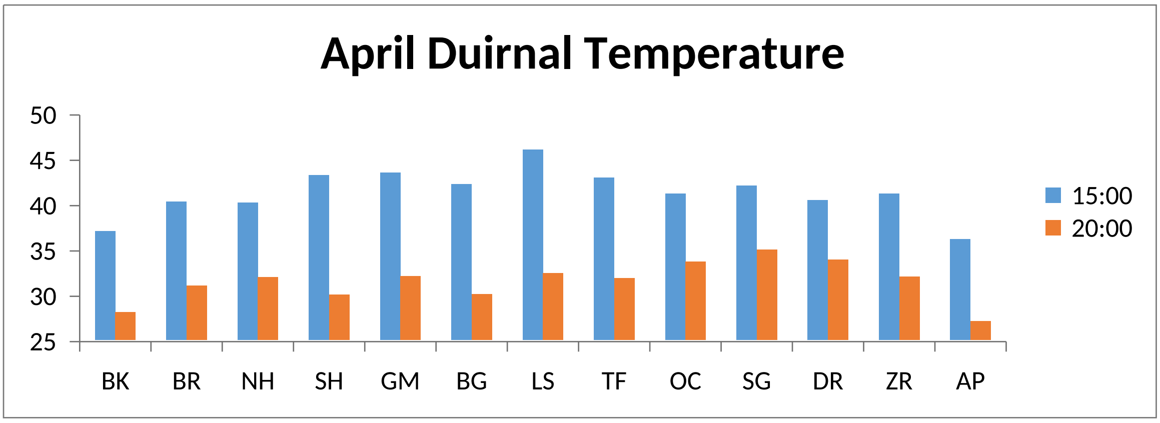


Figure 2: Diurnal temperature variations
BUK(old) (BK); Bello Road (BR); NNPC Hotoro (NH); Sharada (SH); Gidan Murtala (GM); Brigade (BG); Lagos Street (LS); Taludu/Fagge (TF); Old City (OC); Sabon Gari (SG); Dorayi (DR); Zoo Road (ZR); Air Port (AP).

The 20:00hrs profile also revealed that SG, DR, OC and LS have the highest diurnal mean temperature value of 35.13°C, 34.05°C, 33.82°C and 32.54°C, while AP and BK have the lowest diurnal mean temperature value of 27.24°C and 28.24°C respectively. The mean temperature range during this season was 7.84°C. The difference between the day time and night time mean temperature ranges in the area is 2.45°C in the study area. The profile for April shows a higher trend. This is because of the clear sky during this period, and as a result more insolation is received and the surface is warmed more. This translates to the observed temperature, due to the influence of the surface morphology and anthropogenic factors. Stations SG and DR recorded the highest temperatures as a result of the nature of the surface char acteristics, which its influence is heightened during this season, while stations AP and BK records the lower temperature as their surfaces comprising of abundant vegetation still dampens the effect of the higher insolation.

3.2 UCHI Variation

Figure 3 shows a generally warm profile, and this can be attributed to the UCHI, as it is classified as hot and dry, thereby allowing for high insolation and consequent warming of the surface and the overlying atmosphere. The highest record was for LS at 9.85°C, followed by GM, SH and TF at 7.35°C, 7.04°C and 6.78°C respectively. These high values can be attributed to the thick building walls, close-set buildings and large concrete surfaces which have a high retention capacity. They also have high level of human activities and traffic, thereby contributing a lot of anthropogenic heat within the area. The lowest record was for BK at 0.86°C; this could also be attributed to the nature of the surface, as this place has a lot of vegetation and would have had its temperature reduced through shading and evapotranspiration that was taking place in that area. The results obtained are similar to that to those obtained by Okpara (2002) and Balogun and Olaleye (2000) in Akure city of southwestern Nigeria, although their results revealed that their maximum heat island intensity was at 12:00hrs. Chow and Roth (2006) also had a similar result although their maximum UCHI intensity was also at a different time (12:00 LAT).

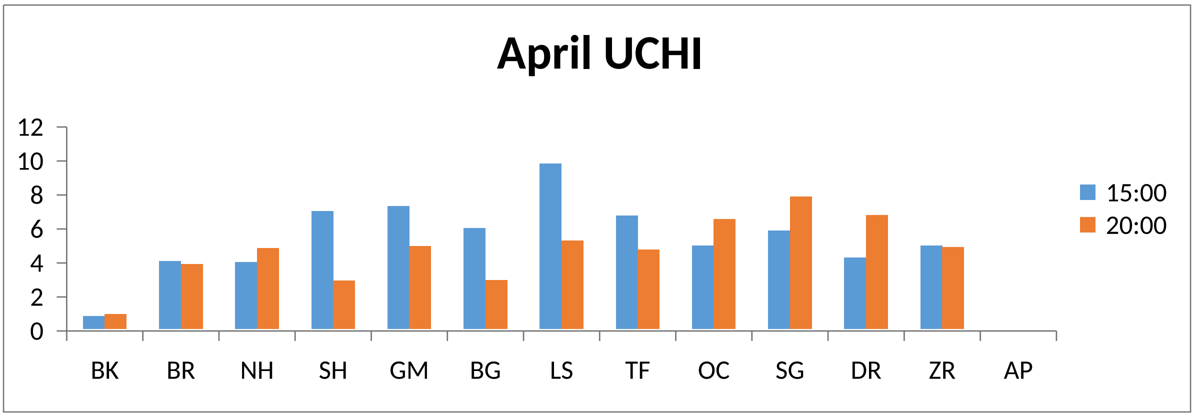


Figure 3: Diurnal UCHI Variations

Figure 3also shows the profile of the UCHI intensity during the night time period and the result suggests a generally warm night, indicating the ability of the various UCZs to retain heat as well as the intensity of insolation that was available during this period. The highest intensity was recorded at SG at 7.89°C, and this was followed closely by DR and OC at 6.81°C and 6.58°C. The mean intensity for this period was 4.39°C and about 67.75% of the stations studied were above this mean. The stations within the high UCHI intensities are those found in the busy and populated parts of the metropolis. SG with the highest intensity is one of the busiest areas in the metropolis, performing of both commercial and residential functions. It is also well known for the bustling activities that go on all day, night and year round. The lowest record was for BK at 1.00°C, which was followed by SH at 2.95°C. These places have notable open spaces especially BK that also gave abundant vegetation. These places are also found towards the fringes of the city. The UCHI range for this period was 6.89°C.Results obtained are in line with UCHI researches in Nigeria (Balogun et al., 2009; Okpara, 2002 and Oguntoyinbo, 1984), where the night time UCHI is less than the day time UCHI. The result is similar in intensity to studies in the extra-tropical regions (Eliasson, 1996; Eliasson and Svensson, 2003) and some in tropical regions (Chow and Roth, 2006).

4. CONCLUSION AND RECOMMENDATION

The UCHI Characteristics in Kano metropolis showed a generally warm profile during the day time, suggesting that most of the stations had high temperatures. This can be attributed to the season, as it is classified as hot and dry, thereby allowing for high insolation and consequent warming of the surface and the overlying atmosphere. The UCHI intensities can be attributed to the nature of the surface materials and characteristics, as well as level of human activities ranging from moderate to high, taking place within the various stations. Also, the results of the night time UCHI intensities suggest a generally warm night, indicating the ability of the various stations to retain heat as well as the intensity of insolation that was available during this period.

This study hereby recommends that traffic conditions within the city should be addressed, as the nodal points within the metropolis play an important role in the temperature/UCHI intensity distribution. Re-forestation should be encouraged rather than deforestation. This is because trees planted around a building shade it from direct solar heating.

REFERENCES

Balogun, A.A. and Olaleye, J.O. (2000).The Characteristics of the Urban Temperature Excess in Akure. *International Journal of Environment and Development*, 2(4): 7 – 12.

Balogun, I.A., Balogun, A.A. and Adeyewa, Z.A (2009).A note on the effect of urbanization on air temperature and humidity in Akure, Nigeria. A paper presented at *IAUC 7th International conference on Urban Climate*. 29th June – 3rd July, 2009, Yokohama, Japan.

Chow, W. and Roth, M. (2006) Temporal Dynamics of the Urban heat Island of Singapore. *International Journal of climatology*, 26: 2243 – 2260.

Eliasson, I. (1996). Urban nocturnal temperatures, street geometry and land use. *Atmospheric Environment*, 30: 379 – 392.

Eliasson, I. and Svensson, M.K. (2003). Spatial air temperature variations and urban land use—a statistical approach. *Meteorological Applications*, 10: 135 – 149.

Hubbart, J.; Link, T.; Campbell, C. and Cobos, D. (2005) Evaluation of a low-cost temperature measurement system for environmental applications. *Hydrol. Process*, 19, 1517–1523

Landsberg, H.E. (1981). The urban climate. *International Geophysics Series*, Vol. 28. Academic Press, New York.

Landsberg, H.E. (1981). The urban climate. *International Geophysics Series*, Vol. 28. Academic Press, New York.

Montávez, J. P., González-Rouco, J.F. and Valero, F. (2008).A simple model for estimating the maximum intensity of nocturnal urban heat island. *Intl. J. Climatol*., 28: 235 – 242.

NPC (2006). National Population Commission, Kano, Nigeria.

Oguntoyinbo, J.S. (1984). Some aspects of the urban climates of tropical Africa. In: Oke, T. R. (Ed). *WMO tech. Note,* 652, 110 – 134.

Olofin, E.A.(1987). Some Aspects of the Physical Geography of the Kano Region, and Related Human Responses, *Departmental Lecture series 1*. Department of Geography BUK. 50pp.

Oke, T.R. (1987). *Boundary Layer Climates*. Methuen, New York, 372pp.

Oke, T.R. (2006). *Instruments and observing methods: World Meteorological Organization Report* No. 81. WMO/TD-NO. 1250.

Okpara, J. N. (2002) A case of Urban Heat Island over Akure city in Nigeria during the end of wet season (October- November) season. *Journal of African Meteorological Society,* 5(2): 43 -53.

Savanna volume 23, Number 1, June, 2016

Thermal Perception in Relation to Physical Characteristics of Urban Outdoor Spaces in Katsina, Katsina State, Nigeria

Usman S.U.[1]*, Abdulhamed A.I.[1], Usman A. K.[2], Dayyabu M.[3], Mallam I.[1] and Azare I.M.[1]

[1] *Department of Environmental Management and Toxicology, Federal University, Dutse*
[2]*Department of Geography & Environmental Management, Ahmadu Bello University, Zaria*
[3]*Department of General Studies, Nuhu Bamalli Polytechnic, Zaria*
**saniuusman@gmail.com*

ABSTRACT

Influence of urban spaces on quality of life in cities has been an issue of concern to researchers for decades. This study investigated the effect of urban physical planning pattern on thermal perception amongst people in a semi-arid town of Katsina, Nigeria during hot dry and cool dry seasons. The study also examined people's awareness of the microclimatic modification effects of some physical characteristics of urban outdoor spaces. Data used in this study include average monthly maximum and minimum temperature, physical characteristics of outdoor spaces (width and orientation of streets, amount of trees), thermal perception and satellite imagery. Data collection involves temperature data from Katsina Airport, physical characteristics of outdoor spaces through field study and using Google Earth software and thermal perception through structured interviews. Results revealed that physical characteristics of urban outdoor spaces and background microclimatic condition influence peoples' thermal perception of their immediate environment. It also revealed a high level of awareness among people as regard ways of enhancing the thermal quality of urban outdoor spaces. This study suggests that in the tropics, minimizing the negative effects of microclimatic modifications of urban physical structures should always be considered before aesthetic in urban planning and design schemes.

Keywords: Thermal perception; thermal pleasure; thermal preference; thermal sensation.

1. INTRODUCTION

Differential thermal perceptions in relation to differences in physical environmental conditions have been noted as far back as the Roman times. In 61 AD, Roman philosopher, Seneca, noted that he always felt an alteration of his disposition as soon as he had gotten out of the heavy air of Rome (Griffiths, 1976). Thermal perception refers to the expression of the conscious feeling of people about the level of cold or warmth of the environment which is normally assessed through subjective evaluation. It is closely related to thermal comfort/discomfort conditions and is determined in individuals by both physical and human factors. Physical factors include air temperature, humidity, mean radiant temperature and wind speed. Human factors include psychological (individual expectations), metabolic rate (degree of work, food and drinks habit), cultural (clothing insulation) and physiological (gender and age) (de Dear and Brager, 1998; Jendritzky, Staiger, Bucher, Graetz and Laschewki, 2002).

In terms of physiological factors, research has established that a tall and skinny person has a larger surface-to-volume ratio, can dissipate heat more easily and can tolerate higher temperatures than a person with rounded shape (Szokolay, 2014). It is also evident that thermal perception declines with age (Lenzuni, Freda, and Del Gaudio, 2009). In the same vein, it has been discovered that clothing is more important determinant of thermal perception than sex of individuals (Graudenz, Paschoalin-Filho, Ribeiro and Tribess, 2013).

Physical characteristics of urban outdoor spaces include height of buildings to width of street/square ratio also known as aspect ratio (AR) and percentages of pervious, impervious and vegetated surfaces. AR controls wind flow, absorption of heat from solar radiation by surfaces and the rate of dissipation of the absorbed heat through the effect of sky view factor (Oke, 1981). Impervious surfaces such as paved sidewalks, roads, parking lots and roofs have high heat absorption, storage and emission capacities. As a result, they increase ambient air temperature within their vicinities (Asaeda, Ca and Wake, 1993; Pomerantz, Pon and Akbari, 2000; Myint, Brazel, Okin and Buyantuyev, 2010). It has also been discovered that evaporation from a single tree can produce the cooling effect of 10 room size air conditioners operating for 20 hours a day (Evans, 2013). The importance of physical characteristics of urban outdoor spaces in determining the microclimate of such spaces is enormous. Thus, the need for investigating the influence of these characteristics on thermal perception among urban dwellers can never be overemphasized.

Most of recent studies involving thermal comfort in Nigeria tend to focus their attention on indoor environments. For instance, Lawal and Ojo (2011) revealed that building types have great influence on ambient indoor temperature in Ibadan. Adebamowo and Adeyemi (2013) revealed that indoor thermal comfort is mostly influenced by orientation of buildings, placement and orientation of windows and use of shading and insulation materials in Lagos. In addition, Malgwi and Sagada (2014) discovered that building materials, orientation of exterior walls, orientation and size of windows and sun-shading using vegetation are the most important parameters in achieving indoor thermal comfort in Abuja. In Warri town, Abotutu and Ojeh (2013) found that wooden windows are more effective in achieving indoor thermal comfort than slide-glass ones in the absence of artificial ventilation. In Bauchi, indoor thermal sensation was found to be highly influenced by seasonal variation of microclimatic condition. In the same context, Abiodun (2014) revealed that indoor thermal comfort cannot be effectively enhanced without mechanical ventilation in Ile-Ife. Furthermore, Ibrahim, Baba and Ishaq (2012) discovered that using evaporative cooling in enhancing thermal comfort is more efficient during dry season than wet season in Kano. In Ilorin, Adegun, Popoola and Faniyan (2009) established an inverse relationship between activity level and indoor thermal comfort. Nevertheless, only few studies investigated the influence of outdoor spaces on thermal comfort. For instance, Ogunsote and Prucnal-Ogunsote (2003) compared the efficacies of using various thermal indices and discovered that Evans scale was more accurate in assessing outdoor thermal comfort within the main campus of Ahmadu Bello University, Zaria.

However, outdoor spaces are very important to sustainability of life in cities. This is because they accommodate daily pedestrian traffic and various outdoor activities and contribute greatly to urban livability and vitality (Chen and Ng, 2012). The importance of thermal perception to outdoor activities is so enormous that Lin and Matzarakis (2011) linked it to success or failure in tourism sector. The aim of this study is to assess thermal perception of people in urban outdoor in relation to physical planning characteristics during hot dry and cool dry (Harmattan) seasons. The objectives include (i) determining the microclimatic condition of the study area (ii) identifying outdoor spaces with contrasting physical characteristics (iii) determining thermal perception among users of the spaces (iv) determining the level of awareness of the users as regard the influence of physical characteristics of outdoor spaces on thermal conditions.

1.1 Study Area

Katsina town is located around intersect of latitude 12° 36'N and longitude 7° 18'E as shown in Figure 1, with an average elevation of 506metres, in the extreme northern end of Nigeria. It has tropical continental (semi arid) climate, with distinct wet (June to September) and dry (November to April) seasons. During hot dry season (March to April), air temperature can be as high as 42°C during the day, while during cool dry season (December to January), minimum temperatures can be as low as 11°C. Katsina is an ancient town, which during the 17th and 18th centuries was more important than all the major cities of Hausa land by virtue of it being the major terminus for trans-Saharan trade (Urquhart, 1977). The town experiences rapid expansion recently as a result of oil boom of the 1970s, severe drought events also of the 1970s (rural agrarian economies of northern Nigeria were ravaged which triggered massive rural-urban migration) and creation of Katsina State as a result of which the town became the capital city of the state.

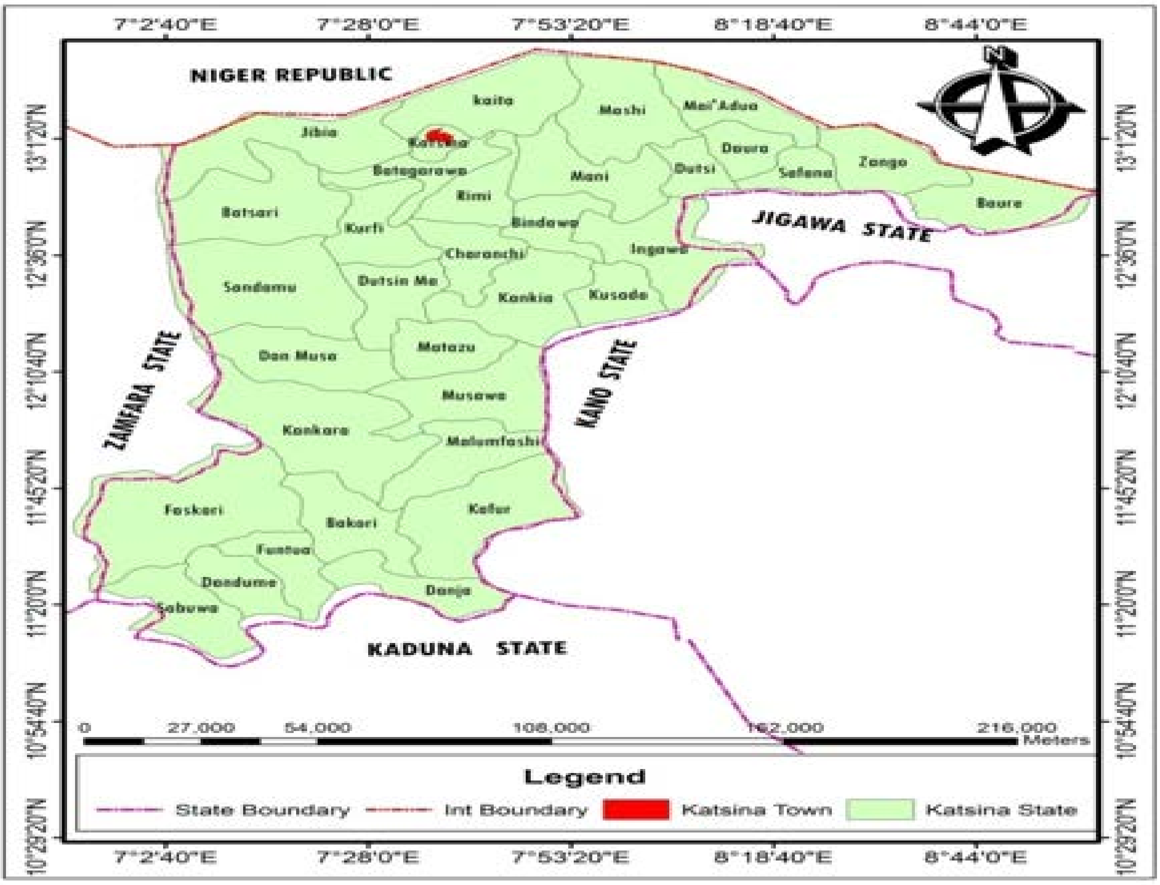


Figure 1: Map of Katsina State showing Katsina Town
Source: Modified From Administrative Map of Katsina State

2. MATERIALS AND METHODS

2.1 Types and Sources of Data

The following data are used in this study:

1. Average monthly minimum and maximum air temperatures and relative humidity data. These were collected from Umaru Musa Yar'adua Airport, Katsina.
2. Data on physical characteristics of urban outdoor spaces which include; landuse types derived from landuse map of the town issued by the Katsina State Urban Planning and Development Authority (KSUPDA). Width and orientation of streets, built-up density and tree cover obtained through field work and Google Earth satellite imagery of the town.
3. Data on thermal perception which include thermal sensation, thermal pleasure and thermal preference and respondents' suggestions on ways of making outdoor spaces thermally comfortable obtained through administration of questionnaire. The questionnaire comprises of three separate Likert scales (see Table 1) was used to assess thermal perception.
4. Geographic coordinates (latitudes and longitudes) of data collection sites were obtained by using a hand-held Garmin GPS receiver, GPSmap 60CSx.

Table 1: Thermal sensation, pleasure and preference scales

Thermal sensation		Thermal pleasure		Thermal preference	
+3	Hot	+3	Very pleasant	+3	Much warmer
+2	Warm	+2	Pleasant	+2	Warmer
+1	Slightly warm	+1	Slightly Pleasant	+1	Slightly warmer
0	Neutral	0	Neutral	0	As it is
1	Slightly cool	1	Slightly unpleasant	1	Slightly cooler
2	Cool	2	Unpleasant	2	Cooler
3	Cold	3	Very unpleasant	3	Much cooler

Source: Jendritzky et al., (2002), Matias et al., (2009) and ASHRAE (2001)

2.2 Sampling Design

Three main physical planning patterns were identified in the study area (see Figure 2) and sites of collection of data on thermal perception were selected out of the identified areas. These are:

1. The Pre-colonial part which has irregular planning pattern. Three locations were selected at Saulawa, Sararin-tsako and Makudawa quarters.
2. The Government Reservation Area (GRA) which is well planned with wide streets and abundant trees. Four locations were selected which include the Water Board, Maryam Park, Katsina Motel and Katsina Club.
3. The new layouts some of which are planned in grid pattern while others are semi-planned. Four locations were selected; two within Kofar Kaura Layout and one in each of Dutsen-safe Low Cost Housing Units and Goriba Road Housing Estate.

Sample of this study comprises of 280 respondents; 10 people at each of the 14 locations during cool dry season or Harmattan period (January, 2015) and the same number of people during hot dry season (April, 2015). Age of the respondents ranges between 20 and 60 years and males comprise of 80% while 20% were females. The field study was carried out between 12:00 noon and 3:00 pm local time on both weekdays and weekends. Distinct thermal conditions between cool dry and hot dry seasons as portrayed in Figure 3, guided the choice of seasons of data collection.


(a) Pre-colonial part – Saulawa


(b) GRA


(c) New layout (Kofar Kaura)


(d) New layout (Goriba Road Housing units)


(e) New layout (Dutsen safe low-cost housing units)

Figure 2: Satellite Images of Some of the Data Collection Sites
Source: Google Earth

3. RESULTS AND DISCUSSION
3.1 Microclimate of the Study Area

Average monthly maximum and minimum air temperature and relative humidity data were used in portraying the microclimatic condition of the study area as shown in Figure 3. It is clear that the hot season fell within the months of March, April and May while the cool season fell within the months of January and December. The months with the highest relative humidity are July, August and September. If not for their low maximum temperatures they would have been the months with the highest thermal discomfort indices.

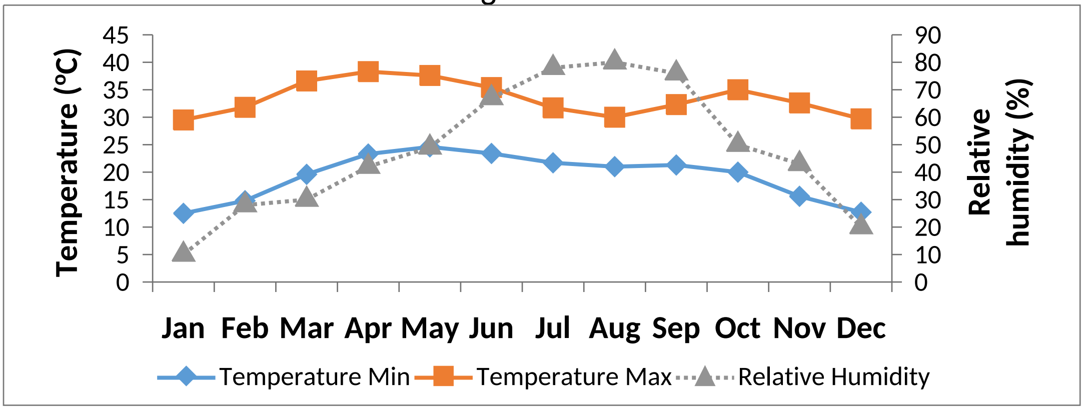


Figure 3: Average Monthly Minimum and Maximum Temperatures and Relative Humidity in Katsina

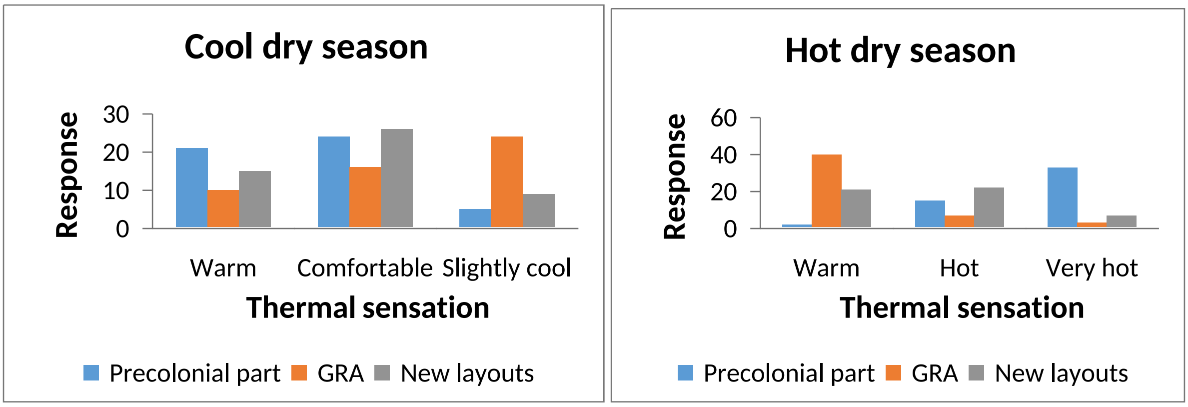
3.2 Thermal Perception

Results of analyses of data on thermal sensation, pleasure and preference presented below represent thermal perceptions of respondents in the study area.

3.2.1 Thermal Sensation

Figure 4 shows the frequency distribution of thermal sensation among the research subjects during cool dry and hot dry seasons. Figure 4 (a) shows that during the cool dry season, most of the respondents sensed the microclimate as more comfortable in the pre-colonial part than in GRA and the new layouts. In contrast to this, Figure 4 (b) reveals that during hot dry season, most of the research subjects sensed the microclimate in the GRA as just warm in contrast to those in the post-colonial part who sensed it as very hot.

Possible explanation behind the spatio-temporal variation in thermal sensation in the study area is that during cool dry season, air temperature at the time of study is about 29°C. At such periods, human body temperature is higher than that of the ambient air, thus, the human body serves as a source of heat while the ambient air as a sink. Therefore, metabolic heat produced by the body is mainly dissipated through radiation while evaporation of sweat is seldom used then as a means of dissipating body heat. Conversely, during hot dry season, air temperature in the study area could be as high as 40°C or higher. At such periods, the ambient air temperature is higher than that of human body thus, it (the ambient air) act as a source of heat rather than a sink. In this context, research has shown that when air temperature is above 35°C, human body cannot regulate heat through radiation or convection since the ambient air is warmer, but almost only through evaporation from lungs and through skin (Oke, 1987). These differential responses of human thermal regulatory mechanisms are controlled by the sub-conscious mind; in return, they affect human thermal perception differently under different thermal conditions.



(a) Harmattan (b) hot seasons

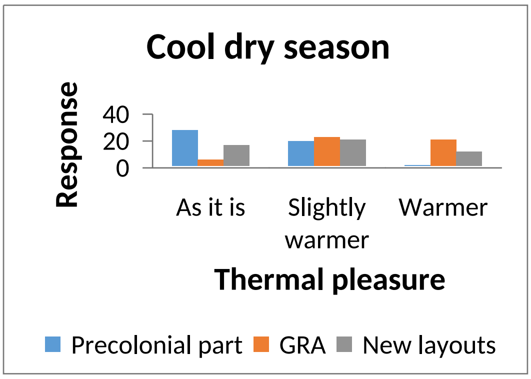
Figure 4: Distribution of thermal sensation among the research subjects during

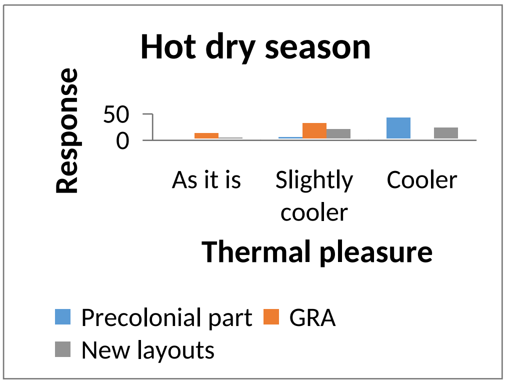
3.2.2 Thermal Pleasure

Figure 5 (a and b) show the spatial distribution of thermal pleasantness and unpleasantness of the study sites as expressed by the respondents. It is clear from Figure 5 (b) that more respondents perceived the urban outdoor environment as pleasant at GRA and the new layouts during hot dry season in contrast to what is obtained at the pre-colonial part. Figure 5 (a) reveals that during cool dry season, most of the respondents find the pre-colonial part to be more pleasant. Possible explanation here is the fact that urban segments with wide and regular street patterns in semi-arid areas (as is obtained in the GRA) are associated with dusty winds with high speed. This is a clear indication that apart from physical characteristics of urban outdoor spaces, background climate also play an important role in determining thermal perception among urban dwellers. These results corroborate the findings of Yahia and Jahansson (2011) and Yahia and Johansson (2012) in Damascus, Syria.

3.2.3 Thermal Preference

Figure 6 (a) shows that during cool dry season, most of the respondents prefer the thermal environment as it is at the pre-colonial part in contrast to the GRA where most of the respondents either prefer a slightly warmer or warmer condition. However, during the hot dry season, only few of the respondents prefer the thermal environment as it is in the pre-colonial part, rather majority prefer it to be cooler. In the same context, the reverse is the case at the GRA because during cool dry season, few respondents prefer the thermal environment as it is. The majority prefer slightly warmer to warmer conditions.

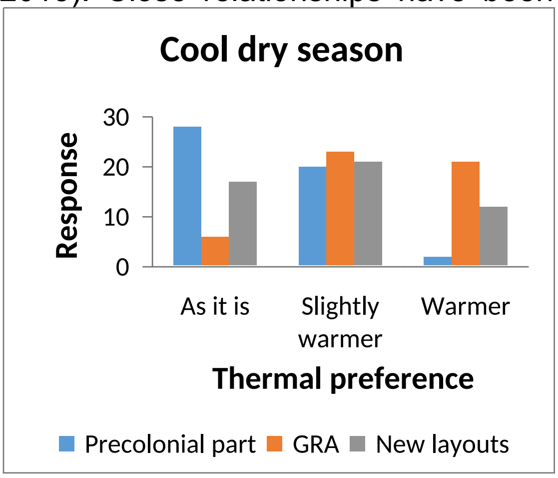


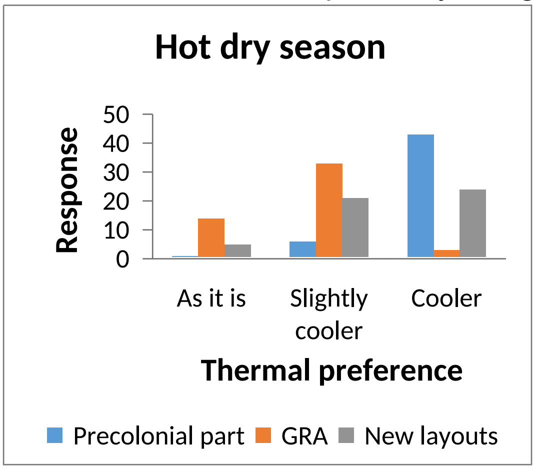


(a) Harmattan (b) hot seasons

Figure 5: Distribution of thermal pleasure among the research subjects during

These results portray the influence of urban geometry and design on microclimate and thermal perception. GRA has low aspect ratio and a lot of trees. These create a positive effect on microclimate and thermal perception during hot season. Although low aspect ratio means reception of higher amount of solar radiation, it allows for more movement of air through which heat is transported away (Shishegar, 2013). Close relationships have been established between wind speed and air temperature on one hand and urban planning and design patterns on the other. That is, the higher the built-up density the lower the wind speed and the higher the air temperature (Mills, 2008; Dimoudi, Kantzioura, Zoras and Kosmopoulous, 2012). This could be the explanation behind lower thermal preference especially during hot dry season in the Pre-colonial part where the built-up density is higher.





(a) Harmattan (b) hot seasons

Figure 6: Distribution of thermal preference among the research subjects

Presence of vegetation especially trees is another important factor that influences microclimate of places. Trees transpire a lot of water, in the process of which sensible heat is lost due to its conversion to latent heat of vapourisation. The United States Department of Energy's Lawrence Berkeley National Laboratory found that a single mature and properly watered tree with a crown of 30 feet can transpire up to 40 gallons of water in a day (USEPA, 2008). Another study discovered that urban parks reduce temperatures of areas up to 30 metres away from them (Katayama, Ishii, Hayashi and Tsutsumi, 1993). Furthermore, Shashua-Bar et al.

(2010) noted that tree shade provided cooling benefits equivalent to preventing 50% of the temperature increase from sunrise to midday under non-tree shaded street condition. It has also been established that the cooling effect of urban trees is more pronounced in areas with warmer background climates (Shashua-Bar and Hoffman, 2002). These effects coupled with wider spaces could be the reason why many people perceived the microclimatic condition at GRA to be more preferable during hot dry season.

3.3 People's Suggestions on ways of Enhancing the Quality of Urban Spaces

Figure 7 shows frequency distribution of ways suggested by the respondents on how the urban spaces could be enhanced in terms of thermal sensation, pleasure and preference. From this figure, 35% of the subjects are of the opinions that for thermal sensation, pleasure and preference levels to be enhanced in urban outdoor spaces within the study area, there should be more open spaces and abundant trees. Those that think only open spaces should be increased account for 34%, while those that think only the number of trees should be increased account for 22%. Very few of the research subjects (9%) expressed no evidence of awareness on how to enhance thermal sensation, pleasure and preference in the urban open spaces. This is a clear indication that there is a high level of awareness among the subjects regarding ways of improving thermal comfort in the study area.

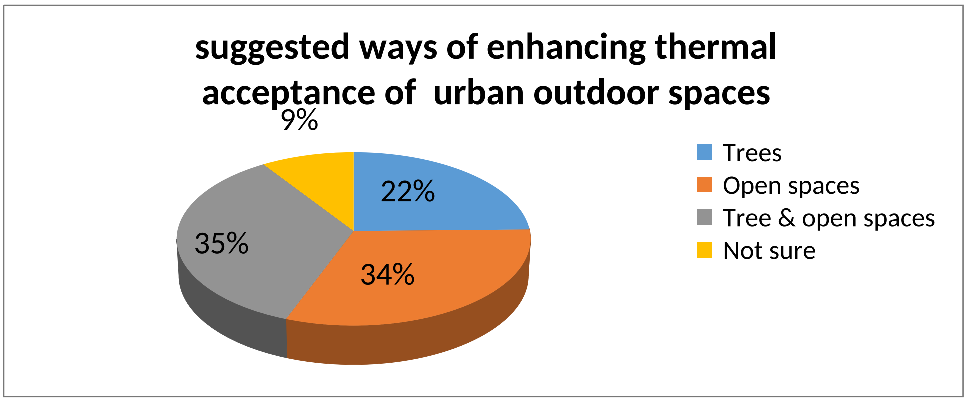


Figure 7: percentage distribution of research subjects' suggested ways of enhancing the thermal acceptance of urban spaces

4. CONCLUSION AND RECOMMENDATIONS

The findings of this study suggest that people's thermal perception appears to be influenced by the physical characteristics of urban outdoor spaces. It can also be concluded from results of this study that in a semi-arid town of Katsina, the capacity for outdoor spaces to provide respite from high summer temperatures is higher in well-planned parts with abundant trees than in the unplanned parts. In addition, the study confirms the usefulness of wide tree-lined streets for improving thermal comfort among dwellers of hot cities.

It is recommended that climate sensitive urban planning and design schemes should be pursued vigorously by governments in the tropics with special considerations given to thermal comfort of urban outdoor spaces. More green areas should be established by urban authorities, because apart from beautifying the environment, they improve air quality, mitigate urban heat island effect, thus, improve sustainability of life in urban areas. This is due to the fact that most often, outdoor spaces serve as environmental refuge to urban dwellers especially from high summer temperatures especially when this is viewed against the backdrop of the ongoing global warming.

REFERENCES

Abiodun, O.E. (2014). Thermal comfort and occupant behaviour in a naturally ventilated hostel in warm-humid climate of Ile-Ife, Nigeria: Field study report during hot season. *Global Journal of Human Social Science,* 14(4): 1-8.

Abotutu, A.A. and Ojeh, V.N. (2013). Structural properties of dwelling and thermal comfort in tropical cities: Evidence from Warri, Nigeria. *Indexed African Research Review,* 2(2): 67-98.

Adebamowo, M.A. and Adeyemi, O. (2013). Do architects design for thermal comfort? A case study of some houses in Lagos. *International Review of Social Sciences and Humanities,* 5(1): 255-264.

Adegun, I.K., Popoola, O.T. and Faniyan, T. (2009). Experimental determination of indoor conditions for human thermal comfort in Nigeria a case study of Ilorin. *International Journal of Applied Engineering Research,* 4(1): 77-88.

Asaeda, T., Ca, V.T. and Wake, A. (1993). Heating of paved ground and its effects on the near surface atmosphere. *Proceedings of the Yokohama Symposium*. Exchange Processes at the land Surface for a Range of space and Time Scales. IAHS Publication No. 212.

Chen, L. and Ng, E. (2012). Outdoor thermal comfort and outdoor activities: A review of research in the past decade. *Cities* (29): 118-125.

de Dear, R. and Brager, G. (1998). Developing an adaptive model of thermal comfort and preference. *ASHRAE Transactions,* 104(1): 145-167.

Dimoudi, A. Kantzioura, A., Zoras, S. and Kosmopoulous, P. (2012). The influence of urban design on microclimate inside the urban canyons. *Proceedings of the 8th International Conference on Urban Climates,* Dublin, Ireland. 6 - 10 August.

Evans, E. (2013). Trees of strength. North Carolina State University [Online] www.treesofstrength.org/benefits.htm [Accessed 5 December 2013].

Graudenz, G.S., Paschoalin-Filho, J.A., Ribeiro, A.P. and Tribess, A. (2013). Gender influences in indoor air quality perception for individuals in tropical climate. *Occupational Medicine & Health Affairs* 1:142. doi: 10.4172/2329-6879.1000142.

Griffiths, J.F. (1976). *Applied Climatology*, Oxford. Oxford University Press pp 106.

Ibrahim, U.H., Baba, A.A. and Ishaq, M. (2012). Evaluation of the potential evaporative cooling for human thermal comfort a case of Kano, Nigeria. *International Journal of Engineering and Applied Sciences,* (4): 21-29.

Jendritzky, G., Staiger, H., Bucher, K., Graetz, A. and Laschewski, G. (2002). *The perceived temperature: The Method of the Deutscher Wettrdienst for the* *assessment of cold tress and heat load for human body*. Deutscher Wetterdienst, Germany www.utci.org/isb/documents/perceived_temperature.pdf [Accessed 19 November 2013].

Kataymа, T., Ishii, A., Hayashi, T. and Tsutsumi, J. (1993). Field surveys on cooling effects of vegetation in urban areas. *Journal of Thermal Biology,* 18(5-6): 571-576.

Lawal, A.F. and Ojo, O.J. (2011). Assessment of thermal performance of residential buildings in Ibadan Land, Nigeria. *Journal of Emerging Trends in Engineering and Applied Sciences,* 2(4): 581-586.

Lenzuni, P., Freda, D. and Del Gaudio, M. (2009). Classification of thermal environments for comfort assessment. *Annals of Occupational Hygiene* 53(4): 325-332 doi:10.1093/aahyg/mep012.PMID 19299555.

Lin, T. and Matzarakis, A. (2011). Tourism climate information based on human thermal perception in Taiwan and eastern China. *Tourism Management,* (32): 492-500.

Malgwi, M.E. and Sagada, M.L. (2014). An evaluation of thermal comfort conditions in an urban entertainment centre in hot-dry climate of Nigeria. *International Journal of Environmental Research,* 2(1): 55-74.

Matias, L., Almeida, S., Pina Santos, C., Rebelo, M. and Correia Guedes, M. (2009). Adaptive thermal comfort for buildings in Portugal based on occupants' thermal perception. *Proceedings of the 26th Conference on Passive and Low Energy Architecture,* Quebec City, Canada, 22-24 June.

Mills, G. (2008). Urban climatology and its relevance to urban design. *Proceedings of the 25th Conference on passive and Low energy Architecture,* Dublin, Ireland, 22 - 24 October.

Myint, S.W., Brazel, A. Okin, G. and Buyantuyev, A. (2010). Combined effects of impervious surface and vegetation cover on air temperature variations in a rapidly expanding desert city. *GIScience & Romote Sensing,* 47(3): 301-320 doi:10.2747/1548-1603.47.3.301.

Ogunsote, O.O. and Prucnal-Ogunsote, B. (2003). Choice of a thermal index for architectural design with climate in Nigeria. *Habitat International,* (27): 63-81.

Oke, T.R. (1981). Canyon geometry and nocturnal urban heat island: Comparison of scale model and field observations. *International Journal of Climatology* (1): 237-254.

Oke, T.R. (1987). *Boundary Layer climates*, London. Methuen.

Pomerantz, M., Pon, B. and Akbari, H. (2000). The effects of pavements' temperature on air temperatures in large cities. Paper LBNL – 43442. Berkeley, California: Earnest Orlando Lawrence National Laboratory.

Shashua-Bar, L. and Hoffman, M.E. (2002). Quantitative evaluation of tree effects on diurnal air temperature cooling in urban streets. In ACAD and GRECO (eds) Design with Environment. *Proceedings of the 19th Passive and Low Energy Architecture* (PLEA)

Conference, Toulouse, France. Pp 235-240.

Shashua-Bar, L., Potchter, O., Bitan, A., Boltansky, D. and Yaakov, Y. (2010). Microclimate modeling of street tree species effects within the varied urban morphology in the Mediterranean city of Tel Aviv, Israel. *International Journal of Climatology,* 30(1): 44-57.

Shishegar, N. (2013). Street design and microclimate: Analyzing the effects of street geometry and orientation on air flow and solar access in urban canyons. *Journal of Clean energy Technologies,* 1(1): 52-56.

Szokolay, S.V. (2014). *Introduction to Architectural Science: The Basis of Sustainable Design.* 3rded. New York: Routledge, pp 19.

Urquhart, A.W. (1977). *Planned Urban Landscapes of Northern Nigeria,* Zaria. Ahmadu Bello University Press. pp 66.

USEPA (United States Environmental Protection Agency) (2008*). Urban Heat Island Basics*. Accessed (7 July 2008) fromwww.epa.com/heatislandeffect.htm.

Yahia, M.W. and Johansson, E. (2011). The influence of environment people's thermal comfort in outdoor urban spaces in hot dry climates-The example of Damascus, Syria. *Proceedings of the 27th International Conference on Passive and Low energy Architecture,* Louvain-la-Neuve.

Yahia, M.W. and Johansson, E. (2012). Thermal perception and physical characteristics of urban spaces in Damascus, Syria. *Proceedings of the 8th International conference on Urban Climates,* Dublin, Ireland. 6-10 August.

Savanna volume 23, Number 1, June, 2016

Assessment of Drought Intensity in Katsina And Its Environs

Suleiman, U.B.[1]*, Abdulhamed, A. I.[2] and Yamusa, A. M.[3]
[1]*Department of Geography, Federal College of Education, Zaria*
[2]*Department of Environmental Management and Toxicology, Federal University, Dutse*
[3]*Department of Soil Science, Institute for Agricultural Research, A.B.U., Zaria*
**talk2usbambale@gmail.com*

ABSTRACT

This study examined drought occurrences and their intensities in Katsina and its environs. Katsina is an area prone to drought. Rainfall data covering 1971 to 2010 was obtained from the archives of Nigerian Meteorological Agency. The data was analyzed using Normalized Rainfall Index .The Normalized Rainfall Index was used to characterize drought occurrences. This was with the intention of finding out their percentages of occurrences over a 40 year period (1971-2010). Results showed that moderate intensity drought prevailed in the study area during the study period representing about 38.46% of the total drought occurrences in the period of study. Findings further indicated that mild and severe droughts were the least occurred intensities in the area representing 30.77% each. These situations means that farmers and other stakeholders like government and non-governmental organisations (NGOs) in the study area need to have a reorientation of not waiting for the occurrence and effects of high intensity drought, but put in place policies and measures that will consistently mitigate occurrences and effects of low intensity drought. The paper concludes that the study area has been tilting towards decreasing number of drought occurrence and intensity due to increasing wetness over the recent years. The paper recommends that there is the need to use spatial and temporal characteristics of past droughts to serve as indicators of their future patterns of occurrence. There is also the need to shift emphasis away from the old methods of tackling high intensity drought effects to newer methods of combating the effects of moderate and low intensity droughts.

Keywords: Drought; Drought Intensities; Normalized Rainfall Index; Katina State.

1. INTRODUCTION

Drought is one of the most important climate-related disasters which climate change is set to exacerbate (Economic Commission for Africa [ECA], 2007). There is no universally accepted definition of drought because drought means different things to different people, depending on their specific interest or areas of specialization (American Meteorological Society [AMS], 2004). A broad definition of drought is a deficiency of precipitation over an extended period of time, usually a season or more, which results in a water shortage for some activity, group, or environmental sectors (International Strategies for disaster Reduction [ISDR], 2007).

According to Abode (2004, 2005), drought is classified into four types. These are permanent, seasonal, contingent, and invisible droughts. Permanent drought is found in arid areas where in no season is precipitation enough to satisfy the water needs of plants. Seasonal drought occurs in areas with well-defined wet and dry seasons as in most parts of the tropics. Contingent drought is characteristics of sub-humid and humid areas and occurs when over a period of time the rains fail to fall. It is unpredictable and therefore, constitutes a hazard to agriculture. Invisible drought occurs any time the daily supply of moisture from the soil or falling precipitation fails to equal the daily water needs of plants.

Drought also has many attributes. Some of these are; on-set, duration, persistency, intensities, return period and termination. However, out of these attributes, a very significant one is the intensity.

This is because it determines the degree of severity or otherwise of the drought (Suleiman, 2014). The various intensities have effects on the environment, agriculture, water availability and human beings in the area of occurrence. However, the degree of impact of extreme drought on the environment for example will be greater than that of mild drought (Aremu, 2011). In the last few decades, several communities in the dry lands of Africa, which include Katsina and its environs, have been facing drastic food shortages as a result of recurrent drought. Major droughts with deleterious consequences to food production occurred in 1968-73; 1982-85; 1990-1992 and 2003 with each drought circle increasing the occurrence of desertification. The reduced capacity for food production and desertification has put a population of over 100million in the dry lands on the brink of starvation (Federal Republic Nigeria [FRN], 2003).

Drought is not a recent phenomenon in Nigeria. Historical records indicate that droughts have occurred frequently in the past. Some of these droughts were severe and accompanied by famines arising from crop failure (Ayoade, 1988; 2005). This situation has resulted in several studies on drought in the region. Examples of such studies are: (James, 1973; Mortimore, 1973; Oguntoyinbo and Richards, 1977; Adefolalu, 1986; Oladipo, 1993; Gashua, 1991; Aremu, 2011; Abaje et al., 2011; Suleiman, 2014). A review of these studies suggests that they focus on the temporal and spatial occurrences of drought. Only few of the studies analysed droughts intensities like Abaje (2010). There are, therefore, few in-depth studies on drought intensity in the study area. Consequently, there is the need to determine the intensities of droughts and its implications in this area as this will help the farmers and other stakeholders like governments to be able to plan and implement comprehensive policies that will mitigate and ameliorate the usually negative effects of drought in this area. It is in view of the above fact this this paper seeks to assess drought in Katsina and its environs with a view to determine the periods and percentages of drought occurrences and the degree of drought intensities in the study area.

1.1 Study Area

The study area (Katsina, Kaita, and Jibia Local Government Areas) is located between latitudes 12°59' –13º20' North and longitudes 7°20′-8°00' East of Greenwhich Meridian. These LGAs (Katsina, Jibiya and Kaita) were selected for the survey because of their proximity to the desert area. It is bordered by Niger Republic to the north, Zamfara State to the west, Batsari, Batagarawa and Rimi LGAs to the south and Mashi LGA to the east. It has a total land mass of 142 km^2.

Katsina state can be classified into the tropical continental and semi-continental climatic zones (Abaje, Sawa, and Ati, 2014). The north of Katsina state (from around Kankiya to the extreme northeast has total rainfall ranging from 600 – 700mm per annum. Generally, rainfalls vary considerably according to months and seasons. This can result in moderate and severe droughts that impose serious socio- economic implications (Abaje, Ati and Iguisi, 2012). The mean annual temperature ranges between 29°C - 31°C. The highest air temperature normally occurs in May to April known as hot dry season, a warm wet season from June to September, a less marked season after rains during the months of October to November characterized by decreasing rainfall and gradual lowering temperature. The lowest temperature occurs in December to February known as Cool dry (Hamattan) season. Evapo-transpiration is generally high all the year round. The highest evaporation occurs in dry season (Abaje, Sawa, and Ati, 2014; Suleiman, 2014).

The relief of the area is composed of undulating plains which generally lies gently from 360m in the northeast, to 600m around Funtua in the southwest. But, the northern part cretaceous sediments overlap the crystalline rocks. The sandy 'drift' deposits of katsina are coarse, resulting in light sandy soils of buff or reddish colours of low medium fertility. These soils are easily worked and well suited to crops such as millet and groundnut (O.N 2003; Suleiman, 2014). Katsina and its environs, belong to the Sudan Savannah Zone in the northern half of the state. The vegetation consists of trees that grow long tap roots and thick barks that make it possible to withstand the long dry season and bush fires.

Figure 1: Katsina State Showing the Study Area
Source: Adapted from Administrative Map of Katsina State, 2017.

2. MATERIALS AND METHODS

2.1 Types and Sources of Data

The basic research data used for this study was the monthly and annual rainfall for Katsina. The data was obtained from the achives of Nigerian Meteorological Agency (NiMet), Katsina, Station No.1307.4, located on latitude 13:01N and longitude 07:41E (Umaru Musa Yar'aduwa Air Port, Katsina) and covered a period of 40 years (1971-2010) for one selected drought prone station. The station was chosen to represent the entire study area because it is the only synoptic station in the study area and the station has no significant missing records during the period of study.

2.2 Methods of Data Analysis

The method used for analysis in this study is the normalized Rainfall Index (NRI). It was used to assess the severity of drought over a period of 40 years as employed by Abaje (2010). Normalized rainfall index is an empirical method that uses monthly rainfall as the sole climatological input. The index is a measure of drought intensity using annual or seasonal rainfall totals and the standard deviation to indicate the shortage of water of any given season (Abaje, 2010). The index has been shown to perform comparatively well in depicting periods and intensities of drought. The index (NRI) also has advantages over other methods when used in the study area as it is simpler and less intricate. The normalized rainfall anomaly (*Asy*) for a given station is computed as:

$A_{sy} = (R_{sy} - \bar{R}_s) / S_s$...................... Equation 1

Where:
Rsy= the rainfall total for the station *s* during a year (or a season), and
*Rs=and*ss the long-term mean (of the period specified for the station)
Ss= Standard deviation of the annual (or seasonal) rainfall total for that station.
Table1 shows description and classification of the index as defined by Turkes (1996).
This study therefore used a modified NRI because extreme values such as ≥ 1.76 and ≤ 1.76 are very rare throughout the study periods (1971-2010).

Table 1: Classification of Normalized Rainfall Index (NRI)

Limit of index	**Character of Rainfall**
1. 76 or more	Extremely wet
1.31 to 1.75	Very wet
0.86 to 1.30	Moderately wet
0.51 to 0.85	Mildly wet
0.50 to -0.50	Near normal
-0.51 to -0.85	Mild drought
-0.86 to -1.30	Moderate drought
-1.31 to -1.75	Severe drought
-1.76 or less	Extremedrought

Source: Turkes (1996).

3. RESULTS AND DISCUSSIONS

The characteristics of drought are expressed in terms of drought index, drought intensity, years of occurrence and percentages. The result of analysis of Normalized Rainfall Index (NRI) of the study area is presented graphically as indicated in Figure 2 and Table 2.

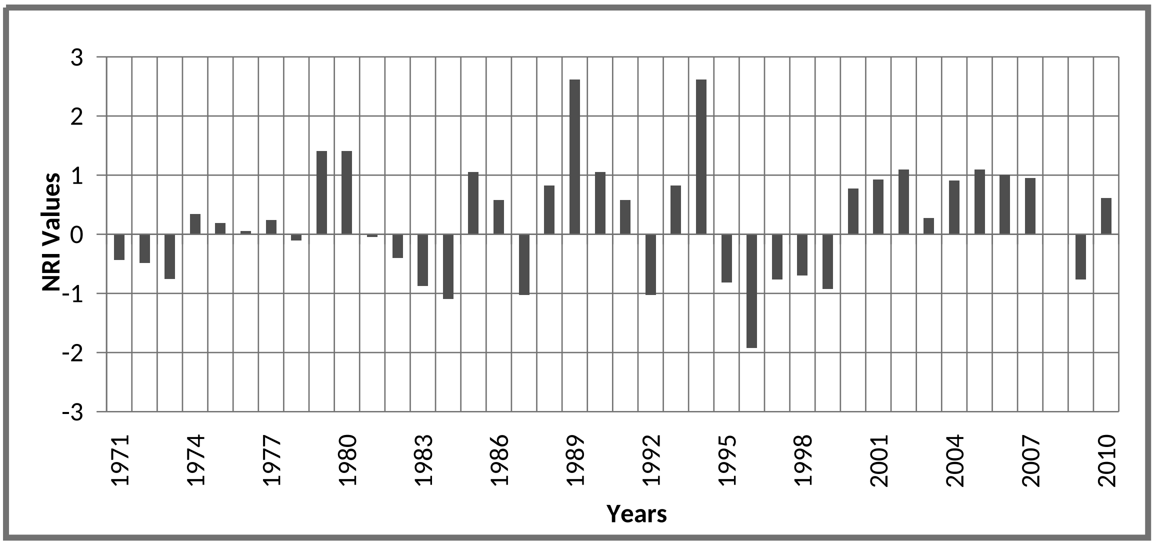


Figure 2: Normalized Rainfall Index for Katsina

Table 2: Drought Intensities, Years of Occurrence and Percentage in Katsina Using NRI

Drought Intensity	NRI Values[	Years	Frequency of Occurrence	Percentage of Total Occurrence
Mild drought	-0.51 to -0.85	1971, 1972, 1982 and 2009	4 years	30.77
Moderate drought	-0.86 to -1.30	1973, 1983, 1995, 1997, 1999	5 years	38.46
Severe drought	-1.31 to -1.75	1984,1987, 1992 and1996	4 years	30.77
Total			**13years**	**100.00**

The result of Normalized Rainfall Index (NRI) presented three different drought scenarios; these are mild, moderate and severe droughts. In the same vein, the temporal trend patterns were also illustrated in Figure 3. Mild drought is a condition where the NRI value ranges between -0.51 to -0.85, moderate drought is a situation in which the NRI value ranges between -0.86 to -1.30, severe drought is a situation in which the NRI value ranges between -1.31 to -1.75. Results indicate that out of the 40 years in which this study was done, Katsina experienced negative NRI values with drought condition for 13 years representing 32.50 % of study period. The dominant drought intensity was moderate drought with 5 years occurrences at 38.46% of total drought occurrences during the period of the study. The least occurred intensity were mild and severe drought with 4 years each representing 30.77% each as shown in Table 2.

From Figure 2 it is evident that Katsina and it's environ were plagued by larger extent of moderate to severe drought since the beginning of 1970s to the end of 1990s. The 1971 drought ranges from mild to moderate. The drought persisted in 1972 attaining its peak level in 1973. However, drought in 1980s became more severe than any other decade in the study period. The 1990s experienced moderate to severe droughts. The study area during the period 2000 to 2010 had experienced near normal to vary wet conditions except some isolated mild and moderate droughts. This is a clear proof that the late 2000s had witnessed decreasing number of drought episodes in the study area. The recent decrease in the intensity and frequency of drought occurrence in the area, particularly the last decade may be due to apparent increase of wet condition in the area. Findings of this research is in agreement with the observation made by Ati, Iguisi, and Afolayan (2007), Abaje (2010), and Abaje, Ati and Iguisi (2012), that the Sudano-Sahelian Ecological Zone of Nigeria has been experiencing decreasing number of drought occurrences and consequently increasing wetness over the recent years.

4. CONCLUSION AND RECOMMENDATIONS

Drought is a common phenomenon in the study area because the mean deviation rainy days are high in the entire area making it highly prone to droughts from mild to severe type. The Normalized Rainfall Index was found suitable in describing drought situation in the area because of its ability to depict all the previously identified drought periods. Based on the result of Normalized Rainfall Index it can be deduced that the study area has been tilting towards decreasing number of drought occurrence and intensity due to increasing wetness over the recent years. Consequently, even if rainfall has come back to near-normal, the study area remains an environmentally sensitive region and climate change is likely to exacerbate repetition of drought circle where the immediate impact is felt is agricultural sector.

Based on the aforementioned findings, the following recommendations are made:

i. There is the need to use spatial and temporal characteristics of past droughts to serve as indicators of their future patterns of occurrence. This would involve mapping of drought occurrence in order to identify recurrent patterns.
ii. Additional functional synoptic weather stations should be provided to complement the existing ones in the study area with distance from each other not more than 100km so as to conform to the World Meteorological Organization (WMO) standard. This will enhance network of data collection and accurate seasonal rainfall prediction.
iii. There is the need to shift emphasis away from the old methods of tackling high intensity drought effects to newer methods of combating the effects of low and moderate intensity.

REFERENCES

Abaje, I.B. (2010). *Occurrence of Drought in the Sudano Sahelian Zone of Nigeria*. Unpublished M.Sc. Thesis Submitted to the Post Graduate School, Ahmadu Bello University, Zaria Nigeria

Abaje, I.B., Ati, O.F. and Iguisi, E.O. (2011). Drought in the North-Eastern part of Nigeria and the Risks on Human Health, in E.O. Iguisi, O. A. Ati,R.O. Yusuf and A.E. Ubogu (eds) *NiMets Zaria 2011 Proceedings of the International Conference of the Nigerian Meteorological Society,* 527-538.

Abaje, I.B., Ati, O.F. and Iguisi, E.O. (2012). Changing Climatic Sceneriosand Strategies for Drought Adaptation and Mitigation in the Sudano-Sahelian Zone of Nigeria.in M.A Iliya and Dankani (eds), *Climate change and Sustainable Development in Nigeria*. (pp 99-121).Ibadan: Crown F. publishers

Abaje, I. B., Sawa, B.A. and Ati, O.F. (2014). Climate Variability and Change, Impacts and Adaptation Strategies in Dutsin-Ma Local Government Area of Katsina State, Nigeria. *Journal of Geography and Geology,* 6(2): 107-108.

Adefolalu, D.O. (1986). Further aspects of Sahelian drought as Evidence from rainfall regime of Nigeria. *Archives for Meteorology Geophysics Bioclimatology Ser.* B 36, 277-295.

American Meteorological Society [AMS] (2004). Meteorological Drought. *Bull. Amer. Met. Soc*, 85 Retrieved January 13, 2009 from http://www.ametsoc.org/policy/drought statement final 0304.html

Aremu, J. K. (2011). *Combating and Mitigating Drought and Desertification in Northern Nigeria,JEHETR* 1(2), University of Benin, Benin City, Nigeria.

Ati, O.F, Iguisi, E.O. and Afolayan, J.O. (2007). Are we

Experiencing Drier Conditions in the Sudano-sahelianZone of Nigeria? *Journal of Applied ScienceResources.,* 3(12):1746-1751. Retrieved May 31, 2008 from http://www/insinet.net/jasr/2007/1746-1751.pdf

Ayoade, J.O. (1988) On Drought and Desertification in Nigeria. In:Sada, P.O and Odemarho, F.O (Eds.), *Environmental Issues and Management in Nigerian Development.* Evans Brothers (Nigerian Publishers) Limited, PP 271-290.

Ayoade, J.O. (2004). *Introduction to Climatology for the Tropics.*2nd ed. Spectrum Books Limited, Ibadan.

Ayoade, J.O. (2005). *Introduction to Agro climatology.*2nded. University Press Plc. Ibadan.

Economic Commission for Africa [ECA], (2007) Drought and Desertification.*Fifth Meeting of the Africa Committee on Sustainable Development* (ACSD-5/Regional Implementation Meeting (RIM) for CSD – 16 Adis Ababa.

Federal Republic Nigeria [FRN], (2003). Nigeria's First National Communication under the United Nations Framework Convention on climate Change. The Ministry of Environment of the Federal Republic of Nigeria.

Gashua, (1991). An Evaluation of Indigenous Techniques of Coping with Drought in Bade Local Government Area, Borno State. Unpublished M.Sc Thesis Submitted to the Post Graduate School, Ahmadu Bello University, Zaria Nigeria.

International Strategies for Disaster Reduction [ISDR] (2007). *Drought Risk Reduction Frame Work and Practice*: Contributing to the Implementation of the Hyogo Frame Work Action. United Nations Secretariat of the of the International Strategy for Disaster Reduction (UN/ISDR), Geneva, Switzerland, 98+ Vi Pp.

James, A.R. (1973). Drought condition in the pressure water zone of North- Eastern Nigeria: Some provisional observations, *Savanna 2(2),* 108-114.

Mortimore, J. (1973). Famine in Hausa land *Savanna* 2(2),103-7. Nigerian Meteorological Agency (NIMET). (2005). Hydrometeorological Bulletin, aHydromet. Publication, Nigerian Meteorological Agency, Abuja, Nigeria, July 15-16.

Oguntoyinbo, J.S. & Richards P. (1977). The extent and intensity of the 1969-73 drought in Nigeria: A provisional analysis in Dalby, D. *et al*. (ed) Drought in Africa 2: *Africa Environment Special Report 6*, London, 114-126.

Oladipo, E.O. (1993). Some aspects of the spatial characteristics of drought in Northern Nigeria, *Natural Hazards 8*, 171-188.

Online Nigeria [ON], (2003). Nigeria: Physical Setting- Kaduna State. Retrieved January,30 2003. From www.onlinenigeria.com/link/kadunaadv.asp?blurb=295

Suleiman, U.B. (2014). *Farmers Adaptation Strategies to Drought in Katsina and its Environs.*(Unpublished M.Sc. Thesis), Department of Geography, Ahmadu Bello University, Zaria- Nigeria.

Turkes, M. (1996). Meteorological Drought in Turkey: A Historical Perspectives, 1930, 93. Drought

Network News, 8 (3):17-21. *A Newsletter of the International Drought Information Center and the National Drought Mitigation Centre*.

Savanna volume 23, Number 1, June, 2016

Assessment of Onset Dates, Cessation Dates and Length of Growing Season in Parts of Katsina State, Nigeria

Haruna Saleh[1]* and B.A. Sawa[2]
[1]*Department of Geography, Umaru Musa Yar'adua University, Katsina*
[2]*Department of Geography & Environmental Management, Ahmadu Bello University, Zaria*
**harunasaleh@gmail.com*

ABSTRACT

This study investigated the onset dates, cessation dates and length of growing season in Katsina, Kaita and Jibia Local Government Areas of Katsina State, Nigeria. The characterization of these parameters was based on daily rainfall records spanning over 1981 – 2010. Methods used for investigation include the ogive cumulative pentad rainfall, trend lines and linear trend line equations. Results obtained indicate later onset dates and later cessation dates of rains during the study period. An increasing trend was observed in the length of growing season in the same period. Based on the foregoing, it is recommended that early maturing seed varieties should be provided to farmers before onset dates of planting. Taking this measure will no doubt be a way forward to our source of security in Katsina State.

Keywords: Onset; Cessation; Growing season; Katsina State.

1. INTRODUCTION

Onset refers to the time a place receives an accumulated amount of rainfall sufficient for growing crop. Koppen and Geiger (1936), cited by Hulme (1987) defined the onset date of growing season rainfall as the month having more than 60mm of rain. Darnault (1947) also cited by Hulme (1987) used a much lower threshold. He took the first month having more than 30mm of rainfall as the start of the growing season rainfall. Davey et al. (1976) defined the start of growing season rainfall as the first ten-day period with 20mm or more of rain. This definition may give false starts. In order to take care of false starts, Stern et al. (1981, 1982) defined the starts of rain of growing season as 20mm in one or more consecutive days with no dry spell of 10 days or more within the next 30 days. Jolliffe and Sarria-Dodd (1994) defined the onset date of growing season rainfall as:

i. A period of 5 days (pentad) with at least 25mm of rainfall;
ii. The start day and at least two other days in this period are wet, i.e. equal to or more than 0.1mm rainfall;
iii. No dry spell of 7 days or more occurs in the following 30 days

Davey et al. (1976) defined the start of growing season rainfall as the first ten-day period with 20mm or more of rain.

Cessation means termination of the effective rainy season. Walter (1967) defined the cessation date of the rains as the last date on which a threshold reached. Determination of cessation date of growing season is done in the same way as the onset date except that here, the working done backward from December. Based on Walter (1967), he said that it is the number of days in the first month from December with cumulative monthly rainfall greater than 51mm multiplied by (51-Rainfall total of the previous month) divided by total rainfall of the first month with cumulative rainfall greater than 51mm. Odekunle (2004) stated that cessation date of the rainy season is when rainfall distribution may no longer sustain plant growth. It implies that cessation date is the stage when plants no longer grow well due to shortage of rainwater, and no need for other means of water supply to sustain them.

Length of growing season is defined as the period of the year during which rainfall distribution characteristics are suitable for crop germination, and full development (Odekunle, 2004). The period of the year is categorized as rainy or wet season. The length of the growing season varies spatially and temporally. The length of growing season can be determined by subtracting for each year, the date at which the rains start from the date that it ends (Madeoye, 1986; Zargina, 1987). Also Oladipo and Kyari (1993) in their study of growing season rainfall of Northern Nigeria indicated that the onset, cessation and length of growing season showed latitudinal progress but with some disruptions due to orographic effect in the central area (Jos). Adefolalu (1993) stated that the length of the growing season could be obtained by subtracting the onset pentad from the cessation pentad and multiplying by five. Among authors that have emphasized linkages of the growing season with reliable onset of rains are Dagga (1965), Bello (1996), Olaniran (1983; 1984), Ati et al. (2002), Sawa and Adebayo (2011).

Trend is defined as a general direction by which a situation is changing or developing (Hornby, 1948). Pronounced long-trends from 1900 to 2005 observed in precipitation amount in some places: significantly wetter in eastern North and South America, northern Europe and northern and central Asia, which increase heavy precipitation events, but drier in the Sahel, southern Africa, the Mediterranean and southern Asia. These changes are associated with increased water vapor in the atmosphere arising from the warming of the world`s oceans, especially at lower latitudes (Trenberth et al., 2007). Obot et al. (2010)) reported that, while other locations in Nigeria had no significant trend yet in annual rainfall, Maiduguri showed an increase at a rate of 9.88mm/year. Although previous studies have reported a declining trend in the mean annual rainfall in Nigeria (e.g., Abaji et al., 2010; Tarhule and Woo, 1998), recent studies have confirmed an increasing trend in northwest region (e.g., Obot et al., 2010; Oguntunde et al., 2012). Twenty percent of Nigeria experiences a Semi- arid climate, which is characterized by increasing aridity since the 1960s, and in these areas, annual rainfall totals have been declining. There is a perception that the duration of growing season has been shortening (LeHou`erou, 1996). In these areas, the trend of length of growing season follows the abrupt end of rains, which occurs in mid-September or early October (Kowal and Knabe, 1972).

Based on these reviews, it is observed that rainfall probability, especially daily rainfall probability, which is the most direct method of rainfall reliability estimate, has not been investigated in assessing the onset, cessation dates and the length of the growing season in Katsina State. This is a research gap, which needs to be bridged. Therefore, this paper is aimed at assessing onset dates, cessation dates and length of growing season in the three selected Local Government Areas of Katsina State by using daily rainfall probability to determine the trends of these parameters in the study area.

1.1 Study Area

The study area covered Katsina, Kaita and Jibia Local Government areas of Katsina State, Nigeria. It is located between latitudes

12°47′N and 13°08′ north of the Equator, longitudes 7°13′E and 7°48′E of Greenwhich Meridian (Figure 1).

Figure 1: Study Area

2. MATERIALS AND METHODS

The study area was selected based on the location of meteorological station at Umara Musa Yar`adua Airport in Katsina Local Government Area. This meteorological station is a synoptic station which has long period of data collection. Daily rainfall data from the period of 1981 – 2010 was sourced from Nigerian Meteorological Agency (NIMET) at the Department of Meteorology, Umara Musa Yar`adua Airport, Katsin. A method proposed by Adefolalu (1993) which is based on relative definition is adopted in this study. He reported that, the length of growing season could be obtained by subtracting the onset of 5 days period (pentad) from the cessation pentad. He determined the onset and cessation dates of the growing season by dividing each year into pentads making 72 pentads, and using the pentad calendar, Pentad rainfall is then calculated for each pentad and cumulated. Pentads rainfall is then plotted against the number of pentad giving an ogive for each year in the study area. The points on the pentad axis corresponding to the first and last point of the maximum inflexion on the rainfall ogive correspond to the onset and cessation pentads respectively (Figure 2). The last date in the onset pentad gives the exact onset date and the first date in the cessation pentad gives the cessation date of the rainy season. The gap between onset and cessation pentads gives the length of growing season.

The derived onset and cessation dates are then converted to Julian days using Julian day calendar to obtain the length of growing season of each year in the study period. The Julian day calender has regular year of 365 days divided by 12 months. A leaf year added to Febuary every four years. The Julian year is therefore, on average of 365.25 days long. The data in Figure 2 revealed that, the onset pentad rainfall falls on pentad 30 and the onset date of rainfall corresponds to 31-May 1981 (Table 1). The cessation pentad rainfall falls on pentad 53 and the cessation date of rainfall corresponds to 25-September 1981 (Table 1). The length of growing is the interval between onset and cessation pentad. The other onset and cessation dates and length of growing season for the study period (1982 to 2010) obtained in similar manner using pentad calendar and Julian day.

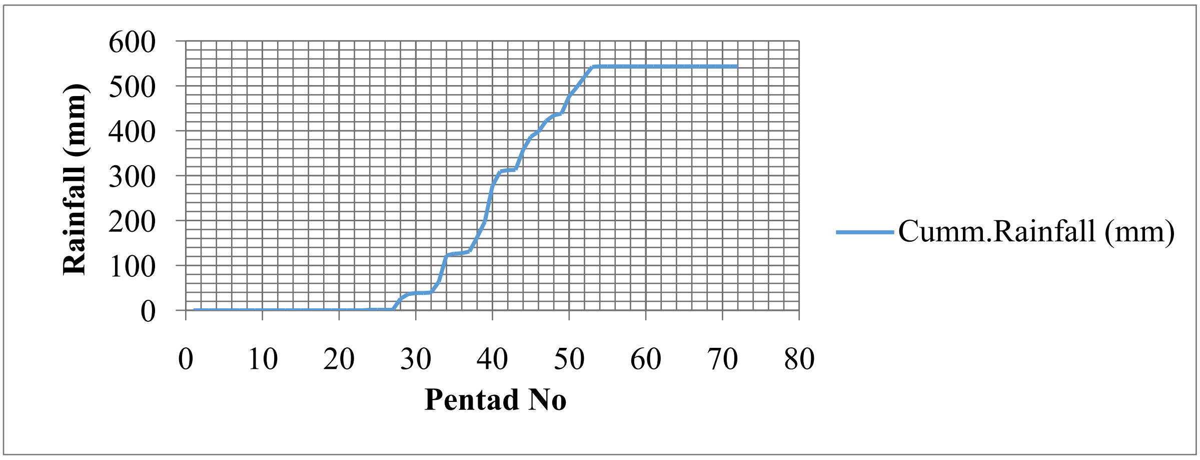


Figure 2: Ogive of Cumulative Pentad Rainfall in the Study Area (1981) for Determination of Onset, Cessation Dates and Length of Growing Season

3. 0 RESULTS AND DISCUSSION

3.1 Onset and Cessation Dates

The derived onset and cessation dates for the study area during the period (1981 to 2010) are presented in Table 1. From the Table, it is observed that, the onset of growing season occurred 15 times in May 13 in June and 2 times in July. The cessation date of growing season was 16 times in September and 14 in October. This finding indicates that the highest frequency of onset date of growing season was in May, and it was in September for the cessation date of growing season during the study period (1981 to 2010). The mean of these variables for the study was calculated using Julian Day Calendar Table. They were obtained by converting onset and cessation dates into Julian Days in the study period (1981 to 2010). The results were summed up and divided by the number of year in the study period to obtain the mean of both onset and cessation date of growing season respectively. In Table 1 the mean of onset and cessation dates of growing season were calculated as 2-June and 2-October respectively.

Table 1. Onset and Cessation Dates in the Study Area (1981-2010)

Years	Onset dates	Cessation dates
1981	30-May	25-Sep
1982	5-Jun	6-Oct
1983	15-Jun	16-Sep
1984	15-Jun	11-Oct
1985	20-May	26-Sep
1986	5-Jul	26-Sep
1987	30-May	21-Sep
1988	5-Jun	26-Sep
1989	10-Jun	6-Oct
1990	25-May	6-Sep
1991	15-May	1-Oct
1992	20-May	16-Sep
1993	30-Jun	21-Sep
1994	31-May	11-Oct
1995	20-Jun	26-Sep
1996	31-May	30-Sep
1997	25-May	26-Sep
1998	31-May	26-Sep
1999	5-Jul	6-Oct
2000	5-Jun	6-Oct
2001	31-May	16-Sep
2002	25-Jun	11-Oct
2003	31-May	11-Oct
2004	20-May	26-Sep
2005	20-Jun	1-Oct
2006	20-Jun	1-Oct
2007	20-May	21-Sep
2008	10-Jun	1-Oct
2009	25-May	16-Oct
2010	25-Jun	1-Oct

Source: Fieldwork, 2013.

3.2 Length of Growing Season

The length of growing season

(LGS) in days for the study area was determined and presented in Table 2. From the Table, it is observed that the mean length of growing season was 121 days all over the study area (Katsina, Kaita and Jibia). The length of growing season varies among years in the study period. For instance, it was 136 days in 1981, 130 in 1982, 101 in 1983, among others. The highest length of growing season was found to be 151 days in 2009 and the least was 91 days in 1986. It is also observed that, there are generally 5 months of growing season starting from May to October in this location over the period of study. This finding corresponds to that of Odekunle (2004) who reported that there are generally 5 months of growing season where rainfall distribution is suitable for crop germination, establishment and full development.

Table 2: Length of Growing Season in the Study Area (1981-2010)

YEARS	LGS(Days)
1981	136
1982	130
1983	101
1984	125
1985	136
1986	91
1987	120
1988	120
1989	125
1990	110
1991	146
1992	125
1993	90
1994	110
1995	105
1996	125
1997	130
1998	125
1999	105
2000	130
2001	115
2002	115
2003	141
2004	136
2005	110
2006	110
2007	130
2008	120
2009	151
2010	105

Mean	121

Source: Field work, 2013

3.3 Trend in Onset and Cessation Dates

Trend lines and linear trend line equations of onset and cessation dates of growing season presented in Figure 3. Figure 3 revealed that the trend line and linear trend line equations of onset and cessation dates of rains in the study area are in positive directions, which indicate late onset and late cessation. They are presented respectively by the equations:

Y = 0.0977x + 41602............. Equation 1

Y = 0.2699x + 41372................Equation 2.

The perpendicular distance between each onset date point to cessation date point on the two graphs indicates the length of growing season. It could be seen that the longest length of growing season was in 2009 and the shortest was in 1993. These findings indicate that the three locations (Katsina, Kaita and Jibia) are experiencing later onset dates and later cessation dates of rains.

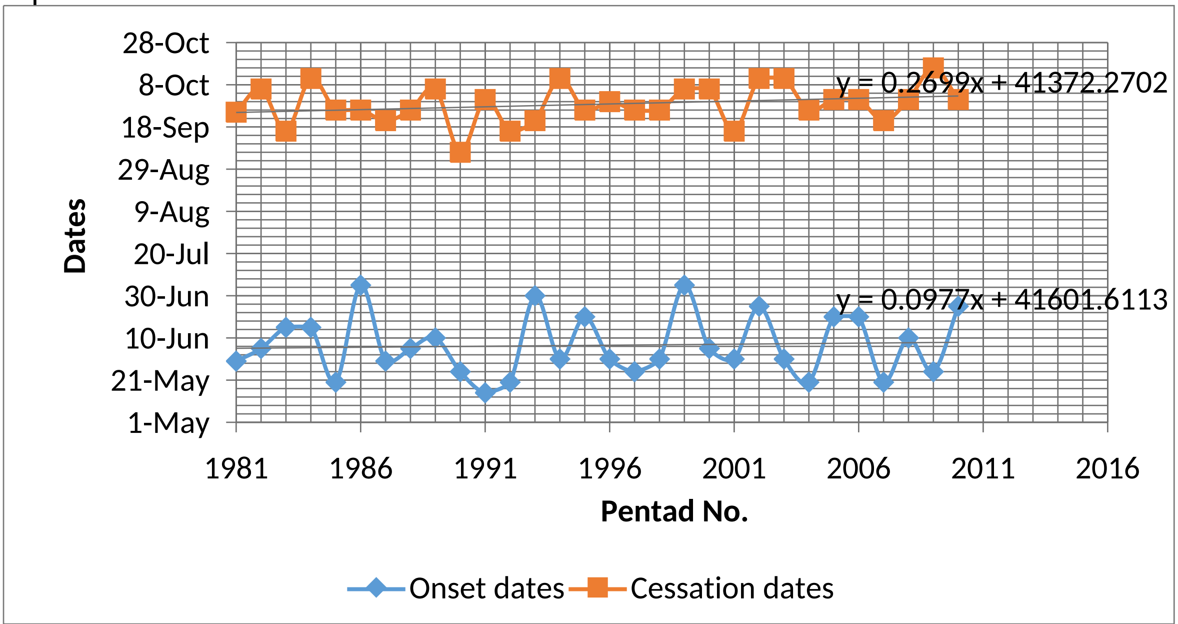


Figure. 3: Trend of Onset and Cessation Dates in the Study Area (1981-2010)

3.4 Trend in Length of Growing Season

The trend line and linear line equation of length of growing season were determined and presented in Figure 4. It is observed from Figure 4 that the slope of the linear trend line equation of length of growing season Y = 0.1279x - 134 in the study area, which indicates positive direction. This implies increasing trend in the length of growing season within the study period.

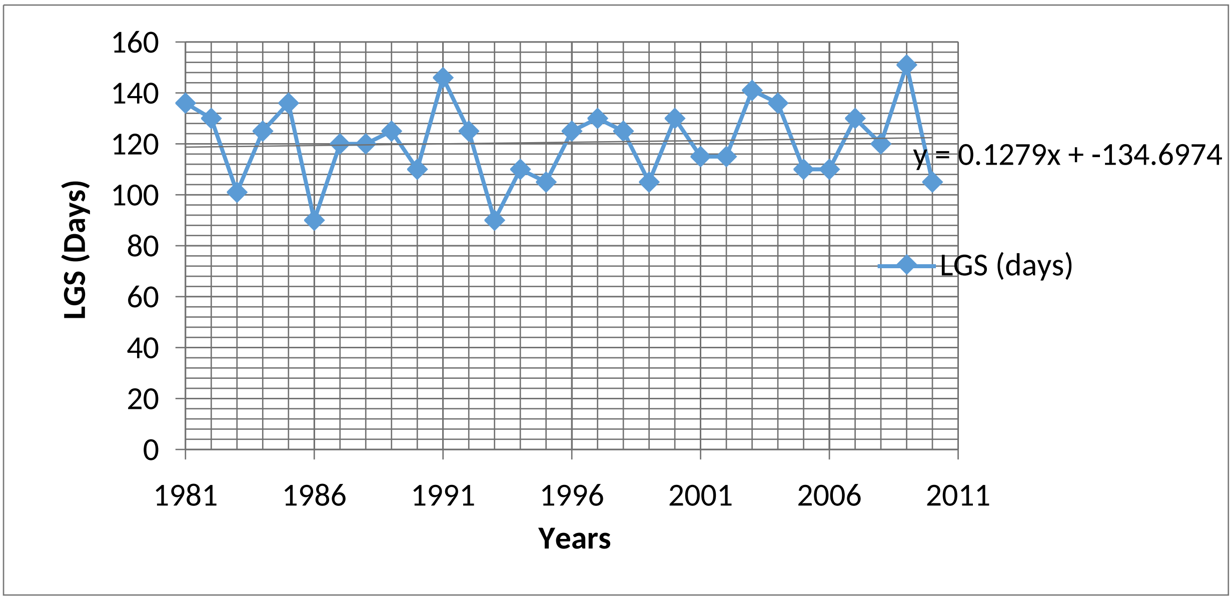


Figure 4: Trend in Length of Growing season in the Study Area (1981-2010)

4. CONCLUSION AND RECOMMENDATIONS

The temporal variation of onset, cessation dates and length of growing season in Katsina, Kaita Jibia Local Government Areas of Katsina State were analyzed using daily rainfall data, ogive of cumulative pentad rainfall, trend lines and linear trend lines equations. Variations in onset, cessation dates and length of growing season were observed in the study area. There was generally shorter length of growing season within the study period. These parameters are considered as the most limiting factors in human activities especially in agriculture in the recent decades, which is influenced by increasing magnitude of climate change.

Based on the findings of the study, it is recommended that early maturing seed varieties should be provided to farmers before onset dates of planting. Taking this measure will be a way forward to our source of security in Katsina State.

REFERENCES

Abaje, I.B., Ishaya, S., and Usman, U. (2010). Analysis of rainfall trends in Kafanchan, Kaduna State, Nigeria, *Research Journal of Environmental Earth Science,* 2(2): 89-96.

Adefolalu, O.O. (1993). *World Meteorological Organization lecture series*, 1993 (1): 1-4.

Ati, O.F., Stigter, C.J. and Oladipo, E.O. (2002). A comparison of methods to determine the onset of growing season in Northern Nigeria, *International Journal of Climatology,* 10: 839-848.

Bello, N.J. (1996). Investigation the spatial pattern of the characteristics of the onset and cessation of rains in Nigeria, *Geography Journal,* 53, 113-123.

Dagga M.(1965). A rational approach to the selection of crops for areas of marginal rainfall in east Afriaca, *East African Agric. Journal,* pp.30, 286-295.

Danault, P. (1947). *Regime de QuelquesCoursdeaud` AfriqueEquatorialeE`tude de leur* utilization industrielle, Paris.

Davey, E.G; Mattie, F.; and Solomon, S.I. (1976). An evaluation of climate and water resources for the development of agriculture in the Sudan Savannah zone of West Africa, *World* *meteorological organization (WHO) special environmental report* No. 9, Geneva, Swizland.

Hornby, A.S.(1948). *Oxford Advanced Learners Dictionary of Current English*. Oxford University Press, pp.1578.

Hulme, M.(1987). Secular changes in wet season structure in central Sudan, *J. Arid Environment,* 13: 31-46.

Jolliffe, I.T., and Sarria-Dodd, D.E.(1994). Early detection of the start of wet season in tropical climates, *Int. J. climatol.,* 14: 6-71.

Koppen, W.P., and Gerger, R. (1936). *Handbuch der Klimatologi foundation international*
PoulaScienc, Berlin, Germany.

Kowal J.M. and Knabe (1972). *An agro-climatic Atlas of the northern States of Nigeria*, Ahmadu Bello University press, Zaria.

Le Houerou, H.N. (1996). Climate change, drought and desertification. *Journal of Arid Environments,* 34: 133-185.

Madeoye, I.J. (1986). *The statistical characteristics of rainfall in Lagos State*, unpublished Bsc. Project Report, Dept. of Geog. University of Jos, Jos Plateau State, Nigeria.

Obot, N.I., Chendo, M.A.C., Udo, S.O., and Ewona, I.O.(2010). Evaluation of rainfall trends in Nigeria for 30 years (1978-2007). *International Journal of Physical Sciences,* 5(14): 2217-2222.

Odekunle, T.O. (2004). Rainfall and length of the growing season in Nigeria, *Int. J. of Climatology,* 24, 731-742.

Oguntunde, P.G., Abiodun, B.J., and Lischeid, G. (2012). Rainfall trends in Nigeria 1901 -2000. *Journal of Hydrology,* 411(3-4), 207-218.

Oladipo, E.O., and Kyari, J.D. (1993). Fluctuations in the onset, termination and length of the growing season in Northern Nigeria, in: *Theor. Appl. Climatol.,* 47(4):50-

Olaniran, J.O. (1983). The start and end of the growing season in Niger River Basin Development Authority of Nigeria, *Malaysia Journal of Tropical Geography,* 58-69.

Olaniran, O.J. (1984). The start and end of the growing season in the Niger River Basin Development Authority area of Nigeria. *Malaysian Journal of Tropical Geography,* 49-58.

Sawa, B.A. and Adebayo, A. A. (2011). Climate change and derived precipitation effectiveness indices in Northern Nigeria: A current synthesis. A paper presented at *52nd annual conference of the Association of Nigerian Geographers* held from 14th-17th February, 2011, at Dept. of Geography Danfodio University, Sokoto, Nigeria.

Stern, R.D., Dennett, M.D., and Daler, I.C.(1982). Analysis of daily rainfall measurements to give agronomical useful results, 1, Ditect methods*: Exp. Agric.,* 18: 36-223.

Stern, R.D., Dennett, M.D., and Garbutt, D.J. (1981). The start of rains in West Africa J*ournal of Climatol.* 1: 59-68.

Tarhule, A., and Woo, M.K. (1998). Changes in rainfall characteristics in northern Nigeria
International Journal of Climatology, 18(11), 1261-1271.

Trenberth, K.E.,P.D.,Jones, P. Ambenje,R., Bojariu,D., Easterling, A., Klein

Tank,D.,Parker,F., Rahimzadeh, J.A., Renwick,M., Rusticucci, B., Sodern,andP.Zhai (2007): Observations: Surface and Atmospheric Climate Change , In: Solomon, S., D. Qin,M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller, (Eds.), *Climate Change 2007: Physical Science Basis, contribution of Working Group 1 to the Fourth Assessment Report of the Intergovernmental Penal on Climate Change*. United Kingdom and New York, NY Cambridge University Press, pp.235-336.

Walter, M.W. (1967). Length of the rainy season in Nigeria, *Nigerian Geogr. J.,* 10: 8-123.

Zargina, A.B. (1987). *Onset of effective rainfall and characteristics of dry spell in Nigerian Savanna*: Unpublished Bsc. Project Report, Dept. of Geog. A.B.U, Zaria, Nigeria

Assessment of the Relationship between Weather and Road Traffic Accidents in Zaria, Kaduna State, Nigeria

Mohammed, H.[1]*, Iguisi, E.O.[1], Abdulhamed, I.A.[2], Tasiu, M.[3], Usman, J.G.[1] and Akhadelor, M.O.[1]

[1]*Department of Geography & Environmental Management, Ahmadu Bello University, Zaria*
[2]*Department of Environmental Management and Toxicology, Federal University, Dutse*
[3]*Department of Statistics, Ahmadu Bello University, Zaria*
**khamminat@gmail.com*

ABSTRACT

Assessment of the association between selected weather parameters which include rainfall, air temperature, visibility, relative humidity, wind speed and evaporation rate and the occurrence of road traffic accidents (RTAs) was conducted in Zaria unit command of the Federal Road Safety Commission (FRSC) which is located between Latitudes 10°49'19'' to 11°28'12'' North and longitudes 7° 05'41'' to 8°08'8'' East. Data transformation was carried out on the data obtained for weather and RTAs while Pearson's product moment correlation coefficient was used to assess the magnitude and direction of association between the weather parameters and the RTA variables in Zaria. The weather parameters were tested against each of the seven RTA variables (which are: fatal, serious, minor and total cases of RTA on one hand and the number of passengers injured or killed and total casualties on the other hand) annually and then monthly to see the nature of association between the two. Rainfall was found to have a positive association with six them; number of wet days on the other hand had a negative association with six of them. Air temperature also had a positive association with six of them including total number of cases and casualties. Visibility and relative humidity had a positive association with all of them while evaporation rate had a negative association with all the RTA variables.

Keywords: Weather parameters; Road Traffic Accident (RTA); Data transformation; FRSC.

1. INTRODUCTION

Climate change is almost invariably considered as an issue of global interest. However, the extent to which climate change represents a problem is still a heavily debated issue. Calculations of future damages associated with climate change, judgments about mitigation and adaptation costs to be made now, differ widely. For example, the influential Stern report claims that the benefits of strong, early action considerably outweigh the costs (Stern, 2007). The main consequences of climate change as predicted by most of the existing climate models are an increase in global temperatures, changes in precipitation patterns and sea level rise. In general, climate models predict that increases in temperature will be higher over land areas than over oceans and seas, higher in interiors of continents than in coastal areas, and higher when going from the tropics to the polar region in the Northern Hemisphere. The potential consequences of climate change for precipitation patterns are more complex and depend largely on continental geometry (vicinity of water) but also on the vicinity and shape of mountains and on wind flow direction (Intergovernmental Panel on Climate Change(IPCC), 2007).

The Stern (2007) and Intergovernmental Panel on Climate Change (IPCC) (2007) reports analyzes damages to, among others, the water, agricultural, health and insurance sectors. A sector that receives fairly little (explicit) attention, however, is the transport sector. This is not entirely surprising since to date, the consequences of climate change and changing weather conditions for the transport sector have not received much attention in the literature.

However, weather parameters have been found to be related to road accidents. Rainfall is said to be related to road accidents due to factors such as skidding due to wetness of road surfaces, poor visibility, wet pavement exposure, surface runoff to mention a few as reported by Burns (1976), Rohde (1977), Andreescu and Frost (1998), Yannis and Karlaftis (2007), Mondal, Sharma, Kumar, Bhangale and Tyagi (2011), among others. A classic example among other effects of rainfall is the case of a vehicle running on a wet road at high speed. Rainwater will flow through the tyre tread grooves given rise to hydrodynamic pressure. The occurrence of this hydrodynamic force deteriorates the tyre traction efficiency because it decreases the tire contact force so that the driving controllability and the braking performance become worse than those on the dry roads (Cho, Lee and Yoo, 2006; Mondal, Dalela et al., 2008).

Furthermore, just as rainfall is said to be related to road accidents, temperature likewise. Chen (2010) reported that temperature affects man (driver) in several ways. A typical example is the effect of high temperature on man leading to heat exhaustion of which dizziness is one of its symptoms. The author also stated that vehicles are affected by temperature in several ways such as it effect on the pressure of tyres as it makes the air in the tyre to expand, drying up of fluids in the battery, failing of fuel pumps due to drying up of petrol blended with ethanol before it reaches the engine making the car to stall. High temperature, in addition to large volume of goods transported on roads, lead to the deformation of roads. Visibility, relative humidity, wind speed and evaporation rate are related to rainfall and temperature (Garg and Nayar, 2007; Wooden, 2011; Umoh, Akpan and Jacob, 2013) and by extension, will also be related to road traffic accident.

In fact, higher temperatures appear to have a decreasing effect on accident frequencies and severity both on daily, weekly and monthly bases (Scott, 1986; Brijs, Karlis and Wets, 2008).The hours of sunlight appear to increase road accidents (Hermans, Brijs, Stiers and Offermans, 2006; Brijs, Vlassenroot, Broekx, De Mol, Panis, and Wets, 2007) while deviations from mean daily or monthly temperatures were found to increase road accidents (Brijs, Karlis and Wets, 2008). Malyshkina, Mannering and Tarko (2008) found that extreme temperatures (both low during winter and high during summer) are positively correlated with road accidents. On the other hand, when the monthly number of days with temperature below zero increases; road accidents are reduced possibly due to reduced exposure (Hermans et al., 2006; Stipdonk, 2008).

However, road safety is treated as a transportation issue and not as a public health issue. Road traffic injuries are called accidents though most could be prevented. As a result, many countries put far less effort in understanding and preventing road traffic injuries than they do into understanding and preventing diseases that do less harm. Every day, as many as 140,000 people are injured on the world's roads of which more than 3,000 die and some 15,000 are disabled for life. Each of those people has a network of family, friends, neighbours, colleagues or classmates who are also affected emotionally and otherwise (Dinesh, 2004). Worldwide, nearly 1.24 million people die in Traffic fatalities annually (WHO, 2013).

Road traffic accidents started in Nigeria in 1906 in Lagos. Ever since, it has been a public health concern based on the number and magnitude of persons killed and injured. Between 1960 through to 2006, a total of 969,618 road crashes were reported leading to a casualty figure of 1,159,642 persons, distributed as 292,703 persons killed and 866,939 persons injured (Arosanyin, Olowosulu and Oyeyemi, 2012). A comparative assessment of the causes of deaths in Nigeria has placed road crashes as the most important killer of Nigerians than a combination of 35 noticeable diseases including malaria and HIV/AIDS. Yet, this burden is more than what the estimate covers as it covers mainly the casualty component (Arosanyin, 2008). In the year 2012, at the special marshal workshop held in Kaduna state, it was announced that between January and July 2012, a total of 2,200 traffic offenders were apprehended while 597 road traffic accidents were recorded in Kaduna state. Out of these accidents, 125 fatal cases, 389 serious cases and 58 minor cases occurred while 297 persons were killed and 2,239 persons were injured (Federal Road Safety Commission, 2012).

Most accidents in Nigeria today occur on federal roads and the roads topping the list include Benin-Ore, Lagos-Ibadan Expressway, Abuja-Lokoja-Okene, Kaduna-Zaria-Kano, Okigwe-Umuahia, Kaduna-Abuja, Enugu-Awka-Onitsha and Otukpo-Otukpa among others (Godwin, 2012). Since Zaria links the other part of the country to other northwestern states and the northeastern part of the country, the probability that traffic flow will be high and the presence of fast moving vehicles will be observed along these major routes will all be high inducing the occurrence of RTA in

Zaria. Hence, the aim of this study is to examine the relationship between some weather element and road traffic accidents in Zaria, Kaduna state, Nigeria.

1.1 Study Area

Zaria unit command of the Federal Road Safety Commission (FRSC) is located between latitudes 10°49'19" to 11°28'12" North and longitudes 7° 05'41" to 8°08'8" East (Figure 1). Zaria is almost centrally located in northern Nigeria and is a major city in Kaduna state. It is characterized by a tropical continental climate which is more pronounced during the dry season especially December and January. The mean maximum daily temperature shows a major peak in April and a minor in October while the mean minimum temperature shows its lowest in December-January and its highest in July-August. Wet season in the area lasts from April through October with the peak in August while the dry season extends from mid-October to April (Abaje and Giwa, 2010).

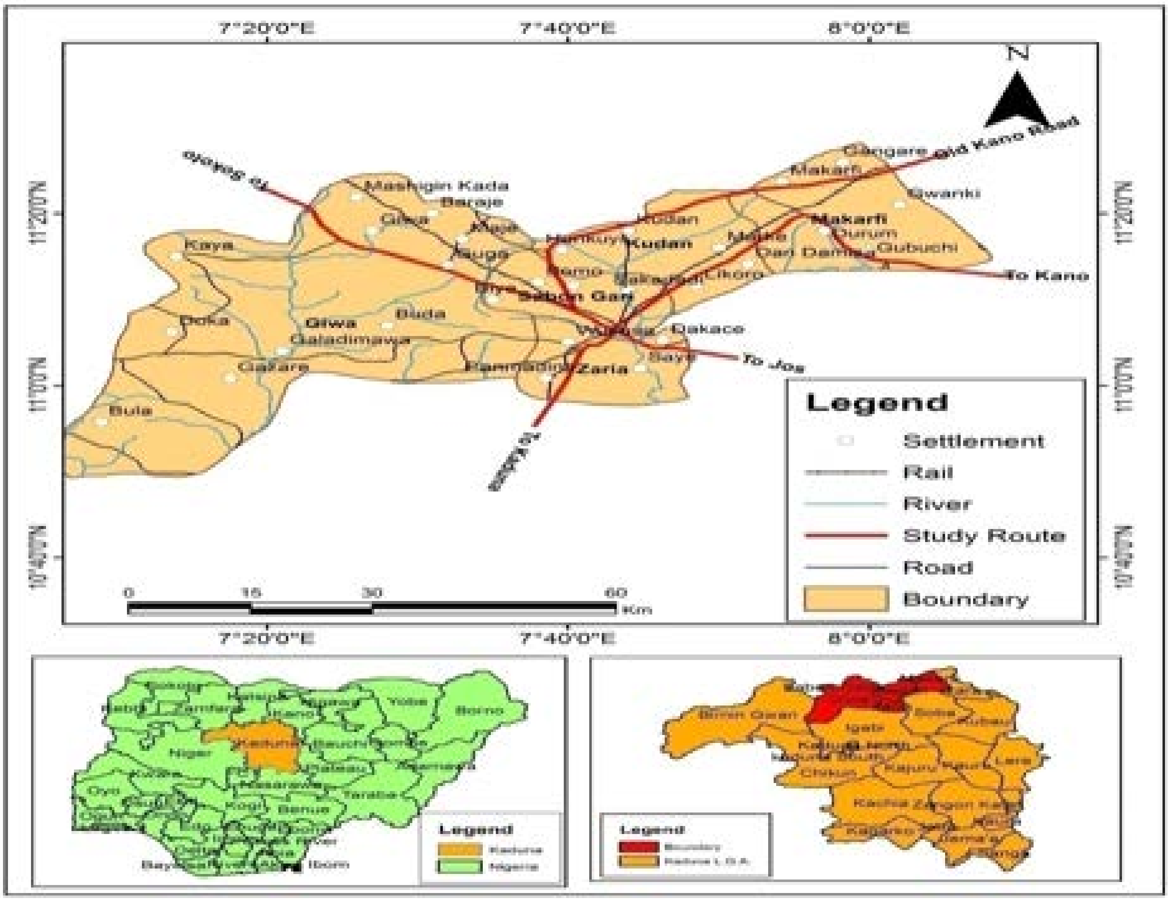


Figure 1: Zaria Unit Command showing major transportation routes
Source: Modified from Administrative Map of Nigeria

2. MATERIALS AND METHODS

Data for daily records of some weather elements were obtained from 1979 to 2014 from Nigerian Meteorological Agency while data for RTAs from 2001 to 2014 along Zaria-Kaduna, Zaria-Kano, Zaria-Sokoto, Zaria-Jos, Old Zaria-Kano and Zaria Township routes were obtained from FRSC. The data for weather and RTAs were transformed using Log base 10, Box-Cox and Johnson transformation via Minitab and R softwares to enable annual and monthly analysis of these variables. Pearson's product moment correlation coefficient was used to assess the magnitude and direction of association between each of the weather parameters and each of the RTA variables (fatal, serious, minor and total cases of RTA on one hand and number of passengers injured, killed and total casualties on the other hand).

3. RESULT AND DISCUSSION

Annual analysis of the nature of association between each of the weather parameters and the selected RTA variables from year 2001 to 2014 within Zaria unit command of FRSC revealed that rainfall had a positive association with total cases of RTA (r = 0.13) and total RTA casualties (r = 0.23) due to skidding and poor visibility during rainfall (see Table 1). Number of wet days on the other hand had a negative association with total cases of RTAs (r = -0.20) and total RTA casualties (r = -0.21). This could be because the more the number of wet days, the more skilled drivers become aware on how to drive on wet corridors. Air temperature as a parameter had a positive association with total cases of RTAs (r = 0.11) and total RTA casualties (r = 0.06) due to heat exhaustion, fatigue and impatience. Visibility had a positive association with total RTA cases (r = 0.43) and total RTA casualties (r = 0.41). This could be because better visibility encourages drivers to be less cautious.

Relative humidity on the other hand also had a positive association with total RTA cases (r= 0.37) due to heat stress resulting to fatigue and impatience and a negative association with total RTA casualties (r = -0.28) which could be as a result of fewer passengers due to the condition of the weather. Wind speed showed that it has a positive association with total RTA cases (r = 0.64) and total RTA casualties (r = 0.64) because it affects the controllability of vehicles. Finally, evaporation rate has a negative association with total RTA cases (r = -0.52) and total RTA casualties (r = -0.54). This could be because lower evaporation rate induces heat stress, fatigue and impatience in humans leading to more RTA cases and casualties. The association between wind speed and all the RTA variables were significant except with minor RTA cases while the association between evaporation rate and fatal RTA cases was also found to be significant. See Table 1 below.

Monthly analysis of the nature of association between each of the weather parameters and the selected RTA variables from year 2001 to 2014 within Zaria unit command of FRSC (see Table 2) revealed that rainfall has a positive association with total cases of RTAs (r = 0.18) and total RTA casualties (r = 0.40) meaning that months that experience more rainfall experience more RTA cases and casualties due to skidding (which affects the frictional force between tyres and the road surface) and poor visibility. Air temperature as a parameter had a positive association with total cases of RTA (r = -0.12) and total RTA casualties (r = 0.01). Visibility had a positive association with total RTA cases (r = 0.05) and total RTA casualties (r = -0.48) which could be due to the fact that better visibility can induce recklessness on the part of road users generally.

Table 2 shows that relative humidity on the other hand also had a positive association with total RTA cases (r= 0.20) due to heat exhaustion leading to fatigue and impatience and a negative association with total RTA casualties (r = -0.42) which may be attributed to fewer travellers due to the nature of the weather. Wind speed showed that it has a positive association with total RTA cases (r = -0.29) and total RTA casualties (r = 0.15) and this may be because it leads to poor controllability of vehicles. Finally, evaporation rate has a negative association with total RTA cases (r = -0.28) and total RTA casualties (r = 0.43). This could be because lower evaporation rate induces heat stress, fatigue and impatience in humans leading to more RTA cases and casualties.The association between visibility and minor cases of RTA and the number of passengers killed due to RTAs were significant.

Table 1: Annual analysis of the nature of association between weather parameters and RTA in Zaria

	Fatal	Serious	Minor	Total cases
Annual Rainfall	0.249	0.091	0.111	0.128
	0.412	0.767	0.718	0.677
Number of wet days	-0.168	-0.244	0.445	-0.200
	0.583	0.422	0.128	0.513
Air temperature	0.090	0.141	-0.234	0.107
	0.771	0.647	0.441	0.727
Visibility	0.353	0.338	0.086	0.335
	0.236	0.259	0.780	0.263
Relative Humidity	-0.261	-0.251	-0.337	0.374
	0.388	0.408	0.260	0.208
Wind speed	0.609	0.617	0.402	0.640
	0.027	0.025	0.173	0.018
Evaporation	-0.605	-0.502	0.111	-0.521
	0.028	0.080	0.719	0.068
	No. injured	No. killed	Total casualty	
Annual Rainfall	0.216	0.258	0.234	
	0.478	0.394	0.442	
Number of Wet days	-0.221	0.020	-0.212	
	0.469	0.948	0.488	
Air temperature	0.026	0.012	0.060	
	0.934	0.969	0.845	
Visibility	0.284	0.551	0.338	
	0.347	0.051	0.259	
Relative Humidity	-0.284	-0.300	-0.279	
	0.347	0.319	0.355	
Wind speed	0.638	0.657	0.635	
	0.019	0.015	0.020	
Evaporation	-0.530	-0.448	-0.536	
	0.062	0.125	0.059	

Cell Contents: Pearson correlation
p-Value
Pearson correlation coefficient is significant if *p*-Value < significant level at 0.05

Findings of this study are in agreement with Stern (2007) and IPCC (2007) reports that analyzed damages for water, agricultural, health and insurance sectors. The reports argued that a sector that receives fairly little attention, however, is the transport sector. This is not entirely surprising, since to date the consequences of climate change and changing weatherconditions for the transport sector have not received much attention in the literature. However, the occurrence of road accidents in hazardous weather conditions be it rainfall, temperature, fog, snowfall and wind broadly follows the regional weather patterns for those conditions (Edwards, 1996; Khan, Qin and Noyce, 2008).

Table 2: Monthly analysis of the nature of association between weather parameters and RTA in Zaria

	Fatal	Serious	Minor	Total cases
Rainfall	0.066	0.125	0.232	0.187
	0.838	0.700	0.467	0.561
Air Temperature	0.273	-0.304	0.158	-0.122
	0.390	0.336	0.624	0.706
Visibility	-0.313	-0.008	0.723	0.051
	0.321	0.980	0.008	0.874
Relative Humidity	-0.124	0.148	0.494	0.199
	0.701	0.647	0.103	0.535
Wind speed	0.254	-0.435	-0.042	-0.288
	0.426	0.158	0.896	0.363
Evaporation	0.365	-0.342	-0.498	-0.278
	0.244	0.277	0.099	0.382
	No. injured	No. killed	Total casualty	
Rainfall	-0.427	-0.137	-0.400	
	0.167	0.672	0.198	
Air Temperature	0.096	-0.154	0.012	
	0.767	0.633	0.971	
Visibility	-0.281	-0.593	-0.475	
	0.377	0.042	0.119	
Relative Humidity	-0.341	-0.353	-0.422	
	0.278	0.261	0.171	
Wind speed	-0.005	0.352	0.145	
	0.988	0.262	0.653	
Evaporation	-0.278	0.326	0.432	
	0.301	0.191	0.161	

Cell Contents: Pearson correlation
p-Value
Pearson correlation coefficient is significant if *p*-Value < significant level at 0.05

Weather could pose hazards to driving. Weather hazard is complexly related with road crash and needs more specific and distinguished research (Mondal et al., 2011). In fact, contrasting reports on the impact of temperature and rainfall on road accident like Atubi (2012) versus Mondal et al. (2011) on one hand and Scott (1986), Brijs, Karlis and Wets (2008) versus Yannis and Karlaftis (2007) have been documented. Atubi (2012) in his study discovered that the month of July which falls under the long rainy season of southern Nigeria recorded the highest number of accidents. Thus, annual rainfall and RTA cases had a positive relationship in this study which is contrary to the finding of Mondal et al. (2011) in their study carried out in India. Mean monthly rainfall also recorded a positive association with RTA cases which is also in agreement with the report by Atubi (2012) in a study carried out in Lagos, Nigeria.

Furthermore, higher temperatures appear to have a decreasing effect on accident frequencies and severity both on daily, weekly and monthly bases according to Scott (1986) and Brijs et al. (2008) which is in agreement with the present study that revealed a negative association between mean monthly air temperature and RTA cases. However, mean annual air temperature revealed a positive association between air temperature and RTA cases which is in agreement with a study carried out by Yannis and Karlaftis (2007). The present study revealed that annual and monthly analysis of the association between visibility and wind speed respectively with fatal and total cases of RTA shows that the association is positive and is in agreement with Hermans et al. (2006) who reported that better visibility and greater wind speed leads to more RTA cases.

At saturation, a dynamic equilibrium exists between the rate of condensation and the rate of evaporation. For a liquid to evaporate, its molecules must vibrate with enough force to break the bonds holding them together. These vibrations cannot happen without energy, so a liquid provided with more energy (in the form of heat) evaporates more quickly. Rate of evaporation depends on both the heat available to the liquid and the strength of the intermolecular forces between the molecules. Evaporation can be faster on sunny days not just because of the extra heat, but also because sunny days are often drier and so have lower relative humidity. Thus, since annual rainfall which has a positive association with RTA cases has a highly significant association with relative humidity which in turn has a negative association with evaporation rate on the other hand (Umoh, Akpan and Jacob, 2013). Thus, it can be deduced that the present study is in agreement with Umoh, Akpan and Jacob (2013) as relative humidity and evaporation rate were discovered to have a positive and negative association with number of RTA cases respectively. This analogy was further substantiated after looking at the monthly analysis of the relationship between rainfall and RTA cases.

4. CONCLUSION

The strength and direction of the association between these weather elements and RTA variables be it fatal, serious, minor or the totality of RTA cases on one hand or the number of passengers injured or killed or the totality of casualties from RTA on the other vary from one weather element to another or from one month to another or one year to another.

REFERENCES

Abaje, I.B., Ishaya, S. and Usman, S.U. (2010). An analysis of rainfall trends in Kafanchan, Kaduna State, Nigeria. *Research Journal of Environmental and Earth Sciences* 2(2): 89- 96.

Andreescu, M. and Frost, D.B. (1998).Weather and traffic accidents in Montreal, Canada. *Climate Res,* 9: 225–230.

Arosanyin, G. T. Olowosulu, A. T. and Oyeyemi, G. M. (2012). Compliance with road safety regulations among commercial motorcyclists in Nigeria. *Canadian Social Science Journal*, 8(1): 92-100.

Atubi, A.O. (2012). A Monthly Analysis of Road Traffic Accident in Selected Local Government Areas of Lagos State, Nigeria. *Mediterranean Journal of Social Sciences* 3(11): 47-62

Brijs, T., Karlis, D. and Wets, G. (2008). Studying the effect of weather conditions on daily crash counts using a discrete time-series model. *Accident Analysis and Prevention* 40: 1180- 1190.

Brijs, T., Vlassenroot, S., Broekx, S., De Mol, J., Panis, L.I. and Wets, G. (2007). Driving with intelligent speed adaptation: Final results of the Belgian ISA trial. *Transportation*

Research Part A: Policy and Practice 41: 267-279

Burns, J.C. (1976). Differential friction: a potential skid hazard. Transportation Res. Record, (602), 46-53.

Chen, G. (2010). Road Traffic Safety in African Countries – Status, Trend, Contributing Factors, Counter Measures and Challenges, *International Journal of Injury Control and Safety Promotion,* 17(4): 247 – 255.

Cho, J.R., Lee, H.W. and Yoo, W.S. (2006). A wet-road braking distance estimate utilizing the hydroplaning analysis of patterned tire. *Int. J. Numer. Meth. Engng,* 69: 1423–1445.

Dinesh, M. (2004). The Road Ahead: Traffic Injuries and Fatalities in India. Transportation research and injury prevention programme. Indian Institute of Technology, Delhi.

Edwards, J.B. (1996). Weather-related road accidents in England and Wales: a spatial analysis. *Journal of Transport Geography*, 4: 201–212.

Federal Road Safety Commission (FRSC). (2012). Auto crashes data. accessed from www.frsc.gov.ng/about-us/what we- do, May, 2013.

Garg, K and Nayar, S.K. (2007). Vision and rain. *International journal of computer vision,*10: 1- 25

Godwin, A.C. (2012). Valleys of Death: Top Dangerous Federal Roads in Nigeria. How Many Lives they've Claimed. DailyPost Nigerian online newspaper.www.dailypost.com.ng/

Hermans, E., Brijs, T., Stiers, T. and Offermans, C. (2006). The impact of weather conditions on road safety investigated on an hourly basis. In: Transportation Research Board Annual Meeting, CD-ROM Paper 06-1120.

Intergovernmental Panel on Climate Change. (2007). Climate change 2007: impacts, adaptation and vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge: Cambridge University Press.

Khan, G., Qin X. and Noyce, D.A. (2008). Spatial Analysis of Weather Crash Patterns. *Journal of Transportation Engineering,* pp.191-202.

Malyshkina, N.V., Mannering, F.L. and Tarko, A.P. (2008). Markov switching negative binomial models: An application to vehicle accident frequencies. Article in press, Accident Analysis & Prevention.

Mondal, P., Dalela, S., Balasubramanian, N., Sharma, G.K. and Singh, R. (2008).Critical Analysis of Road Crashes and a Case Study of Wet Road Condition and Road Crashes in an Indian Metropolitan City. SAE paper no. 2008-28-0078.

Mondal, P., Sharma, N., Kumar, A., Vigay, P., Bhangale, U.D. and Tyagi, D. (2011). Are roadaccidents affected by rainfall? A case study of a large Indian metropolitan city.*British Journal of Applied Science & Technology,* 1(2): 16- 26

Rohde, S.M. (1977). On the combined effects of tread element flexibility and pavement microtexture on thin film wet traction. SAE Paper-770277.

Scott, P. (1986). Modeling Time-Series of British Road Accident Data. *Accident Analysis & Prevention* 18(2): 109-117.

Stern, N. (2007). The Economics of Climate Change: The Stern Review. Cambridge: Cambridge University Press.

Stipdonk, H.L. (2008). Time series applications on road safety developments in Europe.Deliverable D7.10 of the EU FP6 project SafetyNet. Available on-line at: http://www.erso.eu/safetynet/fixed/WP7/SN_D7.10_final.pdf

Umoh, A.A., Akpan, A.O. and Jacob, B.B. (2013).Rainfall and relative humidity occurrence in Uyo metropolis, AkwaIbom State, South-South Nigeria. *IOSR Journal of Engineering,* 3(8): 27-31

Wooden, R.D. (2011).Statistical analysis of the relationship between wind speed, pressure and temperarture. *Journal of Applied Sciences,* 10(15): 2712-2722

World Health Organization. (2013). Report on Accidents in Africa. World Health Organization.

Yannis, G. and Karlaftis, M.G. (2007).Weather Effects on Daily Traffic Accidents and Fatalities: A Time Series Count Data Approach. *Accident Analysis and Prevention,* 38: 18-25.

Savanna volume 23, Number 1, June, 2016

Analysis of Traffic Flow Problems in Ilorin Central Business District, Kwara State, Nigeria

Idris Isah Iliyasu
Department of Urban and Regional Planning, Ahmadu Bello University, Zaria
urbanist2005@gmail.com

ABSTRACT

Nowadays, traffic situation in major Nigerian cities is simply chaotic. Ilorin which is a medium size city is not an exception. The city's (Ilorin) Central Business District (CBD) and important commercial corridors are congested with automobiles. Though the traffic flow problems on these commercial corridors have not yet assumed the deplorable stage as those of the larger cities such as Lagos, but signs of potential bottlenecks are already emerging, as demonstrated by the high rate of growth of commercial activities along the roads and difficulties experienced in traffic movement on these roads. With these anticipatory problems, the issue of traffic flow draws significant attention each day and should not be left until it deteriorates to unbearable level. It is against this background that this paper aimed to analyse traffic flow in commercial areas of Ibrahim Taiwo Road and Murtala Mohammed Way areas of Ilorin CBD as a basis of identifying traffic flow problems and making appropriate recommendations for improvement. The methodology used includes; road inventory, traffic volumetric count, delay study, origin-destination survey and capacity study were conducted to gather information about traffic situation of the studied roads. The study established that traffic congestion due to high volume beyond road capacities at both morning and afternoon peak periods (13,154.97pcu and 15,354.89pcu), traffic delays and time wastage with average delay time of 10.44minutes across all roads, and traffic problems associated with poor design and operational capacity where most of the roads has as high road capacity overused of 5,648pcu and as low as 883pcu in the metropolis. Hence, the paper recommended that, the use of motorcycle and tricycle as a means of public transport should be discouraged by providing Bus Rapid Transit system in the CBD and the metropolis at large. There is also the need to improve on the integration of landuses with transit corridors to reduce excess travel demand in the metropolis.

Keywords: Congestion; Design capacity; Traffic delay; Traffic volume; Urban transport.

1. INTRODUCTION

Cities and their transport systems are fully complementary. As defined by Rodrigue et al. (2006), cities are locations with a high level of accumulation and concentration of economic activities, which form complex spatial structures that are supported by transport systems. These transportation systems according to Berry and Hurton (1970) are the veins and arteries of urban areas linking together residential, social, and economic zones of cities. Urban productivity is highly dependent on the efficiency of its transport systems - the ease to move people and goods between multiple origins and destinations. Thus, the most severe transport problems are often related to urban areas where the transport systems, for a variety of reasons, cannot satisfy the numerous requirements of urban mobility.

The efficiency of urban mobility is revealed by the rate of traffic flow on the urban roads. Traffic flow is defined as the movement of individual drivers and vehicles between two points and the interactions between them (Aderamo, 2012). Traffic congestion emanate from problems encountered with traffic flow. Congestion is experienced when the supply of the urban transport networks can no longer meet the demand for them. Today, nearly all cities in the world suffer from traffic congestion. It manifests itself predominantly in recurrent queues, delays and time wastage which commuters experience along major road networks especially during rush hours. Due to unceasing increase in population, increase in household incomes and its resultant increase in the level of car ownership, coupled with poor landuse planning, poor road design and maintenance, traffic flow and congestion have become intractable problems in urban centres, especially in developing countries like Nigeria.

The forecast of Global Traffic Volume (GTV) shows that traffic congestion is a phenomenon that would double between 1990 and year 2020 and again by 2050 (Ogunbodede, 2006). This type of growth pattern, as envisaged by GTV is an indication of what the future traffic congestion holds for people living in cities. Therefore, traffic congestion which is a product of traffic flow problems is a major curse on urban movements.

Ilorin urban area exhibits a dual city structure with the indigenous area at west, and the Government Reservation Area at the eastern part of the city. It is a non-coherent single centre city, with Central Business District (CBD) located around Emir's palace; and commercial activities spreading along major roads. Ibrahim Taiwo Road and Murtala Mohammed Way are some of the busiest commercial belts in Ilorin with supermarkets, eateries, retailing shops, banks and road-side traders along them. Though the traffic flow problems on these roads have not yet assumed the deplorable stage as those of the core city, but signs of potential bottlenecks are already emerging, as demonstrated by the present trends in the growth of commercial activities and difficulties in traffic movement on the roads. With these anticipatory problems, the issue of traffic flow draws significant attention each day and should not be left until it deteriorates to unbearable level.

From the above, it implies that traffic situation on Ibrahim Taiwo and Murtala Mohammed roads in Ilorin urban area has shown some issues that require research attention so as to establish the extent of the traffic flow problems, the causes and possible management strategies for improvement. This is the focus of this paper.

1.1 Concept of Urban Transportation

Urban transportation is defined as the movement of people and goods from one point (origin) to another (destination) within and outside an urban area (Ogunsanya, 2002). Transportation is one of the consequences of man's activities in space. The ability of man to move himself and his materials from one point to another on the Earth's surface significantly influences his life and his environment. Hartshorne (1993) puts forward that resources and needs are spatially distributed, and in most cases the areas of desires exist away from the areas of fulfilment. The spatial inequality created by these two places calls for interactions and movement between them. Therefore, both intra and inter city transportation system bridges the gaps between areas of desires and places of fulfilment, thereby bringing people and resources together in both space and time.

In 2002, Ogunsanya emphasized on the inevitability of transportation in the cities and stressed that man's basic need of food, clothing and shelter could be hardly achieved without transportation. Hence he refers to transportation as "the life wires of our socio- economic and political life". This simply implies that without transportation, life as it is today would be inconceivable. Therefore, the importance of transportation in development of cities and nations at large cannot be overemphasized. However, as important as transportation is to development of settlements, it is also a major source of urban problems such as traffic congestion, parking problem and pollution. This is why Clark (1958) and Ogunsanya (2002) described transportation as the "maker and breaker of the cities".

1.2 An Overview of Urban Transportation Problems

The beauty of an urban centre is found in its organized landuses and transport system to ease accessibility to various locations of activities. Unfortunately, the arrangement and use of space in most cities of the developing countries are not properly organized. Urban transport problems are some of the consequence of improper urban planning. Transportation problems remain one of the most persisting problems in urban centres today. All over the world, attempts have been made to tackle the problems, yet the situation seems to get worse (Aderamo, 2012). Cities are centres of economic, social, cultural and intellectual activities. These activities result in the drift of the people from rural to urban centres and these congregations have caused cities to expand without control in many areas, causing congestion, environmental and social problems.

According to Rodrigue (2013), the larger the city the greater its complexity and the potential for disruptions, particularly when the city's complexity is not effectively managed. The study identified that, the most important transport problems are often related to urban areas and take place when transport systems could not satisfy the numerous requirements of urban mobility. Rodrigue also noted that some problems are ancient, like congestion (which plagued ancient cities such as Rome), while others are new like urban freight distribution or environmental impacts. Therefore, he conclusively mentioned the followings as the most notable urban transport problems: traffic congestion and parking difficulties; loss of public space; public transport inadequacy; freight distribution and ifficulties for non-motorized transport.

2. MATERIALS AND METHODS

The data used for the traffic analysis of the selected roads in the metropolitan Ilorin consists of the following: satellite imagery of Ilorin which was obtained through the use of Google Earth pro 4.2, base map and road network map of Ilorin, traffic volume and characteristics, roads and their infrastructural characteristics, and adjoining landuses, Traffic Delay data, Origin and Destination data.

2.1 Sources of the Data

The data used for this study were sourced from both primary and secondary sources. The primary sources include; field survey, traffic census, traffic delay and Origin-Destination surveys. While the secondary sources include; Ilorin road network map, existing traffic statistical data and other secondary information sources such as internet, journals, textbooks and past research reports.

2.2 Sampling of the Study Routes

There are several roads in commercial areas of Ibrahim Taiwo and Murtala Mohammed roads of Ilorin, with distinct physical characteristics which have implications on the traffic situations on them. Since it is impossible to study all the routes in the area due to time and resources limitation, some selected routes were used in this research.

The strategy adopted in making choice of the study roads is the conception that the operation of traffic on the first priority or major arterial roads is higher than other types of roads. This is intuitively reasonable because major arterial roads carry the largest volume of traffic. Therefore, a sample size of five (5) major arterial roads was selected for the study. This was done in such a way that the five major routes connecting the study area with all other parts of the city were selected. Hence, the study routes are: Murtala Mohammed Way, Amilegbe Road, Emir's Road, Ibrahim Taiwo Road and Unity Road. Figure 1 shows the extent of the area of coverage for the conduct of the research.

Figure 1: Study Area

3. RESULTS AND DISCUSSIONS

3.1 Analysis of Traffic Volume in Passenger Car Unit (PCU)

The analysis established the existing traffic volume in the study area through volumetric count which was later converted to PCU for further analysis. Tables 1a and 1b shows that most of the studied routes are handling traffic higher than their design capacities. Comparing the PCU values for different roads, it is seen that the upper arm of Murtala Mohammed Road has the highest traffic volume with 13,154.97pcu in the morning peak period and 15,354.89pcu in the afternoon peak period, while Amilegbe Road has the least traffic volume at both the morning peak and afternoon peak periods with 7,009.93pcu and 7,928.06pcu respectively. This outcome is justified by the function served by Murtala Mohammed Road as the central mobility spine of the metropolis and as well the commercial hub of the area, as observed by Ogunbodede (2013).

Table 1a: Average Volume of Traffic at Morning Peak Period for each Road in VPH and PCU

Road	Murtala Moh'd Road Upper Arm (Maraba)		Ibrahim Taiwo Road		Emir's Road		Amilegbe Road		Murtala Moh'd Road Lower Arm (Police A Div)	
Veh. Type (PCU)	**VPH**	**PCU**	**VPH**	**PCU**	**VPH**	**PCU**	**VPH**	**PCU**	**VPH**	**PCU**
Priv. Car (1.00)	3148	3148	2110	2110	1581	1581	1617	1617	1552	1552
Taxi (1.00)	3307	3307	3507	3507	2498	2498	2080	2080	2632	2632
Com. Bus (2.00)	1638	3276	18	36	311	622	475	950	309	618
Light Truck (2.00)	197	394	219	438	153	306	128	256	139	278
H. Duty (3.00)	119	357	166	498	106	318	72	216	84	252
Tricycle (0.75)	65	48.75	29	21.75	39	29.25	77	57.75	11	8.25
Motorcycle (0.75)	3495	2621.25	3627	2720.25	2513	1884.75	2435	1826.25	2938	2203.50
Bicycle (0.33)	9	2.97	1	0.33	4	1.32	21	6.93	3	0.99
Total	**11,978**	**13,154.97**	**9,677**	**9,331.33**	**7,205**	**7,240.32**	**6,905**	**7,009.93**	**7,668**	**7,544.74**

Table 1b: Average Volume of Traffic at Afternoon Peak Period for each Road in VPH and PCU

Figure 2: Comparison of Design and Operating Capacities of the Study Roads

3.2 Comparison of Roads Design Capacity and their Operating Capacity

In order to determine the level of over-usage or under-usage of the sampled roads for the study, the peak hours' volume of traffic was compared with the respective design capacity of the roads as acquired from the Civil Engineering Department of the State overused values of 3,991pcu at the morning peak period and 5,643pcu at the afternoon peak period; while the lower arm has the least overused values of 883pcu at the morning peak periods and 1,466pcu at the afternoon peak periods. The overall analysis indicates that all the roads are presently overused as their operating capacities are higher than their design

Road	Murtala Moh'd Road Upper Arm (Maraba)		Ibrahim Taiwo Road		Emir's Road		Amilegbe Road		Murtala Moh'd Road Lower Arm (Police A Div)	
Veh. Type (PCU)	**VPH**	**PCU**	**VPH**	**PCU**	**VPH**	**PCU**	**VPH**	**PCU**	**VPH**	**PCU**
Priv. Car (1.00)	3148	3148	2110	2110	1581	1581	1617	1617	1552	1552
Taxi (1.00)	3307	3307	3507	3507	2498	2498	2080	2080	2632	2632
Com. Bus (2.00)	1638	3276	18	36	311	622	475	950	309	618
Light Truck (2.00)	197	394	219	438	153	306	128	256	139	278
H. Duty (3.00)	119	357	166	498	106	318	72	216	84	252
Tricycle (0.75)	65	48.75	29	21.75	39	29.25	77	57.75	11	8.25
Motorcycle (0.75)	3495	2621.25	3627	2720.25	2513	1884.75	2435	1826.25	2938	2203.50
Bicycle (0.33)	9	2.97	1	0.33	4	1.32	21	6.93	3	0.99
Total	**11,978**	**13,154.97**	**9,677**	**9,331.33**	**7,205**	**7,240.32**	**6,905**	**7,009.93**	**7,668**	**7,544.74**

Table 2: Comparison of Average Operating Capacity and Design Capacity of the Roads studied

3.3 Analysis of Traffic Composition

The analysis on Table 3a shows a three-day average traffic composition in the study area. It indicates that motorcycle contributed the highest volume of traffic during the two peak periods, with value of 34,801 riders (i.e. 36.53%). This is followed by taxi which has average number of 29,727 (i.e. 31.20%); while bicycle has the least contribution to traffic volume with an average of 63 bikes (i.e. 0.07%).

Table 3a: Average Traffic Composition in the Study Area

Road	Murtala Moh'd Road Upper Arm (Maraba)		Ibrahim Taiwo Road		Emir's Road		Amilegbe Road		Murtala Moh'd Road Lower Arm (Police A Div)		Veh. Type Total	Percent (%)
Veh. Type	Morning	Afternoon	Morning	Afternoon	Morning	Afternoon	Morning	Afternoon	Morning	Afternoon		
Priv. Car	3148	3765	2110	2237	1581	2134	1617	1875	1552	1687	21,706	22.78
Taxi	3307	4283	3507	3123	2498	3319	2080	2248	2632	2730	29,727	31.20
Com. Bus	1638	1589	18	21	311	487	475	545	309	384	5,777	6.06
Light Truck	197	139	219	159	153	264	128	147	139	163	1,708	1.79
H. Duty	119	107	166	116	106	162	72	71	84	131	1,134	1.19
Tricycle	65	47	29	20	39	40	77	17	11	14	359	0.38
Motorcycle	3495	4656	3627	4810	2513	4039	2435	2924	2938	3364	34,801	36.53
Bicycle	9	8	1	3	4	3	24	7	3	1	63	0.07
Total	**11,978**	**14,594**	**9,677**	**10,489**	**7,205**	**10,448**	**6,908**	**7,834**	**7,668**	**8,474**	**95,275**	**100**

Table 3b and Figure 3 shows that on all the roads, the afternoon peak period usually has higher traffic volume than the morning rush hour, this is because; it is during afternoon hours that most schools closes, and children (students) are taken back home by private and commercial modes. It was found out that, on the upper arm of Murtala Mohammed Road, the afternoon volume accounted for 54.92% of the traffic for the two rush hours. On Ibrahim Taiwo Road, the afternoon volume formed 52.01% of the total traffic, while on Emir's Road, Amilegbe Road and the lower arm of Murtala Mohammed Road, the afternoon peak volumes accounted for 59.19%, 53.14% and 52.50% respectively. These situations are attributable to the fact that more trips are usually made during afternoon peak; including inter-cities journeys, journey from workplaces and schools, business trips, etc. Figure 4 below shows the distribution of the volume of the traffic across the spatial units of the study area.

Table 3b: Traffic Volume at Peak Periods

Road	Murtala Moh'd Road, Upper Arm		Ibrahim Taiwo Road		Emir's Road		Amilegbe Road		Murtala Moh'd Road, Lower Arm	
Peak Hour	VPH	(%)	VPH	(%)	VPH	(%)	VPH	(%)	VPH	(%)
Morning	11,978	45.08	9,677	47.99	7,205	40.81	6,908	46.86	7,668	47.50
Afternoon	14,594	54.92	10,489	52.01	10,448	59.19	7,834	53.14	8,474	52.50
Total Vol.	**26,572**	**100**	**20,166**	**100**	**17,653**	**100**	**14,742**	**100**	**16,142**	**100**

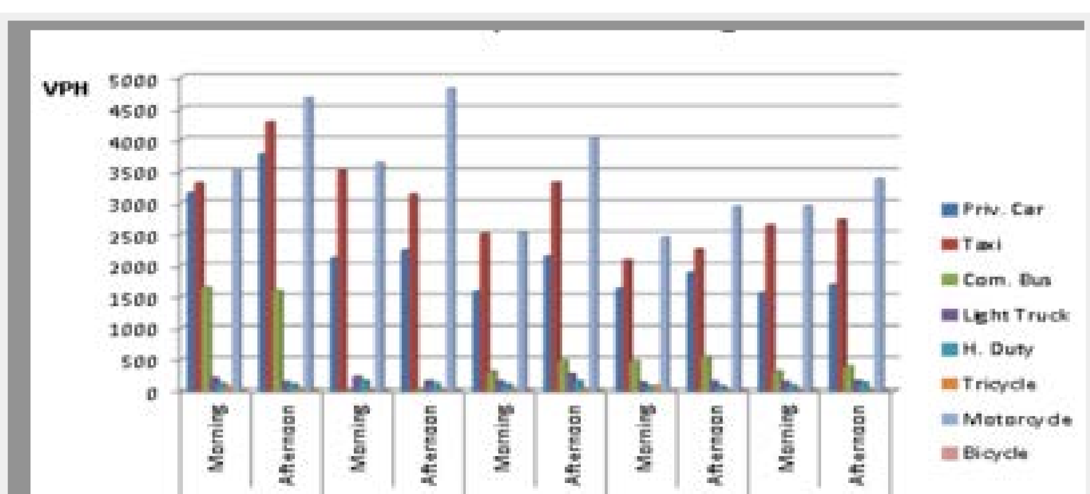


Figure 3: Traffic Composition during the peak periods

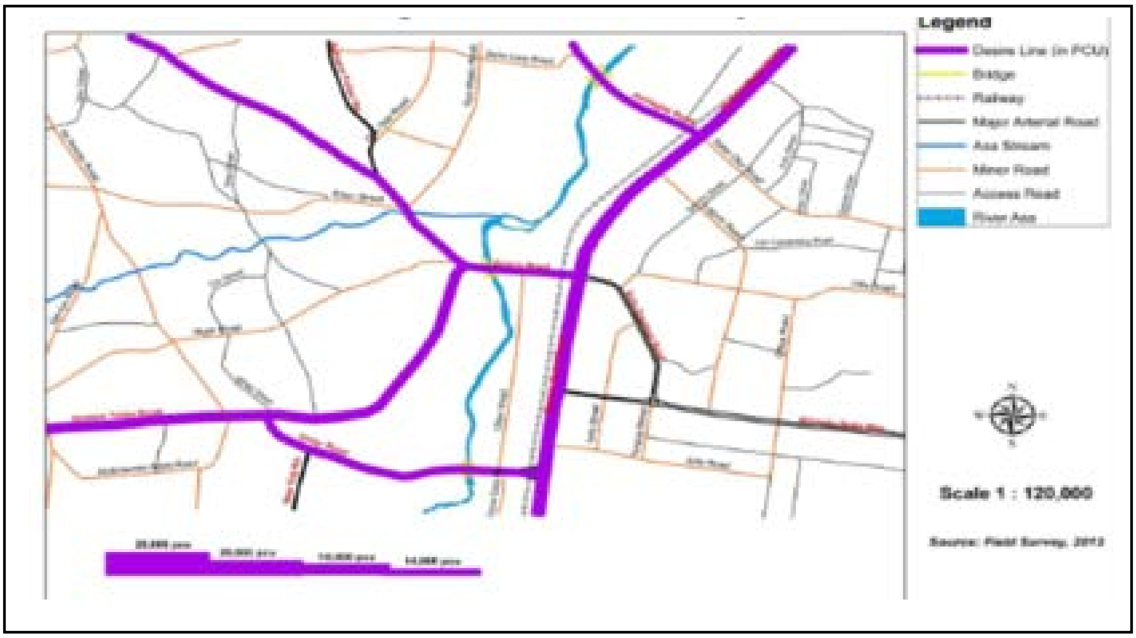


Figure 3: Traffic Composition during the peak periods

3.4 Traffic Delay Survey

Table 4 and Figure 5 shows that Murtala Mohammed Road with a length of 3.54km which could have been covered by a motorist in 3.03minutes under ideal conditions, now takes commuters to spend 18.27minutes to travel the same distance during the peak periods resulting in a delay period of 15.24munutes. Also, Ibrahim Taiwo Road which measured 1.94km that would have taken about 1.66minutes to be covered by commuters, now takes 12.03minutes due to both fixed and operational delays in traffic situation of the area. While Emir's Road which has the shortest distance of 1.35km and took 1.35 minutes to travel, now commuters spend about 13.41minutes due to concentration of on-street traders especially on Sundays. Hence, on average, every motorist would experience a delay period of 10.55minutes on the roads during peak hours' traffic within the study area. This is relatively high due to vehicular congestion, concentration of commercial activities, many on-street parked vehicles and too many junctions located close to one another along the roads in the study area

Name of the Road	Length of the Road (Km)	Road's Design Speed (Km/hr)	Ideal Travel Time (Min.)	Travel Time Obtained (Min.)	Delay Time (Min.)
Murtala Moh'd Rd.	3.54km	70km/hr	3.03 minute	18.27 minute	15.24 min
Ibrahim Taiwo Rd.	1.94km	70km/hr	1.66 minute	12.03 minute	10.37 min
Unity Road	1.68km	70km/hr	1.44 minute	9.45 minute	8.01 min
Emir's Road	1.35km	60km/hr	1.35 minute	13.41 minute	12.06 min
Amilegbe Road	1.02km	60km/hr	1.02 minute	8.09 minute	7.07 min
	Average delay time within the Study Area is **10.55minutes**				

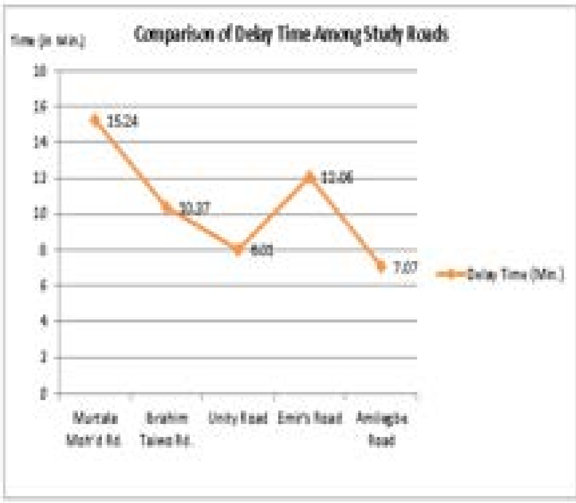


Table 4: Traffic Delay Analysis

Figure 5: Comparison between delay times among study roads

4. CONCLUSION AND RECOMMENDATION

This paper has examined traffic flow problems in the commercial corridors of Ibrahim Taiwo and Murtala Mohammed roads of Ilorin metropolis, and identified problems such as; traffic congestion due to high volume beyond road capacities, traffic delays and time wastage, and traffic problems associated with poor design and operational capacity of the roads in the area. However, this chaotic nature of traffic in the study area is not going to be solved overnight, just as the problems did not sprung up in a day. It will require coordinated efforts on the part of government, urban and regional planners, transportation planners and engineers, stakeholders, commuters and the general public. Beside the traditional traffic management strategies used in the past, the traffic problems also require innovative solutions in a more holistic manner. Therefore, it is strongly recommended that, the use of motorcycle and tricycle as a means of public transport should be discouraged by providing Bus Rapid Transit system in the city. There is also the need to improve on the integration of land uses with transit corridors to reduce excess travel demand in the metropolis.

REFERENCES

Adeleke, O.O., and Jimoh, Y. A. (2005). Potential Benefits of Intelligent Transportation System (ITS) in Nigeria. A Journal of Research Information in Civil Engineering University of Ilorin Science and Engineering Periodic: 2(1), 2005.

Adeleke, O.O., and Jimoh, Y. A. (2011). *Sampling of Intersections for Traffic Delay Study in an African Sub Region Urban City.* Department of Civil

Engineering University of Ilorin, Nigeria.

Aderamo, A.J. (1998). *Route Forms and Traffic Flow in a medium-sized city. The Case of Ilorin-Nigeria*. University press, Ilorin.

Aderamo, A.J. (2000). Spatial Pattern of Intra-Urban Trips in Ilorin, Nigeria. *Journal of Geo-Studies forum.*

Aderamo, A.J. (2012). *Urban Transportation Problems and Challenges in Nigeria: A planner's view*. Prime Research on Education (PRE), Ilorin, Nigeria.

Ahmed, Y.A. (2012). *Urban Traffic Dilemma and Potential Remedy: Example from Ilorin City, Nigeria.* An unpublished M.Sc. thesis, Department of Geography and Environmental Management University of Ilorin, Nigeria

Atubi, A.O. (2010). Road Transport System Management and Traffic in Lagos, South-Western Nigeria. *An International Multi-Disciplinary Ethiopian Journal,* 4(16).

Berry, B.L., and Hurton, F.E. (1970). *Geographic Perspective on Urban Systems*. Englewood Cliffs New York: Prentice Hall.

Bruton, M.J. (1975). *Introduction to Transportation Planning*. Hutchison Educational Ltd.

ESRI *Canada & Transportation*: www.esricanada.com/english/transportation

Hartshorne T. A. (1993). *Interpreting the City: An Urban Geography*. John Wiley and Sons Publisher, England.

Miller, Harvey J. and S. L. Shaw (2001). *Geographic Information Systems for Transportation*. Oxford University Press, New York City.

Mchsare, W.R., Roess, P.R., and Prassas, E.D. (1998). *Traffic Engineering*. Second Edition. New Jersey: Prentice Hall.

Ogunsanya, A. A. (1984). Traffic Congestion in an Urban Centre: The Case of Ilorin, Nigeria. *The Nigerian Geographical Journal,* 27(1-2):23 – 33.

Ogunsanya, A. A. (1984). Improving Urban Traffic Flow by Restraint of Traffic: The Case of Lagos, Nigeria. *Transportation Journal,* 12: 183 – 194.

Ogunsanya, A. A., (1993). Directions in Urban Transport Studies in Nigeria. In Ikya, S.G. (ed.). *Urban Passenger Transportation in Nigeria*. Heinemann Educational Books (Nig.) Plc.

Ogunsanya, A. A., (1998). "Moving the Urban Masses: Two Steps Forward One Backwards" *Issues in Transport Planning and Management*. Published by NITT, Zaria-Nigeria.

Ogunsanya, A. A., (2002). Maker and Breaker of Cities. *Fifty-ninth Inaugural Lecture in University of Ilorin*. Library and Publication Committee.

Ogunbodede, E. F. (2006). Urban Road Transportation in Nigeria from 1960 to 2006: Problems, Prospects and Challenges. *Ethiopian Journal of Environmental Studies and Management*, 1(1), 2008.

Ogunbodede, E. F. (2006). "Movement Pattern of Commuters and its Implications for Transportation Planning in Akure". *Anyigba Journal of Environmental Studies*, Department of Geography and Planning, Kogi State University, Anyigba, 1(2): 1-16.

Ogunbodede, E. F. (2013). Traffic situations and its implication for

Sustainable transport management in metropolitan Ilorin. *Anyigba Journal of Environmental Studies*, Department of Geography and Planning, Kogi State University, Anyigba, 2(1): 13-22.
Oloru, A.J. (1998). *A Guide to Ilorin*. Famous publisher Ltd. Ilorin Nigeria.
O'Flaherty, C.A., (2002). *Transport Planning and Traffic Engineering*. London: Butterworth Heinemann.
Research Board, Washington, D.C.
Rodrigue, J.P., Comtois C., and Slack, B. (2006). *The Geography of Transport Systems*. London: Routledge.
Shaw, S.L., (2002). Book Review: Geographic Information Systems in Transportation Research. *Journal of Regional Science*, 42(2): 418-421.
Vonderohe, A. P., L. Travis, R. L. Smith and Tsai, V. (1993). Adaptation of Geographic Information Systems for Transportation. *NCHRP Report 359*. Transportation

An Analysis of Traffic Congestion in Zaria Urban Area of Kaduna State, Nigeria

Garba S.*, Okeji O. B. and Saab, Y.
Department of Geography & Environmental Management, Ahmadu Bello University, Zaria
*ismailgarba@gmail.com

ABSTRACT

Traffic congestion hinders smooth flow of traffic and increases time between origins and destinations. This study is aimed at analyzing traffic congestion in Zaria urban area. The study obtained data from questionnaire survey, observation and secondary sources. The analysis was done using simple descriptive statistics and it revealed that the causes of traffic congestion in the study area includes; poor parking habits, encroachment of commercial activities such as the erection of container and wood shops on road shoulders, street hawking, existence of narrow road and presence of pot holes. It was found that traffic congestion occurs mostly at peak periods which depicts the time for rush hour and this covers both morning and evening periods. The findings also showed that 86% of the respondents opined that traffic congestion can last for hours, while 14% of the respondents were of the opinion that it can last for a few minutes to half an hour. Deductions from the analysis of the study showed that consequences of traffic congestion can result in lateness to work and school, loss of business contacts and increase in travel time. It is however recommended that the authorities concerned should construct alternative routes in order to mitigate traffic congestion especially in the hotspots and ensure enforcement of traffic control regulations in the study area.

Keywords: Traffic Congestion; Origins; Destinations; Zaria Urban Area.

1. INTRODUCTION

Traffic congestion is a condition on road network that occurs as usage increases, and it is characterized by slower speeds, longer trip times and increased vehicular queues. The most common example is the physical use of roads by vehicles (Sheyin, 2012). When traffic demand is very high, the interaction between vehicles slows the speed of traffic stream, this results in some congestion. As demand becomes greater, the carrying capacity of a road reduces thereby setting extreme traffic congestion leading to complete halt of vehicles for a period of time (Ikya, 2005).

Traffic congestion is often classified as recurrent and non-recurrent. The type of congestion depends on whether the capacity or the demand factor is out of balance. The recurrent congestion is the type found in every day rush-hour stop and go traffic, occurring when the capacity of the freeway is exceeded. This occurs when demand increases beyond the available capacity. It is usually associated with the morning and afternoon work commutes, when demand reaches such a level that the freeway is overwhelmed by speed versus flow rate (Ogunsanya, 1985). The non-recurrent congestion results from a temporary decrease in capacity while the demand remains unchanged, this kind of congestion usually results from the freeway capacity becoming temporary restricted. A stopped vehicle, can take a lane out of service; however the same number of vehicles requires passages. Speed and volume drop till the lane is reopened, and the freeway returns to full capacity. Capacity can also be decreased by weather events and events near the travel way (i.e. "rubber necking" also known as "gawking"), leading to non-recurrent congestion and reduced reliability of the entire transportation system. A technique to reduce the effect of non-recurrent congestion includes deducing the time to clear an incident and motorist diversion (Ogunsanya, 1985).

Traffic congestion studies still cannot fully predict under which conditions congestion (as opposed to heavy but smooth flowing traffic) may suddenly occur. While traffic congestion has been fully managed in developed countries, it has continued to defy solutions in the developing world. Global Traffic Volume (GTV) has shown that the phenomenon will double between 1990 and the year 2020 and again by the year 2050 (Engwitch, 1992). This type of growth pattern can be envisaged as an indication of what future congestion portends for people living in Zaria urban area. Efficient urban mobility is essential for economic development since it enables citizens to have access to goods and services, jobs, educational opportunities, and social contacts. Access to mobility enhances quality of life but growing motorization and unmanaged transport in many cities have given rise to traffic congestion, air pollution, traffic related accidents, waste of productive time, and other social and environmental costs (Emeasoba, 2012).

Road traffic congestion poses a challenge for all large and growing urban areas. According to Aworemi, Abdulazeez, Oyedokun and Adewoye (2009), traffic congestion occurs because too many people want to move at the same time each day. Efficient operation of both the economy and school systems (in Zaria urban area) requires that people should work, go to school, and even run errands about the same hour so that they interact with one another. Zaria urban area acts as a prime economic mover in terms of education due to it being an educational town, hence having a higher influx of immigrants from rural areas than vice versa. Another major factor for the high traffic congestion is that the city is located between major towns of commuting. This situation coupled with ever increasing personal mobility, where the number of vehicles on the road outgrows the available transportation networks is the basis of traffic congestion. The existence of colonial roads particularly in Zaria City were narrow and this is because the volume of vehicle then that plough the road were few and the capacity of vehicles of which it was envisioned for has been out-dated due to the growth of more industries, increasing immigration to urban Zaria, population increase, growth and development of economic activities leading to urbanization. These were not looked into in the aspect of timely road widening or expansion by the series of regimes and policy makers appropriately to meet up with the contemporary demand (Adesina, 1996).

However, previous works on analysis of traffic congestion from selected regions of Nigeria is not adequately applicable to ease the traffic grid lock in Zaria urban area. According to Danladi (2014) who analyzed traffic congestion along Nyanya Mararaba highway in Abuja, revealed that the factors that are contributing to road traffic congestion range from the impatience of drivers, maneuvering attitudes of drivers, small road capacity, and poor road traffic facilities. He recommended management strategies at mitigating them; as to widening of roads, construction of bypass, construction of flyover, restriction of heavy duty vehicles, and enforcement of some of the current road traffic laws. Also, Ishaya (2014) showed that traffic flow along the Gusau - Bypass road is highest at morning and evening hours because it is usually the period when people go to and get back from their primary places of concern. He then recommended on traffic management measures, provision of road infrastructures, investment in additional road capacity, provision of more terminal facilities, vehicle restraint schemes and enforcement of traffic control regulations.

The studies on the traffic congestion conducted by the authors mentioned above where carried out in different locations. The components constituting Zaria as an entity and the variables responsible for traffic congestion in Zaria urban area are not the same as those in some of the locations mentioned above. It is against this backdrop that this study was conducted to achieve the following objectives: to study the causes of traffic congestion, to examine the period of the day traffic congestion occurs mostly in the area, to determine the duration of traffic congestion and to analyze the consequences of traffic congestion.

1.1 Study Area

Relatively, the area is bounded to the North by Funtua Local Government Area (LGA) of Katsina State, to the south by Kachia LGA in Kaduna State. The Southern limit of Igabi LGA forms the southeastern part. To the west is Birnin Gwari LGA. While to the east and southeast are Ikara and Lere LGAs respectively all in Kaduna State (Mortimore, 1970). The study area is located in the political region of Kaduna State of Northern Nigeria between latitudes 11°00′ - 11° 10′North of the Equator and longitudes 7°36′ - 7°45′East of the Greenwich Meridian, as shown in Figure 1.

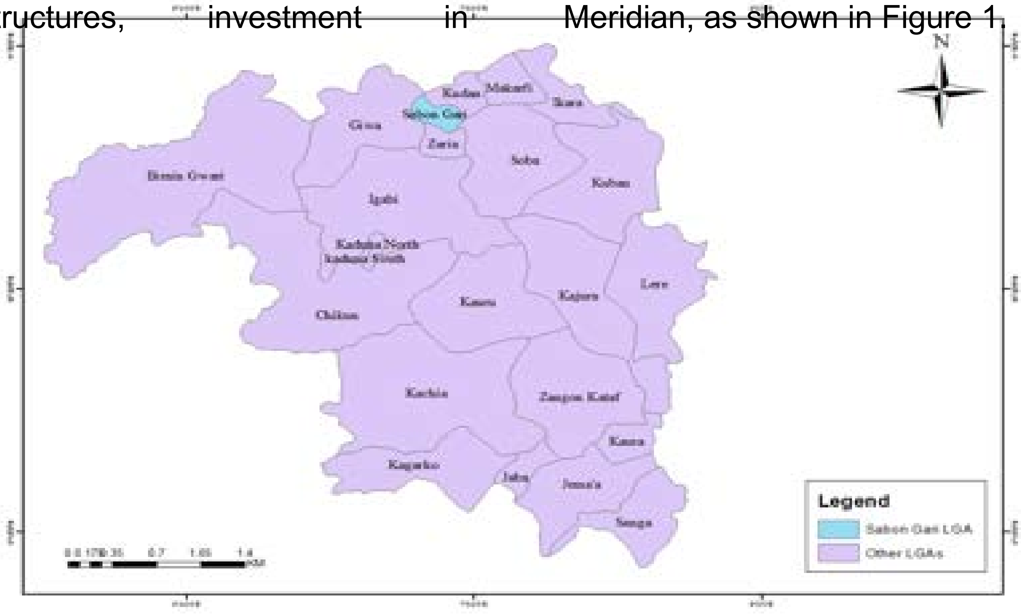


Figure 1: Map of Kaduna State showing Sabon-Gari Local Government Area

Source: Kaduna GIS, 2015

2. MATERIALS AND METHODS

2.1 Types and Sources of Data

The data used for this study were mainly obtained from primary sources. Hence data on causes of road traffic congestion, period of the day with most congestions and consequences of road traffic congestion were sourced from road users using questionnaire. The administering of questionnaire was conducted at the four selected traffic congestion zones namely; Motor Transport Division (MTD), Kwangila (Fly over), PZ (CBD) and Samaru Market as displayed in the Figure 2. The selection was done to determine temporal variation of traffic flow along these roads. The study was carried out for one week, from 6am - 6pm daily. One hundred and fifty (150) structured questionnaires were administered to different road users. The reason is because, since the unit of study was based on road users and commuters, therefore, a population of 240 road users and commuters was used and a sample size of 150 was selected from that population using the Slovin's formula for calculating sampling size: $n = N/(1+Ne^2)$ where;

n = Sample size, N = Population of the Selected Area, e = Marginal error represented by 0.05 confidence level.

In this case, every element in the population road users and commuters had an equal chance of being selected and those selected gave a fair representation of the population. While secondary data was sourced from relevant existing materials from published and unpublished documents. These include; relevant textbooks, internet materials, journals and related literatures.

Furthermore, simple descriptive statistics such as tables, graphs and percentages were employed to analyze road traffic congestion in this study. The results obtained were discussed in various paragraphs supporting the output.

2.2 Sampling Technique

Four zones were selected out of the various traffic congestion areas. This is because the selected four zones are known to be major traffic congestion hotspots in the study area. These zones are: PZ Area (known as the CBD) Motor Transport Division (MTD), Kwangila Fly-over, and Samaru Market Area as shown in Table 1. Table 1 shows that one hundred and fifty (150) questionnaire were administered to the respondents in the selected zones within Zaria urban area. The distribution was done according to the physical population of the selected zones.

Table 1: Selected Traffic Congestion Zones Used in the Study Area.

S/No.	Selected Zones	Number of Questionnaire Issued
1	PZ Area (CBD)	40
2	Motor Transport Division (MTD)	35
3	Kwangila Flyover	35
4	Samaru Market Area	40
5	Total	150

Figure 2: Zaria Road Network showing the Selected Traffic Congestion Zones used for this study

3. RESULTS AND DISCUSSIONS

3.1 Sex Distribution of Respondents

Figure 3 shows that a greater proportion of the road users in the study area are males constituting 53%; while the females are 47%. This shows that males are highly exposed to different forms of road uses and subsequently get themselves involved in traffic congestion more than the females. The result clearly portrays that males have a greater percentage of road users in the study area.

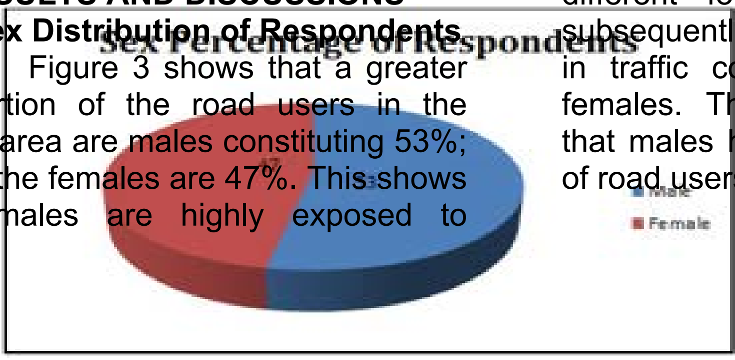
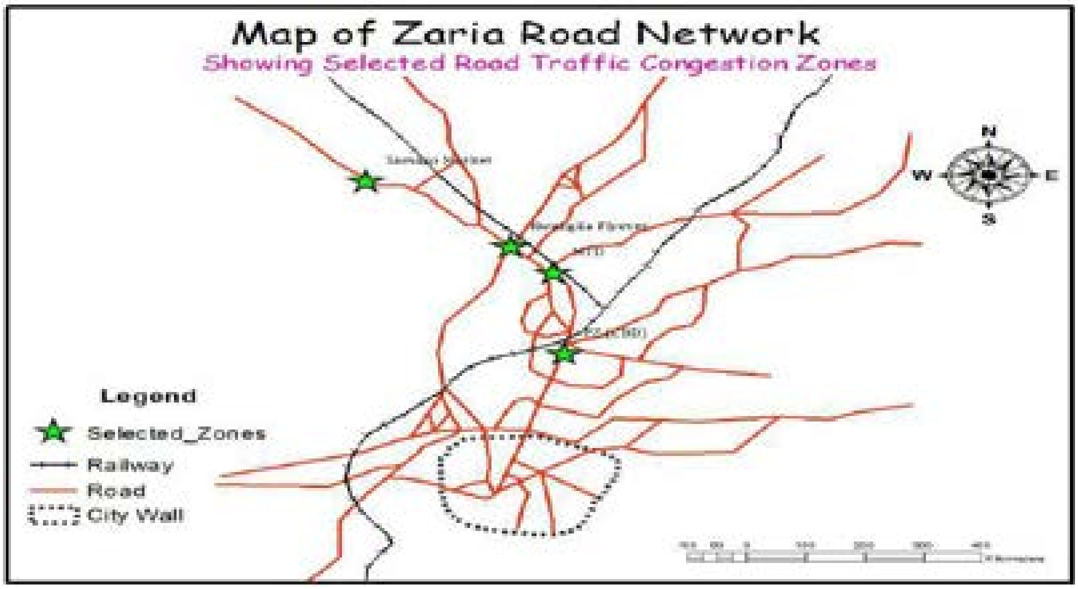


Figure 3: Sex Distribution of Respondents

3.2 Causes of Traffic Congestion in Zaria Urban Area

Figure 4 shows the views of the respondents on the causes of traffic congestion in the study area. It shows that 22.0% of the respondents agreed that congestion within the study area is caused by poor parking. This is also evident in the fact that most road users especially those engaged in commercial road transport park in parts of the road that are not appropriate. However, 34.0% viewed that it is caused by street trading which entails the fixing of containers and other forms of wooden structures along parts of the road that is supposed to be utilized by vehicles and not structures. In another view, 13.5% of the respondents were of the believe that causes of congestion can also be attributed to the existence of narrow roads while 7.8% says as a



result of bad roads and 22.7% believed in other factors outside those mentioned. Here, 22.0% of respondents who attributed it to poor parking conditions particularly made emphasis on trailers or freight vehicles at around PZ and Tudun-Wada area constituting the major traffic hold ups while loading and off-loading of goods as negotiating bends along this Central Business District (CBD). On the other hand, 34.0% who viewed it is caused by street trading included the road blocks and check points by law enforcement agencies as well as street hawkers as the main cause of congestion in Zaria urban area. Regarding solutions to traffic congestion, 13.5% of the respondents who owe it to the issue of narrow roads having majority from PZ (CBD) area and Sabon-Gari area emphasized on the need for road expansion; 7.8% of them complained of bad roads mainly from Sabon Gari area; 22.7% of them suggested the need for more road median, street lights, pedestrian bridge, use of transponders and traffic lights.

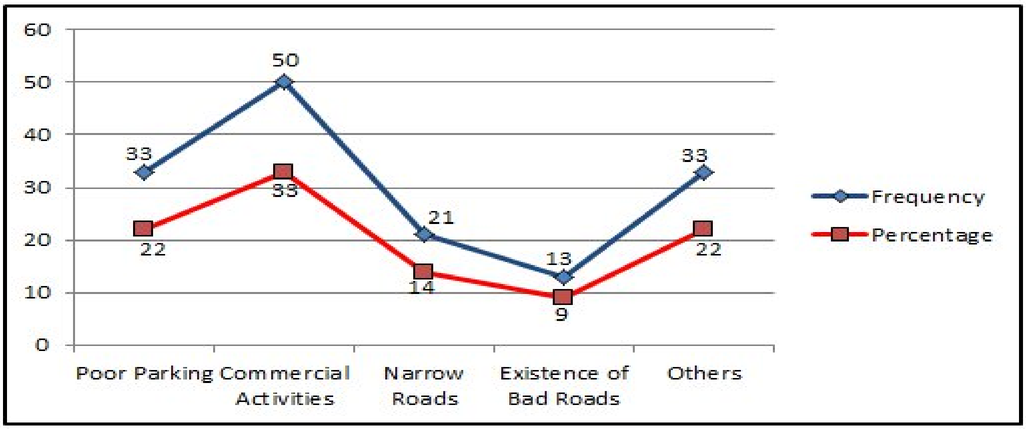


Figure 4: Respondent’s view on the Causes of Road Traffic Congestion

3.3 Period of Traffic Conjestion in Zaria Urban Area

Ogunsanya (2001) noted that traffic congestion is at its peak during the early morning rush hours to work and evening returning to various destinations. Figure 5 shows that 23% of respondents experience traffic congestion in the morning, 17% in the afternoon, 21% in the evening, 37% said both morning and evening and 2% says every time (meaning all of the above). The data presented and analyzed in this study corresponds with the referenced author. Most people rush during the morning hours in order to avoid being late in their various places of work and at the same time even for those not actively engaged would want to have their kids taken to schools so as to avoid being late too. Closing hours is almost general both for the workers and some schools in the area.

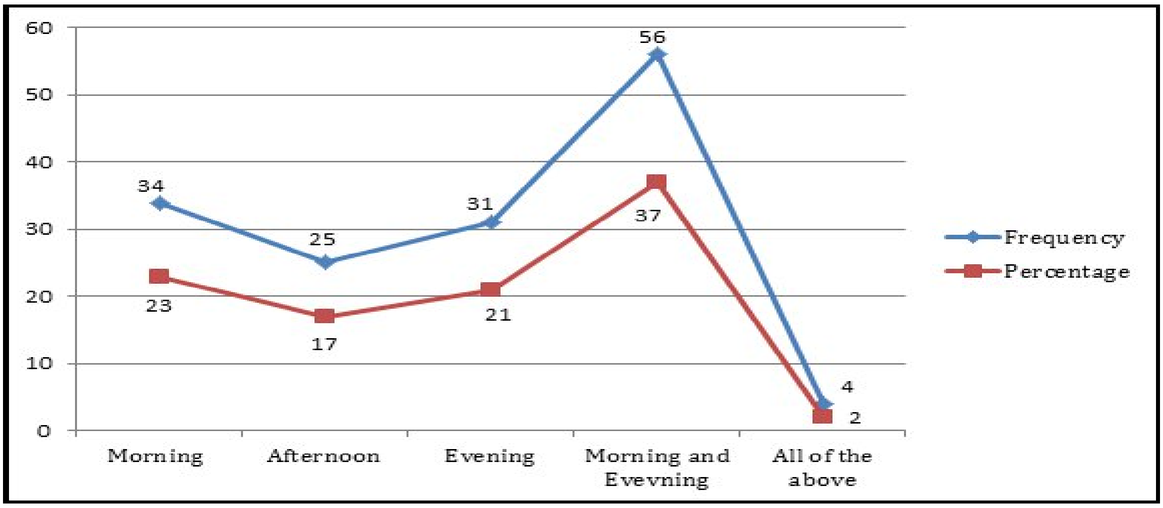


Figure 5: Period of the day respondents experience the most traffic congestion

3.4 Duration of Traffic Congestion

Table 2 above shows an analyzed data of how long an average respondent spends on a congested traffic. 80% says they spent less than thirty minutes, 13% says at least half an hour (30 minutes) and 7% claimed to have spent more than an hour. It therefore means that the most common type of traffic hold up is the short duration hold ups, which is associated with stress, fatigue and lateness to destinations.

Table 2: Respondents View on their Duration in Traffic Congestion

S/No.	Extent of Duration	Frequency (f)	Percentage (%)
1.	< 30 minutes	120	80
2.	30minutes	20	13
3.	> 30 minutes	10	7
	Total	**150**	**100**

3.5 Consequences of Traffic Congestion in Zaria Urban Area

Transport system plays a vital role in creating an expedite access to goods and services which is the heartbeat of growth and sustainable development of any regional economy. Figure 6 shows the consequences of traffic congestion, where 26% of the respondents say it makes you late to work, 5% say it causes loss of business contacts, 33% say it causes lateness to school, 21% say it increases travel time and 15% thought otherwise.

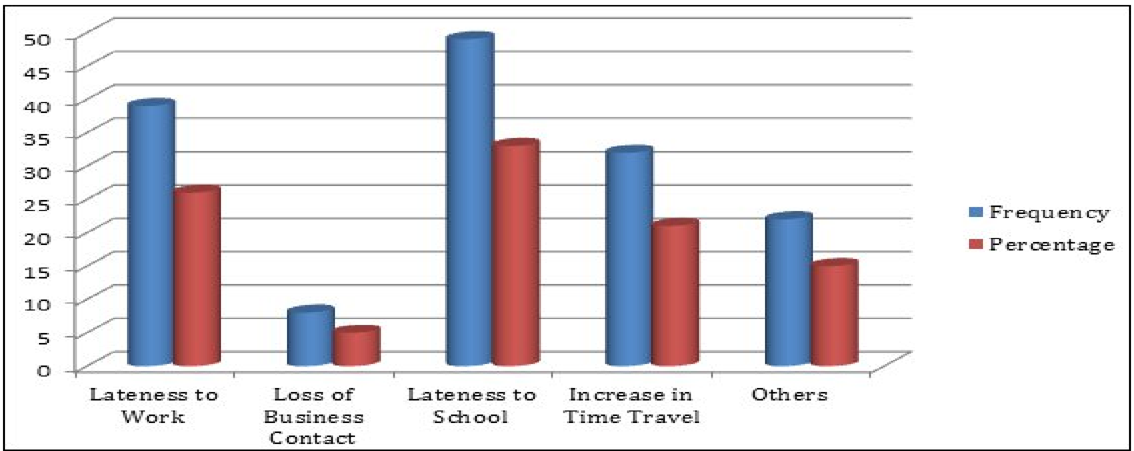


Figure 6: Respondents view on Consequences of Road Traffic Congestion

4. CONCLUSION AND RECOMMENDATIONS

Zaria urban area being an educational settlement has the consequences of traffic congestion born predominantly on the formal sector in the form of lateness to school, work place and increased travel time. The findings of this study showed that Traffic hold-ups take less than thirty minutes while a few of the respondents showed that they have spent more than an hour in road traffic congestion. However, both morning and evening periods happens to be the peaks of traffic congestion on a daily bases which could easily be described as flash traffic congestion. The following recommendations were proposed: restriction of heavy duty trucks and use of mass transit buses. Heavy duty trucks should be restricted from operating during the day period to allow other commuters to freely use the road at day time while the trucks should be operating mainly at night. They should mainly operate at the out skirt of the urban area between industries. The creation of additional road capacity which is the most commonly adopted method of combatting traffic congestion in urban centers is hereby recommended, it involves the construction of bypasses to divert traffic and the enforcement of traffic control regulations in order to discourage breaking of traffic rules.

REFERENCES

Adesina, A. T. (1996). *Land Use and Traffic Circulation Problem in Urban Areas: Case Study of Zaria Central Business District*. Unpublished Masters Thesis. Nigerian Institute of Transport Technology (NITT).

Aworemi, J. R, Abdul-Azeez, I. A, Oyedokun, A. J and Adewoye, J. O.(2009). A Study of the Causes, Effect and Ameliorative Measures of Road Traffic Congestion in Lagos Metropolis. *European Journal of Social Sciences*, 11 (1) 119-127.

Danladi, A. (2014). *Analysis of Road Traffic Congestion Along Nyanya-Marara Highway, Federal Capital Territory Abuja*. Unpublished BSc Thesis, Department of Geography, Ahmadu Bello University, Zaria.

Emeasoba, U. (2012). Management of Urban Traffic Congestion in Enugu Metropolis for Sustainable Economic Development: *Journal of Environmental Management and Safety*, 3 (2), 38-53.

Engwitch, D. (1992). *Towards an Eco-City; Calming the Traffic*. Enviro Publishers.

Garba, S. (2005). *Geographical Analysis on Road Accessibility and Connectivity in Zaria Urban Area*. Unpublished BSc Thesis. Department of Geography, Ahmadu Bello University Zaria.

Ikya, S. G. (2005). Urban Passenger Transportation in Nigeria, Heinemann Education Books (Nigeria) PLC. *Journal of Research in National Development*, 6 (1), 123-208.

Ishaya, A. (2014). *An assessment of Traffic Congestion in Sokoto Metropolis*. Unpublished BSc Thesis, Department of Geography, Ahmadu Bello University Zaria.

Kaduna GIS (2015). *Digitized Map of Nigeria and Kaduna State*. KADGIS, Kaduna State.

Mortimore, M. J. (1970). *Zaria and Its Region; A Nigerian Savannah City and Its Environs*. Department of Geography, Ahmadu Bello University, Zaria.
National Population Commission Report (2006). *Nigerian Population Census*. Federal Republic of Nigeria.
Ogunsanyanya, A. A. (1985). Improving Traffic Congestion Flow by Restraint of Traffic: *Journal of The Study of Lagos Transportation*, 12 (2), 183-194.
Sheyin, E. A. (2012). *Road Traffic Congestion in Apapa-Oshodi Expressway: Case Study of Mile 2-T.C.I.P segment*.

Evaluation of the Pollution Level of Some Heavy Metals in Soil of Bompai Industrial Area, Kano State, Nigeria

Mohammed, M.A.[1]* and Butu, A.W.[2]
[1]*Department of Geography, Bayero University, Kano*
[2]*Department of Geography, Nigerian Defence Academy, Kaduna*
*mamohammed.geog@buk.edu.ng

ABSTRACT

Soil pollution has become an issue of global concern due to it effect on soil, ecosystem and the entire environment. This study evaluated the concentration of some heavy metals and pH and determined the level of their pollution. Two locations (contaminated and control locations) were identified whereby ten soil samples were collected and then analyzed for Cr, Cd, Fe, Ni, Pb and Cu and pH. The results revealed that the mean value of heavy metals in contaminated location are Cr (64.81±10.12), Cd (4.37±0.6), Fe (55.54±5.28), Ni (191.94±22.34), Pb (43.6±3.77), Cu (118.28±15.12), which were found to be higher than that of the control location Cr (18.72±1.48), Cd (3.59±0.92), Fe (45.49±6.0), Ni (171.53±12.06), Pb (32.04±3.0), Cu (45.39±3.01). Some heavy metals Cr, Pb, Fe and Cu were found to be below the European Union Regulatory values (EU), while Cd and Ni were found to be higher than EU values. The single pollution model evaluation revealed that the soil of the area is potentially and slightly polluted with Cd and Ni respectively. Increase of organic matter and establishment of private treatment plant for the treatment of waste before discharge were recommended.

Keywords: Soil; Heavy metals; Pollution level; Bompai Industrial Area.

1. INTRODUCTION

Population growth and the proliferation of basic industrial processes particularly in major cities of the world have led to emergence of civilization that has greater impact on the environment (Liu et al., 2007). The industrial revolution gave birth to environmental pollution and the large volume of industrial chemical discharges have added to the growing load of untreated domestic waste in urban centers. The disposal of domestic, commercial and industrial waste in the world is a problem that continues to grow with human civilization and no disposal method so far is completely safe. Experience has shown that all forms of waste disposal have negative consequences on the environment, public health, and local economies (Liu et al., 2007).

Soil pollution is concerned with the presence of heavy metals in the soils, the metals are considered heavy when their density is greater than 6 or 5 Mg/m^{-3} (Lal, 2006). Heavy metals enter into our environment from both natural and anthropogenic sources such as processing industries and incomplete combustion of burning fuel (Akporida and Asagba, 2013). Heavy metals are considered toxic when they are found in large concentration or above the threshold level. Toxic metals exert their toxicity in a number of ways including the displacement of essential metals from their normal binding sites on biological molecules, inhibition of enzymatic functioning and disruption of nucleic acid structure (Sharma, Agrawal and Marshall, 2008). Environmental and occupational exposure to heavy metals such as Cadmium, Mercury and Lead results in to severe health hazards including prenatal and developmental defects (Sharma, Agrawal and Marshall, 2008).

The sources of contamination of urban soils are mainly from domestic waste disposal, discharges from industries and domestic sources which finally get into public sewage system. The wastewater ultimately discharged into rivers that are usually utilized in various ways including irrigation, exhausts of motorized machines and vehicles, organic wastes, corrosive metal waste and sewage sludge are of great concern in metropolitan areas. Sewage sludge is another source of heavy metals in soil which produced from both domestic and industrial waste water and direct run – off from road. The composition of sewage sludge is very variable and depends on the local industrial processes, domestic activities and on the amount of sand and silt that it contains (Wang and Yang, 2008). The organic matter in sewage sludge helps to improve soil structure when applied to land and therefore has beneficial effect. Problems arise if large amount are applied too frequently or over prolonged period and the sludge contains high concentration of metals which are toxic to plants and animals (Carbonell et al., 2009).

Heavy metals concentration varies greatly according to the source of the waste and particularly on the amount of industrialization and nature of the industrial processes in the catchment area. Organic wastes emanating from municipal sewage, garbage, food-processing industries, pulp mills, and animal enterprises are attacked by aerobic bacteria. When this occurs in water, the oxygen content of the water is depleted or reduced to zero, at which point the anaerobic bacteria complete the process of reducing the wastes to inert material. This produces septic conditions that make the water unfit for irrigation (Bada, Amusan and Salami, 2001).

The disposal of industrial effluent is a problem of increasing gravity throughout the world. Huge amounts of effluents are generated from Bompai industrial area in Kano State which is discharged into Rivers

Getsi. The waste water has an important role to play in irrigated agriculture in view of the scarcity of fresh water resources for that purpose. Besides being useful source of soil nutrient, these effluents often contain high amount of various organic and inorganic materials as well as toxic heavy metals (Dawaki and Adamu, 2010). However, these may accumulate in the soil in excessive quantities over a long-term use. Subsequently, these toxic heavy metals may have a detrimental effect on the environment such as the contamination of surface and ground water, as well as soil which would interfere with key biochemical processes in the soil.

This study is aimed at assessing the pollution level of selected heavy metals: Chromium (Cr), Cadmium (Cd), Iron (Fe), Nickel (Ni) and Lead (Pb) in Bompai area. This was achieved through the following objectives: to evaluate the concentration of Cr, Cd, Fe, Ni and Pb and also assess the pollution level of these heavy metals in the soil of the Bompai irrigated area.

1.1 Study Area

The study area is Gayawa irrigated land situated within Ungogo Local Government Area, in Kano State of Northwestern Nigeria. The farmers irrigate their crops with waste water from River Getsi where the water is contaminated from industrial waste generated from Bompai industrial estate. It lies between latitude $12^{\circ}10'$N to $12^{\circ}21'$N and longitude $8^{\circ}46'$E to $8^{\circ}53'$E.The climate in the area is tropical wet and dry climate. The factors of soil formation in the study area are not different from the factors elsewhere, however the role of parent materials has great influence in the studies area and parent rock appears to pull a great influence than climate (Olofin, 1987). The soils of the study area (Kano metropolis) are ferruginous tropical soils type which are equivalent to nitrosols according to Food and Agriculture Organization (FAO, 1991) and they are also equivalent to Ultisol and Alfisol according to United State Department of Agriculture (USDA, 1987). The farmers in the study area obtain their irrigation water from River Getsi which is contaminated by industrial waste emanated from Bompai industrial area as shown in Figure 1.

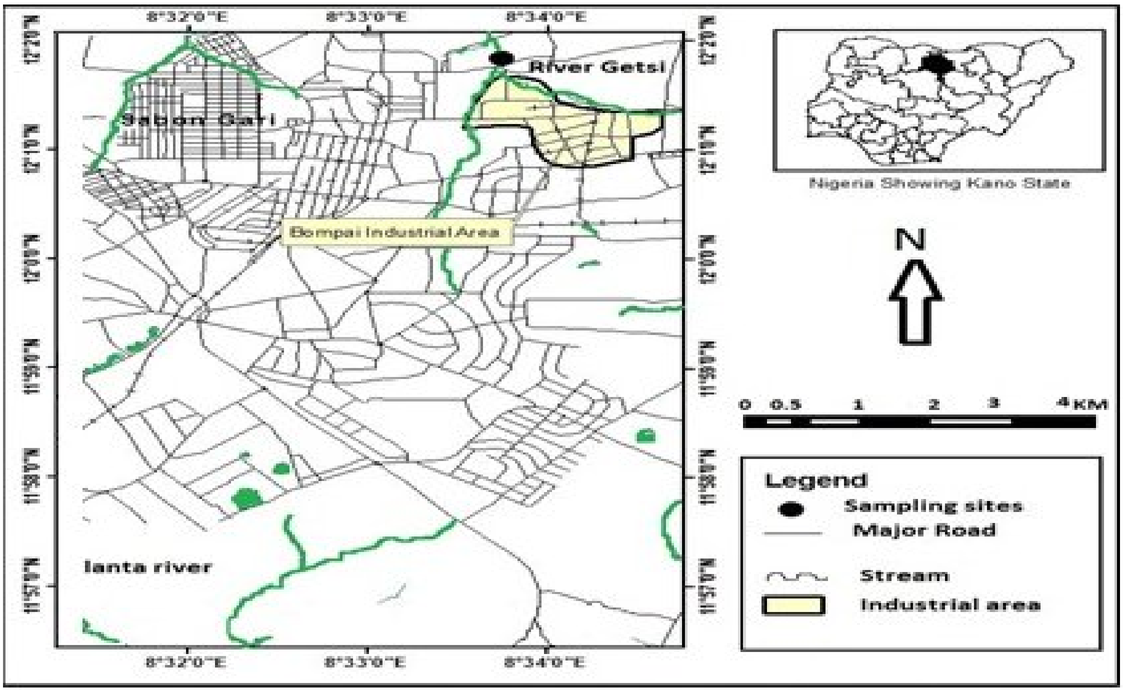


Figure 1: Study area showing Sampling points
Source: Cartography Lab, Bayero University Kano, 2016

2. MATERIALS AND METHODS

2.1 Materials

The materials used in this study are soil auger and spade for collection of soil samples, polythene bags for keeping the soil samples collected, marker for labeling the samples, global positioning system (GPS) for recording the coordinate of sampling points, pH and electrical conductivity (Ec) meter for determining the soil pH and Ec respectively; as well as Atomic Absorption Spectrophotometer (AAS, 210 VGP American Model) for assessing the heavy metal concentration of the soil and it was selected because of its sensitivity, reliability, affordability, versatility, accuracy and precision (Khamms, Al-Ayash and Jasin, 2009).

2.2 Sampling Techniques

The study area is divided into two: an area where farmers used waste water directly from contaminated stream for irrigation is considered as contaminated location, while location adjacent to the contaminated location where farmers use less contaminated underground water from tubes walls, boreholes and hand dug wells for irrigation because their farms are somehow far away from the contaminated stream channels (River Getsi) is considered as control location.

A base map of the Bompai irrigated site was used which formed the base information whereby contaminated and control location were delineated based on the sources of irrigation water used in each area. The grid survey method was used for sampling the soil, thereby, ten grid-squares were made within 1km^2 superimposed on the base map for good presentation of the parameters under study in the study area. Ten samples were collected from contaminated and control location making twenty soil samples for the whole analyses. In each sampling location, GPS was used to identify the actual sampling point marked on the base map and then samples were collected using composite soil sampling techniques from the surface to depth of 0 - 30cm. Soil auger and spade were used for taking the soil samples. However, in areas with little moisture, a cut up spade was used because the soil is dry and loose. The samples collected were placed into polythene bags, labeled appropriately, air dried and then taken to the laboratory for further analysis.

2.3 Laboratory Analyses of Some Heavy Metals and Soil pH

The soil samples were digested through wet digestion method as described by Anderson (1974), wherebyten grams of air dried soil was placed in a clean 300ml calibrated digestion tube and 5ml of concentrated sulpharic acid (H_2SO_4) was added in the fume hood and swirled carefully. Five millilitre (5ml) of tri-acid mixtures (HNO_3, H_2SO_4 and HCl) were added and then heated to 240°C for further one hour and kept overnight to avoid excessive foaming and then allowed to cool at room temperature, then filtered through Whatman No. 42 filter papers and stored in pre-cleaned polythene bottles for further analysis. Atomic Absorption Spectrophotometer (AAS, 210 VGP American Model) was used. The instrument was set up at a wavelength for each analyte. The flame was switched on and allowed to stabilize for about 10 minutes. The digested and filtered samples were aspirated and the results were dispensed on the read out unit of Atomic Absorption Spectrophotometer.

Calculation:

$$\text{Heavy metal} = \frac{\frac{X}{Y}\ X\ V.F\ X100}{1000\ X\ W.T} \quad ....1$$

Where X is absurbance, Y is slope, V.F is comverting factor 100 and weight of soil sample is 10g.

For the soil reaction determination, ten grammes (10g) of soil sample was placed in a 50 ml beaker and 25 ml of 1.0 (N) KCl was added and suspension was stirred for 1 hour. The pH was measured with the glass electrode by immersing it into the suspension. The pH meter was switched on at least 15 minutes for the pH meter to warm up and standardized the glass electrode. The standard buffer was used and the temperature compensation knobs to the temperature of the test solution were adjusted. The electrode was rinsed with distilled water after each determination and a blotting paper was used for water removal from its surface. The standardization process was checked after every ten determinations.

2.4 Evaluation Model

The single pollution index evaluation method was used to evaluate the level of soil pollution by six selected heavy metals in both contaminated and control locations of the study locations (Hong – gui *et al.*, 2013).

$$P_{ij} = \frac{C_{ij}}{S_{ij}} \text{.......................2}$$

Where P_{ij} is the pollution index of heavy metal in the j–th functional area of soil, C_{ij} is the measured contaminant value of heavy metal j in the j–th functional area and S_{ij} is the background contaminant value of heavy metal j (See Table 1).

The S_{ij} values for Cr, Cd, Fe, Ni, Pb and Cu were based on the European Union (EU) values specified in the European Union Standards for Soil Quality (Reddy and Dhal et al., 2014). With reference to the value of P_{ij}, the pollutants (heavy metals) that exceed limits and the most serious pollutant (heavy metals) in the study location were determine if any.

Table 1: Grading standards of the single-factor index

Sub – index	$P_{ij} < 1$	$1 \leq P_{ij} < 2$	$2 \leq P_{ij} < 3$	$3 \leq P_{ij}$
Quality grade	Clean	Potential pollution	Slightly polluted	Heavily polluted

Source: Adopted from Cheng et al. (2007)

3. RESULTS AND DISCUSSION

3.1 Concentration of Heavy Metals in Bompai Industrial Area

The laboratory analyses of the selected heavy metals, soil pH and pollution level of the heavy metals were evaluated and discussed. The mean value, standard deviation and coefficient of variation of some selected heavy metals and pH is presented in Table 2 which shows that there is variation in the concentration of each individual heavy metal in the study locations. Table 2 shows that some heavy metals such as Fe, Cu and Ni were found to be higher in concentration in the study locations, while Cr is found to have low mean values in all the study locations. The variation in the individual heavy metals in the study locations is probably attributed to the fact that their concentration in soil varies from one metal to another because some are relatively abundant in nature such as Fe, while some are rare and can be toxic even at low concentration such as Cd.

Table 2: Distribution of heavy metals in Bompai industrial area

		Heavy metals (mg/kg)						
Study locations	Statistics	Cr	Cd	Fe	Ni	Pb	Cu	pH (Kcl)
Contaminated	Mean	64.81	4.37	55.54	191.94	43.61	118.28	7.6
	±SD	10.12	0.6	5.28	22.34	3.77	10.12	0.46
	CV%	15.61	13.72	9.5	11.63	8.64	8.55	
Control	Mean	18.72	3.59	45.49	171.53	32.04	45.39	7.11
	±SD	1.48	0.92	6	12.06	3	3.01	0.25
	CV%	7.9	23.3	13.18	7.03	9.36	6.63	

The spatial variation of heavy metals among the study locations shows that all the heavy metals under study were found to be higher in contaminated location than its control location. High mean values of all heavy metals under investigation in the contaminated location is probably attributed to the discharges of industrial waste from Bomapai industrial estate and domestic waste from densely populated city center, Sabon Gari and Brigade quarters, city abattoir and heavily traffic flows along airport road in to the river. This is contended by Lal (2006) who reported that the concentration of heavy metal in soil depends on their concentration in the waste discharged into the area. This is further adduced by Wuand and Okieimen (2011) who reported in their findings that major causes of the presence or increased load of heavy metals in the soil could be attributed to some factors such as discharge of industrial and domestic waste, sewage sludge and effluent.

The results obtained in this study is in line with the results obtained by Mohammed (2010) and Chukulobe and Saeed (2014) who reported higher mean values of some heavy metals in contaminated location and attributed it to industrial and domestic waste released into suchlocations. The results of this study indicate that mean values of Fe, Ni, Cr, Pb and Cu were found to be higher than the mean values obtained by Bichi and Bello (2013). This implies that there is gradual accumulation of these heavy metals in the study location. The mean values of Co, Cr, Fe, Pb, and Cu in soil of the area were found to be lower than European Union Regulatory Values, while Cd and Ni were found to be higher than the European Union Regulatory Values (see Table 3). This indicates that the soils of the study locations could be at risk of being polluted by Cd and Ni if there is continues accumulation of these heavy metals in the soil of the area.

Table 3: Comparison of some heavy metals with international standard

	Heavy metals (mg/kg)					
Study locations	Cr	Cd	Fe	Ni	pb	Cu
Contaminated	64.81	4.37	55.54	191.9	43.61	118.28
Control	18.72	3.95	45.5	171.5	32.05	45.4
EU Values (mg/kg)	180	3	1500	75	300	140

Source: CEC (2001); Field survey (2015)

3.2 Pollution Level of Heavy Metals in Soil of Bompai Industrial Area

Table 4 shows the single pollution index of Cr, Cd, Fe, Ni, Pb and Cu in Bompai area. The assessment shows that the soil of the study location was potentially and slightly polluted with Cd an Ni respectively and were clean from Cr, Fe, Pb and Cu, based on the single pollution index as shown on Table 4.

Table 4: Pollution index of individual heavy metal in Bompai area

Heavy merals	Cr	Cd	Fe	Ni	Pb	Cu
Contaminated						
Cij	65	4.37	56	192	44	118
Sij	180	3	1500	75	300	140
Pij	0.36	1.45	0.03	2.56	0.14	0.84
Quality grade	Clean	Potential Polluted	Clean	Slight polluted	Clean	Clean
Control						
Cij	19	10.01	45	172	32	45
Sij	180	3	1500	75	300	140
Pij	0.1	1.31	0.03	2.29	0.1	0.32
Quality grade	Clean	Potentially Polluted	Clean	Slightly polluted	Clean	Clean

The soil pollution level with Cd and Ni in the study locations may be attributed to the use of effluents containing high amount of Cd and Ni generated from industries and domestic activities through the use of sewage sludge containing high amount of these metals as manure in the area as well as from high traffic flows of Sabon Gari and Airport road. This is adduced by Popoola et al. *(*2012) who reported that the major sources of Cd in urban soil are mainly associated with the activities like waste disposal, waste incineration, and fertilizer application in soil and vehicle exhausts.

4. CONCLUSION AND RECOMMENDATIONS

The variation in the concentration of heavy metals among the study locations is due to geological composition of the soil in the area and the concentration of heavy metals found in the waste discharged in the river. High mean values of heavy metals in contaminated locations are due to industrial and domestic waste discharge into the area. However, the soil of the area is at risk of been polluted with Cd and Ni, and the soil is relatively clean from Cr, Fe, Pb and Cu.

Based on the findings of this study, the following were recommended in the study area in order to reduce the concentration of heavy metals in the soil of the area.

i. Aerial contamination from industrial operation should be reduced. This therefore calls for the establishment of private treatment plant facilities, whereby waste from the different industries are to be channelled/piped to the (private) treatment plant that are metered. The treatment system charge for the cost of treatment and monitoring for compliance are to be set by government.
ii. Biological methods to remediate heavy metals contaminated soils are also recommended where certain plants which includes *Salix spp*, *Thlapsi spp*, *Urtica spp, Chenopodiumsachalase* and *Alyssum spp*, have the ability to absorb cadmium, copper, lead and nickel respectively.
iii. Adequate drainage networks and water stabilization pond should be constructed and connected to all waste water channels around the industrial area so as to stabilize the raw waste, thereby the effect and toxicity of heavy metals to soil ecosystem will be reduced.

REFERENCES

Akporida, S.O. and Asagba, S.O. (2013). Quality characteristics of soil close to the Benin River in the vicinity of a lubricating oil producing factory, Koko, Nigeria. *International journal of soil science.* 10 (3): 9–23.

Anderson, J. (1974). *Wet* Digestion *Versus Dry for the Analysis of Fish Tissue for Trace Metals;* Afon Absorbtion Newsletter.

Bada, S.B., Amusan, A.A. and Salami, A.T. (2001). Level of Some Metals in Soils and Vegetation along Roadsides in Osun State, *Nigeria Journal of Agriculture and Environment,* 2 (2)*: 345-356.*

Bichi, M.H. and Bello, F.U. (2013). Heavy metals in soils used for irrigation of crops along River Tatsawarki in Kano. *International journal of engineering research and development.* 8(4): 01-017

Carbonell, G., Gomez, J.P.N., Babin, N.M., Fernandez, C., Alonso, E. and Tarazona, J.V. (2009). Sewage sludge applied to agricultural soil: ecotoxixological effects on representative soil organisms, *Ecotoxicology and Environmental Safety,* 7 (2): 1309-1319.

CEC, (2001).Commission of the European Communities: Council Directive on the

Protection of the Environment and in Particular of the Soil, when Sewage Sludge is used in Agriculture, *Official Journal of Environmental Communication*, (1): 8 - 1 6.

Cheng, J. L., Shi, Z. and Zhu, Y. W. (2007). Assessment and Mapping of Environmental Quality in Agricultural Soil of Zhejian Province, China. *Journal of Environmental Science.* (58): 442 – 478.

Chukulobe, E. E. and Saeed, M. D. (2014). Assessment of Some Physicochemical Properties and Level of Pb, Cu, and Zn in Soil of Selected Dump site in Kano Metropolis, North West, Nigeria. *Int. J. boil. Chem. Scie.* 8 (2): 717 – 726.

Dawaki, M. U. and Adamu, G. K. (2010). Effect of Some Heavy Metals Pollution on Fertility Characteristics of an Irrigated Savannah Alfisol. *BayeroJournal of Pure and Applied Science.* 3(1): 255 – 259.

Hong – Gui, D. Teng – feng, D. U, Ming-hu, L. I. and Xuxu, D. (2013). Comprehensive
Assessment Model of Heavy Metal Pollution In Soil. *International journal of Electro Chemical Science.* (7): 5286 – 5296.

Lal, R. (2006). *Encyclopedia of Soil Science (2nd Edition)*. The Ohio State University Colombus,
Ohio, U.S.A. Newyork London. (1 & 2): 817 – 1813.Tailor and Francis group

Liu, C., Zhang, Y., Zhang, F., Zhang, S., Ye, H., Hou, H., Dong, H., Zhang, M., Jiang, J. and
Pie, L. (2007). Assessing Pollution of Soil and Plant by Municipal Waste Dump.*Environmental Geology,* 52 (4): 641 – 651.

Mohammed, M.A. (2010). An Assessment of Heavy Metals Pollution in Soils Under urban and Peri- Urban Irrigation in Kano Metropolis. *Unpublished M.Sc Thesis,* Geography Department, Bayero UniversityKano- Nigeria. 45 – 58.

Popoola, O. E, Bamgbose, O., Okonkwo, O.J., Arowolo,T. A., Odukoya, O.and Poppola, A. O (2012). Heavy metals content in playground topsoil of some public primary school in
metropolitan Lagos, Nigeria. *Research Journal of environmental Earth science. 4* (1): 434– 439

Sharma, R.K., Agrawal, M. and Marshall, F. (2007). Heavy Metal Contamination of Soil And Vegetables in Suburban Areas of Varanasi, India. *Ecotoxicology and Environmental Safety Journal,* (66): 258–266

United State Department of Agriculture, Soil Survey Staff (USDA, 1987). *Key to Soil Taxonomy*. Soil Management 6. USDA, Washington D.C

Wang, W. and Yang, Y. (2008). Calculating Pollution Indices by Heavy Metals in Ecological
Geochemistry Assessment and a Case Study in Parks of Beijing State Key Laboratory of Geological Processes and Mineral Resources. *China University of Geosciences,* 67: 75–81

Wuand, R. and Okieimen F. (2011). Heavy metals in contaminated soil: A review soil
Chemistry, risk and best available strategies for remediation. *International scholarly research network, 20:* 479-485

Yaylali-Abanuz, G. (2011). Heavy Metal Contamination of Surface Soil around Gebze Industrial

Area. *Turkey Micro Chemistry Journal,* 99 (1)*:* 82–92.

The Effect of Industrial Clustering on the Performance of Small and Medium Scale Tailoring Businesses in Samaru, Sabon Gari Local Government Area of Kaduna State, Nigeria

Abubakar S.*, Ibrahim M., Garba S., Shagali A.A. and Giwa S.M.
Department of Geography and Environmental Management, Ahmadu Bello University, Zaria
**galaxyabu@yahoo.com*

ABSTRACT

This study examined the effect of industrial clustering on the performance of small and medium scale tailoring businesses in Samaru, Sabon Gari Local Government Area of Kaduna State in Nigeria. Questionnaire and Global Positioning System (GPS) were used for data collection. A total of 180 questionnaires were administered to the respondents. Data was analysed using both descriptive and Pearson Product Moment Correlation (PPMC) statistics. The Average Nearest Neighbour Analysis tool in ArcGIS 10.1 software was used to determine the spatial distribution of tailoring businesses in the study area. Findings revealed a strong correlation index of 0.704 between industrial clustering and the performance of small and medium scale tailoring businesses. Also, the result showed nearest neighbour index with a p-value of 0.000001, and a z-score of -19.288510 which indicated that the spatial distribution of the SMEs is clustered. Hence, SMEs derive a lot of benefits from clustering; it was recommended that SMEs should have access to low interest loan that would improve the productive capacity of the tailoring businesses.

Keywords: Small and Medium Scale Enterprises; Cluster; Tailoring businesses; Samaru.

1. INTRODUCTION

Globally, there is no unified agreement as regards to specific definition of Small and Medium Enterprise (SMEs). This is consistent with the study from International Labour Organization (ILO, 2005) which shows that over 50 definitions were identified in 75 countries. However, in Nigeria, with the introduction of the National Policy on MSMEs has addressed the issue of definition as to what constitutes micro, small and medium enterprises (MSMEs). The definition adopts a classification based on dual criteria, employment and assets (excluding land and buildings); Micro Enterprises are those enterprises whose total assets (excluding land and buildings) are less than five million Naira with a workforce not exceeding ten employees. Small Enterprises are those enterprises whose total assets (excluding land and building) are above five million Naira but not exceeding fifty million Naira with a total workforce of above ten, but not exceeding forty-nine employees. On the other hand, Medium Enterprises are those enterprises with total assets (excluding land and building) are above fifty million Naira, but not exceeding five hundred million Naira with a total workforce of between 50 and 199 employees (SMEDAN, 2013).

Nowadays there has been a growing attention on clustering and networking as a useful strategy for SMEs development. The term clusters was brought into the regional development vocabulary by Porter in (1998) who defined it as geographic concentrations of interconnected companies, specialized suppliers, service providers, firms in related industries, and associated institutions in a particular field that compete but also cooperate. Industrial clusters are increasingly seen as viable solutions for economic growth in developing countries. Through the benefits of external economies and joint action, clusters help to reduce the industrial isolation faced by Small and Medium Enterprises (SMEs) which tend to be the main actors in the production process in many African countries (McCormick,1999).

Recently, development studies have witnessed a surge of interest in clustering of industrial activities as means for supporting innovation and thus generating economic growth in developing countries (Bell and Albu, 1999; Giuliani et al., 2005). Despite its critics (Martin and Sunley, 2003; Markussen, 2003), the cluster concept has proven to be a useful device for identifying geographical concentrations of industrial activities, analyzing the consequences of clustering for innovation and economic development in developing countries (Pietrobelli and Rabelotti, 2004; Giuliani et al., 2005).

The literature on industrial clusters establishes that clustering generates externalities in terms of cheapest access to production factors (static externalities) as well as enhancing learning and innovation (dynamic externalities) through interactive learning. Several studies showed that SMEs external relations are more confined to the cluster than those of large firms (Giuliani et al., 2005). For this reason, clusters have been considered as an efficient tool for development of SMEs and, as such, have been widely adopted as a development tool by regional governments and international organizations (such asUnited Nations Industrial Development Organization (UNIDO), World Bank).

The relevance of clustering in enhancing SMEs' innovative performance has received increasing attention over recent years both among academics, consultants and policy makers. The success in the nineties of the Third Italy, Silicon Valley and Hollywood turned the attention of researchers, consultants and policy makers towards conceptualizing clusters as engines for stimulating innovative (i.e. radical and incremental) behavior among the clustered SMEs. The success of clusters in the developed world diffused rapidly to developing countries, thereby awakening the interest of scholars, practitioners and policy makers. While scholars have tried to unfold the specific dynamics of clusters in developing regions such as Asia or Latin America (Bell and Albu, 1999; Giuliani, 2004; Giuliani and Bell, 2005; Pietrobelli and Rabellotti, 2004), international organizations such as the United Nations (UNIDO) and the Organisation of Economic Co-operation and Development (OECD) adopted the cluster as a policy and development tool (OECD, 1999 and 2001; UNIDO 1997 and 2004).

A good example of SMEs cluster in Nigeria is the Otigba Information and Communication Technology Cluster (Computer Village) in Lagos. In the midst of relatively high poverty, inequality and unemployment levels, Otigba serves as a sample of self-starting and self-sustaining small enterprises that are in some cases family owned (Oyelaran-Oyeyinka, 2006), providing employment for many including graduates. Firms in the cluster obtain their input products and purchases from within the cluster, others have been able to establish contacts with foreign firms for steady input supply.

Applying the cluster approach has proven useful as the point of departure for the design of innovation policies to support SMEs in Asian countries. In contrast to other more atomistic approaches working with the same variables but in isolation, this is supported by the behavioral pattern of the Asian SMEs whose interactions tend to be embedded locally. Available data in Nigeria has indicated that highly centralized government bodies tend to lack the local knowledge and base their interventions on aggregated data that often fails to capture both local and industry specificities. Thus the particular needs of the local SMEs, morphology of local networks and so forth are ignored. For these reasons, centralized governments might even intervene in counterproductive ways that negatively affects SMEs growth and development. The focus of this research therefore is to examine the geographic locations of the small and medium scale tailoring businesses, to identify their spatial distributional pattern and also to analyse the effects of industrial cluster on the performance of the tailoring businesses in Samaru town.

1.1 Study Area

Samaru is a ward located in Sabon Gari Local Government Area (LGA) of Kaduna State in Nigeria. It is located at a height of about 670m above sea level in the centre of Northern Nigeria, about 664km away from the sea and approximately within latitude 11°3N-11°15N and longitude 7°30E and 7°45E of the Greenwich meridian (Figure 1). The area is bounded by: Kudan LGA to the north, to the west by Giwa LGA, to the south by Zaria LGA, and Makarfi LGA to the southeast (Olowolafe, Bamike and Ishaya, 2010). Samaru as a ward has four districts (Samaru market, Dan raka, Hayin dogo, new extension). The population of Samaru according to 2006 population census was 92,664 with a growth rate of 2.5 % per annum (National Population Commission (NPC), 2006). Samaru town has a number of educational institutions such as Ahmadu Bello University, Leather Research Institute and Industrial Development Center etc. Some other institutions that are only a few kilometers away from Samaru include Nigerian College of Aviation Technology (NCAT), National Animal Production Institute (NAPRI) and Division of Agricultural Colleges (DAC) etc. A large number of employees from these institutions do patronize businesses that are located in Samaru town on daily basis. A great number of Samaru residents are employees of Ahmadu Bello University either as academic or non-academic staff; others include students, civil servants as well as traders. As a developing town, Samaru has a big market where both retail and wholesale activities take place daily. A number of SMEs are widely spread within and outside the market area; some of these SMEs include furniture making businesses, sachet water companies, metal and aluminum works, block industries and tailoring businesses etc. Modern infrastructures such as electricity, telecommunication, roads, and pipe borne water, clinics as well as a number of both private and public primary and secondary schools are also available (Tobi, 2010).

2. MATERIALS AND METHODS

Samaru as a political ward in Sabon Gari Local Government Area has four districts namely: Samaru market, Dan raka, New Extension and Hayin Dogo. The study covered all the available tailoring businesses located in the study area, in which a total of 180 businesses were identified using snowball sampling technique. Questionnaire were administered to all the 180 SMEs so as to solicit information from the respondents (proprietors or managers). Proprietors or managers are expected to be more knowledgeable regarding information that affects SMEs operation, growth and development. A GPS (Global Positioning System) devise was used to record the geographical coordinates of the tailioring businesses. Both descriptive and inferential statistics were employed in the analysis. Simple percentages were used to analyse the demographic characteristics of the respondents while product moment correlation was used to determine the relationship between industrial clustering and the performance of small scale tailoring businesses. Product moment correlation is used to determine the strength of association between variables. Also Nearest neighbor Analysis was carried out using ArcGIS 10.1 software to determine the spatial pattern of the distribution of the SMEs.

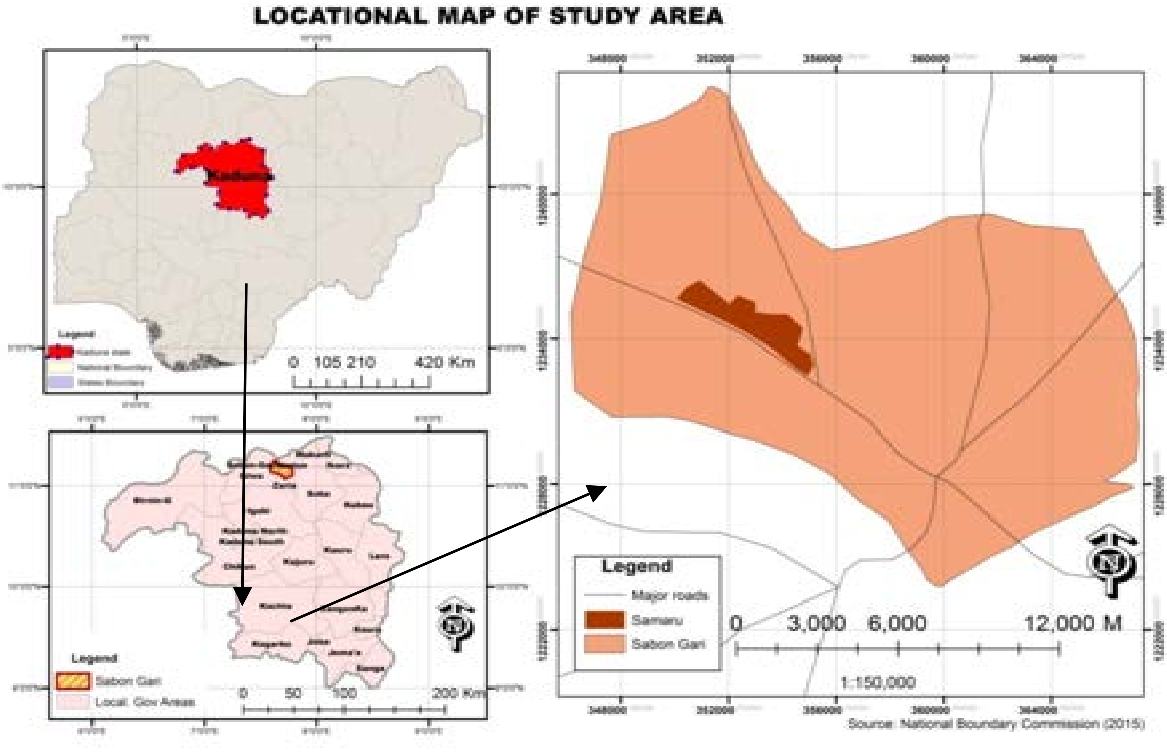


Figure 1: Map of Sabon Gari Local Government Area Showing the Study Area

Source: Adapted from the administrative map of Kaduna State

3. RESULTS AND DISCUSSION

3.1 Socio-economic Characteristics of the Respondents

This study on the effects of industrial clustering on the performance of small and medium scale tailoring businesses in Samaru revealed that industrial clustering plays a great role in the performance of small-medium scale industries. Figure 2 revealed that majority of the tailoring businesses in Samaru are owned by people between the ages of 35-44 years which constitutes about 35% of the respondents.

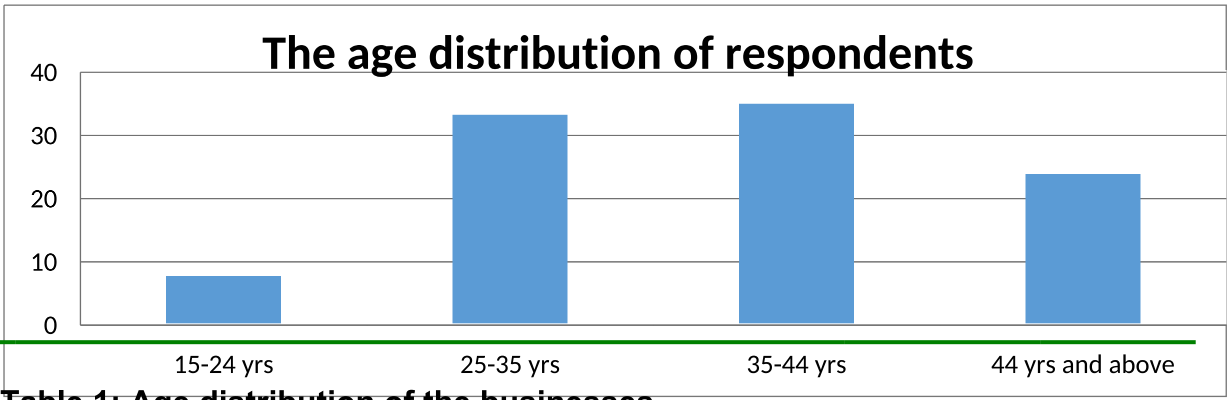


Figure 2: The age distribution of respondents

The age group of 15-24 years constitutes the least respondents (7.8%), while 33.3% are between 25-35 years as against 23.9% that belong to the age group of 44 years and above. This result shows that the tailoring businesses in Samaru is dominated by entrepreneurs between the age of 25-44 years old, and this can be attributed to the dominance of youth in the fashion industry.

Table 1: Age distribution of the businesses

Age	Frequency	Percent
Less than 5 Yrs	34	18.9
5 - 9 Yrs	83	46.1
10 - 19 Yrs	47	26.1
20 Yrs and Above	16	8.9
Total	180	100.0

Age distribution of the businesses are summarized in Table 1. A greater proportion of the tailoring businesses in Samaru are less than nine (9) years of age. This can be explained based on the fact that a lot of youth in Samaru have now been engaged in various businesses which may be a response to the rapid population growth of Samaru over the years. These tailoring businesses were established to meet the needs of the population of migrants, civil servants, and students residing in the study area. The study revealed that about half of the tailoring businesses (46.1%) in Samaru are within the age of 5-9 years old, 26.1% are between 10-19 years old, and 18.9% are less than 5 years, while only 8.9% are over 20 years old.

The result on Table 2 revealed that generally, distance to sources of raw material in tailoring business is one of the factors that significantly affect the location of the SMEs; it is one of the factors that gears the tailoring business in terms of profit maximization and reduced cost of production. The result revealed that about half of the of the tailoring business (46.1%) gets their raw materials for production within Samaru, it can be attributed to the nature and characteristics of the business. The materials needed for production are obtainable within the Samaru environs and main market which helps in profit maximization.

Type of employments is illustrated in Figure 2. The graph presented the nature of workforce in the tailoring businesses which varies based on the type of apprenticeship, full time worker, part-time worker and family labour. It shows that more than half of the entrepreneurs (62.2%) make use of the services of apprenticeship, while 5.7% employ the services of full time workers. Also, about 28.9% made use of family labour while only 2.2% made use of part time workers. The probable reason for this observed pattern could be attributed to the influx of youth who are trying to learn the business on one hand as well as poor capital base of most of the small and medium scale tailoring businesses. Consequently, they prefer to make use of apprentice workers in order to minimize cost of production and by so doing can maximize profit.

Table 2: Sources of raw material for the businesses

Location	Frequency	Percent
Within Samaru	83	46.1
Within Zaria Urban Area	47	26.1
Within Kaduna	50	27.8
Total	180	100.0

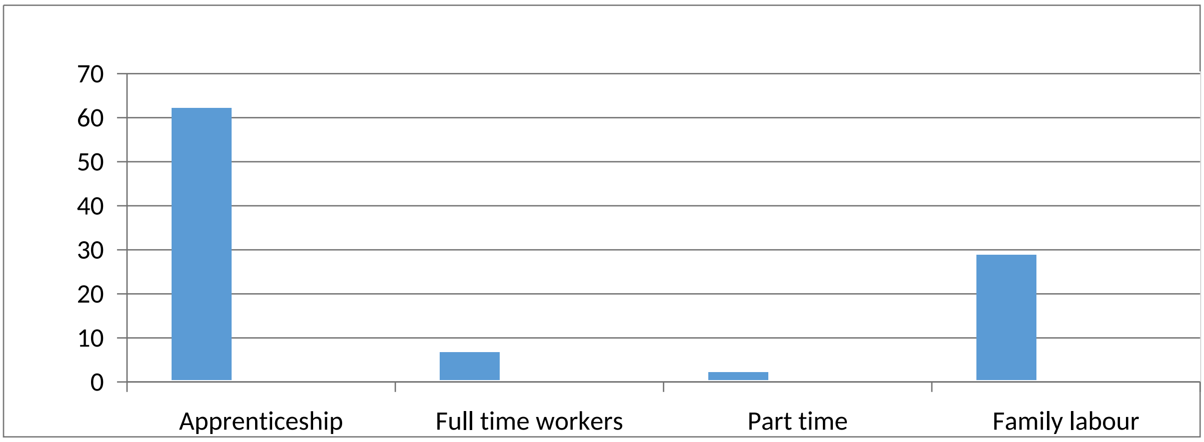


Figure 2: The type of employees engaged in tailoring businesses

3.2 Perception on Industrial Clustering

Industrial clustering is regarded as an important way by which industries particularly small and medium scale industries derived many benefits that significantly impact on their growth and development. This section tried to assess the perception of the various tailoring businesses with regards to the benefits they derived from operating in a cluster. The means and standard deviations on the impacts of industrial clustering on the performance of tailoring businesses are summarized in Table 3. Generally, the businesses are in agreement that the seven factors (some of the benefits derived from industrial clustering) have tremendous effect on the performance of tailoring businesses. This is because the calculated cumulative mean response of 4.088 is higher than the decision mean of 3.000. Specifically, lowering production cost has the highest effect on small and medium scale tailoring businesses as this view attracted the highest mean response of 4.938. Details showed that 173 of the respondents considered it very important, while 5 others considered this factor important and the rest 2 considered this factor as fairly important. In the same vein, they also believed that access to knowledge and information resources and creation of knowledge also affects SMEs growth within clusters. This factor attracted the second highest mean response of 4.905.

This finding is similar to that of Visser (1999), when he studied some industrial clusters and therefore concluded that the benefits industries derived from operating in clusters include process innovations on the basis of technical/commercial dialogue between users and producers of intermediary products (vertical linkages), or enhanced volumes and product quality through cooperation among producers making similar products (horizontal linkages).

Table 3: Perception of respondents on the impacts of industrial clustering on the performance of tailoring businesses

S/No	Factors	Response Categories					Mean	S D
		Strongly Agreed	Agreed	Undecided	Disagreed	Strongly Disagreed		
1	Lower production cost	173	5	0	2	0	4.938	0
2	Low-transaction costs	165	11	4	0	0	4.894	0
3	Access knowledge and information resource and creation of knowledge	170	7	0	2	1	4.905	0
4	Enhance competence and create competitive advantages	106	43	14	11	6	2.088	0
5	Establish co-perative linkages between SMEs	64	53	8	10	45	2.300	1
6	A pool of specialized labor	160	11	1	7	1	4.788	0
7	A pool of suppliers of raw material, equipment and specialized services	145	26	2	5	2	4.705	0
	Cumulative/grand mean						***4.088***	

Decision mean = 3.000

Correlation statistics was used here to determine the significant association between tailoring businesses locating close together in industrial clusters and their general performance.The Pearson Product Moment Correlation (PPMC) statistics results summarized in Table 4 showed that a strong and positive relationship exists between industrial clustering and the performance of tailoring businesses. This is because the correlation coefficient was found to be 0.704 and the p-value of 0.000 was also found to be lower than the 0.05 alpha level of significance. This shows that the clustering of tailoring businesses significantly affects their level of performance.

Table 4: Pearson Product Moment Correlation (PPMC) statistics results on the relationship between industrial clustering and the performance of tailoring businesses.

VARIABLES	N	MEAN	S.D	CORRELATION INDEX R	Df	SIG (P)
Industrial clustering	180	28.6222	2.19994	0.704**.	178	0.000
Performance of small scale tailoring businesses	180	47.5889	4.20533			

****. Correlation is significant at the 0.05 level (2-tailed).**

3.3 Spatial Distribution Pattern of Tailoring Businesses

Geographical Information System (GIS) was used to determine the spatial distribution pattern of the tailoring businesses using the Nearest Neighbour Analysis tool. The results of the spatial distribution of tailoring businesses in Samaru town are given in Figures 3 and 4. Figure 4 shows the nature of the spatial distribution of the tailoring businesses in Samaru as clustered.

The z-score and p-value are measures of statistical significance which indicate whether or not the distribution are clustered, random or dispersed. The Nearest Neighbour Index is expressed as the ratio of the Observed Mean Distance to the Expected Mean

Distance. The expected distance is the average distance between neighbours in a distribution. If the index is less than 1, the pattern exhibits clustering; if the index is greater than 1, the trend is toward random or dispersed.

Figure 4 showed the nearest neighbour index with a p-value of 0.000001, and the z-score of -19.288510 which indicated that the spatial distribution of the SMEs is clustered. The findings of this study concur with what of Parsons (2007), who stated that many factors are brought into consideration when choosing a location for business activities and that entrepreneurs critically assess the incentives available for setting up their enterprises in certain regions against the alternative locations. In this study, such factors as population size, accessibility, proximity to market and closeness to source of raw materials were found to be very important determinants of SMEs location and distribution pattern. Campos and Prothero (2012) also showed that there are specific enterprises which tend to serve specific population hence they are concentrated in certain regions and therefore business environment has significant effect on the distribution of businesses.

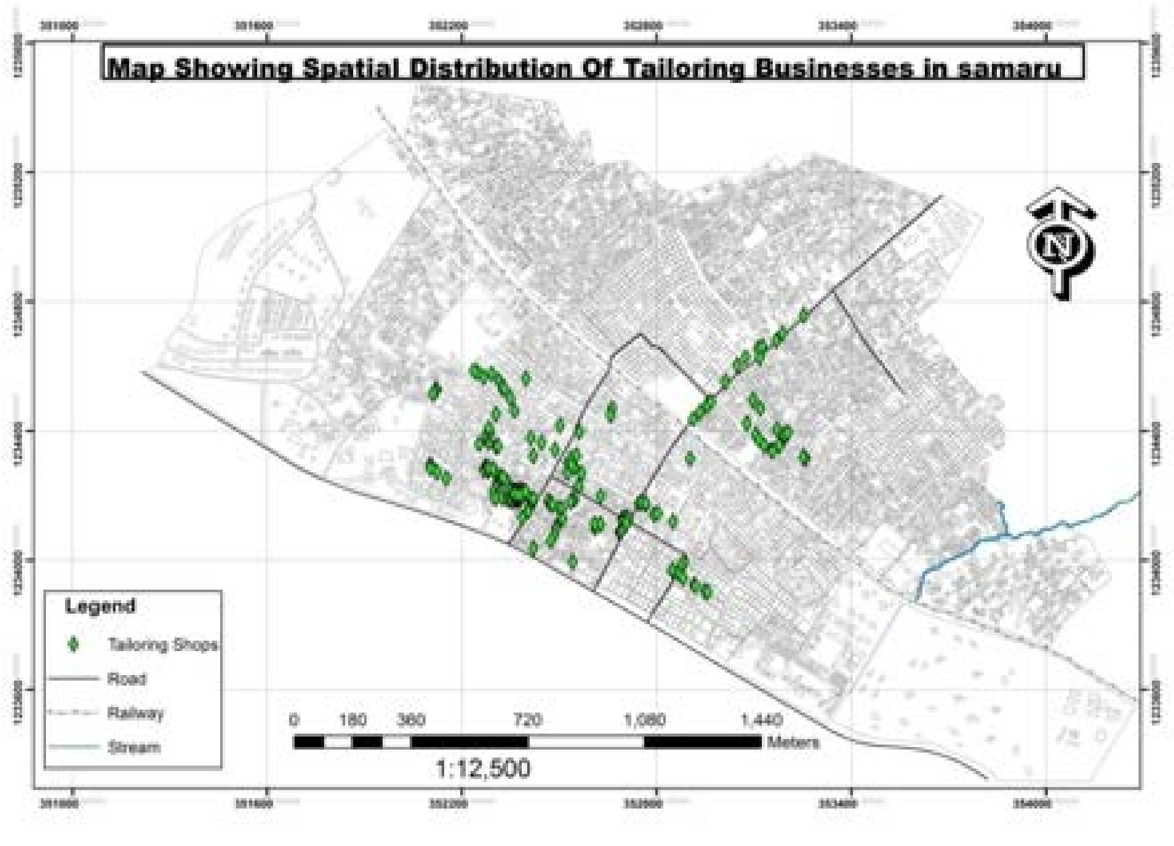


Figure 3: Map showing spatial distribution of tailoring shops

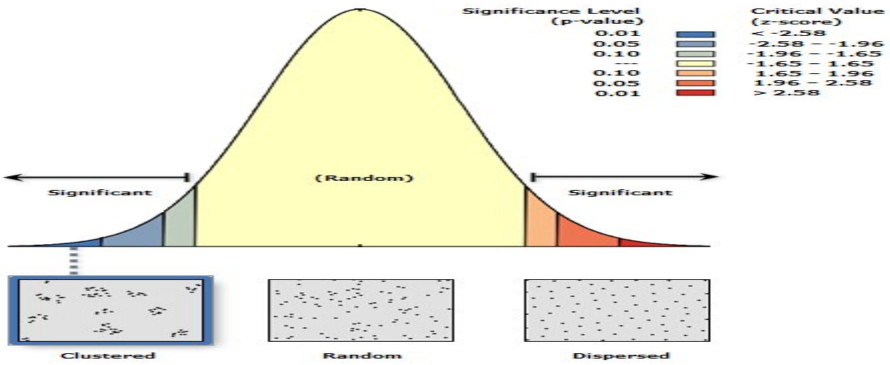


Figure 4: Spatial distribution of the industries

Average Nearest Neighbour Summary	
Observed Mean Distance:	16.0789 Meters
Expected Mean Distance:	64.7051 Meters
Nearest Neighbour Ratio:	0.248496
z-score:	-19.288510
p-value:	0.000001

4. CONCLUSION

The concept of spatial distribution of SMEs is very important because the spatial pattern of employment across industries influences the economic opportunities and growth. Enhancing spatial distribution of SMEs in a geographical area ensures equal distribution of economic growth in the area. This results in the creation of more job opportunities thus reducing the influx of people in major urban centers in search of employment. This study revealed that most of the entrepreneurs utilized the services of apprentice and family labour. It also showed that lowering production cost and access to knowledge and information resources as well as lowering-transaction costs are the most important benefits that tailoring businesses enjoy in Samaru cluster. Therefore, this study concludes that small and medium scale tailoring businesses in Samaru operate in a cluster which gives them so many advantages over those that locate far away from the cluster. This includes increased patronage and reduced cost of transportation when purchasing of raw materials, time savings as well as increased diffusion of ideas and knowledge.

4.1 Recommendations

Based on the findings of this study, the following recommendations were made:

The Government should assist the small and medium scale businesses through the provision of long-term and low interest loans. SMEs should be encouraged to participate in organised seminars and workshops so as to improve the productive capacity of the businesses. Also important is the provision of consistent power supply, as majority of the tailoring businesses complained that irregular power supply was the main challenge to their business performance.

REFERENCES

Asheim, B. and Gertler, M. (2004). The Geography of Innovation: Regional Innovation

Systems. *The Oxford Handbook of Innovation*. J. Fagerberg, d. Mowery and r. Nelson. Oxford, OUP: 291-317.

Bell, M. and Albu, M. (1999). Knowledge Systems and Technological Dynamism in Industrial Clusters in Developing Countries. *World Development* 27(9): 1715-1734.

Campos, C., and Prothero, R. (2012). The Spatial Distribution of Industries. *Regional Economic Release*

Giuliani, E. (2004). Laggard Clusters as Slow Learners, Emerging Clusters as Locus of Knowledge Cohesion (and Exclusion): A Comparative Study in the Wine Industry. *LEM Working papers*. Pisa, Laboratory of Economics and Management-Sant'Anna School of Advanced Studies: 38.

Giuliani, E. and Bell, M (2005). When Micro Shapes the Meso: Learning Networks in a Chilean Wine Cluster. *Research Policy* 34(1): 47-68.

International Labour Organisation (2005). *Assessment the Influence of the Business Environment on Small Enterprise Employment: An Assessment Guide*, Geneva 22, Switzerland, ILO Publications.

Markusen A. (2003). Fuzzy Concepts, Scanty Evidence, Policy Distance: The Case for Rigour and Policy Relevance in Critical Regional Studies. *Regional Studies* **37**, 701-717.

Martin, R. and Sunley, P. (2003). Deconstructing Clusters: Chaotic Concept or Policy Panacea? *Journal of Economic Geography* (3): 5-35.

McCormick, D. (1999). African enterprises clusters and industrialization: Theory and reality."*World Development*, *27*(9), 1531-1551

National Population Commission (NPC) (2006) *Published National Population Census 2006.*

Organisation of Economic Co-operation and Development (OECD) (1999) *Innovative clusters. Drivers of national growth*. Paris. OECD.

Organisation of Economic Co-operation and Development (OECD) (2001) *Boosting innovation: the cluster approach.* Paris. OECD.

Olowolafe E.A, Bamike T.J. and Ishaya S. (2010), Conference Proceedings: *Contemporal Issues in Infrastructural Development and Management in Nigeria.* Remote Sensing and GIS Application in Assessing Changes in Land Use.

Oyelaran-Oyeyinka, B. (2006). Learning in hi-tech and knowledge in local systems: The Otigba Computer Hardware Cluster in Nigeria. *Working Paper 2006-007*, Institute for New Technologies, United Nations University, Maastricht.

Parsons, J. (2007). *Theories of Location*. Oxford studies in metaphysics, 3, 201.

Pietrobello, C. and Rabellotti, R. (2004). Upgrading in Clusters and Value Chains in Latinamerica: The Role of Policies. *Sustainable department Best Practices Series*. New York, Inter-American Development Bank: 97.

Porter, M. (1998) *"Extensive Market, technical, and competitive* information" Theories of Industrial Modernization and enterprise development.

Small and Medium Enterprises Development Agency of Nigeria (SMEDAN), (2013). "National Policy on Micro, Small and Medium Enterprises". Federal Republic of Nigeria, SMEDAN, Abuja, Nigeria.

Tobi, B. O. (2010) .Urban growth and housing problems in Samaru-Zaria. Unpublished B.Sc Thesis, Department of Geography, Ahmadu Bello University Zaria.

Unido (United Nations Industrial Development Organization) (1997). Progress and Prospects for Industrial Development in Least Developed Countries (Ldsc) - Towards the 21st Century. *Fourth LDC Ministerial Symposium: IndustrialCapacity Building and Entrepreneurship Development in LDCs with particularemphasis on agro-related industries*. Vienna.

Unido (United Nations Industrial Development Organization) and U.U.N.D.Program) (2004). Partnerships for Small Enterprise Development. New York, United Nations**:** 46.

Visser, E.J. (1999). A comparison of clustered and dispersed firms in the small-scale clothing industry in Lima. *World Development,* *27*(9), 1553-1570.

Sources and Seasonal Variation in Prices of Livestock and Farm Produce in Maigatari and Dungass Markets

Umar Ali Madaka[1]* and Bello Gambo[2]

[1]*Jigawa State Ministry of Education Science and Technology, Dutse,*

[2]*Department of Geography, Bayero University Kano, Nigeria*

*****umaralimadaka1@gamail.com

ABSTRACT

This study analyzed the sources and seasonal variation in livestock and farm produce in Maigatari and Dungass markets across Nigeria and Niger border. The study relied mainly on primary data derived using focus group discussions. The data was analyzed qualitatively through careful collation and arrangement, and the results presented in tables. The findings revealed that the supply and prices of both livestock and farm produce fluctuated according to seasons. Farm produce were cheaper in Maigatari market than in Dungass market and livestock were cheaper in Dungass than in Maigatari market. It was also discovered that there was inadequate market infrastructural facilities. Therefore, it was recommended that there should be urgent needs to educate traders on these seasonal variations, provide enough market infrastructures and encourage traders to buy farm produce in Maigatari market and exchange it with livestock from Dungass to boost their capitals and profits.

Keywords: Farm Produce; Livestock; Inter-boundary Trade; Seasonal Variation.

1. INTRODUCTION

As the world is rushing towards regional and mega-regional trade agreements, the place and role of the African continent have transformed international trade relation and set the next boundaries of global economic governance system. As such, Africa is receiving special attention due to its contributions rendered to global commercial transaction or vagaries of its participation in trade negotiations (Cheikh, 2015). All African countries and their regional economic communities are participating simultaneously in series of multi-lateral, regional and bilateral negotiations that welcome international commerce. This proves that Africa is widening its participation in the international markets. Consequently, this is disproving the saying that Africa is not doing enough to integrate with global trade. Between 1995 and now, trade has become a significant issue on the agenda of almost all African states including Nigeria (Cheikh, 2015).

The large size of Nigeria is well known, but the actual volume of its trade with its neighbors is often inaccurately perceived. Language differences, disparities in economics and monitory policy, and socio-cultural bias have made some less informed analysts think that the trade between Nigeria and the other countries in the sub-region is impossible. In fact, in both official and informal trade, Nigeria is a major regional partner for other West African countries (Soulé, and Obi, 2001). Niger Republic as one of the neighboring countries of Nigeria is a trading partner and has been linked in the trans-Saharan trade going back to the medieval period; cities such as Kano and Katsina have long been the southern terminus of trade networks which sustains much of Niger's economy. Traders from southern Niger and northern Nigeria understand each other perfectly belonging to Hausa-Fulani in the western and central border and Kanuri in the eastern part of the border, and are often related by families, religious and lineage links (William, 2005).

The long diplomatic and cordial relationship between the communities living along the boundary region of Niger and Nigeria has given room to the potential of inter boundary trade to improve livelihood security between the two countries; as a result promotes the production of agricultural crops and livestock. To make the communities crossing the border to cope with the recurrent climatic variation, there is symbiotic relationship between the two countries as the product of each country is exported to the other to sustain the life of the communities as it happened between Maigatari (Nigeria) and Dungass communities (Niger) (William, 2005). However, the nature and volume of the trade have been influenced by seasonal variations, i.e. the fluctuations in the volume of trade that occur regularly at annual intervals, with a periodicity determined by climatic or other seasonal influences and other social conventions, which need careful understanding by traders. A major reason why economists are interested in studying seasonal variations is that they are relatively exogenous factors, and hence studying them can help us better understand how markets work (Hong and Yu, 2006).

Various studies have been conducted in the area which gives more attention to the items traded. For example, Abdullahi (2013) analyzed cross border cattle trade between Nigeria and Niger Republic. However, his work was restricted to cattle trade alone neglecting other forms of livestock like camel, horses and goats that are equally important. Yakubu (2014) examined cattle trade and development of Maigatari economy from 1960-2010. He explained the general economy of Maigatari (1960-2010) under agriculture, craft and trade with particular emphasis on cattle trade. Also, his work was restricted to Maigatari market only. Sahel and West Africa Club (SWAC) in collaboration with Niger Food Crises

Unit (2007) examined a cross border issues in Kano, Katsina and Maradi areas with a focus on improving information on food crops market and the cross border movement of goods and capital. Maty (2011) investigated how the cross border flows of staple foodstuffs from Nigeria allowed Niger to ensure its food security. However, livestock trade was not included. Addo (2006) examined some of the criminal activities across the West African borders like smuggling of goods through illegal routes across the borders.

This study concentrates on the marketing of livestock and farm produce with a view to examine the seasonal variation in the nature and volume of the trade in Maigatari and Dungass markets across Nigeria and Niger border. Knowledge of prices of agricultural commodities in the market is very important to both buyers, traders and policy makers, especially because the prices fluctuate seasonally. In particular, rainfall change and variability are very important determinants of livelihood in the Sahelian region (Mortimore, 2000). Two main objectives were set to achieve in this study: (i) to identify and describe the sources of supply of livestock and farm produce for Maigatari and Dungass markets; (ii) to establish and explain the seasonal variation in prices of livestock and farm produce in the markets.

1.1 The Study Area

Maigatari is located on latitude 12°80′ 78″ N and longitude 9°46′16″ E, and it covers an area of 1,250km^2. Maigatari market is located at the extreme end of Northern Nigeria, in Maigatari town, the headquarters of Maigatari Local Government Area (LGA) in Jigawa State. It is located about 140 kilometers from Dutse, the state capital. It consists of five districts namely Maigatari, Galadi, Garmaka, Madana and Bosuwa. It shares a common border with Niger Republic, where it is bordered to the north by Dungass LGA of Zinder in Niger Republic and to the South by Gumel LGA. It shares borders with SuleTankarkar LGA to the west, and Kaugama LGA to the east (Figure 1) (Yakubu, 2014).

Dungass town is located on latitude 13°03′50″N and 9°20′03″E. The district of Dungass covers an area of 1297km^2. Dungass market is located at the western part of Dungass town, the headquarters of Dungass Local Government Area *(Prefecture)* of Zinder state (Damagaram region) in Niger Republic. It is approximately 165 kilometers by road and 70 kilometers by air from Zinder (its state capital), and 28 kilometers to Maigatari. It consists of seven districts (*Communue*), namely Dungass, Bande, Danchiyau, Dogo-dogo, Gauche, Malawa and Washa. It is bordered with Magarya LGA in the west, Murya in the north, Gure in the east, and with Nigerian border of Maigatari LGA of Jigawa State in the south (Figure 1).

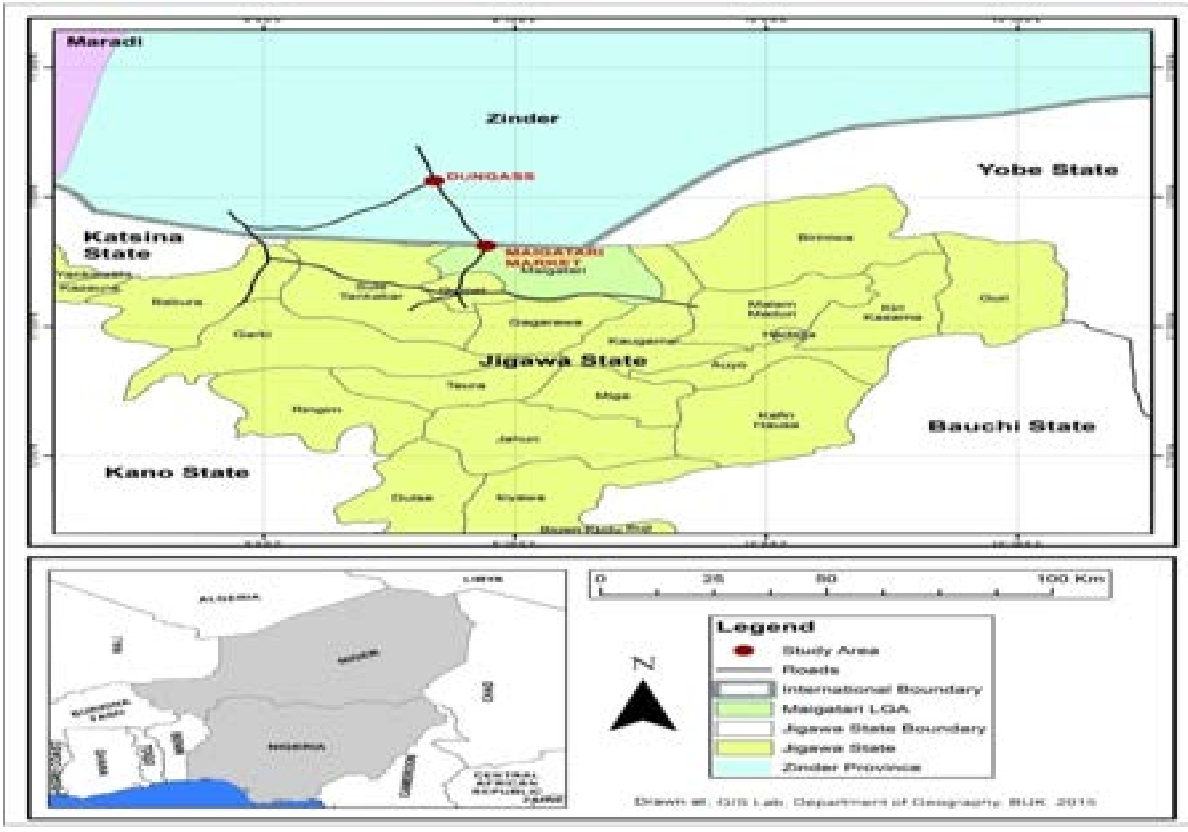


Figure 1: The study Area (Dungass and Maigatari markets)
Source: Mortimore, 2000

2. MATERIALS AND METHODS

Reconnaissance survey was carried out from the first week of October to fourth week of December 2014, after which focus group discussion was conducted in both markets. In Dungass market the discussion lasted for one hour with 6 participants, while in Maigatari market (because it is relatively larger than Dungass market) it lasted for one hour forty five minutes with ten respondents. In both markets, the discussions centered on the sources of both livestock and farm produce and seasonal variation in the volume and prices of livestock and farm produce traded. The analysis was done manually. The results were presented in tables. ArcGIS software was used to map out the sources of livestock and farm produce to Maigatari and Dungass markets.

3. RESULTS AND DISCUSSIONS

3.1 Source of Livestock Supply

The livestock traded in Maigatari and Dungass markets include cattle, camels, horses, donkeys, sheep and goats. The sources of supply of these livestock to Maigatari market were mostly from Niger republic. All the five classes of livestock were mostly coming from the following markets in Niger Republic: Dungass, Gure, Zarmu, Gauchi, Damagaran takaya, Guidimoni, and Bultum. Others are coming from Nigeria especially from Gaidan, Garin Alkali and Nguru, in Yobe state as well as the neighboring villages and nearby markets like Malam Madori, Hadejia, Gujungu, Babura, and Sule Tankarkar. While the sources of livestock to Dungass market include the entire sources from Niger to Maigatari market (Gure, Zarmu, Gauchi, Damagaran takaya, Guidimoni and Bultum) with exception of those from Nigeria. In addition to these, some livestock come from neighboring villages of Dungass such as Dan kargo Fulani, Mallamawa Fulani, Garin Gako and Gujiyawa. So, there is no supply from Nigeria to Dungass (Figure 2).

3.2 Source of Farm Produce Supply

The sources of farm produce supply to Maigatari market were mostly from neighboring villages and nearby markets in Nigeria, such places include: Gumel, Galadi, Babura, Sule Tankarkar, Hadejia and Gujungu. All these areas supply millet, guinea corn, beans, sesame and groundnut. In addition to that, beans and sesame are also supplied from Niger Republic especially from Dungass markets and its neighboring villages. Whereas, the source of farm produce to Dungass markets are mostly from Nigeria, like Maigatari, Gumel, Gujungu, Babura, Daura (particularly guinea corn and ground nut), and the neighboring villages of Dungass market (particularly millet guinea corn, beans and sesame (Figure 2).

3.3 Seasonal Variation in the Price of Livestock

There were five main types of livestock traded in both markets i.e. in Maigatari and Dungass markets, these are: cattle, camels, goat/sheep, horses and donkeys. The prices of these livestock vary according to season and period of supply, as indicated in Table 1 for the prices of cattle and camels in Maigatari and Dungass markets.

3.3.1 Cattle

Cattle as one of the most important livestocks traded in Maigatari and Dungass markets were more abundant in the markets during wet and warm season (*Damina*) which, according to Olofin (2008) is from May to September and dry and warm season (*Rani*) . During this period the prices of the cattle become low in both markets especially in Dungass market. They are moderate during moderate period of supply which came during dry and cool season (*Kaka*) or Harmattan period. While their prices become high during low period of supply i.e. during dry and hot season (*Bazara*) (Table 1).

Table 1: Prices of Cattle at Different Period of Supply

Size	Period of Supply	Price at Maigatari Market (₦)	Price at Dungass Market (₦)
Big	Peak	170,000 – 280,000	120,000 – 180,000
	Moderate	180,000 – 250,000	140,000 – 200,000
	Low	200,000 –300,000	160,000 – 230,000
Medium	Peak	120,00 – 200,000	65,000 – 120,000
	Moderate	120,000 – 170,000	75,000 – 130,000
	Low	160,000 – 200,000	80,000 – 150,000
Small	Peak	35,000 – 100,000	30,000 - 60,000
	Moderate	40,000 – 100,000	30,000 – 75,000
	Low	60,000 – 120,000	40,000 – 80,000

In some cases, the prices can increase or reduce due to some factors, for example during Christmas and *Sallah* celebration the prices may increase because of high demand. While in situation where the buyers are scarce in the market, their prices fall. In addition to the seasonal fluctuation in the prices of cattle, there is also daily price fluctuation; normally cattle sold in the morning their prices may increase in the afternoon or evening especially when there is increase in the number of buyers in the markets, but at times the prices of the cattle drop in the afternoon. Consequently, this analysis revealed that there are seasonal variations in supply and price of cattle in both markets.

3.3.2 Camels

The prices of camels fluctuate according to their demand in the markets. Normally, their supply in both markets became high during high demand period which come during dry and hot season (*Rani*) and their prices become low. Their prices become moderate during moderate period of supply which comes during dry and cool season (*Kaka*), while high prices come during low period of supply i.e. during dry and warm season (*Bazara*) and warm and wet season (*Damina*) (Table 2).

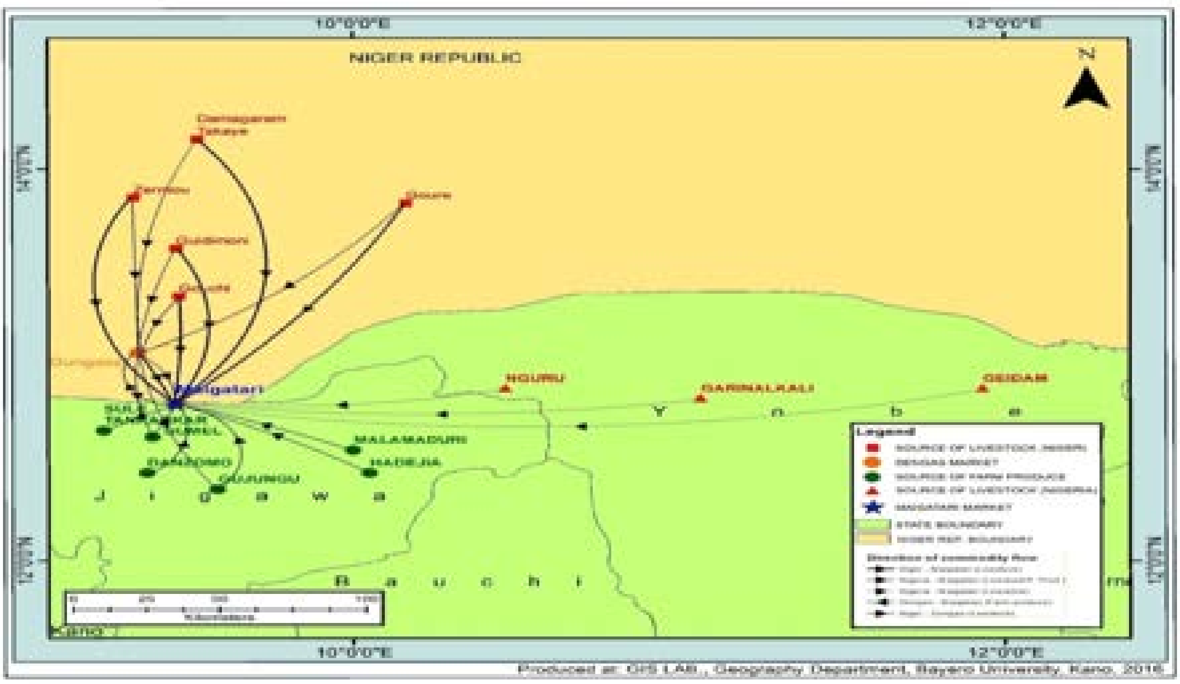


Figure 2: Map of Niger and Nigeria showing Sources of Livestock and Farm Produce between Maigatari and Dungass Markets

Source: Modified from Google Earth Satellite Imagery of the Study Area

Table 2: Prices of camels at different period of supply

Size	Period of supply	Price at Maigatari market (₦)	Price at Dungass market (₦)
Big	Peak	60,000 – 80,000	50,000 – 70,000
	Moderate	80,000 - 140,000	70,000 – 140,000
	Low	150,000 –200,000	140,000 – 190,000
Moderate	Peak	45,00 – 55,000	40,000 – 50,000
	Moderate	60,000 – 110,000	50,000 – 100,000
	Low	120,000 – 180,000	110,000 – 170,000
Small	Peak	40,000 – 50,000	35,000 - 50,000
	Moderate	50,00 – 75,000	45,000 – 70,000
	Low	110,000 – 170,000	100,000 – 160,000

3.3.3 Horses

The determinant of horse prices is not only on their sizes, but on their skin color and their good training to participate in racing competitions. Their supply to the market differs from season to season and from time to time. There are three peak periods of horses supply and low price: (i) during ceremonial activities of *Maulud, Id-alkabir,* and *Id-al fitr* of Muslims religious festivals; (ii) during Christmas celebration; (iii) during cool and dry season *(kaka*). Warm and wet season is the moderate period of their prices. While the lowest price period is hot and dry season (Table 3).

The prices in Table 3 are the normal market prices, but the prices increase based on special cases, especially those horses who have three qualities i.e. color, structure and a well trained horse for racing game, and such horses can cost over one million Naira (1,000,000). The best color that attracts high cost is pure white color and cheapest and lowest quality color is black and ugly.

3.3.4 Donkeys

The fourth category of the livestock sold in Maigatari and Dungass markets are donkeys. Their prices also fluctuate between seasons and according to supply and demand relations. Their peak period of supply in both markets are during harvesting period i.e. cool and dry season and that time is their lowest price period. Hot and dry season (*Bazara*) is their moderate supply and prices period and their low supply period is warm and wet season (*Damina*) and the highest price period (Table 4). The tabulated prices may increase or decrease according to supply and demand relationship.

Table 3: Prices of Horses at Different Times of Supply

Size	Period of supply	Price at Maigatari (₦)	Price at Dungass (₦)
Big	Peak period	80,000 – 95,000	60,000 – 80,000
	Moderate period	100,000 – 115,000	80’000 – 140,000
	Low period	120,0000 - 250,000	100,000 – 220,000
Moderate	Peak period	50,000 – 100,000	40,000 – 95,000
	Moderate period	80’000 – 120,000	70’000 – 100’000
	Low period	110,000 – 220,000	100,000 –200,000
Small	Peak period	30,000 – 60,000	30,000 – 55,000
	Moderate period	40,000 – 50,000	30,000 – 60,000

	Low period	50,000 – 80,000	35,000 – 80,000

Table 4: Prices of Donkeys at Different Times of Supply

Period of supply	**Size**	**Price at Maigatari (₦)**	**Price at Dungass (₦)**
Peak period	Big	20,000 – 24,000	17,000 – 29,000
	Moderate	25,000 – 29,000	20,000 – 30,000
	Small	30,000 - 35,000	25,000 – 32,000
Moderate period	Big	15,000 – 18,000	13,000 – 16,500
	Moderate	20,000 – 25,000	17,000 – 24,000
	Small	28,000 – 30,000	26,000 – 29,000
Low period	Big	17,000 – 20,000	15,000 – 18,000
	Moderate	23,000 – 25,000	20,000 - 23,500
	Small	27,000 – 29,000	24,000 – 28,000

3.3.5 Goat and Sheep

The seasonal variation in the prices of sheep and goats depends largely on the relationship of supply and demand. When the supply is at its peak and demand is low, their prices will drop, in contrast when the demand is high and the supply is low their prices will be high. There are three different periods of supply - peak, moderate and low periods. The peak period of their supply comes during cool and dry season (*Kaka*), moderate period comes in warm and wet season (*Damina*), and the markets experience low supply during hot and dry season. At normal market price, they are cheaper during their peak period of supply, their prices are moderate during moderate period of supply and their highest price period comes when supply is low (Tables 5 and 6). The above are the normal market prices, but the price may exceed the one listed above based on sex differences, fatness of the goat or sheep, and as a result of religious festival or ceremonies.

Table 5: Prices of Goats at Different Times of Supply

Period of Supply	Size	Price at Maigatari (₦)	Price at Dungass (₦)
Peak period	Big	6,000 – 9,000	4,500 – 7,500
	Moderate	10,000 – 13,000	8,000 – 10,000
	Small	14,000 – 20,000	12,000 – 15,000
Moderate period	Big	6,000 – 7,000	4000 - 5,500
	Moderate	8,000 – 11,000	6,000 - 8,000
	Small	12,000 – 15,000	10,000 – 12,500
Low period	Big	4,000 – 6,000	4,000 – 5,500
	Moderate	6,500 – 8,000	6,000 – 7,500
	Small	10,000 - 12,500	8,000 – 11,000

Table 6: Prices of Sheep in Different Times of Supply

Period of supply	Size	Price at Maigatari (₦)	Price at Dungass (₦)
Peak period	Big	7,000 – 11,000	6,000 – 9,500
	Moderate	12,000 – 17,000	10,000 – 14,000
	Small	18,000 – 30,000	15,000 – 25,000
Moderate period	Big	7,000 – 10,000	8.000 - 9,000
	Moderate	12,000 – 13,000	10,000 - 11,500
	Small	15,000 – 25,000	12,000 – 23,500
Low period	Big	6,000 – 9,500	5,000 – 8,000
	Moderate	10,000 – 12,000	8,000 – 11,000
	Small	13,000 - 14,500	11,000 – 13,000

3.4 Seasonal Variation in the Price of Farm Produce

Farm produce, like livestock traded in Maigatari and Dungass markets, experience price fluctuations across the year. Their prices change from season to season and from time to time. It can even change on daily basis, i.e. from morning to evening. The most important farm produce cultivated and traded in the study area are millets, guinea corn, beans, sesames, and groundnut. Their prices change according to their supply and demand in the markets. When their supply in the market is high, their prices would be low and this happen during harvesting period i.e. cool and dry season (*Kaka*). When their supplies and demands are at equilibrium their prices would be moderate and this occurs during dry and hot season. While in situation where the supply is low, the prices of the farm produce would be high and costly, and this is what is happening during warm and wet season *(Damina*). In addition to that, two of the farm produce are cheaper in Maigatari market i.e. millet and guinea corn. While local beans (*Dan aloka)* is cheaper in Dungass market than in Maigatari market, but the price of sesame and groundnut are the same in both markets (Table 7).

Table 7: Prices of Farm Produce per Sack of 50kg at Different Times of Supply

Period of Supply	Type of Produce	Price at Maigatari (₦)	Price at Dungass (₦)
Peak period (cool and dry season)	Millet	3200 – 4800	4000 – 5,600
	Guinea corn	2400 – 3400	3000 – 4,200
	Beans	6000 – 7,200	3,200 – 5,200
	Sesames	8000 – 10,000	8,000 – 10,000
	Ground nut	12,000 – 14,000	12,000 – 14,000
Moderate (dry and hot season)	Millet	6,000 – 6,800	7,200 – 8,000
	Guinea corn	3,600 – 4,800	4,000 – 5,200
	Beans	7,600 – 8,000	6,400 – 7,200
	Sesames	10,400 – 12,000	10,000 – 12,000
	Ground nut	16,000 – 20,000	16,000 – 20,000
Low period of supply (warm and wet season)	Millet	7,200 – 8,000	8,000 – 8,800
	Guinea corn	6,000 – 6.400	7,200 - 8,000

Beans	10,000 – 20,000	8,800 – 12,000
Sesames	16,000 – 20,000	16,000 – 20,000
Ground nut	20,800 – 22,000.	20,800 – 22,000.

4. CONCLUSION

From the findings of this study, it can be concluded that the source of most livestock traded in both markets comes from Niger Republic, and the sources of farm produce traded in both markets comes from Nigeria, as such livestock are cheaper in Dungass market and farm produce are cheaper in Maigatari market. It can also be concluded that traders were suffering from problems of price fluctuating across the seasons of the year, which as a result leads to trade deficit. Therefore, this study was conducted to educate the traders on the nature of these fluctuations at different climatic seasons. This study showed that the supply and prices of both livestock and farm produce fluctuate according to season and due to religious festival or ceremonial activities, normally the prices become low during cool and dry season when the supply of the commodities are high and there is low demand. Also, the prices become high due to high demand and low supply which normally happen during warm and wet season.

4.1 Recommendations

Based on the findings of this study, it is hereby recommended that:

i. As the livestock are cheaper in Dungass market and farm produce are cheaper in Maigatari market, traders should be buying livestock from Dungass and market and exchanging them with farm produce of Maigatari to gain more profit.

ii. Good extension services should be provided to enlighten the traders on the reason for fluctuating in the price and supplies of the commodities to minimize the risk of loses and maximize their gains.

iii. Government and private organizations should be giving loan to traders to boast their capitals especially during peak periods of supply. This will in turn assist the producers to gain more profit.

iv. Market association should be encouraged to be participating in national and international trade conferences so as to attain world trade standard.

v. Due to dynamic nature of the trade in livestock and farm produce, further study is recommended on this topic periodically.

REFERENCES

Abdullahi, B. (2013). *Analysis of Cross Border Cattle Trade between Niger and Nigeria.* Unpublished PhD Thesis, Department of Economics, Abubakar Tafawa Balewa University of Science and Technology, Bauchi.

Addo, P. (2006) Cross – Border Criminal Activities in West Africa: Options for Effective Responses. *KAIPTC paper No. 1*, May 2006.

Cheikh, T.D. (2015). *What African Worth in International Trade System?* (ICTSD) Publications Switzerland. www.ictsd.org/bridge-news/bridge-africa/news.

Hong, H. and Yu, J. (2006). Gone Fishing: Seasonality in Trading Activity and Asset Prices, paper presented at

USC FBE Finance Seminar held at Columbia University, April 7.

Maty (2011). *Cross-border Flows of Staple Foodstuff from Nigeria to Niger Republic*.www.inter-reseaux.org/…/nigeria/…/nigeri…. Accessed on 18/07/2015.

Mortimore, M. (2000). *Profile of Rainfall Change and Variability in the Kano-Maradi Region, 1960-2000*. UK: Drylands Research Crewkerne, Somerset.

Olofin, E.A, Nabegu, A.B. and Dambazau, A.M. (2008). *Wudil within Kano Region. A geographical Thesis*. Publication of the Department of Geography, Kano University of Science and Technology, Wudil.

Sahel and West Africa Club and Niger food crises unit (2007). Workshop: "*Food security and cross border trade*" organized in Katsina 19 – 21 September, 2007.

Soulé, B.G. and Obi, C. (2001). *Prospects for Trade between Nigeria and its Neighbours*. Organisation for Economic Cooperation and Development (OECD).

William, F.S. (2005). Development not division: Local versus external perception of Nigeria – Niger boundary. *The Journal of Modern African Studies*. http://en.m.wikipedia.org/wiki/nigeri-nigerboundary.

Yakubu, A. (2014). *The role of Cattle Trade in Maigatari Economy of Jigawa State, Nigeria: 1960-2010*. Unpublished M.A. Thesis, Department of History and International Studies, University of Nigeria, Nsukka.

Savanna volume 23, Number 1, June, 2016

Land Suitability For Irish Potato *(Solanum tuberosum L.*) In Rugu-Rugu Village of Kano State, Nigeria

Umar I.A.[1], Ahmed M.[2]*, Salisu K.[2] and Murtala U. Mohammed[2]
[1]*Department of Geography, Kano University of Science and Technology, Wudil*
[2]*Department of Geography, Bayero University Kano*
**ma7766554@gmail.com*

ABSTRACT

Lack of soil information contributed to the low output especially in the drylands region. This study conducted land evaluation for Irish potato cultivation under fadama irrigation management in Rugu-Rugu district, Tudun-Wada Local Government Area, Kano state. The Food and Agriculture Organisation (FAO) framework was adopted. Simple random sampling method was used in the collections of soil samples in each of the mapping units. Three soil mapping units were identified on the basis of soil characteristics which includes the Recessional land (RA), Lower fadama land (LF) and the Upper fadama land (UF). The result indicated that mapping unit RA (Recessional land) was found to have only two limitations – soils chemical properties and drainage, mapping unit LF (Lower fadama land) was found to have four limitations – soils chemical properties, slope, drainage and land workability and mapping unit UF (Upper fadama land) was the most serious with five limitations – soils chemical properties, slope, drainage, erosion hazard and land workability. The study recommends for application of organic and inorganic fertilizers in a complimentary manner, drainage network of the irrigated area should be revisited and ridges to be constructed across the slope direction.

Keywords: Land suitability; Soil mapping units; Fadama irrigation management; Irish potato.

1. INTRODUCTION

The world population has been increasing rapidly for many years. According to experts, if this trend continues at the present rate, the population will double in the next few years. However, land resources are not infinite. The Food and Agriculture Organization of the United Nations (FAO, 1993) indicated that there is an urgent need to match land types and landuses in the most practical and logical ways in order to continue sustainable food production for the teaming population. Land evaluation is concerned with assessment of land performance when used for a specified purpose. In other words, land evaluation is likely to be the prediction of land potentials for productive landuse types. The results are a measure of the suitability of each kind of landuse for each type of land (Dent, 1981). Many potential lands are annually being degraded because of mismanagement (Saida et al., 2006). There have been many examples of damages to the soil resources such as loss of soil nutrient, soil erosion and destruction of soil structure. Land evaluation therefore has a very important role to play in bringing about such understanding and in presenting planners with a comparison of the requirements of different kinds of landuse (Adamu et al., 2014).

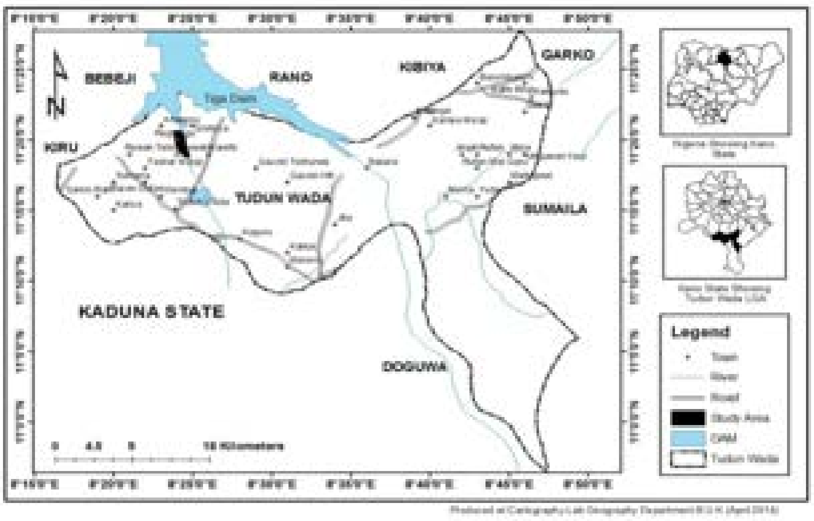
Irish potato (*solanum tuberosum L.*) is the main root or tuber crop and fourth most important food crop in the world after rice, wheat and maize, and is produced in over 125 countries, consumed by over a billion people (International Potato Center, 2008). Potatoes are an important source of food, employment and income in the production areas. Its high energy content and ease of production have also made it an important component of urban agriculture during dry season which provides jobs and food security to some 800 million people (FAO, 2008).

Irish potato like many other crops require certain soil conditions to grow. Therefore, this study analyzed the suitability for Irish potato production in the fadama irrigated land of Rugu-Rugu district. It is imperative to assess the fadama irrigated land in the area to determine the overall suitability of the land for sustainable Irish potato cultivation.

1.1 Study Area

Rugu-Rugu area is one of the important districts in Tudun Wada Local Government Area (LGA) which comprises of Rugu-Rugu, Yalwa and Shuwaki villages. Its description would be mere description of the entire T/wada LGA because of their similarity of climatic and environmental characteristics. Its therefore located between latitude ($11^\circ 00' - 11^\circ 30'$N) of the Equator and longitude ($8^\circ 15' - 8^\circ 45'$E) of Greenwhich Meridian (Figure 1). It receives average annual rainfall of about 800mm to 1000mm (Hocking, 1979 in Ahmad, 2006).

Figure 1: Study Area



2. MATERIALS AND METHODS

Land or soil evaluation information particularly field measurable variable data, soil fertility parameters and other observable data were considered as primary sources for this research. For the purpose of this study, slope, soil texture, pH, NPK OM. Map such as satellite imagery, topo sheet etc and other documents on climate, soils and water resources form part of the secondary sources of data used for the study.

2.1 Sampling Technique

Three mapping areas were identified based on moisture regime, topography and soil colour (Figure 2); three were identified namely: the Recessional Land- where recessional farming is being carried out and is labelled with index (RA), the Lower Fadama Land- where irrigated farming is carried out and the soils are darker in colour and indexed as (LF) and the Upper Fadama Land where- irrigated farming is also at a full scale and the soils are brown in colour and thus indexed as (UF) (Figure 6). These mapping units were demarcated for easy classification of the area according to suitability of potato cultivation. However, mapping unit RA is located very close to Tiga dam along river Gishirya, near Yalwa village and is the largest area with total land area of 79 Ha, the second largest is the mapping unit LF which is located near

Rugu-Rugu village having total land area of 75 Ha, and the last and the smallest is mapping unit UF which is located near Shuwaki village- the extreme south of river Gishirya and it covers a total land area of 49 Ha. The areas cover a total of 203 Ha of land along the river (Figure 6).

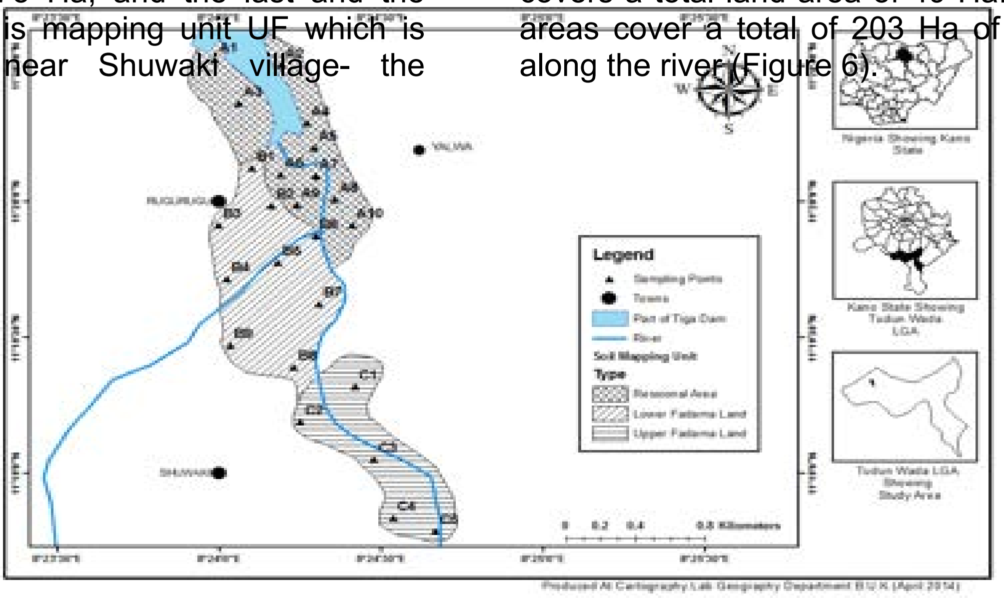


Figure 2: Mapping units and sample points.

2.2 Laboratory Analysis

The distributed soil samples collected from 0-30cm for fertility evaluation were air-dried, ground and sieved to remove materials larger than 2mm. The less than 2mm was used to determine some selected physico-chemical properties of the soils. Particle size distribution was determined by the hydrometer method (Day, 1965) and textural class using the USDA textural triangle. Soil pH was determined potentiometically after equilibrium with water and $CaCl_2$ in a 1:2.5 soils to solution ratio using a glass electrode pH meter. These were extracted using Ammonium Acetate (1N NH_4OAc) solution at pH7 (IITA, 1979). Ca and Mg were read on the atomic absorption spectrometer (AAS) and K and Na by using flame photometer. The CEC was determined by the neutral 1N NH_4OAc solution saturation method (Chapman, 1965) Available phosphorus was extracted by Bray No. 1 method (Bray and Kurtz, 1945). TN was determined by the macro-kjedall method (Bremmer, 1965). The OC content was determined by the Walkley and Black method (1934).

2.3 Mapping Procedure

The laboratory result was entered into Microsoft excel and exported into the GIS environment ArcGIS 9.3 software. The classified soil units were extracted from the Google Earth (image) which was compiled during the fieldwork. The image was geo-referenced and digitized. The laboratory results were combined with the extracted shapefiles of the soil units. The parameters (laboratory result) were mapped based on suitability for Irish potato.

Table 1: Land/agronomic requirement for Irish potato production

Land quality	Severity level			
Chemical soil properties	**S1 Highly suitable**	**S2 Moderately suitable**	**S3 Marginally suitable**	**N1 Currently not suitable**
N (%)	> 1.0	0.5-1.0	0.2-0.5	< 0.2
$P_{(ppm)}$	> 10	6.5-10	2.5-6.5	< 2.5
$K_{(ppm)}$	> 50	40-50	20-40	< 20
$pH_{(m)}$	5.5-5.6	5.0-5.5	4.7-5.0	< 4.7 - > 5.6
OM (%)	3-5	2-3	0.5-2	< 0.5
$CEC_{(meq/100g)}$	20-15	15-10	< 10	-
OC (%)	> 0.5	0.2-0.5	< 0.2	-
$Na_{(ppm)}$	> 20	20-15	15-10	< 10
$Ca_{(ppm)}$	> 10	8-10	4-8	< 4
$Mg_{(ppm)}$	> 2.0	0.5 -2.0	< 0.5	-
Physical properties				
Soil texture	SL, L	LS, SC, ÷	SiL, CL	C
Slope (^{0})	0-3	3-5	5-6	> 6
Soil drainage	Well drained	Moderately drained	Drained	Poorly drained
Erosion Hazard	None	Slightly eroded	Eroded	Severely eroded
Workability	Easily worked	Worked	Partially worked	Badly worked

Source: Dent and Young (1981), Okonkwo (1995), Metson (1961), Muthoni (2009), Babaji (2005), Babaji (2006) and Kiiya (2006).

2.4 Suitability Rating for Erosion

Soil erosion status of the study area was determined qualitatively. Soil erosion is closely associated with soil texture and slope of the land. Though, other environmental condition needed for the growth of potato like physical condition especially temperature and humidity (Merlyn and Jajang, 2016).

3. RESULTS AND DISCUSSION

To characterise the land evaluation (mapping) units into suitability classes, FAO (1985) was used which include the relevant land qualities and characteristics considered, these include; chemical soil fertility indices like organic matter /carbon, cation exchange capacity, exchangeable bases, soil reaction, available phosphorous, nitrogen, potassium. Other parameters include soils texture, slope, land workability and erosion hazard were also discussed.

3.1 Physical Properties of the Mapping Areas

Physical properties concern not only soil solids but water and air as well. The important physical property of soils considered in this work is the soil texture. These properties help determine not only the nutrients-supplying ability of soil but also the supply of water and air necessary for plant root activity. The proportion of each size group in a given soil (the texture) cannot be easily altered, it is considered a basic property of a soil and is also grouped in to three; the clay, silt and sand. These are classified into; sandy soils, loamy soils and clayey soils using USDA soil textural class. Other physical properties such as soil aeration, erosion and ease of tillage have direct relationship with soil textural class of a given location.

3.2 Soil Texture, AWHC and Slope

The textures of the soils of the study area are generally loamy (moderately coarse to medium coarse loamy soil) (Table 2). The Recessional Land (unit RA) has the proportion of 43.40% sand, 39.60% silt and 5.735% clay on the average and therefore was classified as loam soils. The Lower Fadama Land (unit LF) has the proportion of 38.11% sand, 42.0% silt and 19.889% clay on the average and is classified as loam soils. The mapping unit UF (Upper Fadama Land) possess the proportion of 51.0% sand, 34.0% silt and 15.0% clay and hence is classified as loam soils. Thus in general, the soils of the mapping areas indicated clearly loam soils. Slope angle of the study area was measured to be at the ranges between 2 to 6 degrees (3.25 averages). The mapping unit RA (Recessional Land) was measured at 2.1 degree, mapping unit LF (Lower Fadama Land) was measured at 3.5 degree and mapping unit UF (Upper Fadama Land) was measured at 5.0 degree. The slope as observed is within the acceptable ranges for irrigation farming (Ya'u, 1998).

Table 2: Physical Properties of the Mapping Units (Texture, AWHC and Slope)

Soil Mapping Units	%Sand	%Silt	%Clay	Textural Class	AWHC (cm/cm)	Slope (^{0})
Recessional Land (RA)	**43.400**	**39.600**	**17.000**	**Loam**	**0.160**	**2.1**
SD	11.853	8.488	5.735		0.023	2.645
CV	0.273	0.214	0.337		0.163	1.259
Lower Fadama (LF)	**38.111**	**42.000**	**19.889**	**Loam**	**0.146**	**3.5**
SD	9.597	6.164	7.688		0.014	2.298
CV	0.252	0.147	0.387		0.098	0.656
Upper Fadama(UF)	**51.000**	**34.000**	**15.000**	**Loam**	**0.124**	**5.0**
SD	5.831	6.164	1.414		0.011	2.309
CV	0.114	0.181	0.094		0.092	0.461

3.3 Soil Chemical Properties of the Mapping Units

3.3.1 Soil Reaction (pH)

Generally, the pH of the area ranges from 4.2-6.4, for all the samples collected from all the mapping units, indicating the soils are generally acidic. The pH values of the soil mapping unit RA (Recessional Land) was 5.04 on the average, which indicates the soils are moderately acidic; the pH value of the soil mapping unit LF (Lower Fadama Land) was 5.5 indicating the soils also being moderately acidic and for soil mapping unit UF (Upper Fadama Land) which was 5.8 indicates the soils as acidic. The pH value between soils mapping units shows slight increase towards neutral (Table 3) and (Figure 3 Appendix 1).

Table 3: Mean values of some chemical properties of the mapping units

Soil Mapping Units	Na (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)	P (ppm)	pH	CEC (meq/100g)
Recessional Land (RA)	**12.200**	**44.467**	**7.320**	**0.127**	**13.740**	**5.040**	**12.020**
SD	2.649	13.706	1.951	0.086	1.902	0.440	3.513
CV	0.217	0.308	0.266	0.675	0.138	0.087	0.292
Lower Fadama (LF)	**14.296**	**39.778**	**9.407**	**0.089**	**17.811**	**5.467**	**11.400**
SD	2.771	12.441	2.381	0.047	5.797	0.245	5.026
CV	0.194	0.313	0.253	0.527	0.325	0.045	0.441
Upper Fadama (UF)	**11.600**	**30.133**	**6.933**	**0.120**	**8.731**	**5.820**	**7.040**
SD	1.673	14.790	1.402	0.030	1.176	0.460	1.278
CV	0.144	0.491	0.202	0.246	0.135	0.079	0.182

Nevertheless, Babaji (2006) recommended for pH to be between 4.7 and 5.2 while Dent and Young (1981) have also recommended pH of 5.6 for potato. The average values of each mapping unit observed are within the threshold of the crop. The acidic nature of the soils can be ascertained as a result of the influence it has on intensive growth of various crops in the area especially in the upper fadama land.

3.3.2 Cation Exchange Capacity (CEC)

The CEC of the study area generally ranges from 4.8-18.2meq/100g of soil. The CEC mean value of the soil mapping unit RA (Recessional land) is 12.020meq/100g of soil, the CEC mean value of the soil mapping unit LF (Lower fadama land) is 11.400meq/100g of soil and the CEC mean value of the soil mapping unit UF (Upper Fadama Land) is 7.040meq/100g of soil (Figure 6 Appendix 1).

FAO (1976) revealed that, CEC greater than 15 is the higher, 8-15 medium and less than 8 being the lower which is recognized for all tropical crops. As per the study conducted in a similar environment it was found that, the CEC needed by Irish potato crop is between 20-10meq/100g of soil (Kiiya, 2006).

3.3.3 Exchangeable Bases (Ca, Mg, Na, K)

The mean values of potassium (K) in the study area were generally measured to be 30.133ppm-44.467ppm. This indicated medium K contents in the soils of the study area. The mean value of K contents of the soil mapping unit RA (Recessional Land) was measured as 44.467ppm, the mean values in the soil mapping unit LF (Lower Fadama Land) was 39.778ppm and that of soil mapping unit UF (Upper Fadama) is 30.133ppm, with the K contents of unit RA been the highest (see Figure 5 Appendix 1). Babaji (2006), Kiiya (2006) and Muthoni (2009) in their studies have unanimously agreed on 66.3ppm-81.9ppm to be the optimum ranges of K value for a higher yield of irrigated crops.

The mean values of sodium (Na) for all soil mapping units studied were generally very low, however, the contents of Na is far greater than that of Ca and Mg (ppm). Soil mapping unit RA (Recessional Land) was found to be 12.2ppm on the average, mapping unit LF (Lower Fadama Land) was 14.297ppm on the average which recorded the highest amongst units and unit UF (Upper Fadama Land) was 11.600ppm on the average (see Figure 7 Appendix 1).

The value of Calcium (Ca) in the study area was very low and that it was found to be higher than Magnesium (Mg). Ca contents of all the mapping units were 12.067ppm-3.6ppm. In the mapping unit RA (Recessional land), the mean value was 7.320ppm, for mapping unit LF (Lower Fadama Land) it was 9.407ppm and for mapping unit UF (Upper Fadama Land) was recorded to be 6.933ppm (see Figure 4 Appendix 1).

The values of magnesium (Mg) were measured and found to be the least among metals in the area studied (0.333ppm-0.067ppm). In the mapping unit RA (Recessional land) Mg was measured 0.127ppm, for unit LF (Lower Fadama Land) is 0.089ppm and 0.120ppm for unit UF (Upper Fadama Land) (see Figure 8 Appendix 1)

3.3.4 Percentages of Organic Carbon, Nitrogen and Organic Matter (OM) Composition

The general nitrogen contents of the soils of the study area have been found to be medium to low (Table 9). Metson (1961) recommended the broad rating of nitrogen measurements as; greater than 1.0 (very high), 0.5-1.0 (high), 0.2-0.5 (medium) and 0.2 and below (low). The nitrogen contents mean values for the entire study area was found to be 0.028%-0.322%; and 0.134%, 0.072% and 0.062% mean values were obtained from mapping units RA (Recessional land), LF (Lower fadama land) and UF (Upper fadama land) respectively (see Figure 9 Appendix 1).

Table 4: Mean values of some chemical properties of the mapping units

Soil Mapping Units	Nitrogen (%)	% C	OM %
Recessional (RA)	**0.134**	**0.551**	**0.950**
SD	0.097	0.257	0.440
CV	0.723	0.467	0.463
Lower Fadama (LF)	**0.072**	**0.802**	**1.360**
SD	0.047	0.238	0.410
CV	0.653	0.297	0.301
Upper Fadama (UF)	**0.062**	**1.245**	**2.150**
SD	0.019	0.523	0.900
CV	0.305	0.420	0.419

The organic matter contents of the soil of the study area were generally measured between 0.207%-3.311% ranges. The organic matter contents (OM) of the soil mapping unit RA (Recessional land) was measured to be 0.950% on the average, the OM contents of the soil mapping unit LF (Lower fadama land) was found to be 1.360% on the average and that of soil mapping unit UF (Lower fadama land) was found to be 2.150% on the average. This indicated that result of OM shows a significant result in the area when compared with the finding of Ahmed and Jeb (2015).

3.3.5 Available Phosphorous (P)

The range of values of phosphorous contents for all the mapping units in the study area are generally high to medium (8.73ppm-17.81ppm) and with the average values of 13.740ppm, 17.811ppm and 8.731ppm were measured for soil mapping units RA (Recessional Land), LF (Lower Fadama Land) and UF (Upper Fadama Land) respectively. Mapping unit LF was found to be the highest and unit UF been lower (see Figure 11 Appendix 1).

3.4 Suitability for Drainability

Soil drainage for this study was determined qualitatively where certain physical properties were considered. The soil textural class was first considered in assessing the drainage conditions of the study area. The proportions of soils of the study area (sand, silt and clay) were found to be nearly equals. Therefore, it comprises of all types of soil and thus would have drained moderately. Some portion of the area was found to be sandy loam soils which drained much quicker and the dominant soils are loam, and its drainage is within the threshold of most crops (Brady, 1990).

3.5 Suitability Classification for Irish Potato

The suitability rating was assessed after comparing the data obtained from the mapping units with ratings provided by the literature consulted. The combination of the ratings of the individual land characteristics for each mapping unit gives the suitability of each mapping unit for the land utilization type (Irish potato).

Suitability assessment was carried out using maximum limitation methods (FAO, 1985) and the results shows that, all the three mapping units were classified as marginally suitable for the used specified with various degree of limitations as shown in Figure 3.

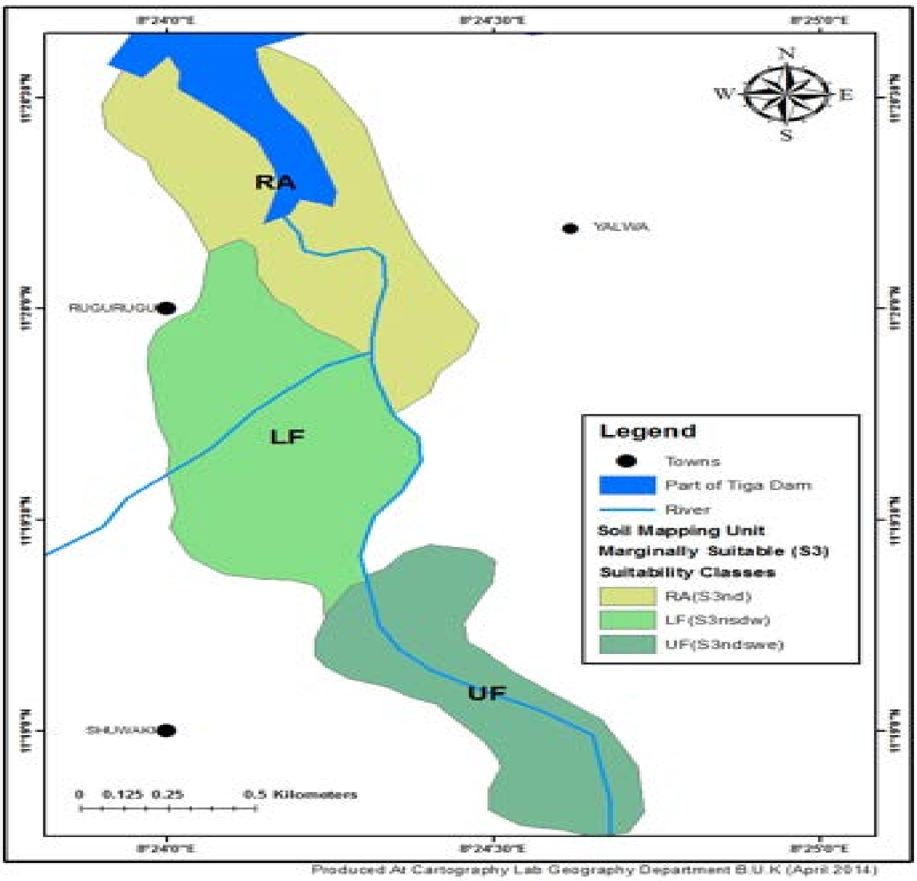


Figure 2: Suitability map for Irish Potato

4. CONCLUSION AND RECOMMENDATIONS

The research has identified the limitations associated with each mapping units requiring effort to correcting them. This include soil fertility indices (nutrient deficiency in the soils), which mostly have been existing in a low to medium content in all the three mapping units, drainage, slope, erosion hazard and land workability for the cultivation of Irish potato in the area.

Therefore, this study put forward the following recommendations:

i. The soils should be properly manured using both animal dung and crop residues to improve fertility of the soil and maintain its drainage.
ii. Inorganic fertilizers should also be applied in a complementary manner to replace lost nutrients.
iii. In case of areas that are prone to erosion, ridges should be made at cross direction to the slope while irrigated channels should be properly constructed.
iv. There is need for further studies to include other physical parameters like rainfall, temperature and humidity

REFERENCES

Adamu, G.K. (2013). *An Assessment of the Characteristics of Fadama Soils and Their Potentials in the Reaches of Major Streams in Parts of Kano State, Nigeria*. Unpublished PhD. Theses submitted to the Departmet of Geography Bayero University Kano, Nigeria.

Adamu, G.K, Yusuf, M.A. and Ahmed, M. (2014). Soil Degradation in Drylands*Part-I: Natural and Applied Sciences.*SAVAP International www.savap.org.pk

Ahmad, U.I. (2006). *Effects of gully erosion on agricultural farmland in Shuwaki Ward, Tudun-wada LGA, Kano State*.Unpublished B.Sc project, Dept. of Geography, B.U.K.

Ahmed, M. and Jeb, D.N. (2014). Land Suitability for Sorghum Using Multicriteria Evaluation (MCE) and Analytical Hierarchy Process (AHP) in Bunkure Kano State, Nigeria. *Journal of Agriculture and Veterinary Science* (IOSR-JAVS) e-ISSN: 2319- 2380. Volume 7, Issue 9 Ver. IV PP 25-37

Ahmed, K. (2006) *The Physical Environment of Kano State*, www.kanostate.net/physicalenvironment.html. 8th May, 2013.

Alonge, S.A. (1985). *Land evaluation for irrigated rice production in Kadawa irrigation project, Kano state*. Unpublished M.Sc thesis Bayero University, Kano.

Babaji, B.A., Mahmud, M., Jaliya, M.M. and Mohammed, S.G. (2006).Evaluating the contribution of Soil NP and K Contents to Tuber Yield of Irish Potato (Solanum tuberosum L.) at Samaru, Nigeria.Savannah *Journal of Agriculture,* 1(2). 94-102.

Babaji, B.A., Falaki, A.M, Abubakar, I.U and Ahmad, Y.S (2005). Contribution of some growth parameters to tuber yield of Irish potato (SolanumTuberosum, L.). *Journal of Tropical Bioscience,* 5(1).

Bagnall, R.H. (1977). Resistance to the Aphid-Borne Viruses in the Potato *Aphids As Virus Vectors* Pages 501–526

Brady, N.C. (1990). *The nature and properties of soils.* 10th edition.

Bray, R.H. and Kurts, L.T. (1945) Determination of total organic and available forms of phosphorus in soil. *Soil Science,* 59:39-45.

Bremner, J.M. and Mulvaney, C.S. (1982).Nitrogen-Total. In Page, A.L., Miller, R.H. and Keeney, D.R. (eds). *Methods of Soil Analysis.*Part 2 Agron 9.Madison WI. 595-624.

Buba, L.F. (2010). *Spatio Temporal rainfall and temperature variation in Northern Nigeria*. An Unpublished PhD thesis Submitted to the Geography Department Bayero University Kano, Nigeria

Chapman, H.D. (1965) Cation Exchange Capacity.In :Black C.A (ed). Methods of Soil Analysis.Part 2. *American Society of Agronomy*, Madison. Pp. 1149-1178.

CIP (International Potato Centre) (2008). *The international year of potato*.[http:/www.cipotato.org/pressroom/facts-figures/2008-international-year-ofpotato.asp]

Dent, D. and Young, A. (1981). *Soil Survey and Land Evaluation*. Geoge Allen and Unwininc. London.

Esseit U.E. (2013). *Soils. Geography of The Kano Region.* Published by Adonis & Abbey Publishers Ltd (ed) AITanko and S.B. Momale

FAO (1993). Guidelines for Land Use Planning. *FAO Development Series No. 1*, FAO, Rome, Italy.

FAO (Food and Agriculture Organization) (1985). *Food and Nutrition Series No.27*

FAO, (1976). A framework for land evaluation. *Soil Bulletin No: 32*. Food and Agriculture Organization of the United Nations (FAO), Rome, Italy.

FAO, (1985). Guidelines: land evaluation for irrigated agriculture, *FAO Bulletin No.55*, Rome, Italy.

FAO, (2008). Food and Agricultural Organisation of the United Nations. *International year of potato*, 2008.www.potato2008.org 14th April, 2013

IITA. (1979). Selected methods for soil and plant analysis. International Institute of Tropical Agriculture. *Manual series No. 1* pp 70.

Jamala, G.Y., Shehu, H.E., Musa, A.M. and Abraham, P. (2012). The Agricultural potentials of the Fadama Soils in northern Nigeria. *Journal of Soil Science and Environmental Management,* 3 (7) pp 176-181.

Kiiya, W.W., Mureithi, J.G. and Kiama, J.M. (2006). *Improving Production of Irish Potato. in Kenya: The use of green manure legumes for soil fertility Improvement*. KARI, 2006

Kowal, J. M. and Knabe, D.T. (1972). *An Agroclimatological atlas of Northern States of Nigeria with Explanatory Notes*. ABU Press, Zaria. Nigeria.

Liman, M., Idris, H.A. and Mohammed, U.K. (2014). Weather and Climate. In A.I Tanko and S.B. Mumale (Eds.) *Kano Environment, Society and Development*. London and Abuja, Adonis and Abbey Publishers.

London, J.R. (1991). Booker Tropical Soils Manual. John Willey and Sons Inc. New York

Merlyn, M., and Jajang S.H. (2016) Growth and Yield of *Solanumtuberosum* at Medium Plain with Application of Paclobutrazol and Paranet Shade. *Agriculture and Agricultural Science Procedia,* 9: 26 – 3

Metson, A.J. (1961) Method of Chemical analysis for soil survey samples.New Zealand DSIR. Soil Bur Bull Govt. Printer, Wellington New Zealand.

Muthoni, J. and Nyamongo, D.O. (2009).A review of Constraints to ware Irish Potatoes Production in Kenya.*Journal of Horticulture and Forestry,* 1(7): 98-102.

Okonkwo, J.C., Ene, L.S.O. and Okoli, O.O. (1995). *Potato production in Nigeria*. National Root Crops Research Institute, Umudike, Umuahia, Abia State, Nigeria. Pp109.

Usman, A. (2014). "*Rainfall variability in Kano region*". Unpublished M Sc. Theses submitted to the Geography Department Bayero University Kano, Nigeria

Saida A., Novita, E. and Ilsan, M. (2016). Sustainability Analysis of Potato Farming System at Sloping Land in Gowa Regency, South Sulawesi *Agriculture and Agricultural Science Procedia,* 9: 4-12 2210-7843. Available online at www.sciencedirect.com

Walkley, A. and Black, A. (1934**).** An examination of Degtjareff Method of Determining Soil Organic Matter and a proposed modification of the chromic acid titration method. *Soil Science,* 37: 29-38.

Ya'u, S. (1998). *Land suitability evaluation for improved rice cultivation in Watari Irrigation Project, Kano State, Nigeria*. Unpublished M.Sc thesis, Dept., of Geography, Bayero University, Kano.

Yusuf, M.A. (1994). *The Influence of Agricultural Management on Present and Potential Soil Quality under Small holder Conditions. A Case Study of Tumbau*. M.Sc. (Land Resource) Thesis, Department of Geography, Bayero University, Kano.

Yusuf, M.A. (2009). *Soil Quality and Sustainability of Agricultural Management under Small holder Conditions in the Kano Close-settled Zone, Kano State, Nigeria*.

APPENDIX 1

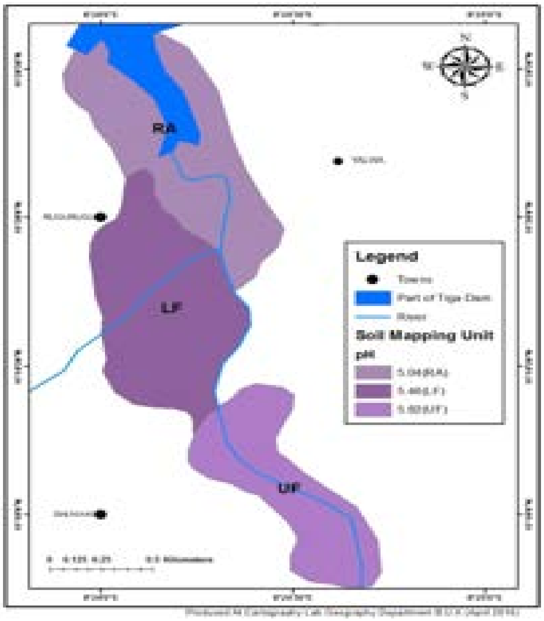


Figure 3: pH

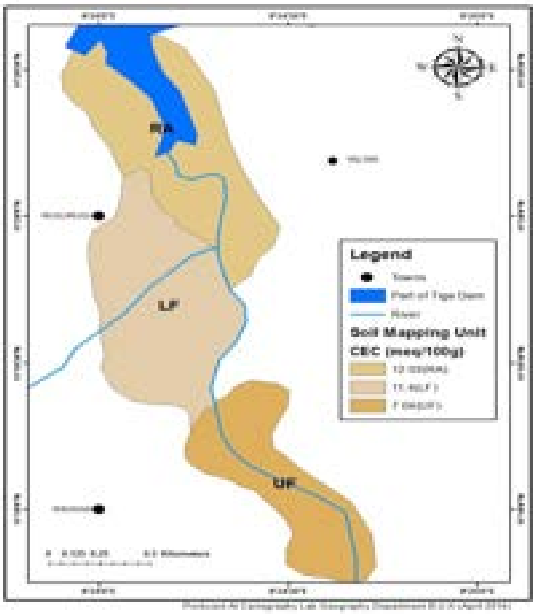
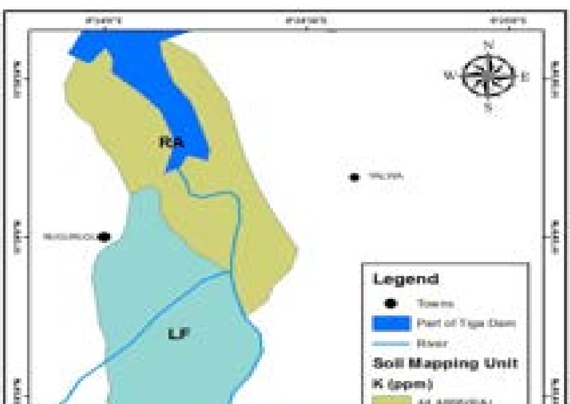


Figure 4: CE



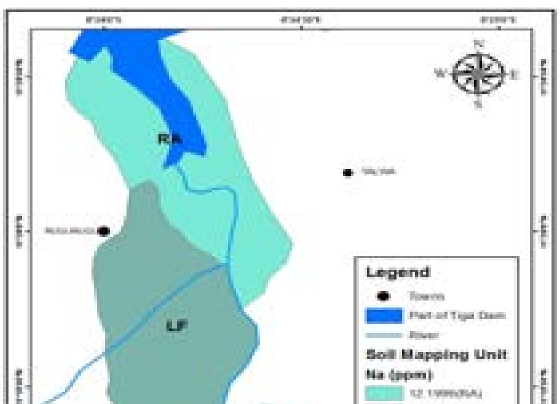


Figure 5: Potassium (K)

Figure 6: Sodium (Na)

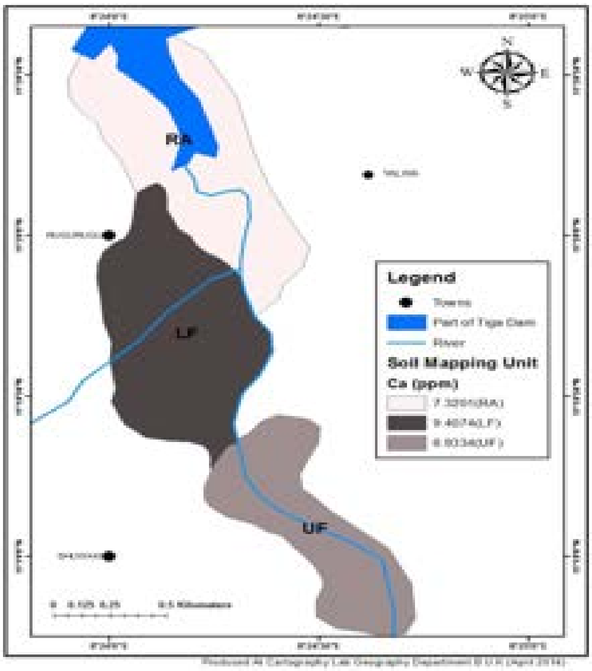


Figure 7: Ca

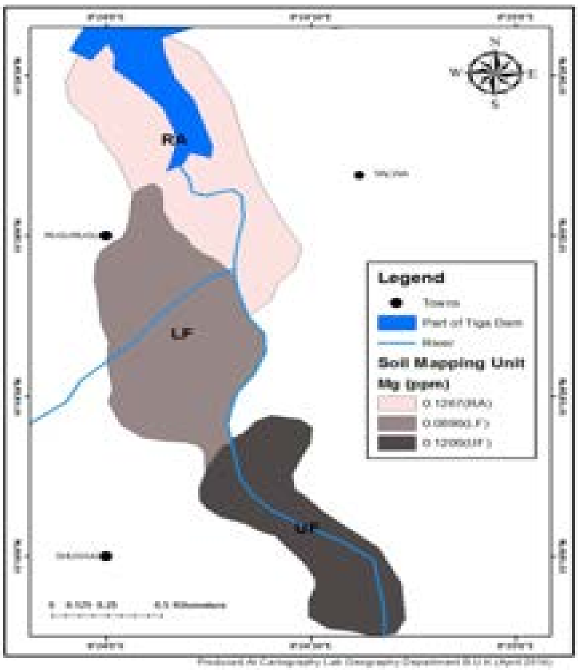
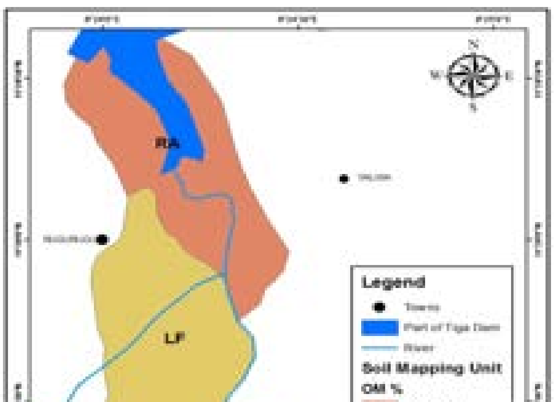


Figure 8: Magnesium (Mg)



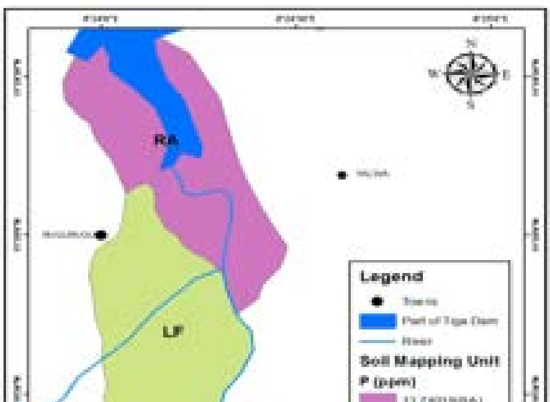


Figure 9: Organic Matter (OM)

Figure 10: Phosphorus (P)

Savanna volume 23, Number 1, June, 2016

An Assessment of the Geomorphological Significance of Soils in Parts of Niger State, Nigeria

Zuni Aminu[1]*, Jeffrey Friday Umoru[2], Haruna Gattah Aminu[3]
[1]*Department of Geography, Federal University Birnin-Kebbi, Kebbi State, Nigeria*
[2]*Department of Geography, Ibrahim Badamasi Babangida University, Lapai, Niger State, Nigeria*
[3]*Department of Agricultural Engineering, Ahmadu Bello University, Zaria*
*****aminuzuni@yahoo.com

ABSTRACT

This study assessed the geomorphological significance of soils in parts of Niger State. The objectives of the study include identifying the types of geomorphic responses in the study area and determining key soil physical properties of the study area. Fifty six soil samples comprising of four sub-samples were taken over eleven locations and analysed for particle size distribution and Atterberg limits. Slope characteristics along sampled points were also determined. The results of Atterberg limits tests indicate that 7.1% of the samples have a plasticity index less than 7, with 80.3% of the samples ranging between 7- 17, while 12.5% of the samples have plasticity index greater than 17- 27. Particle size distribution tests indicate that the soils of the study area are generally sandy –sandy clay loam. Five classes of slopes were identified in the study area and the results showed that slope classes between 2°– 2°.59″ and 3°– 3°59″ have the highest frequency of 14 and 12 respectively. This study showed that the soils in the area have moderate plasticity index and are well drained. However, the presence of active clays in some of the samples and the slope characteristics of the study area may mutually re-enforce swelling and heaving in soils and geomorphic processes such as gullying and water ponding in concavities (depressions and potholes). Recommendations include linking geomorphological information to infrastructural planning and development and timely repairs of infrastructures.

Keywords: Atterberg limits; geomorphological significance; plasticity; soils.

1. INTRODUCTION

Soil geomorphology deals with diverse and complex interactions between soil-forming processes and geomorphic responses on landscapes (Daniels & Hammer, 1992; Gerrard 1992) and gives a geomorphological view of the properties of soils and their applications. Soil geomorphology is an attempt to meld pedology and geomorphology to provide information about fine scale geomorphic aspects of the landscape (Gerrard, 1992; Brady and Weil, 2002; Gardiner and Miller, 2004). For example, a major role of geomorphology in construction is to provide adequate information on landscape forms and processes and the implications of any landscape modification by man. Soils have many properties, including texture, water holding capacity, adhesion, cohesion and flocculation. These properties combine to make soils useful for a wide range of purposes (Brady and Weil, 2002; Gardiner and Miller, 2004). As the basic structural foundation for construction of roads, buildings and so on, soil materials play an important role in the stability of such structures. For example, the particle size distribution, soil shrinkage limits, plastic and liquid limits determine the quality of roads, houses and construction of drainage facilities (Cameron et al., 1998).

With rising population and changes in landuse and landcover characteristics, soil and landscapes undergo modifications with often, dire hydro-geomorphic consequences such as accelerated erosion and flooding. For example, a survey by the Central Bank of Nigeria (CBN, 2002) on the state of Nigerian highways indicated that the poor state of Nigerian roads are exacerbated by cracking and collapses due to excessive gullying. In the study area, roads and other infrastructures are often undermined by advancing gully heads. Although various studies have been carried out in the study area on landuse and landcover changes (Dadzi, 2013), there is a dearth of information on the geomorphic significance of soils in the study area. Field observations in the study area during the rainy seasons showed that gully development, sediment deposition along paved and unpaved roads and building collapses are prevalent. Therefore, the aim of this study is to assess the geomorphic significance of soils in parts of Niger State. Specifically, the objectives of the study include identifying the types of geomorphic responses in the study area, and determining key soil physical properties of the study area with the view of establishing a relationship between the soil properties and the geomorphic responses observed in the study area.

1.1 Study Area

The study area is located between Latitudes 9°05′00″ to 9°25′00″N and Longitudes 6°25′ 00″ to 7°15′00″E (Figure 1), in a tropical climate characterized by two distinct seasons of wet and dry. The area has an annual rainfall ranging between 1400mm to 1600mm (Afolabi et al., 2014), where rainy season occurs between April and September with peak periods between July and August. The temperature varies within the seasons. During the dry season, the area is characterized by high temperatures between 30ºC and 36ºC which last from December to April, while the rainy season experiences low temperatures between 27°C and 30°C. Geologically, the study area belongs to the the Basement Complex rocks of mainly gneiss, magmatite and schist (Obaje, 2009). The ferruginous tropical soil is the most predominant soil type found in the study area while those around the inselbergs and other residual hills, and at the bed of rivers, are weakly developed soils (Jaiyeoba and Essoka, 2006). Hydromorphic soil is largely found in extensive flood plains of the Niger River. The study area, although drained by River Gurara, is characterized by seasonal shallow valley streams which dry out during the dry season and overflow their banks during the rainy season.

The natural vegetation of the study area belongs to the parkland guinea savannah which is characterized by a mixture of trees, scrubs and tall grasses. Common trees found in this area are locust bean, shear butter trees, and *Isoberlinia doka*. However, human activities such as cultivation and deforestation have greatly altered the density of vegetation cover in the study area (Jaiyeoba and Essoka, 2006).

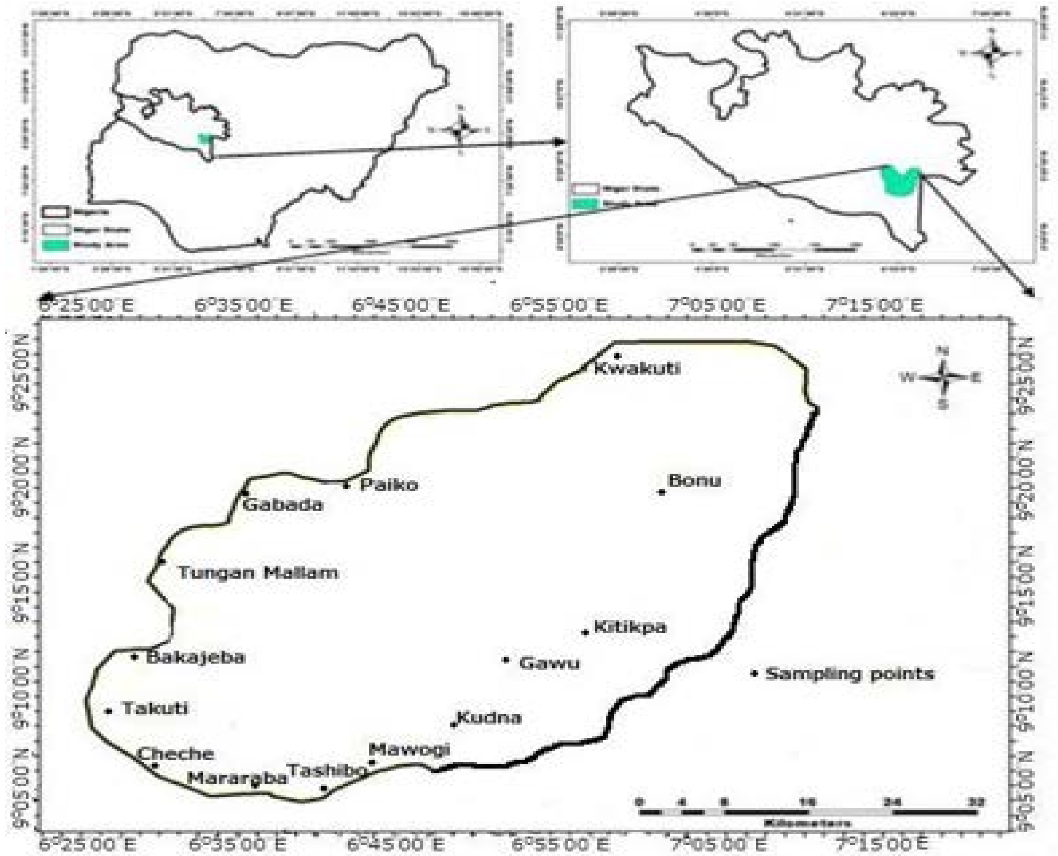


Figure 1: Geographical Location of the Study Area

2. MATERIALS AND METHODS

2.1 Methods of Data Collection

The spatial scope of this study centered specifically on Bonu, Kwakuti, Paiko Gabada, Tungan Mallam, Bakajeba, Takuti, Che-che, Mararaba, Tashibo, Mawogi, Kudna, Gawu, and Kitikpa villages. These villages were selected because of the prevalence of gully erosion along the degraded roads. Thus, the simple traverse method was used to collect samples for the study. Soil samples were taken from a depth of 0.5 – 1 meter. A total of fifty six (56) soil samples were taken at 100 meters interval across 14 locations (that is, four samples per location× 14) and used for the determination of particle size distribution and Atterberg limits tests. Particles size distribution tests were determined using the wet sieving technique. For the Atterberg limits tests, the soil samples were crushed and oven dried at a temperature of 105°C and sieved. Tests for three limits were carried out (at Material Testing Laboratory, Gilmor Engineering Nigeria limited, Abuja) and these are; plastic limit (PL), liquid limit (LL), and shrinkage limit (SL) tests. The plasticity index (PI) is the difference between the liquid limit (LL) and the plastic limit (PL) and indicates the water-content range over which the soil has plastic properties (Whalley, 1976; Engineering Manual, 1990; Braja, 1999; Nyle and Ray, 1999). Similarly, slope profiles along sampled points were measured using a handheld Abney level and a steel tape for slope angles and profile length.

3. RESULTS AND DISCUSSION

3.1 Particle Size Distribution Analysis

Results of the particle size distribution tests were used to plot the particle size distribution curves as presented in Figure 2. Soil particle distribution range between clay (0.002mm), silt (0.006-0.075mm), sand (0.150-0.600 mm) and gravel (1.18-12.70mm). The results indicate that the soils grains are generally sandy and ranged between sandy clay loam, sandy clay and loamy soils. The dominance of sand fractions in the soils can be attributed to the granitic lithology of the study area (Afolabi et al., 2014) or strong leaching regimes associated with the Savanna soils.

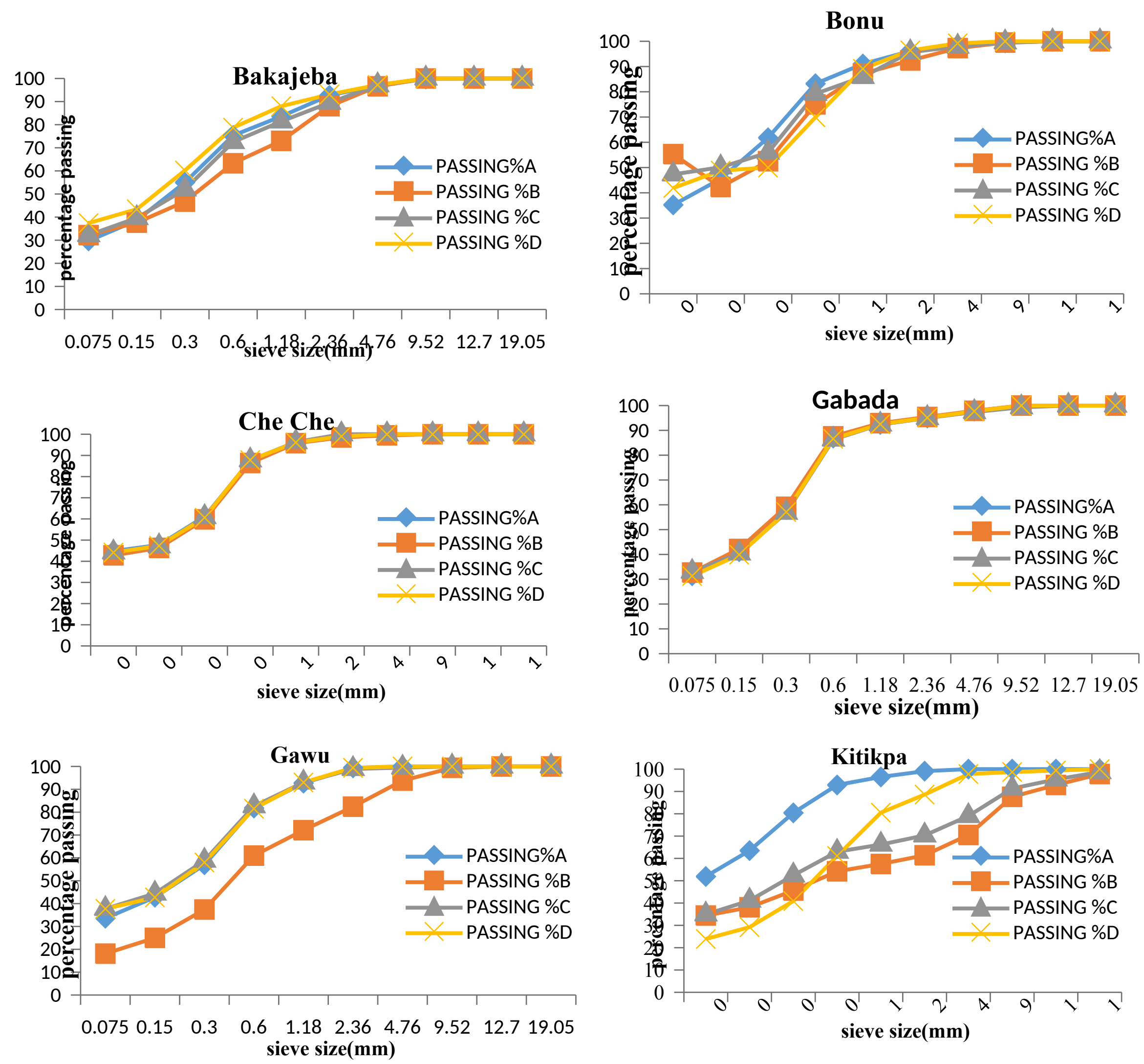


Figure 2a: Particle size distribution curves for soils in the study area

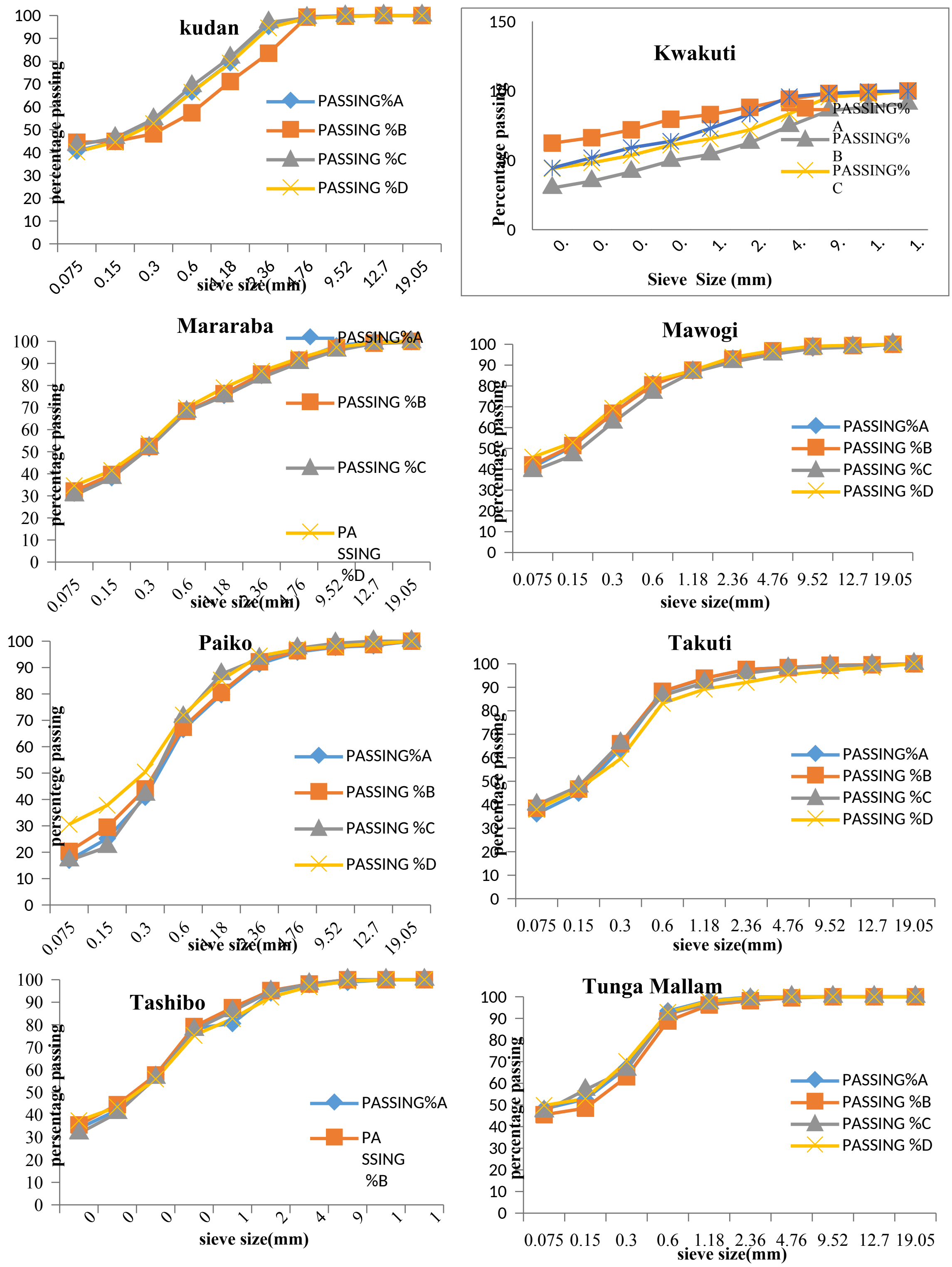


Figure 2b: Particle size distribution curves for soils in the study area

3.2 Atterberg Limits Tests

The results of Atterberg limits tests are presented in Table 1. The results indicate that four (7.1%) of the samples have a plasticity index less than 7, forty-five (80.3%) of the samples range between 7- 17, while seven (12.5%) of the samples have plasticity index greater than 17 to as high as a PI of 27. By Atterberg's classification, soils with plasticity index less than 7 are said to possess low plasticity. Plasticity index between 7 - 17 is medium, while soils with plasticity index greater than 17 are said to be highly plastic. This means that soils of the study area are by Atterberg's classification, medium plastic, slightly cohesive soils and are useful building materials. However, low PI in soils indicates that the soil is an undesirable foundation material (Waziri et al., 2012). The shrinkage limit (SL) for the soils ranges between 2.2 - 14.3. This has implication for soils with active clay fractions because when fine grains are wetted they absorb water and swell but crack when dry (Aminu et al., 2012).

Table 1: Atterberg Limits Tests Results for the Study Area

Study Location	Samples/ Sampling Points	LL	PL	PI	SL	Slope Distance (m)	Slope Angle (^{0})
BONU	A	48	31	17	9.4	-	
	B	28	18	20	8.6	100	3.20
	C	36	21	15	11.4	100	3.40
	D	44	30	14	12.9	100	2.45
KWAKUTI	A	56	31	25	12.9	-	
	B	38	11	27	11.4	100	4.11
	C	43	33	10	12.1	100	2.45
	D	47	38	9	12.2	100	2.30
PAIKO	A	20	15	7	8.6	-	
	B	31	19	12	7.9	100	1.08
	C	44	26	18	7.1	100	1.44
	D	33	20	13	9.4	100	2.05
GABADA	A	22	13	9	2.9	-	
	B	28	20	8	3.5	100	1.00
	C	25	16	9	2.9	100	0.49
	D	32	18	14	5.7	100	1.00
TUNGAN	A	47	29	18	13.7	-	
MALLAM	B	35	22	13	14.3	100	3.45
	C	33	20	13	13.7	100	2.05
	D	29	18	12	8.6	100	3.11
BAKAJEBA	A	21	18	3	3.6	-	
	B	25	16	9	2.9	100	2.08
	C	35	25	10	3.6	100	2.34
	D	44	29	15	13.7	100	3.40
TAKUTI	A	25	16	9	2.2	-	
	B	28	17	11	2.2	100	1.50
	C	24	14	10	2.9	100	1.55
	D	29	17	12	8.6	100	3.45
CHE-CHE	A	28	16	12	10	-	
	B	39	25	14	8.6	100	2.45
	C	49	31	18	10.7	100	3.20
	D	34	24	10	9.4	100	2.20
MARARABA	A	30	19	11	5.7	-	
	B	27	15	12	5.0	100	3.11
	C	24	13	11	5.7	100	2.08
	D	45	26	19	3.6	100	3.45
TASHIBO	A	28	20	8	3.6	-	
	B	25	21	4	5.0	100	2.05
	C	23	20	3	5.0	100	3.08
	D	26	12	14	5.0	100	1.45
MAWOGI	A	26	10	16	5.0	-	
	B	28	18	10	5.7	100	2.05
	C	30	19	11	5.0	100	2.48
	D	30	15	15	5.7	100	4.05
KUDNA	A	35	21	14	7.1	-	
	B	34	22	12	7.1	100	3.10
	C	48	32	16	7.1	100	1.35
	D	41	29	10	5.0	100	4.11
GAWU	A	27	13	14	5.0	-	
	B	28	16	12	5.7	100	2.08
	C	32	22	10	5.0	100	1.10
	D	28	15	13	5.7	100	4.38
KITIKPA	A	29	19	10	2.9	-	
	B	41	36	5	2.9	100	3.10
	C	47	30	17	3.6	100	2.05
	D	29	19	9	4.3	100	1.15

3.3 Slope Characteristics

Summary results of slope classes and distribution in the study area are presented in Table 2. Five classes of slopes were identified in the study area. The result from the table shows that slopes in the study area range between 1° – 4°, with slopes of between 2°– 2°.59″and 3°– 3°59° having the highest frequency of 14 and 12 respectively.

Table 2: Slope Angle Classifications and Description

Slope Description	Slope class	Slope frequency	Cumulative frequency
Undulating to very gentle	<1°	1	1
Gentle	1° – 1° 59″	11	12
Moderately steep	2°– 2°59″	14	26
Steep	3°– 3°59″	12	38
Very steep	4°– 4°59″	4	42
Total length (m)	4200		

This indicates that the study area is characterized by moderately steep to steep slopes. The slope characteristics have implication on all basin processes. For example, the slope characteristics influence storm runoff direction and sediment transport in response to heavy downpour occurring during the rainy season which influences the ground water conditions of a basin (Abashiya, 2006; Aminu et al., 2012; Aminu, 2015). Similarly, studies have shown that steeper slopes are characterized by shallow soil depths, coarse soil fractions, low organic matter content and low water tables while rills and gully developments are exacerbated by steep slopes (Aminu, 2015).

3.4 Relationship between Prevalent Geomorphic Responses and Soil Characteristics in the Study Area

Field observations showed that dominant geomorphic responses identified in the study area are erosion (gully and rill) and flooding. This is evidenced by deep gullies at the down-end of slopes along roads. Similarly, water ponding is observed in the middle of roads and in potholes. This may be attributed to the climatic, terrain and soil characteristics. For example, the study area is characterized by wet climatic regimes with rainfall depth of about 1400mm per annum (Afolabi et al., 2014). This predisposes the soil to erosion under the driving impact of rain, which detaches soil particles away from foundations of structures such as embankments, roads and buildings. High rainfall depths increase the antecedent moisture conditions of soils and encourage surface ponding and flooding by rain water (Plate Ia and b). Similarly, the nature of the terrain which is characterized by moderately steep slopes and the near absence of man-made drainages along all major roads in the study area influence storm runoff generation because where drains are inefficient or non-existent, roads and pathways often become arteries for runoff leading to localized flooding and erosion (Abashiya, 2006; Aminu, 2015). Field observations during the study showed that geomorphic processes such as water ponding and gully development around concavities where slopes dip are prevalent along major roads and may further exacerbate the poor conditions of major roads in the study area.

The particles size distribution tests indicate that the soils of the study area are composed of high sand fractions and are by USDA classification, sandy clay loam. The soils are well drained and predisposed to erosion due to the macro pores in the soil (Afolabi et al., 2014). Over exposed soils, the soil grains are prone to the abrasive effect of raindrop impact and may explain the prevalence of various forms of soil erosion such as gullying and sediment deposition along stretches of roads in the study area. Similarly, the low silt and clay fractions in soils may be attributed to the slow rate of weathering and the relatively young age of the soils (Waziri et al., 2012; Afolabi et al., 2014) and these bear considerable influence on the stability of structures especially pavements and roads. Similarly, the presence of gravels in high percentages in some of the samples destroys cohesion between soil particles. This coupled with thin coatings of tar, results in cracking and may be responsible for some of the dangerous potholes which characterize long stretches of the study area.

Results from the study also showed that soils at lower ends of slopes along stretches in the study area have high plasticity index due to the presence of active clays. This agrees with studies which have found that soils swell and expand when they are soaked and make poor foundations because the swelling or expansion of soils lower the liquid limits of such soils and result in heaving of structures (Nyle and Ray, 1999; Aminu et al., 2012; Waziri et al., 2012). This situation may be further exacerbated by terrain characteristics such as slope and the prevailing ground water conditions of the study area (Aminu, 2015).

Plate Ia: A Degraded Road in the Study Area Without Man-made Drainages.

Plate Ib: An Example of Water Ponding in Concavities Along Untarred Roads

4. CONCLUSION AND RECOMMENDATION

This study affirmed that despite the well drained nature of the soils of the study area, the presence of active clays in parts of the study area, slope characteristics and prevailing soil moisture conditions in the study area may encourage swelling and heaving of soils which pose serious dangers to foundations of built-up structures such as roads. Similarly, geomorphic processes such as water ponding in concavities (depressions and potholes) and gully development at down ends of slopes may further exacerbate the poor conditions of major roads in the study area. There is, therefore, the need for policies which encourage sustainable land management practices such as linking geomorphological information to infrastructural planning and development and timely repairs of infrastructures.

REFERENCES

Abashiya, M. (2006). *Influence of Man-made Structures on Floods in the Northern Parts of Kaduna Metropolis, Nigeria*. Unpublished MSc Thesis, Department of Geography, A.B.U., Zaria.

Afolabi, S.G., Adeboye, M.K.A., Lawal, B.A., Adekanmbi, A.A., Yusuf, A.A. and Tsado, P.A.
(2014). 'Evaluation of Some Soils of Minna Southern Guinea Savanna of Nigeria for Arable Crop Production'. *Nigerian*

Journal of Agriculture, Food and Environment, 10(4): 6-9.

Aminu, Z. (2015). *Geomorphology: An Introduction*. Ahmadu Bello University Press.

Aminu, Z., Bello, A.L and Iguisi, E.O. (2013). An Assessment of Drainage Characteristics and Their Hydro-geomorphic Implications on Housing in Zaria City, Kaduna State. *Biological and Environmental Sciences Journal for the Tropics* (BEST), 9(3), BUK, Kano.

Brady, N. and Weil, R. (2002). *The Nature and Properties of Soils*, 13th Edition. Prentice Hall. Upper Saddle River, New Jersey. 960pp.

Braja, M.D. (1999). *Principles of foundation Engineering*. Fourth Edition, Brooks/Cole Publishing Co. International Thompson Publishing Co. 43pp.

Cameron, K., Beare, M.H., McLaren, R.P. and Di, H. (1998). Selecting Physical, Chemical, and Biological indicators of Soil Quality for Degraded or Polluted Soils. *Proceedings of 16thWorld Congress of Soil Science. Scientific Registration No. 2516. Symposium No. 37.* August 20-26, Montpelier, France.

Central Bank of Nigeria (2002). *Annual Reports and Statement of Accounts for the Year Ended* December, 2002.

Dadzi, A. (2013). *Assessing Land Use Changes in Lapai Local Government Area*. An Unpublished B.sc Project Submitted to Geography Department, Ibrahim Badamasi University, Lapai, Niger State, Nigeria.

Daniels, R. B., Hammer, Richard D. (1992). *Soil Geomorphology*. New York, John Wiley & Sons, Inc.

Gardiner, D. T. and Miller, R.W. (2004). *Soils in Our Environment*, 10th Edition. Pearson Education, inc. Upper Saddle River New Jersey. P. 641

Gerrard, J. (1992). *Soil Geomorphology - An Integration of Pedology and Geomorphology*. London, Chapman & Hall.

Jaiyeoba, I.A. and Essoka, P.E. (2006). 'Soils and Vegetation' in *The Middle Niger River Basin :A field Course Hand Book*. Department of Geography, Ahmadu Bello University, Zaria.

Nyle, B.C. and Ray, W.R. (1999). *The nature and properties of soil*. Twelfth Edition. Prentice Hall Inc. New Jersey.

Obaje, N.G. (2009). Geology and Mineral Resources of Nigeria. *Lecture Notes in Earth Sciences*. Published by Springers, Dordreccht Heidelberg, London and Newyork.

Waziri, .S.H., Idris-Nda, A., Okunlola, I.O., Akano, J.T. and Yusuf, I. (2012). An Integration of Electrical Restivity Method and Geotechnical Analysis for Foundation Investigation : a Case Study of Talba Estate, Minna, Niger State. *Development Journal of Science and Technology (DJOSTER),* 1(1).

Whalley, W.B. (1976). *Properties of Materials and Geomorphological Explanation*. Oxford University Press. 60 p.

Savanna volume 23, Number 1, June, 2016

Spatial Analysis of the Distribution of Soil Characteristics on Fadama Land along River Challawa in Kano State, Nigeria

Abdulkadir, M.[1]*, Iguisi, E.O.[2], Akpu, B.[2] and Ahmed, M.[3]
[1]*Kano State Secondary Schools Management Board, Kano, Nigeria*
[2]*Department of Geography & Environmental Management, Ahmadu Bello University, Zaria*
[3]*Department of Geography, Bayero University, Kano, Nigeria*
**abdulkadir2037@gmail.com*

ABSTRACT

This study analyzed the spatial distribution of soil characteristics on Fadama land along River Challawa in Kano State, Nigeria. Considering the apparent variability of soils at the river bank to support landcover, some six clusters were chosen for sampling three points per cluster at a single level depth of 15cm. Standard laboratory's soil routine analysis was utilized for analyzing selected parameters (pH, N, P, K, Ca, Mg, Na, OC, CEC and Zn). From the results, the primary nutrients NPK had the mean values as 0.76 g/kg^{-1}, 26.35 g/kg^{-1} and 0.31 g/kg^{-1} respectively; and secondary nutrients, Ca, Mg and Na were found to have mean values of 4.42cmol/kg^{-1}, 0.80cmol/kg^{-1} and 0.30cmol/kg^{-} respectively. Sand, silt and clay particles had the following respective mean levels of 48.78g/kg^{-1}, 39.11g/kg^{-1} and 12.11g/kg^{-1} respectively. Similarly, the values for soil reactions range from (pH H_2O 6.00-6.900 and pH $CaCl_2$ 5.40-5.90). These data were subsequently transformed in Geographic Information System (GIS) environment using Inverse Distance Weighted (IDW) interpolation model in the ArcGIS 10.1 software. The results showed spatial variability in the distributions of soil parameters. While some parameters such as nitrogen are moderately and adequately distributed, others like potassium were grossly under represented by a fraction of distribution measure. However, some others such as calcium, magnesium and sodium were relatively and fairly distributed in the whole study area. This study recommended that farm site analyses of soil parameters should be periodic rather than on irregular basis.

Keywords: Fadama; River Challawa; Remote Sensing; GIS; Inverse Distance Weighting.

1. INTRODUCTION

Soils play vital role in the making of qualitative agricultural outputs and by extension boost the overall food production. The quality of a given soil is essentially related to biological, chemical and physical properties, processes and coupling with interactionswithin each resource unit (Karlen, Andrews, and Doran, 2001). Such processes do not function in isolation but rather combined with various nutrients which when supplied in appropriate quantities will enrich soils. The presence of sufficiently fertile soils that support the cultivation of crops has been identified as a significant potential of an agro-system (World Bank and DIFD, 2002).

The severe degradation of soil's productive capacity has occurred on over 10% of the Earth's vegetated land owing to decline in soil fertility (Lal, 1997). As farmers keep struggling to increase food production by means of expanding cultivable areas, their effort is sometimes hampered by factors of fertility decline (Ogunkoya and Adekayode, 2009). There is however clear distinction on manner by which the quality of agricultural soils is reduced between developed and developing countries. In developed countries, over-application of inorganic fertilizer is reported to have led to environmental contamination of soils (Baanante 1999). On a different angle, in developing countries, harsh climatic conditions, population pressure, insufficient application of nutrients and poor soil management are among the factors responsible for the degrading quality of soils (Smaling et all, 1997). Eventually, these features irrespective of their area of domain often affect both quality of soils and quantity of food production.

The vulnerability of Nigerians soils to fertility decline is a function of several factors.It is estimated that about 63% of agricultural soils in Nigeria are low in productivity because over 90% of these soils are alfisols and ultisols which are low in organic matter and have low-activity clays (Ojeniyi, 2008). This deteriorated soil's condition is no exception to particular soils scattered all over Nigeria, better known as Fadama soils. These hydromorphic soils found more often along river systems and have some viability for somewhat higher agriculture output and their extensive use makes them of high economic benefits (African Development Fund, 2013).

Insufficient technical knowledge on some aspects of Fadama lands and soils generally has probably rendered their proper management ineffective. In other words, information are still substantially generated manually to the exclusion of modern technology and many researchers have considered this practice as rigid, insufficient and so ineffective for optimum use of these soils. In recent years however, there has been increasing interest for integrating Geographic Information System (GIS) techniques in determination, spatial planning and management of soil information so as to provide support in decision making process about agriculture. Numerous interpolation tools in GIS such as spline, triangulation, kriging and Inverse Distance Weighted (IDW) allow the determination and distribution of continuous data on phenomenon like rainfall, temperature, humidity, soil or distribution soil properties (Chen and Wuing, 2012).

These efforts have so far proved invaluable in addressing soil related challenges because detailed spatial information are readily made accessible (Burrough, Macmillan and Van Deursen, 1992), as attested by the following instances. The research carried out by Ishaya, Mashi and Ifatimehin (2008) with its follow-up undertaken by Ishaya and Ifatimehin (2009) employing the combined techniques of remote sensing and GIS produced map of Fadama farming areas along the bank of River Usuma in Gwagwalada, Abuja. The result of the study shows that some 21.8% of the entire study areas were considered favourable for Fadama farming. Similarly, Ogunkoya and Adekayode (2009) used buffering technique in GIS to successfully estimate the potentials of Fadama land area in Akure Southwestern Nigeria. More aptly similar study is the assessment of spatial distribution of selected physiochemical parameters of soils using GIS techniques in Bunkure area of Kano State, Nigeria by Ahmed et al. (2014). It is interesting that the study has highlighted the application of IDW to soil studies. In the light of foregoing, this study seeks to use GIS technique to determine the spatial distribution of soil characteristics; and how they relate to fertility of Fadama soils along River Challawa floodplains in Kano State Nigeria.

1.1 Study Area

The study area is the Fadama floodplains along River Challawa, located between Latitudes11° 02′ 00″ N, 11° 3′ 43″N, and Longitudes 08° 41′ 35″ E, 08° 57 ′ 06″ E. The river serves as natural boundary that separate Kumbotso Local Government Area in the northeast from Madobi Local Government Area in the southwest. The study area is shown in Figure 1 below.

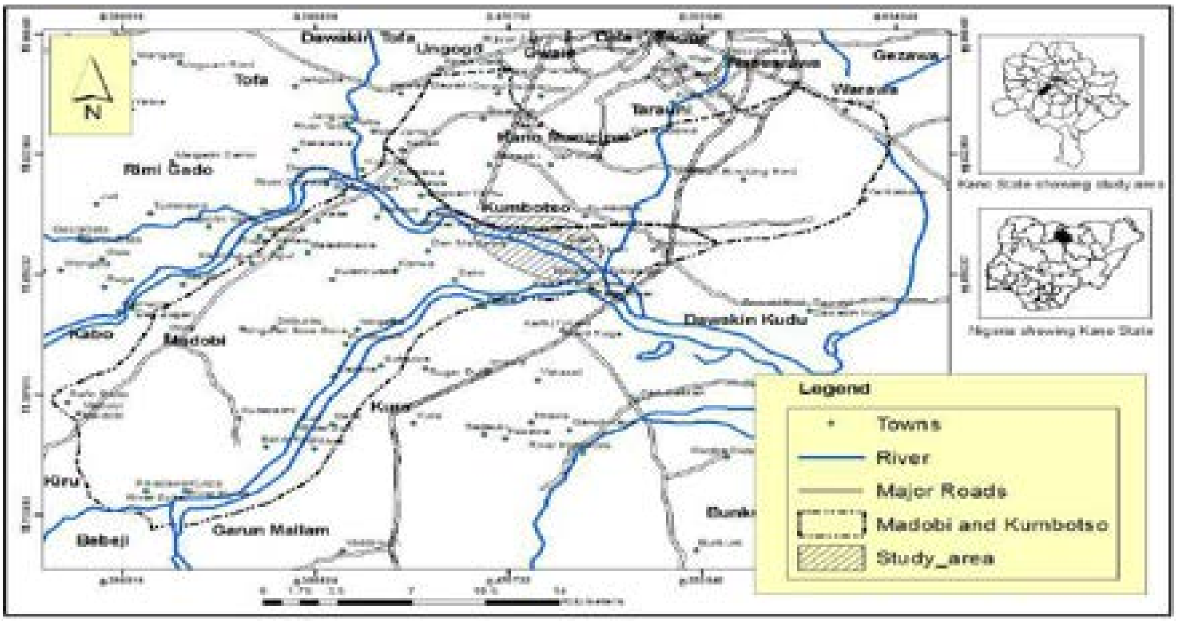


Figure 1: The Study Area
Source: Ministry of Land and Physical Planning, Kano State

The current climate of Kano region is prevailed by Tropical wet-and-dry, coded Aw based on Koppens system (Olofin, 1987). The mean annual rainfall ranges from over 1,000mm in the extreme south, decreases progressively to a little less than that in the extreme north (Ahmed, 2003). Kano experiences four distinct: *Rani, Damina, Kaka* and *Bazara.*Ahmed (2003) reported that there are three major rock formations namely Basement Complex Rocks, the younger granite rocks and the youngest Chad sediment. The drainage system in the basement complex area of Kano, according to USDA (1968) as quoted by Ahmed (2003), has two hydrological areas: the upland area and the Gari area. Thus, the upland area where Challawa belongs, receives higher annual rainfall (Over 800mm).

Intensive use of soils and addition of manure and chemical fertilizers have combined to alter their general characteristics (Falola, 2000). The dominant soils are less leached, slightly acid soils derived from wind rip soils, generally shallow and coarse (Ahmed, 2003). Though the subsistence rain-fed farming is the dominant agricultural system in the area (Ahmed, 2014); it is however complemented with more intensive yet more return per hectare, Fadama system. The intensification of agricultural activities along River Challawa and similar rivers has inevitably led to exhaustion of nutrients; a situation is compounded by an average of 11% low clay content (Ahmed, 2014).

2. MATERIALS AND METHODS

2.1 Types and Source of Data

The data used for this study were derived from primary sources and are presented below:

i. Topographic map of the study area at scale of 1:50,000.
ii. Spot-5 imagery (5metre resolution) of the study area for 2012, sourced from the Archive of the National Remote Sensing Centre (NRSC).
iii. Soil samples. The soil sampling, preparations and analyses were

carried out in accordance with Tan (2005) suggestions.

2.2 Sampling Technique

Onscreen gridding (2cm × 2cm) method was firstly performed on Google Earth which served as base map, for the identification of area. Because the study area had been embodied with heterogeneity in vegetation cover, clustering was chosen (Tan, 2005) as sampling technique so that the whole area was divided into clusters. Similarly, as a two-stage sampling plan, some six clusters were chosen and three sample grid cells per cluster were selected by simple random sample as was done by Ahmed (2009). These sample points are shown in Figure 2, and their coordinate values are in Appendix 1.

2.3 Field Survey and Samples Collection

Auger method was used in soil sample collections. Soils were collected at one layered-depth of 0-15cm using USDA's Soil Survey Manual (Soil Survey Staff, 1981). Again, at each point, a GPS reading was taken as point coordinates. Other field equipment used in soil sample collection were 30 meters measuring tape and ranging pole. Altogether, a total of 18 sampling points with same number soil samples were collected.

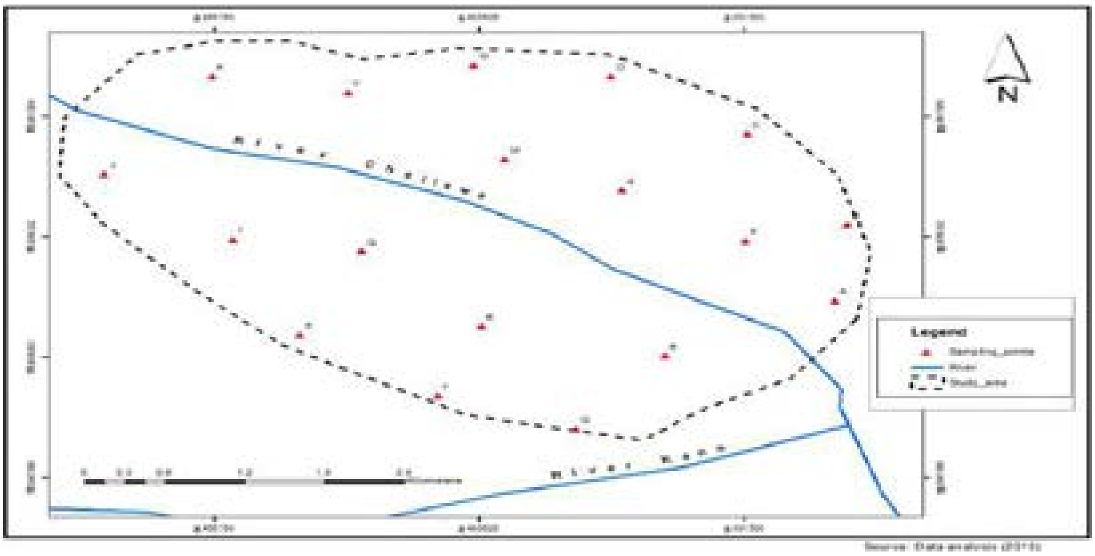


Figure 2: The Sampling Points of the Study Area

2.4 Methods of Data Analyses

The analyses of data were conducted in two stages: stage one was carried out in soil laboratory (Dept. of Soil Science, Ahmadu Bello University, Zaria, Nigeria) and stage two was done as GIS analysis.

2.4.1 Laboratory Analysis

This is the standard Routine Analysis consisting of the following procedures: firstly, the soil samples were air dried and gently crushed with porcelain pestleand mortar; and then passed through a 2mm sieve to remove coarse fragments. The sieved samples (<2mm soil portion) were analysed for the differentphysiochemical parameters.

Particlesize distribution was determined using hydrometer method (Gee, and Bauder, 1986); sand, silt and clay were determined by dispersing the soil samples in 5% calgon (sodium hexametaphosphate) solution; the textural classes were determinedwith the aid of USDA textural triangle; the soil pH was determined both in water and 0.01M $CaCl_2$ solution, using a soil to solution ratio of 1:2.5 (International Institute for Tropical Agriculture, 1979); pH reading was taken with a glass electrode on a Pye-Unicam model 290mk pH meter; total nitrogen was determined using the macro – kjedhal method; available phosphorus was determined using the Bray I method calorimetrically; potassium and sodium in the extract were read on a Gallen Kamp flame Analyzer; organic carbon content was determined in laboratory by using Walkley (1934).

Wet digestion method was used to determine the organic carbon; exchangeable Ca, mg, Na and K were extractedwith 1m ammonium acetate (1m NH_4OAc) solution buffered at pH 7.0 as described by Anderson and Ingram (1998); the potassium and sodium in the extract were read on a Gallen Kamp flame Analyzer; the extracts were diluted two times with the addition of 2ml of 6.5% Lanthanum chloride solution to prevent ionic interference before Ca and Mg was read; the Ca and Mg were read on a pye unicammodel SP 192 atomic absorption spectrophotometer (AAS) at 423 and 285nmwavelength respectively. The sum of Ca, Mg, Na, and K gives total exchangeable bases.

The soils were leached with 1m KCl solution and Exchange acidity (Al^+H) in the 1m KCl extractwas determined by titration with 0.1m sodium hydroxide solution as described by Anderson and Ingram (1998). Cation Exchange Capacity (CEC) of the soil was determined with 1m NH4OAc (1m ammonium acetate), buffered at pH 7.0 (Chapman, 1965).The excess acetate was removed by repeated washing with alcohol. The absorbed ammonium ions were displaced with 10% sodium chloride (pH 2.5) and determined by the Kjeldahl procedure (Soil Survey Staff, 1972).

2.4.2 Geostatistics and Geographic Information System Method

The laboratory results were placed into the Microsoft Excel application with their respective coordinates (Latitude and Longitude) and imported into GIS environment in order to analyse the spatial distribution of the parameters. The geostatistical technique of Inverse Distance Weighted interpolation in the Arc GIS 10.1 software was applied for the analysis of the distribution of soil parameters so that different thematic maps (layers) were produced as in Ahmed et al. (2014). Each parameter was reclassified and converted into raster format.

3. RESULTS AND DISCUSSION

3.1 Result of Laboratory Analysis

The summary of result of various physico-chemical parameters are presented in Table 1. For each soil parameter, its minimum value, maximum value, mean value, sample variance, standard error and standard deviation are presented.

Table 1: Level of Soil Parameters

Soil Parameter	Minimum Statistic	Maximum Statistic	Mean Statistic	Sample Variance	Standard Error	Standard Deviation
Sand kg^{-1}	28.00	78.00	48.78	168.07	3.06	12.96
Siltkg^{-1}	14.00	54.00	39.11	92.81	2.27	9.63
Claykg^{-1}	6.00	26.00	12.11	32.22	1.34	5.68
pH H_2O	6.00	6.90	6.49	0.06	0.06	0.25
pH $Cacl_2$	5.40	5.90	5.65	0.02	0.04	0.15
OCkg^{-1}	2.19	14.16	6.36	11.97	0.82	3.46
Nkg^{-1}	0.14	1.89	0.76	0.17	0.10	0.41

Avail. P kg^{-1}	8.75	50.23	26.35	224.76	3.53	14.99
Cacmol kg^{-1}	2.24	7.72	4.42	2.13	0.34	1.46
Mgcmol kg^{-1}	0.62	1.02	0.80	0.01	0.02	0.10
Kcmol kg^{-1}	0.10	1.20	26.35	0.10	0.07	0.32
Nacmol kg^{-1}	0.10	0.87	0.30	0.03	0.04	0.18
H+Alcmol kg^{-1}	0.20	0.80	0.41	0.04	0.04	0.19
CECcmol kg^{-1}	5.00	27.80	11.53	29.04	1.27	5.39
Zn Kg^{-1}	14.64	56.85	28.11	150.62	2.89	12.27

3.2 Analysisof the Spatial Distribution of Soil Parameters

The distribution of the soil parameters serves as guide in the identification of their spatial variability at a point relative to another. Generally, the distributions of the soil parameters in the study area were contrasting as it was uneven. Although soils in Kano have been described as deficient in important nutrient elements such as nitrogen, phosphorus, potassium, sulphur, boron, zinc and molybdenum (Essiet, 2014), this general assertion does not however reflect the distribution of nutrient themselves. For example, nitrogen as represented in Figure 3 was distributed as strips of blocks that had their origin from the centre and outstripping to the edges around the area. Its strength ensued in the centre and outstripped as a pointer to the north, while its least intensity was found in the southeast. In-between these two contrasts were strength of variable level found all over. In Table 1, the mean value of nitrogen was 0.76g/kg^{-1}.Apart from its central role in almost all plant metabolic processes (Tucker et al., 1999), grain crops needed it more than any other nutrient for economic yield (Essiet, 2014).

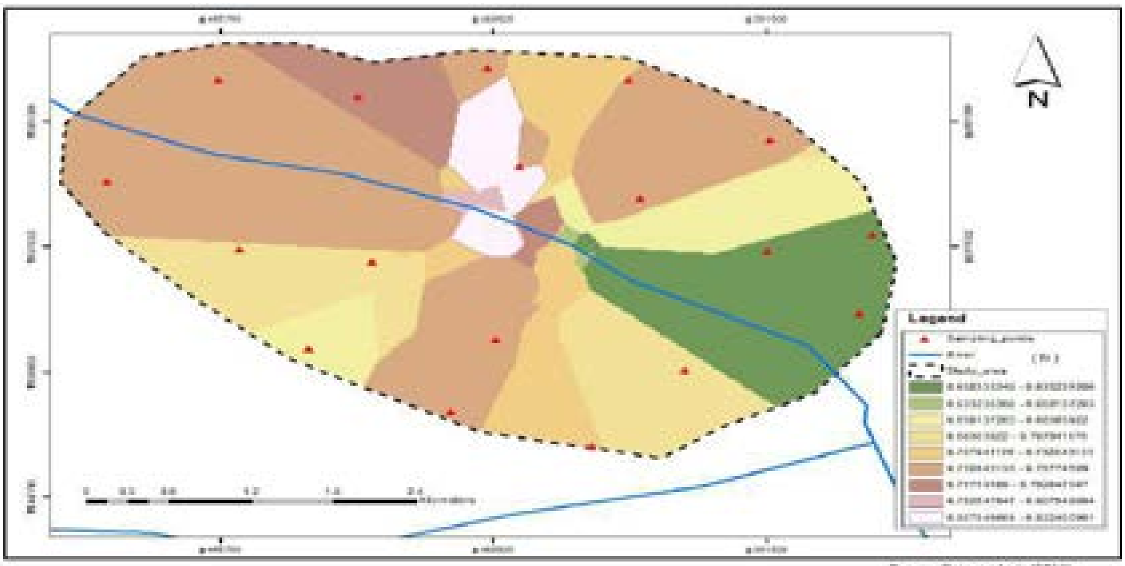
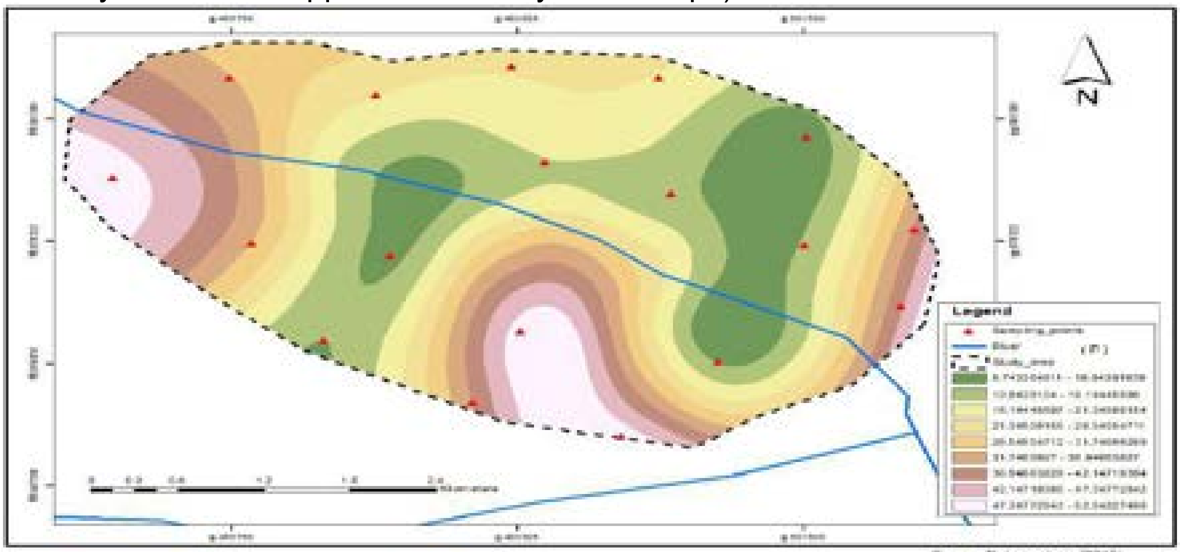


Figure 3: Spatial Distribution of Nitrogen

The mean value for laboratory result of phosphorus as indicated in Table 1 is 26.35g/kg^{-1}. This value is excessively higher than what was found in two locations of Kano and which were described by Shehu, Jibrin and Samndi (2015) as moderate (7.0-20.0 mg kg^1 in each site). The occurrence of this value of phosphorus was probably the outcome of high chemical fertilizer inputs as reported by Dawaki and Adamu (2008). The illustration of phophorus in Figure 4 shows least intensity and appears slowly distributed towards the centre in form of two ridges separated by nearly a pass-formed structure. Its strength increases at different level outward in a meandering manner. High intensity distribution of the parameter however occurred at the tip ends of south (fingerlike), east (semi concentric) and northwest of the study area (elongated strips).



Source: Data analysis (2015)

Figure 4: Spatial Distribution of Phosphorus

From Table 1, potassium has mean value of 26.35cmol kg^{-1}. It indicates an extremely low amount because Landon (1991) puts high benchmark to be 1.2cmol^{-1}. Shehu, Jibrin and Samndi (2015) observed toggling in the distribution of potassium surveyed, between low and moderate status. The deficiency of potassium in plants shows chlorosis or loss of green colour on leaf margins (Tucker et al., 1999). Figure 5 represents the distribution of potassium. It is solely represented by three lower layered strengths, except for a strip of lowest at the centre, and two block of relatively higher intensity, adjoining the central block to the north of the river and another of the same strength as latter (stripping to the border in the south), the whole area was dominated by relatively lower dilution.

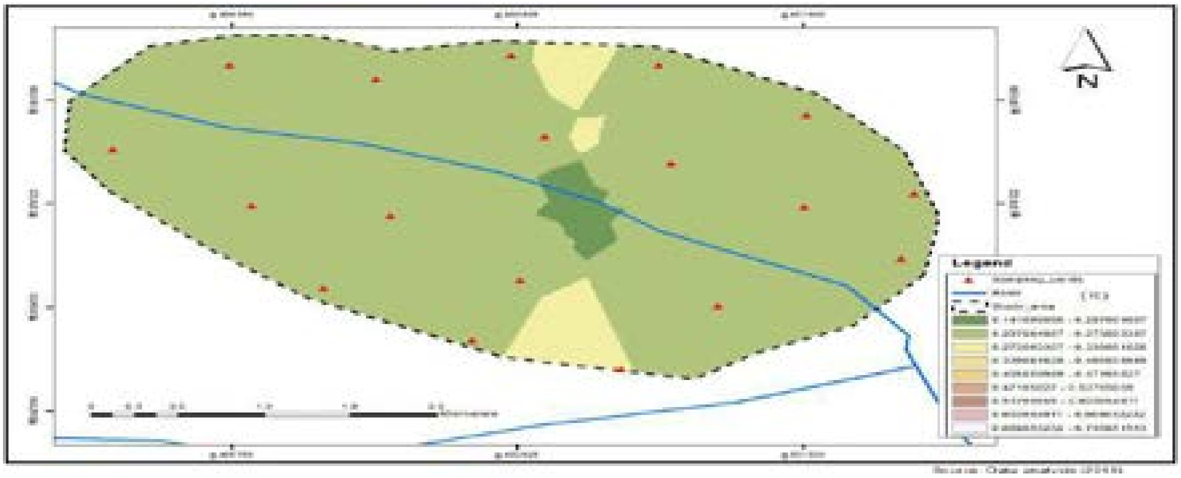


Figure 5: Spatial Distribution of Potassium

For the secondary nutrient calcium (in Table 1) has the value of 4.42cmol/kg^{-1}. This result is in the same range of findings of Adamu and Dawaki (2008) which was 4.54cmol^{-1}, but slightly higher than what was obtained by Abu and Malgwi (2011), 3.03cmol/kg^{-1}. Calcium, as shown in Figure 6, has least concentration as represented by a relatively biggest block in northwest of the study area. Moving in anticlockwise and embodied by varying sizes blocks, the strength increases in the same variable manner with the highest intensity in northeast and diminishes toward the centre of the area.

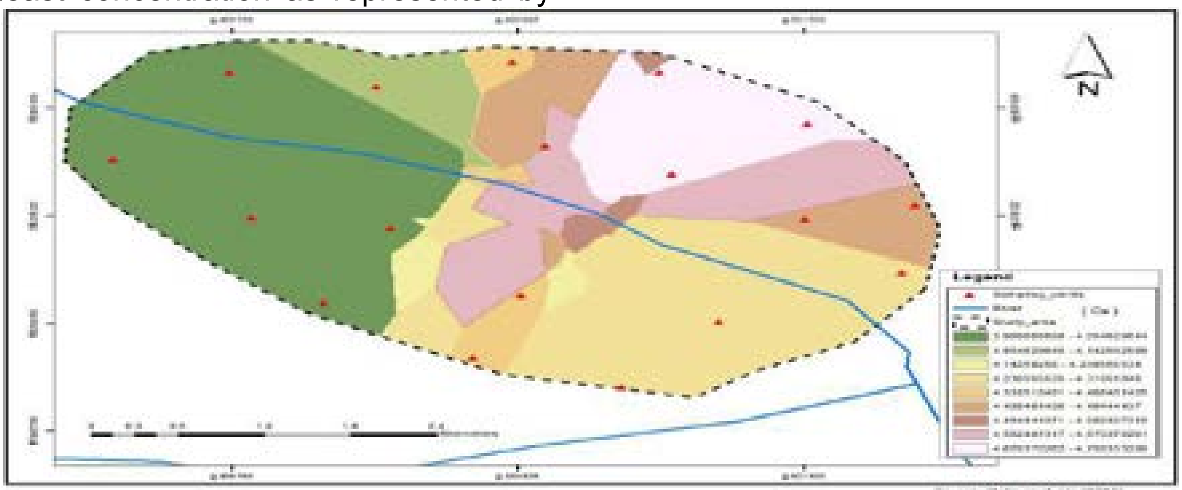


Figure 6: Spatial Distribution of Calcium

The laboratory result of exchangeable cation magnesium is 0.80cmol/kg^{-1}. This is grossly undervalued in comparison to 83.380cmol/kg^{-1} and 87.080cmol/kg^{-1} from two different sites as reported by Shehu, Jibrin and Samndi (2015). Concentration in the distribution of magnesium may not necessarily be observed over a considerable area (Jamala, Shehu, Musa and Abraham, 2012). For the distribution of magnesium in Figures 7, the highest intensity was found in the eastern corner of the study area (forming conical hill like structure and concentrically arranged in decreasing order outwards). To the south of the area was a fingerlike two layered strips of lower strength. Overshadowing this was layers of relatively higher intensity ensuing in meandering form and increasing intensity but dominated by layers of relatively middle level intensities in the northern part.

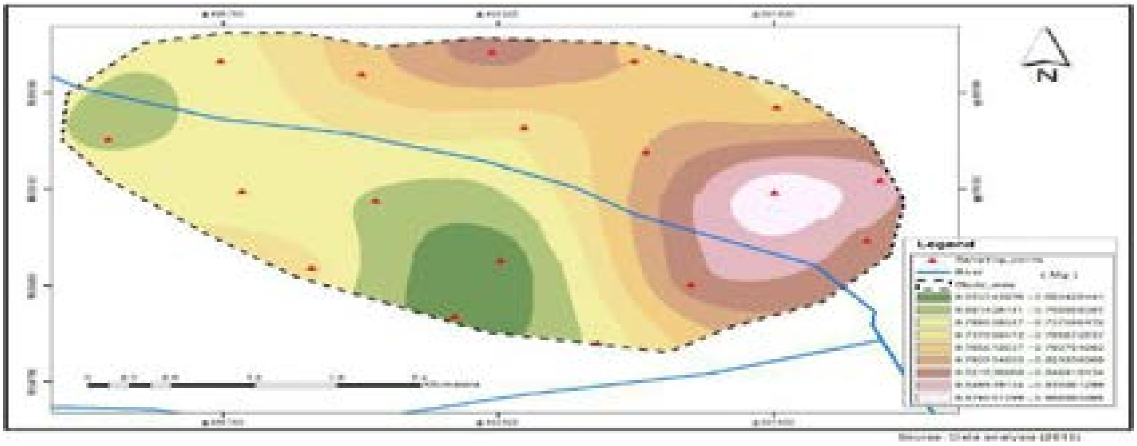


Figure 7: Spatial Distribution of Magnesium

Another exchangeable parameter whose laboratory mean value was found as 0.30cmol/kg^{-1} is sodium. Interestingly, this is within the range of values measured by Adamu (2013). In the latter, measurement of sodium were between 0.20cmol/kg^{-1} to 1.07cmol/kg^{-1}. Whereas magnesium was concentrically arranged, sodium, in Figure 8is in strips of blocks. Its distributions start with a relatively largest block of lowest strength in the northwest corner, decrease proportionally in strips of blocks in the direction of southeast of the area with a relatively large block as the highest level of intensities occurred at tip end of southeastern corner.

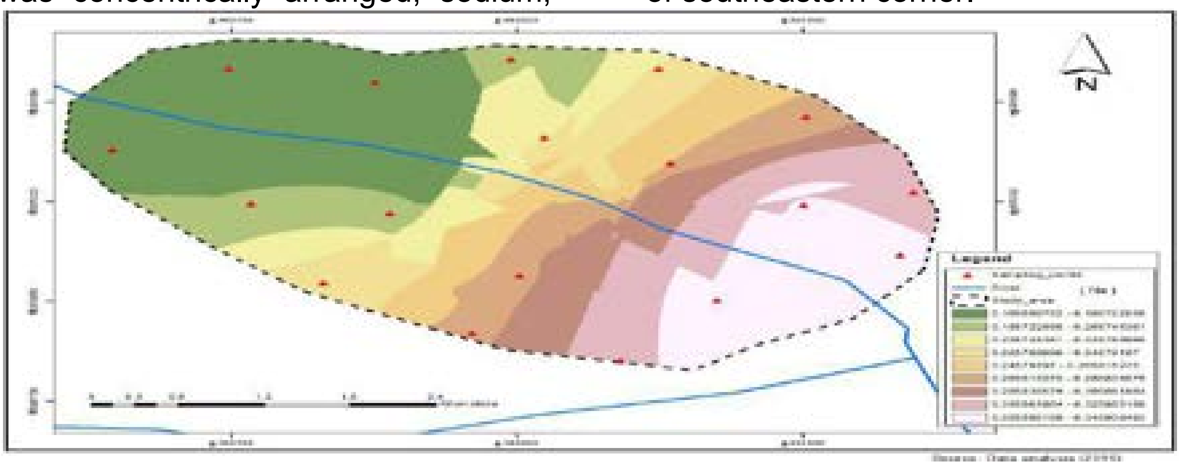


Figure 8: Spatial Distribution of Sodium

From Table 1, the laboratory mean value of organic carbon is 6.36 g/kg^{-1}. It is important for the determination of organic matter, which itself is vital for development of fertility in soils. Ahmed et al. (2014) noted the same pattern of variations between organic carbon and organic matter in some sorghum fields. The organic carbon's pattern of distribution as represented in Figure 9 was nearly in same fashion as magnesium. Except that in organic carbon, a relatively lower dilution forms a ridge with a pass like passage, running southwest to northeast across the area. Conical hill-like intensities were spread to the north of the study area, and were concentrically arranged in decreasing order of intensity. Its least strengths were found at the eastern part and somehow northwest of the study area.

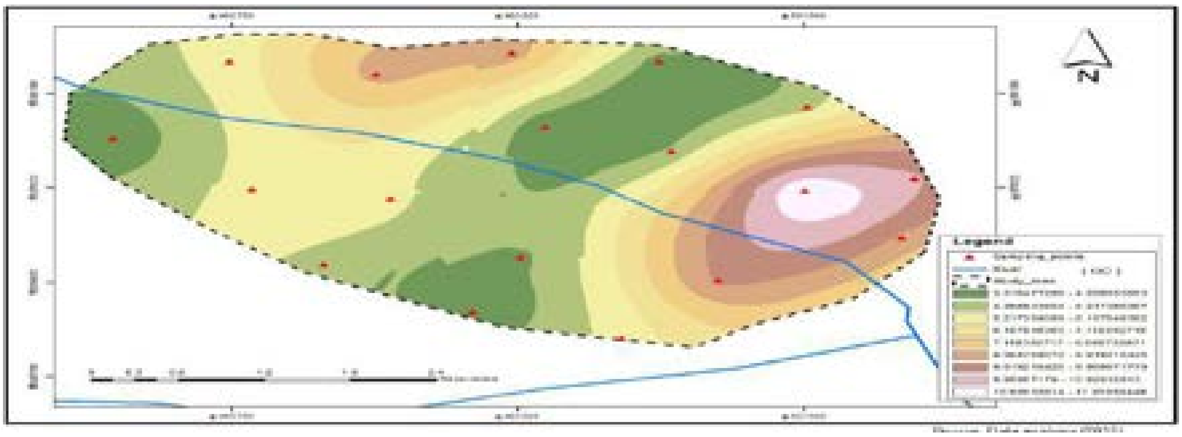


Figure 9: Spatial Distribution of Organic Carbon

The laboratory result of cation exchange capacity from Table 1 is 11.53cmol/kg^{-1}. This value based on Landon (1991) suggestions, is considered low. It is however relatively higher than findings of A bu and Malgwi (2011) where 6.3cmol/kg^{-1}was the value. Its distributions in the study area appear in irregular block form (of varying sizes). Running in clockwise manner, the highest intensity was distributed in northeast extreme. On the contrary, its lowest concentration was in the northwest corner. It was reported elsewhere to have limited use for fertilizer recommendations.

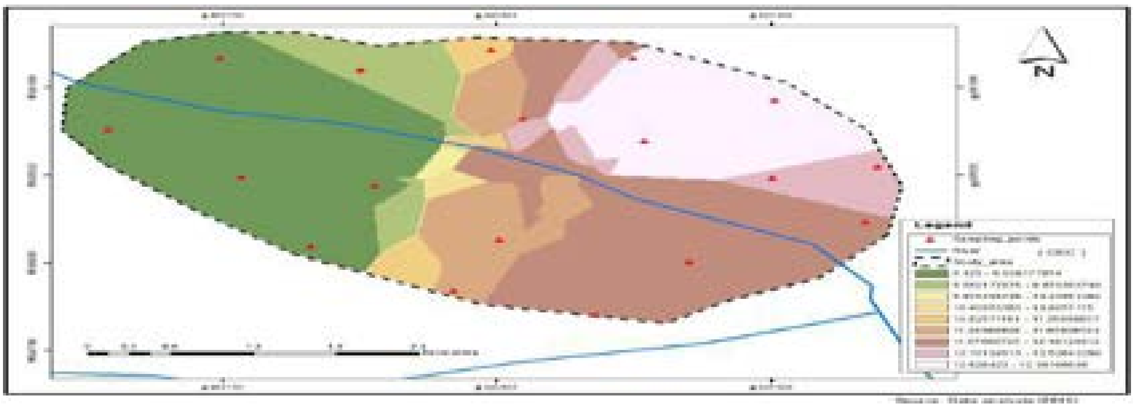


Figure 10: Spatial Distribution of Cation Exchange Capacity

The result of micro nutrient zinc from Table 1 is 28.11kg^{-1}. This result has somehow conform to surveys in one of the two sites, where Shehu, Jibrin and Samndi (2015) found zinc level to be 30.4mg kg^{-1} but in second site, it skyrocketed to 91.7mg kg^{-1}. This parameter as shown in Figure 11 had low distributions meandered and strips arranged from northeast to southwest direction. These increase in intensity in both directions (northwest and southeast) from the centre. The increment of higher intensity climaxed at both tip ends is found in the centre of the study area, with the highest at northwest end. Two fingers like structures of lowest strengths occurred, pointing to the centre, at edges of northeast and southwest of the study area. Zinc activates enzymes and stimulates plants (Tsonko and

Lidon, 2012).

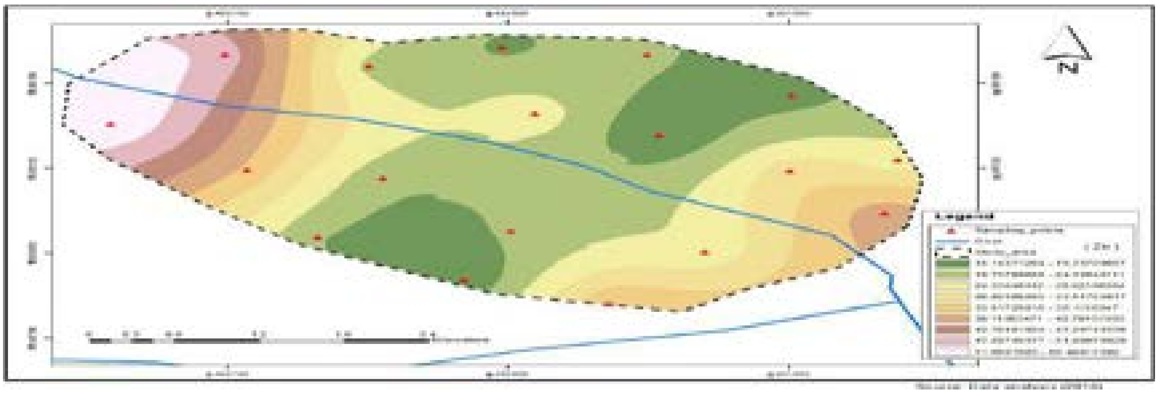


Figure 11: Spatial Distribution of Zinc

Perhaps, no distribution of two parameters in this study appeared striking than pH $CaCl_2$ as illustrated in Figure 12, pH $CaCl_2$ and pH H_2O (Figure 13). In both cases generally, the highest strength starts in the northwest end, declining progressively and eventually ends in east of the area. While they had almost the same grouping of strengths in the distributions, there was however some variable intensity which can be noticed from slight variables in terms concentration and spread of each parameter. From Table 1, the mean value of pH H_2O, is 6.49 and pH $CaCl_2$ is 5.65. This has somehow contrasted with the findings of Abu and Malgwi (2011) whose mean value for pH H_2O was relatively higher (7.83). The difference can be explained in terms of possible accumulation of soluble salt, because the latter value was obtained from irrigated fields of Kadawa.

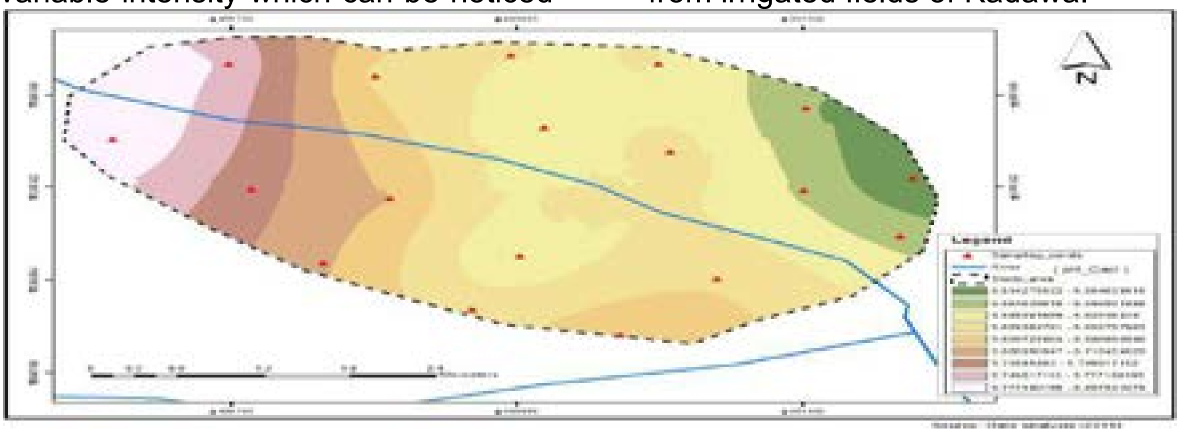


Figure 12: Spatial Distribution of pH $CaCl_2$

Soil acidity is created through removal of bases by harvested crops, leaching, and an acid residual left in the soil from N fertilizers; the availability of P is however greatest in the pH range between 5.5 and 7.5, not below (Fernandez and Hoeft, 2012). However, Ahmed et al. (2014) opined that pH values of 6.43–8.20 which range from slight acid, neutral and moderate alkaline are mostly found in highwater retention but poorly drained areas.

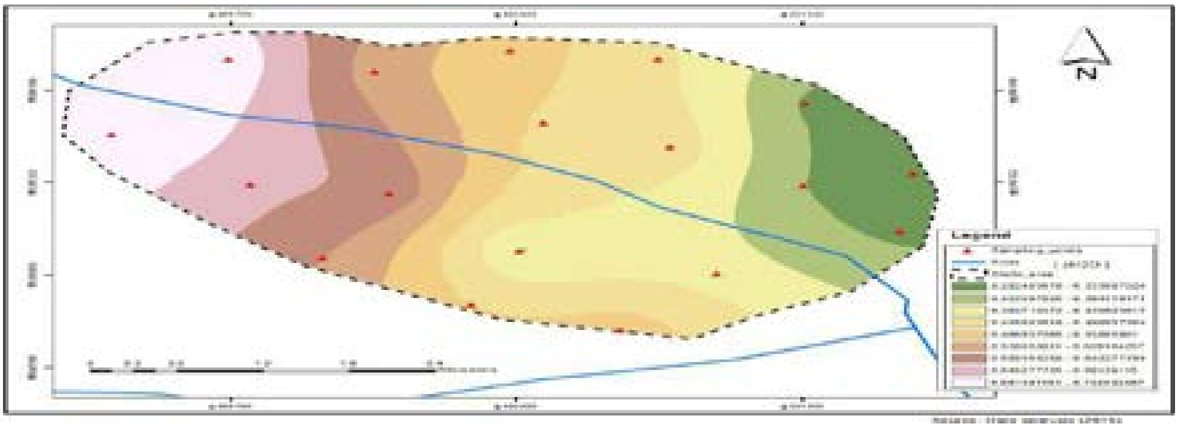


Figure 13: Spatial Distribution of pH H_2O

From the technical point of view, many factors may have been jointly or separately responsible, but most especially the issue of management practices like intensification of cultivation and high inputs of mineral fertilizers. Intensification of farming system has its own problems, because it brings about compaction, structural deterioration, disaggregation of particles, restricted root development and surface crust to soils.

4. CONCLUSIONS

The integration of GIS and RS in the recurrent but inevitable challenge of soil fertility decline studies has added some impetus to soil studies generally. A study of this nature using conventional approach would have otherwise been costly and tasking. Besides its being financially cost effective and labour less-intensive, the study establishes that GIS approach generally ensure precision in measurement in comparison to traditional method where soil units were drudgery evaluated. The approach for instance supports interpolation method such as IDW, to find out unknown value of a point from known points.

The combination of major factors of soil characteristics and management practices has resulted into spatial variability of available soil parameters in the study area. Soil fertility decline is most often treated homogeneously leading to misapplication of fertilizer and related chemicals. Changing this scenario requires knowledge in the level of spatial variability of soil properties (Parfitt et al., 2009), which is important in the decision making process for a more rational management of corrective and fertilizer applications. The facts that the soil particles in the study area were predominantly sandy loam and slightly acidic indicate soil viability and so there was high potentialities of cultivating wide range of crops. Whilst some parameters were moderately and adequately supplied, others were grossly unavailable. On the extreme, some parameters were still disproportionately available.

4.1 Recommendations

In view of above stated research findings, the study wishes to make the following recommendations:

i. Given the dynamic nature of soil conditions, spatial assessment of soil parameters should be periodic rather than occasional exercise. It is only when required information is generated and gathered on regular basis that an in-depth, comprehensive, logical and more meaningful interpretation of desired challenges could be worked out appropriately.

ii. Farmers should strive to strike balance between nutrients content in fertilizer applied, crops requirements and soils management. Fertilizer application should strictly be based on GIS analysis (maps) to avoid over application which may cause soil degradation.

iii. Other models for interpolations like Krigging, Spline, and triangulation should be explored in same area of this study, or be explored concurrently in the future studies elsewhere for validation of IDW analysis.

REFERENCES

Adamu G. K (2013). An Assessment of Soil Properties of Watari Irrigation Project, Kano State Nigeria. Academic Research International. Downloaded from www.savap.org.pk on 31/12/2016

Adamu, G. K., and Dawaki, M.U. (2008). Fertility Status of Soils under Irrigation along the Jakara Stream in Metropolitan Kano. *Bayero Journal of Pure and Applied Sciences,BAJOPAS,* 1(1):67 – 70. Accessed on 04/06/2013.

African Development Fund (2013). *Third National Fadama Development Project (Fadama III). Federal Republic of Nigeria. Central West Region*. http//www.uni-sz.bg. Accessed on 14/09/2016

Ahmed K. (2003). *The Kano Physical Environment*. www.kanoonline.com. Accessed on 26/06/2014

Ahmed, M. (2014). *Land Suitability Classification for Sorghum (Sorghum bicolor L. moench) in Bunkure, Kano State, Nigeria.* Unpublished M.Sc Thesis, Ahmadu Bello University, Zaria

Ahmed, M., Jeb D.N., Usman A.K., Adamu G.K. and Mohammed M.U. (2014). Spatial Distribution and Assessment of Selected Physiochemical Parameters of Soils Using GIS Techniques in Bunkure Kano State, Nigeria. *International Journal of Plant and Soil Science 5(3): 143-154, 2015; Article no. IJPSS.2015.068 ISSN: 2320-7035*

Ahmed, S. (2009). *Methods in Sampling Surveys: Cluster Sampling. Department of Biostatistics,* School of Hygiene and Public Health, John Hopkins University. Visited on 06/09/20015

Anderson, J.M. and Ingram J.S.I. (1998). *A hand book of methods*. 2nd edn., CAB International, Wallingford U.K. 1998;37.

Baanante, H.C. (1999). *Estimating Rates of Nutrient Depletion in Soils of Agricultural Lands of Africa*. International Fertilizer Development Center (IFDC) Muscle Shoals, Alabama, U.S.A. Accessed on 20/12/2016

Burrough, P.A., Macmillan, R.A., and Van Deursen, W. (1992) Fuzzy classification methods for determining suitability from soil profile observation and topography. *Journal of soil science,* 43, 193-210.

Chapman, H.D. (1965). Cation Exchange Capacity. In: Black C.A. (ed). *Methods of Soil Analysis*. Part 2. American Society of Agronomy, Madison, 1965: 1149-1178.

Chen and Wuing (2012) in Ahmed M., Jeb D. N., Usman A. K., Adamu G. K. and Mohammed M. U.

(2014). Spatial Distribution and Assessment of Selected Physiochemical Parameters of Soils Using GIS Techniques in Bunkure Kano State, Nigeria. *International Journal of Plant and Soil Science,* 5(3): 143-154.

Essiet, U. (2014). Soils; in Tanko AI and Momale SB (2014). *Kano: Environment, Society and Development* (eds.). Adonis and Abbey Publishers Ltd. Abuja.

Fabian, G.F. and Robert, G.H. (2012). *Managing Soil pH and Crop Nutrients*. Department of Crop Sciences

Feng W.C., Chen, W.L. (2012). *Estimation of the Spatial Rainfall Distribution using Inverse Distance Weighting (IDW) in the Middle of Taiwan Paddy Water Environ*; 2012.

Gee, G.W. and Bauder, J.W. (1986). *Particle Size Analysis. In 'Methods of soil analysis*, (Ed. A Klute). American Society of Agronomy: Madison, WI; 1986; 9(1):91–100.

International Institute of Tropical Agriculture (1979). Selected methods for Soil and Plant Analysis. *Manual series No 1*. Jou, A.S.R. (ed). IITA, Ibadan, Nigeria.

Ishaya, S. and Mashi, S.A. and Ifatimehin, O.O. (2008). Using GIS to Map Fadama Areas in the Central Abuja, Nigeria. *Journal of Sustainable Development in Agriculture and Environment* 3(2):110-118.

Ishaya, S. and Ifatimehin O.O. (2009). Application of Remote Sensing and GIS Techniques in Mapping Fadama Farming Areas. *American-Eurasian Journal of Sustainable Agriculture, 3(1):* 37-44, 2009. Accessed on 11/07/2005

Jamala, G.Y., Shehu, H.E., Musa, A.M. and Abraham, P. (2012). Evaluation of fertility status and irrigation potentials of selected *Fadama* soils in Adamawa State, North-eastern Nigeria. *Journal of Soil Science and Environmental Management,* 3(7): 176-181.

Jidauna, Dabi and Dia, (2012). In Ahmed M., Jeb D. N., Usman A. K., Adamu G. K. and Mohammed M. U. (2014). Spatial Distribution and Assessment of Selected Physiochemical Parameters of Soils Using GIS Techniques in Bunkure Kano State, Nigeria. *International Journal of Plant and Soil Science* 5(3): 143-154.

Karlen, D. L., Andrews, S. S. and Doran J. W. (2001). Soil Quality: Current Concepts and Applications. *Advances in Agronomy* 74: 1-40.

Lal, Rattan (1997). Long-term Tillage and Maize Mono culture Effects on a Tropical Alfisol in Western Nigeria. Crop yield and Soil Physical Properties. *Soil and Tillage*, 42, 145-160

Landon J.R. (ed) (1991), in Adamu, G. K., and Dawaki, M.U. (2008). Fertility Status of Soils under Irrigation along the Jakara Stream in Metropolitan Kano. *Bayero Journal of Pure and Applied Sciences,BAJOPAS,* 1(1): 67 – 70. Accessed on 04/06/2017

Mustafa AA, Man Singh, RN Sahoo, Nayan Ahmed, Manoj Khanna, A Sarangi, Mishra AK. (2011). Land Suitability Analysis for Different Crops: A Multi Criteria Decision Making Approach using Remote Sensing and GIS. *The Researcher Journal, 3(12).*

Ogunkoya M.O. and Adekayode F.O. (2009). The use of Geographic

Information Systems (GIS) in Estimating a Potential Fadama Land Area for Inland Farming: The Buffering Technique *Journal of Food, Agriculture and Environment,* 7 (3&4): 7 0 5 - 7 0 9.

Ojeniyi, Stephen Olusola (2008). "That our Soil May Not Die" *Professorial Inaugural Lecture Series*. Federal University of Technology, Akure.

Olofin EA. (1987). *Some Aspects of the Physical Geography of the Kano Region and Related Human Responses*. BUK Press. 1987:50.

Parfitt J.M.B., Timm L.C., Pauletto E.A., de Sousa R.O., Castilhos D.D., de Avila C.L. and Reckziegel N.L. (2009). Spatial Variability of the Chemical, Physical and Biological Properties in Lowland Cultivated with Irrigated Rice. *R. Bras. Ci. Solo*, 33:819-830, 2009

Reza SK, Dipak S, Utpal B, Das TH. (2010). Evaluation and Comparison of Ordinary Kriging and IDW Methods for Prediction of Spatial Variability of Some Chemical Parameters of Dhalai district, *Trpura Agropedology,* 20(1):38-48.

S.T. Abu and W.B. Malgwi (2011). Spatial Variability of Soil Physico-chemical Properties in Kadawa Irrigation Project in Sudan Savanna Agro ecology of Nigeria. *International Journal of Agricultural Research.* 6 (10): 714-735. 2011.

Shehu B.M., Jibrin J.M. and Samndi A.M. (2015). Fertility Status of Selected Soils in the Sudan Savanna Biome of Northern Nigeria. *International Journal of Soil Science* 10 (2): 74-83.

Soil Survey Staff (1972). Soil Taxonomy. *US Dept. Agric. Handbook 436.* US Govt. Printing Office, Washington D.C; 1972.

Soil Survey Staff (1981). *Keys to Soil Taxonomy,* 8th edition. USDA Natural Resource Conservation Service, US. Government Printing Office, Washington DC; 1981.

Tan K.H. (2005). *Soil Sampling Preparations and Analyses. Second edition.* CRC press, Boca Raton, FL. Pp 12 – 13.

Thomas HT. (1966). The use of Agricultural Soil Surveys in the Planning and Construction of Highways. *Soil Surveys and Land Use Planning*, 1966; 87-103

Tsonev Tsonko and Lidon Jose Fernando (2012). Zinc in Plants: An Overview. *Emirate Journal of Food Agriculture,* 24(4): 322-333.

Tucker Katherine L., Hannan Marian T, Chen Honglei, Cupples L Adrienne, Wilson and Kiel Douglas P (1999). *Potassium, Magnesium, and Fruit and Vegetable intakes are Associated with Greater Bone Mineral Density in Elderly Men and Women*. American Society for Clinical Nutrition

Walkley, A. and Black, A. (1934). An Examination of Degtjareff Method of Determining Soil Organic Matter and a proposed Modification of the Chromic Acid Titration Method. *Soil Science*, 37: 29-38.

World Bank and Department for International Development (2002). *Fadama Project I, II, and III*. Visited on 30/06/2017.

World Bank, (2003). *Sustainable development in a Dynamic World. Transforming*

Institutions, Growth, and Quality of Life. World Development Report. The World Bank, Washington, DC.

Young, A. (1981). *Tropical Soils and Soil Survey*. Cambridge University Press, Cambridge.

Savanna volume 23, Number 1, June, 2016

The Role of Women in Water Resource Utilization in Gwale Local Government Area of Kano State, Nigeria

Fatima Abdulkadir Aliyu, Aliyu Shu'aibu Muhammad and Abubakar Abdullahi Bichi*

Department of Geography, Federal College of Education, Kano

**bichiabubakar@gmail.com*

ABSTRACT

Women are rarely involved in decisions relating to water policies and strategies as well as water resource management. This study aimed to assess the role of women on water resource management in Gwale Local Government Area, Kano State. The major sources of domestic water supply, uses of water in the study area, method and utilization of domestic water uses were identified. Five wards were selected in the local government area with twenty respondents drawn from each for the study. Simple random sampling techniques were used for the study. Questionnaire was used as instrument for data collection. The data obtained were analyzed using simple descriptive statistics. The study revealed that, majority of the people in the study area obtain their domestic water from the borehole and some buy water from vendors for their domestic activities every day. The supply of water by vendors in this area reduces the tension of water scarcity by making it affordable and in turn it provides jobs to them. Women in the study area play a vital role in managing the water available to them every day in all areas of domestic uses including sanitation management. The study recommended that, women should be encouraged to participate in committees on water resource policies and programmes. Government should ensure gender equity with regards to access to and control of water resources. Public-Private Partnership should be encourage towards the development of a well-designed project for integrated water supply in the area.

Keywords: Role; Women; Water Resources; Utilization.

1. INTRODUCTION

Water is a basic human need and a basic human right. In situations of scarcity, decisions about access to water and use of water involve actors at the intergovernmental, governmental, regional, community and household levels (Rathgeber, 2003). The role of safe drinking water in societal welfare and development has long been recognized. Water supply like energy, capital and communication is very important for sustainable development. Apart from its primary role in enhancing human health and wellbeing, water is also essential for maintaining a vibrant economy (Bichi, 2016). Adequate water is absolutely necessary to support the population and economic life of a city. Critical shortages of water not only inhibit or stop economic development but also directly affect the health of people adversely. The recognition of the significant role of water resources to support life in a city and its use for urban development has instigated interest on it at the global level and its inclusion on the subject of sustainable development and environmental sustainability.

According to Haq (1993), the United Nation Development Program (UNEP) defined sustainable development as programs to improve people's quality of life within the carrying capacity of the Earth's life support systems that is meeting the needs of the present generation without damaging the Earth's resources in such a way that would prevent the future generation from meeting theirs. The main idea behind this notion is to create an effective system of resource distribution and utilization with a long-term perspective in mind. Consequently, United Nations Conference on Environment and Development (UNCED) has produced Agenda 21 which states that “urban growth has outstripped society’s capacity to meet human needs, enslaving hundreds of millions of people without adequate incomes diet, housing and services”. Therefore chapter 18 of Agenda 21 specifically alludes to the need for “special attention” to be given to the growing effects of urbanization on water demands and usage. Various surveys showed that in many cities, the quantity, quality and affordability of water in low-income urban settlements fall short of acceptable standards (UN-HABITAT, 2006/07).

According to Jalal (2014), there is a gender gap in water management leadership at all levels of government (national, state and local) and women are rarely involved in decisions relating to water policies and strategies and management. This led to a missing gap in key areas of water-related decision making in the state. To sustain the gender gap in water resources management and ensure water security for all at all levels, there is a need for greater involvement of women in the decision making. Some studies (such as Mohammed, 2014; Jalal, 2014 and UNDP, 2006) on women and environment have shown that women are significant actors in natural resources management, and they are major contributors to environmental rehabilitation and conservation because of their roles as farmers and as collectors of water and firewood, which have a close connection with their local environment and often suffer most directly from environmental problems. Thus, due to the important roles women are playing as home managers, they are not only knowledgeable about the environment; they also extend their good attitudes of being protective and caring.

Women are the primary water users due to the fact that they are known to play a substantial role in food production, although it varies regionally and from country to country (Mohammed, 2014). In Africa, women produce over 70% of the food which makes them the managers in agricultural and industrial sectors (UNDP, 2006). According to Mohammed (2014), the roles, responsibilities, and access to resources are highly differentiated both in men and women and amongst the women themselves. In terms of patterns of managing water, two kinds of tasks for women are identified: first is the creation and maintenance of water sources and second is their participation in the decision making processes governing the water resources (Mohammed, 2014).

However despite the role that women play in managing water resources, they are often excluded from decision making processes in water management approaches and other projects and initiatives on natural resources allocation because of other reasons. Excluding women in water sector leadership according to Jalal (2014) is largely due to the scarcity of women water professionals, entrenched cultural and traditional attitudes, gender stereotyping, and perceptions that women lack managerial and technical skills. However, there is no individual factor that can adequately explain the absence of women in water governance, policy making, and water agencies but rather, it is the confluence of the multiple elements that work in tandem to keep women at the margins of water leadership such as the lack of female water professionals which is compounded by cultural attitudes, social norms, historical and systemic gender discrimination combined with the absence of inspiring female role models, limited mentoring opportunities, and the challenges of maintaining a work–life balance, are just some of the reasons that explain the dearth of women in water leadership positions (Jalal, 2014). To Muhammed (2014) Social arrangements, age and generation are among the factors that show variations in the role of women in water management and Utilization.

In fact, according to FAO (1994), development in Africa is unattainable without the active participation of women since women who constitute more than half of the world's population. Women being primarily responsible for domestic and household management interact more intensively with both the natural and built environment more than men. Consequently, they are more likely to suffer from a degraded home, neighborhood and city environment and to shoulder more of the burden that go with living in poor housing and communities with inadequate residential and health infrastructure since they spend more time at home and its immediate vicinity (Etta, 1999). Thus, women manage water resources not only for productive but also for domestic purposes, sanitation, hygiene and they often play an active role in water resource allocation to various home needs. In the developing countries such as Nigeria, where millions of families still lack clean water and adequate sanitation, women invariably have to ensure that the family has water. Yet, despite their numbers and their roles and responsibilities, women often have had no voice and choice in water related matters. It is against this background that this study is aimed at assessing the role of women on water resource utilization in Gwale Local Government area of Kano State with emphasis on sources of domestic water supply, methods of distribution and utilization processes in the area.

1.1 The Study Area

The ancient Gwale came into existence over one thousand years ago with moderated population, then gradually the area and population expanded and it is located at the center of Kano city. According to 2006 Census, the total population of Gwale local government area (LGA) was 362,059 out of which 157,441 were females. Therefore, Gwale has a border with three LGAs. To the northeast, it is bounded by Tarauni LGA, to the south it is bounded by Kano Municipal and Dala LGAs. It extends between latitudes 11°58′and 11°967' North and longitudes 8°30' and 8°50′. It occupies an area of about 19.1Km^2, as shown in Figure 1.

The area is characterized by the Basement complex rocks of pre-Cambrian age to the west and south, and the Chad formation to the northeast. The relief can be described under three types which are found in three zones. These are the south and southeastern highlands, the middle and western high plains and northeastern low Chadplains. The first two types are part of the Chad plains of Hausa land and the third is part of the Chad plains. The Kano region occupies the southwestern rim of the Chad depression and shares physiographic divides with the Niger and Benue River Systems to the south and southeast, with the Niger System to the southwest and west, including the Chad-Sokoto Divide (Olofin, 2014). The climate of the area is controlled by the interplay of the tropical maritime airmass which originated from the Atlantic Ocean to southern part and the tropical continental airmass which originated from the Sahara desert to the North, Inter Tropical Discontinuity (ITD).

Generally, Kano Region lies within the “wet and dry” climate with more dry than wet months (Olofin, 1987) which are categorized under A_W in Koppen’s classification. It has a low mean annual rainfall of over 1,000 mm in the upstream area and about 500 mm in the downstream (Sanyu, 1994). In drought years, it could be lower than 450mm as in the case of 1972/73 drought. Recently, between 1997 and 1999 heavy downpours were recorded; in 1998 alone, over 1000 mm of rainfall was recorded (Abdulhamid, 2000). The area is characterized by five months of wet season and seven months of dry season. Therefore, water availability is very critical in the area. Temperature is relatively warm to hot from March to October, and cool from November to February. The mean annual temperature is 26°C. The hottest months (April/May) have the mean of 31°C, and the coolest months (December/January) has the mean of 21°C (Olofin, 1987). Two major rivers, Jakara in the north and Challawa in the south dominate the drainage system of the urban Kano area.

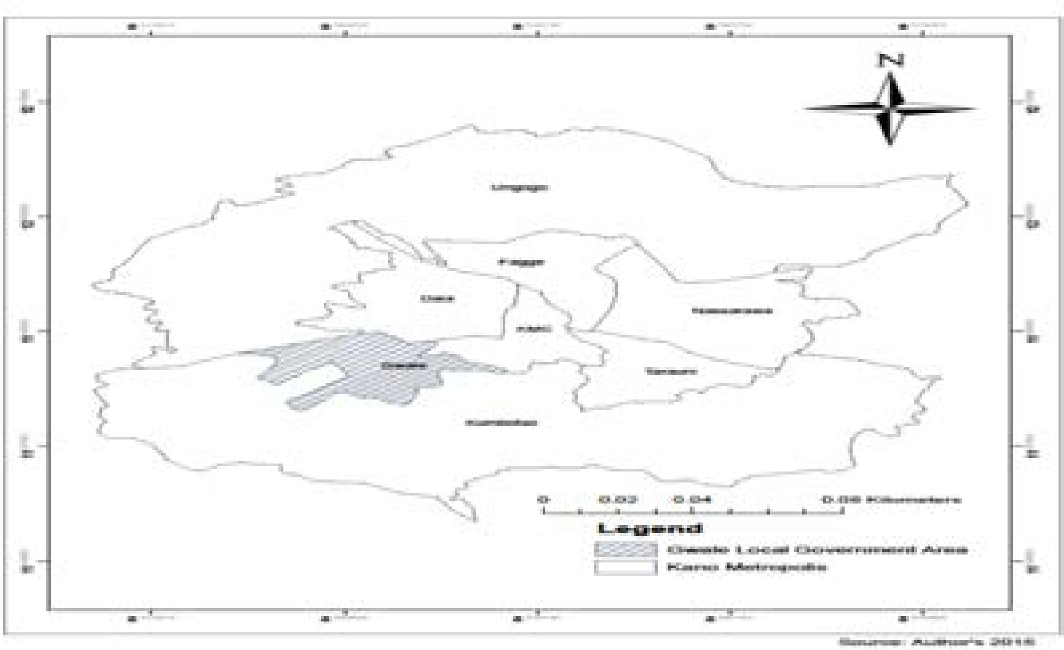


Figure 1: Map of Kano Metropolis showing Gwale Local Government Area
Source: Adapted from the Administrative Map of Kano

2. MATERIAL AND METHODS

2.1 Types and Sources of Data

The data were obtained mainly from primary and secondary sources. The primary data was generated through administration of questionnaire, while the secondary data include all secondary sources such as textbooks, journals, periodicals, encyclopedias, proceedings, theses and dissertations consulted as literature materials.

2.2 Method of Data Collection and Analysis

The instrument used for data collection is questionnaire survey. The questionnaire was designed to contain questions on the personal characteristics of the respondents such as the age, marital status, educational level, occupation, size of family, sources of water supply and access and other relevant issues.The data obtained from the respondents were subjected to statistical analysis using simple percentage technique.

2.3 Sample Size and Sampling Techniques

The population of the study area consists of the entire housewives in Gwale LGA. Five wards (Kabuga, Galadanchi, Dorayi, Gadon Kaya and Sani Mainagge) were selected in the LGA randomly with twenty respondents in each ward for the study. Out of the target population, hundred (100) women respondents were sampled for the study for convenience. Twenty (20) housewives were selected from each of the five wards using simple random sampling technique.

3. RESULTS AND DISCUSSION

This section discusses the results of the questionnaire survey administered to the respondents on the role of women in water resource utilization in the study area. Table 1 shows the family size per household. The table clearly shows that majority of the respondents are between 6-10 people per house with 37.89%. This indicates that they need large quantity of water which requires effective water management.

Table 1: Family Size per household among respondents in Gwale LGA

Family size per household	Frequency	Percentage %
1-5	16	16.84
6-10	36	37.89
11-15	17	17.89
16-20	13	13.68
21-25	5	5.26
26-30	4	4.21
31-35	1	1.05
36-40	0	0
40-Above	3	3.15
Total	95	100

Table 2 indicates the sources of domestic water supply in the study area. The study shows that majority of the people in Gwale LGA (42.10%) depend on borehole as their major source of domestic water supply. This may be due to the fact that borehole water is considered safe, sustainably supplied (free or at a reasonable cost) and is usually being provided by the wealthy people in the neighbourhood. Only 2.10% depend on other sources like water vendors as their major sources of water supply. The pipe borne water is not constantly supplied and this leads to sourcing water from other means. It was also found that 51% of the people living in the area are purchasing water from water vendors for their domestic use, due to inadequate water supply via the pipe borne water. While 48.42% are not buying because they have well and borehole in their houses or near it in order to supplement the insufficient pipe borne water supply by government. The total water demand of Kano metropolis presently is about 550 million litres but the whole Water Works is able to supply only 200 million litres, which is about 36% of the total demand (Bello and Abdullahi, 2014). This shows that the government alone cannot satisfy the demand of the public, as a result, community, private individual like commercial water vendors and philanthropist come in to supplement government effort in water production in Kano city (Bello and Abdullahi, 2014).

Table 2: Sources of domestic water supply among respondents in Gwale LGA

Sources of Domestic Water Supply	Frequency	Percentage %
Borehole	40	42.10
Well	25	26.31
Pipe borne water	28	29.50
Other	02	2.10
Total	95	100

Table 3 shows that a significant number of the respondents (22.44%) use to buy 50 litres of water every day for their domestic uses. It is followed closely by those buying 75 litres daily. Only 6.12% use to buy up to 150 litres and above. This could be related to the purchasing power and family size of the respondents. Thus, this situation of water in the area falls short within the range of minimum requirement for a healthy living. Moser (1993) opined that domestic water supply in most rural areas of Africa is an issue of serious concern; where an average household in developing countries consumes about 40-60 L of water daily for drinking, cooking, cleaning, personal hygiene, etc. This led to a situation where women minimize use of water by reducing the number of times children and other members of the family wash clothes and take bath per day which may affect health and other socio-economic activities of people in the area.

Table 3: Quantity of Water bought every day by respondents in Gwale LGA

Quantity of Water bought daily	Frequency	Percentage %
25 litres	9	18.36
50 litres	11	22.44
75 litres	10	20.40
100 litres	8	16.32
125 litres	8	16.32
150 and above	3	6.12
Total	49	100

Table 4 shows that majority of the respondents (42.85%) are buy each 20 litres jerry can of water at the cost of ₦20 each, followed closely by 36.73% that buy at the cost of ₦25. Only 7.04% of them buy at the cost of ₦30. This indicates that, supply of water by vendors in these areas reduces the tension of water scarcity by making it affordable and in turn provides jobs to them.

Table 4: Price of water used by the respondents in Gwale LGA

Price	Frequency	Percentage %
₦20	21	42.85
₦25	18	36.73
₦30	4	8.1
₦35	1	7.04

~~N~~ others	5	10.20
Total	**49**	**100**

Moreover, findings revealed that majority of the respondents (50.52%) are using one bucket of water for bathing while only18.94% uses up to 2 buckets of water daily. Based on the above, there is some level of water resource management among the people in the study area, because one bucket is enough for one take bath no matter how dirty one is.

Table 5 indicates that majority of the respondents (41.65%) uses 40 litres of water for washing, while only few of them (4.26%) uses up to 100 litres of water when it is washing time. This could be linked to the fact that washing of cloth is usually done at different phases by different individuals. Some people wash their dirty clothes twice in a week, some weekly, some every other week while some during month end. The quantity of cloth, the hygienic habit and other factors lead to the existence of wide range in the quantity of water being used for washing among the respondents in Gwale LGA.

Table 5: Quantity of water used for washing among respondents in Gwale LGA

Quantity of water used for washing	Frequency	Percentage %
20 litres	33	34.73
40 litres	39	41.65
60 litres	14	14.75
80 litres	5	5.26
100 litres	4	4.26
Others	0	0%
Total	95	100

From Table 6, the apportionment of water for sanitation purposes also varies among respondents. Majority of them (35.78%) allocate up to 4 buckets of water and above for sanitation, whereas only 2.10% allocate about 1½ buckets of water for sanitation purposes. The family size and socio-economic status are the key determinants of the quantity apportioned.

Table 6: Amount of Water allocation for Sanitation among respondents in Gwale LGA

Amount of Water allocated for Sanitation per day	Frequency	Percentage %
1 bucket	0	0
1½ bucket	2	2.10
2 buckets	15	15.78
2½ buckets	14	14.73
3 buckets	30	31.57
4 buckets and above	34	35.78
Total	95	100

Table 7 shows that majority of the

respondents (40.00) are using up to 40 litres for cooking and drinking purposes every day. Only 4.21% are using up to 100 litres of water daily for cooking and drinking in Gwale LGA. Major variant factors could be family size and socio-economic status.

Table 7: Amount of Water use for Cooking and Drinking among respondents in Gwale

Amount of domestic Water Usage per day	Frequency	Percentage %
20 litres	35	36.84
40 litres	38	40.00
60 litres	12	12.63
80 litres	6	6.31
100 litres	4	4.21
Others	0	0.00
Total	95	100

4. CONCLUSION

Majority of the people in the study area obtain their domestic water from borehole. Also, the over 40 litres used per household daily is mainly bought from vendors for domestic activities. The supply of water by vendors in this area reduces the tension of water scarcity by making it affordable and in turn provides jobs. Women in the study area play a vital role in managing the water available to them every day in all areas of domestic uses including sanitation management.

In conclusion, women being the primary users of water should be in a better position to preserve and manage water. Their ability to preserve and manage water well, will translate into ample time for other productive activities which will invariably mean more income and savings for the welfare of the family.

4.1 Recommendations

To enhance women participation in water resource utilization for sustainable development in the area, the following recommendations are proffered:

- Public-Private Partnership should be encouraged towards the development of a well-designed project for integrated water supply in the area. This should include construction of more public wells, boreholes such as the new improved solar borehole, and also the provision of clean, safe, and reliable pipe borne water.
- The people in general need to be more informed on proper water management techniques and utilization in order to save time spent on fetching water in times of scarcity and cost expended on purchasing water.
- Women access to water and other resources should be ensured and not undermined. The government will have to come in to ensure gender equity with regards to access and control of water resources.

REFERENCES

Abdulhamid, A. (2000). *Groundwater Conditions in Parts of Kano Metropolis.* Unpublished M.Sc Thesis, Department of Geography, B.U.K.

Bello, N. I and Abdullahi, I. K (2014). Water Supply Situations in Kano Metropolitant Prospects and Challenges. *International Journal of Research in Earth & Environmental Sciences*, 1(4): 25-32.

Bichi, A. A. (2016). *An Assessment of the Effect of Land use Activities on Metal Concentration in River Hadejia Kano Region, Nigeria*. Unpublished PhD Thesis, Department of Geography, A.B.U. Zaria.

Etta, F. E. (1999). Maroko low- income Settlement in Lagos, Nigeria; Gender and Urban Natural Resources Management. In D. L. Smith *Women managing resources.* Mazigira Institute, Nairobi.

FAO. (1994). *Improving the Relevance and Effectiveness of Agricultural Extension activities for Women*. United Nations, New York.

Haq, B. U. (1993). New Models Needed for Sustainable Human Development UNEP. *Our Planet,* 5(4): 14-15.

Hossain, K. Z. (2011). C*ontribution of Public Private Partnerships (PPPs) between slum dweller's CBOs and Public Water Supply Authority to improve Urban Water Governance: Experience of DSK, Bangladesh.* Unpublished M.A. thesis, Department of Economics, Jahangirnagar University, Bangladesh.

Jalal, I. (2014). Women, water, and leadership. *ADB Brief*. ADB headquarters, Manila.

Mohammed, N. (2014). Management of Domestic Water by Women in Parts of Kano State, Nigeria. *Academic Research International,*5(4) July 2014. SAVAP International

Moser, C.O.N. (1993). *Gender Planning and Development: Theory, Practice and Training*. Rout ledge London**.**

National Population Commission (2006): *The 2006 Population Census Data*. Nigeria.

Olofin, E. A. (2006). *The Varied Facets of Sustainable Development.* A Paper presented at the *48th Annual National Conference of the Association of Nigerian Geographers (ANG),* Department of Geography, Federal University of Technology, Yola.

Olofin, E. A. (1987). *Some Aspects of Physical Geography of the Kano Region and Related Human Responses.* KanoB.U.K. Debis Standard Printers.

Olofin, E. A. (2014). Location Relief and Landforms; in Tanko, A. I. and Momale, S. B. (Eds.) *Kano: Environment, Society and Development*. London & Abuja, Adonis & Abbey Publishers. Pp 1-11.

Rathgeber, E. (2003). *Dry Taps … Gender and Poverty in Water Resource Management.* Food and Agriculture Organization of the United Nations (FAO)

Sanyu, (1994). *The study of the National Water Resources Master Plan*. Sanyu Consultants Inc. for Japan International Cooperation Agency.

UNEP (United Nations Environment Programme) (1991). *Environmental Data Report (1999)*. Oxford GEMS Monitoring and Assessment Research Centre, Blackwell.

UNDP (2006). Human Development Report 2006. *Beyond Scarcity: Power, Poverty and the global* *water crises*. United Nations Development Programme. http://hdr.undp.org/ /report/cfm

UN-HABITANT (2006/07). *State of the world's cities report*. London: Earthscan

World Bank (1994). *Towards theevelopment of an Environmental Action Plan for Nigeria.*
Report Number 9002-UNI. The World hdr 2006 Bank, Washington, D.C.

Allocative Efficiency among Sesame Farmers in Benue State, Nigeria

Dzer, F.A.[1]*, Ogunwede, O.A.[2], Magaji, B.D.[1]
[1]Department of Agricultural Economics and Rural sociology, Faculty of Agriculture, Ahmadu Bello University, Zaria, Nigeria
[2]Department of Economics, Federal College of Education, Nigeria
*goodspeedng@gmail.com

ABSTRACT

This research was conducted to examine the allocative efficiency and its determinants of sesame farmers in Benue State, Nigeria.The allocative efficiency and its determinants were determined by the use of Cobb-Douglas stochastic frontier production function. Structured questionnaires were used for the collection of primary data on socio-economic characteristics, the inputs used and the outputs of sesame from 154 farmers. Multistage sampling technique was used for this study. Results of the study revealed that costs of farm size, seed and labour impacted positively on sesame output and were significant at ($p < 0.01$) level. The determinants of allocative efficiency were age, farming experience, household size, extension contact, membership of cooperative society and amount of credit received. Age, farming experience and extension contact were found to reduce allocative inefficiency, while household size, cooperative society membership and amount of credit received increased allocative inefficiency. The result shows a mean allocative efficiency of 0.69 and a range of 0.31 to 0.92. The study concludes that allocative inefficiency exists in the study areas as depicted by the maximum value of 0.92. Therefore, it is recommended that sesame farmers should adopt cost-saving agricultural technologies and practices in order to reduce allocative inefficiencies. Sesame farmers should also be prudent in the use of credit facilities for sesame production.

Keywords: Allocative efficiency; Sesame; Determinants; Cobb-Douglas stochastic; Credit.

1. INTRODUCTION

Agriculture is a major sector in the development of African economies, contributing a significant proportion to the national Gross Domestic Product and employing over 75% of the population (Salami et al., 2010). However, this agriculture is in the hands of mainly small-scale farmers who use traditional methods and crude tools of production, resulting in unsustainably low crop yields, despite their high commercial and export potential (Amaza et al., 2007).

Among the crops that have increasingly gained importance in Nigeria is sesame (Chemonics, 2002). Sesame seed is approximately 50 percent oil (out of which 35% is monounsaturated fatty acids and 44% polyunsaturated fatty acids) and 45 percent meal (out of which 20% is protein) (Ghandi, 2009 and Hansen, 2011). The oil fraction shows a remarkable stability to oxidation. This could be attributed to endogenous antioxidants namely lignins and tocopherols (Elleuch et al., 2007 and Lee et al., 2008). The crop has started receiving wide acceptance among farmers in other parts of the country because of the economic importance of its oil in the international markets (Olowe, 2007).

The decreasing production levels of sesame with increasing landuse, and of course other productive resources, might be attributed to inefficient allocation of available farm resources (Usman et al., 2010). Pham et al. (2010) opined that sesame production worldwide is still below expectation and the potential to increase production is considered higher. Potential yields are probably as high as 2000 kg/ha (Mkamilo and Bedigian, 2007). Unfortunately, the actual yield of sesame in Nigeria is estimated to be 485.3kg/ha (FAOSTAT, 2013) which is far less than the potential yield of 2000kg/ha. Thus, the yield of sesame can be increased by 21-53% with adoption of improved technologies (Singh and Khan 2003).

Sesame is an important export crop of Nigeria and the country has a substantial role in the global sesame trade. Nigeria is the primary supplier of sesame seed to the world's largest importer, Japan (Chemonics, 2002). Thus, the potentials for sesame seeds production in Nigeria is high since Japan, as well as Taiwan and Korea, generate global demand and offer opportunity for Nigerian growers. In response to the growing export market demand, Nigeria's production of the crop has consistently increased from about 42,000 tonnes in 1981, to about 165,000 tonnes in 2013 (FAOSTAT, 2013). In an effort to increase and ensure the sustenance of sesame production in Nigeria, this research becomes necessary with the aim of examining the allocative efficiency and its determinants of sesame farmers in Benue State of Nigeria.

1.1 Study Area

The research was conducted in Benue State of Nigeria. Benue State is located in the middle-belt zone of Nigeria, approximately between latitudes 6.3°N to 8.1° N and longitudes 8°E to 10°E (BNARDA, 2000). Benue state is bounded by the following states: Nasarawa to the North, Taraba to the East, Cross-River to the Southeast, Enugu to the Southwest and Kogi to the West. The southeastern part of the state also shares border with the Republic of Cameroon. According to National Population Commission (NPC) (2006) census, Benue State had a population of 4,219,244 people. Based on the projected annual population growth rate of 3.2 per cent estimated by National Population Commission in 2015, Benue State had a population of 5,647,784 people. The state has a total land area of 34,059 square kilometres (NPC, 2006). Benue State is divided into three agricultural zones, namely northern, eastern and central agricultural zones, with headquarters at Guma, Vandeikya and Oju respectively. Gwer East and Konshisha Local Government Areas are located in the northern and eastern agricultural zones.

Benue State has a tropical climate with two distinct seasons: rainy and dry seasons. The rainy season begins sometimes in April and extends to the end of October, while the dry season begins from November to March. According to BNARDA (2000), the daily mean temperature during the rainy season is 28°C while in the dry season; the average temperature is 35°C. The major occupation of the people in the state is agriculture. The major agricultural crops produced include cassava, rice, sesame, maize, yam, soya bean, sorghum, sweet potatoes, groundnut, cocoyam, cowpea, plantain, banana and oranges. The livestock reared include goat, pigs, sheep and cattle (BNARDA, 2000). A small proportion of the people engage in trading, while others are in the civil service, but are still engage in some farming activities

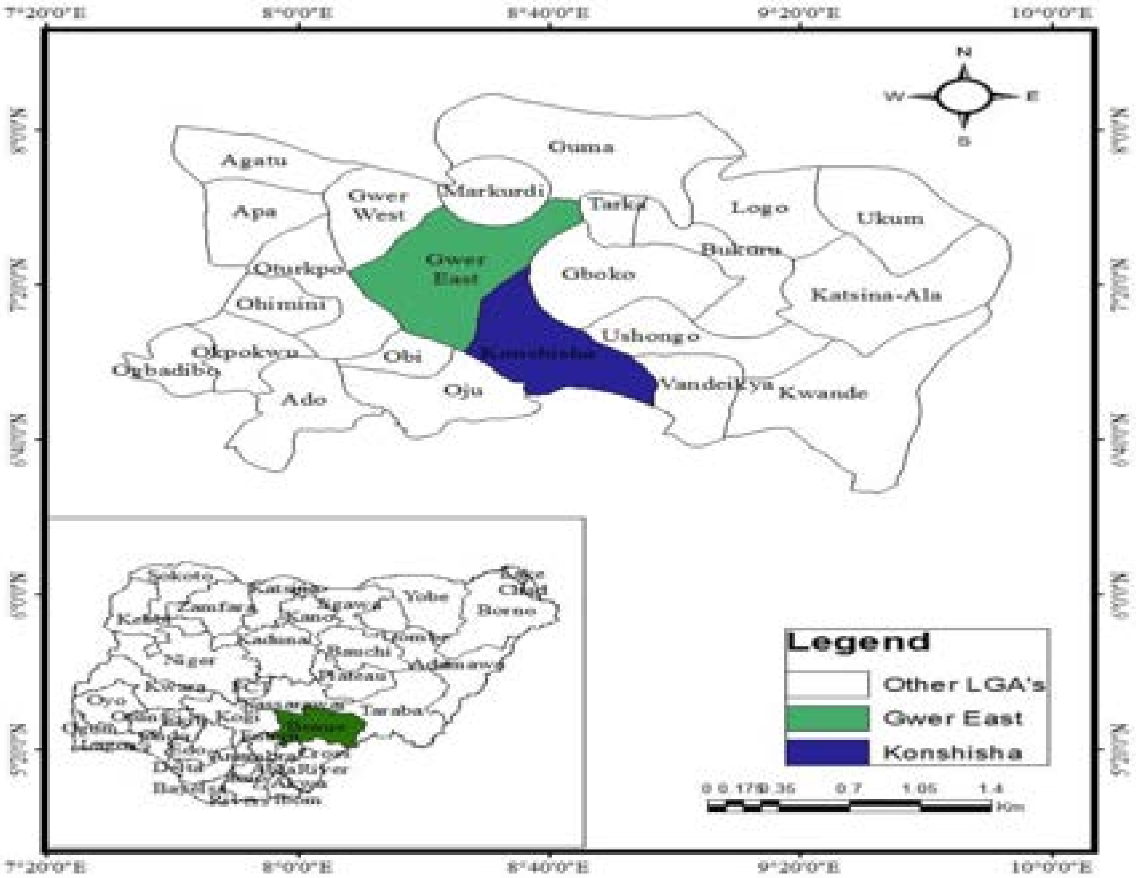


Figure 1: Map of Benue State showing the Study Areas

2. MATERIALS AND METHODS

2.1 Data Collection and Analysis

The study used primary data collected from the 2014 cropping season with the aid of structured questionnaire. Data was collected on the socio-economic characteristics of the farmers, the inputs used and the output of sesame. Data collected was analysed using stochastic frontier production function. The stochastic frontier production function was used to find the allocative efficiency and its determinants of the sesame farmers.

2.2 Sampling Procedure

This research employed the use of multi-stage sampling. The first stage involved the purposive selection of the study areas: Gwer East and Konshisha Local Government Areas (L.G.A) respectively, considering their position as the highest sesame-producing LGAs in Benue state. Secondly, since Gwer East has more number of villages than Konshisha, five villages were proportionally selected from the three districts of Gwer East LGA and three villages from the two districts of Konshisha LGA. Thirdly, 50% of the sesame farmers in each village were randomly selected to give a sample size of one hundred and fifty four sesame farmers.

2.3 Model Specification

The stochastic frontier model for estimating the allocative efficiency of the sesame farms is specified in the log form of the Cobb-Douglas frontier production function following Aigner et al. (1977) and Battese and Corra (1977) as follows:

$$\ln C = \beta_0 + \beta_1 \ln X_1 i + \beta_2 \ln X_2 i + \beta_3 \ln X_3 i + \beta_4 \ln X_4 i + (Vi + Ui) \ldots\ldots\ldots 1$$

Where:
In = the natural logarithm
C = Cost of production of sesame (₦)
β_0 = constant term
β_1- β_4 = regression coefficients
X_1 = cost of farm (rent) (₦)
X_2 = cost of seed (₦)
X_3 = cost of labour (₦)
X_4 = cost of agrochemicals (₦)
Vi = random variability in the production that cannot be influenced by the farmer.
Ui = deviation from the production cost frontier attributable to technical inefficiency.

The determinants of allocative inefficiency were estimated using:

$$Ui = \delta_0 + \delta_1 1nZ_1 + \delta_2 \ln Z_2 + \delta_3 \ln Z_3 + \delta_4 \ln Z_4 + \delta_5 \ln Z_5 + \delta_6 \ln Z_6 + \delta_7 \ln Z_7 \ldots\ldots\ldots 2$$

Where:
Ui = allocative inefficiency of the ith farmer
δ_0 = constant
δ_1- δ_7 = parameters to be estimated.
Z_1 = age of farmer (years)
Z_2 = sesame farming experience (years)
Z_3 = formal education (years)
Z_4 = household size (number of persons in the household)
Z_5 = extension contact (number of times of contact)
Z_6 = membership of cooperative societies (years)
Z_7 = amount of credit received (in naira and kind)

3. RESULTS AND DISCUSSION

3.1 Estimation of the Allocative Efficiency of Sesame Farmers

The Maximum Likelihood (ML) estimate of the stochastic frontier cost model of sesame farmers in the study areas is presented in Table 1. The diagnostic statistics estimates for sigma-squared and gamma are 0.15720 and 0.81247 respectively, and they are significant at $p<0.01$ level. The sigma-squared indicates the goodness of fit and correctness of the distributional form assumed for the composite error term while the gamma indicates the systematic influences that are unexplained by the cost function and the dominant sources of random error. The estimated sigma-squared parameter of 0.15720 indicates that about 15% variation in the cost of sesame production of the sesame farmers is attributed to factors beyond the farmers' control such as weather fluctuation, luck, pest and disease outbreak e.t.c. On the other hand, the estimated gamma parameter of 0.81247 indicates the presence of allocative inefficiency effects in sesame production and implies that about 81% variation in the cost of production of sesame was due to the differences in the allocative efficiencies of the sesame famers. On a general note, a positively signed variable coefficient indicates that the coefficient contributes to increasing allocative inefficiency, while a negatively signed coefficient implies that the variable contributes to reducing allocative inefficiency or increasing allocative efficiency.

The result revealed that the costs of all independent variables conform with a priori expectation as all the estimated coefficients of the costs of farm size, seed, labour and agrochemical were all positive implying conformity with the assumption that the cost function monotonically increases with the input prices. The coefficients of the variables were significant at $p<0.01$ level, except agrochemical that was not significant. This implies that costs of farm size, seed and labour exert significant positive influence on the cost of production of sesame in the study areas. The result showed that the coefficient of the cost of farm size is

0.29121 and significant at $p<0.01$ level. This implies that a 1 unit increase in the cost of farm size will raise the cost of sesame production by 0.29.

Table 1: Maximum Likelihood Estimates Results of Stochastic Frontier Cost Function (Allocative Efficiency) of Sesame Production.

Variables	Parameters	Coefficients	Standard errors	T- Values
Constant	β_0	8.92577	0.14448	61.7752*
Cost of farm size	β_1	0.29121	0.07663	3.8001*
Cost of seed	β_2	0.34762	0.08545	4.068*
Cost of labour	β_3	0.46426	0.04726	9.8243*
Cost of agrochemical	β_4	0.00267	0.00448	0.5965
Diagnostic statistics				
Sigma-squared	(σ2)	0.15720	0.02084	7.5424*
Gamma	(γ)	0.81247	0.04586	17.7152*
Log likelihood function	L/f		34.3432	
LR test	52.8198			
Total number of observation	154			
Mean efficiency	0.69			

Significance level: *= $p<0.01$; **= $p<0.05$; ***= $p<0.1$

The coefficient of seed is 0.34762 and significant at $p<0.01$ level. The implication of this is that 1 unit increase in the cost of seed will give rise to 0.34 increase in the cost of sesame production. The cost of labour has a coefficient of 0.46426 and significant at $p<0.01$ level. This implies that 1 unit increment in cost of labour will increase the cost of sesame production by 0.46. The significant influence of seed cost and labour cost is in agreement with the findings of Okoh (2009), which found seed and labour cost as determinants of allocative efficiency in the Fadama production of tomato in Benue State. The cost elasticity of sesame production with respect to agrochemical is 0.00267, but not significant. This is an indication that 100 unit increase in the cost of agrochemical will result to 0.27 increase in the cost of sesame production.

3.2 The Determinants of Allocative Efficiency of Sesame Farmers

The inefficiency model of the stochastic frontier cost function revealed that age, farm experience, household size, extension contact, membership of sesame cooperative society and amount of credit received were the determinants of allocative efficiency among the sesame farmers. The coefficients of the variables were all significant at $p<0.01$ level, with exception of amount of credit received that is significant at $p<0.05$ significance level.

The coefficient of age is -0.11001, indicating that the older a farmer is, the more allocatively efficient he will be. This may be due to the fact that older farmers have more life experience which informed their effective decision of optimal combination of resource inputs leading to the reduction in allocative inefficiency. This contradicts the findings of Kolawole and Ojo (2007), who in their study of the economic efficiency of small scale food production in Nigeria found age to be positively related to allocative inefficiency. Farming experience has an estimated coefficient of -0.07032. This implies that the more experienced a sesame farmer is, the lower will be his allocative inefficiency. This can be attributed to a farmer's familiarity with choices of input combination which result to him making the best allocatively efficient choice among alternative input combination.

The coefficient of level of education is -0.01307. This implies that the more educated a sesame farmer is, the more allocatively efficient he is. This is as a result of a sesame farmer's ability to make wise choices as regards to inputs combination owing to his knowledge of costs of inputs. Education enhances a farmer's ability to seek and make good use of information about production inputs (Kepede, 2001). However, this variable is not significant in enhancing the allocative efficiency or reducing the allocative inefficiency of sesame farmers.

Household size has an estimated coefficient of 0.15311. The implication of this result is that larger sesame households are more allocatively inefficient than small sesame household size. That is to say, the smaller a sesame household, the more efficient it will be in the allocation of productive resources. This may be due to the fact that larger sesame households have more mouths to feed than small sesame households, as a result of this, the ability to make appropriate choices between alternative farm inputs is constrained by the shortage of financial resources. The coefficient of extension contact is -0.21464. This is an indication that extension contact contributed towards reducing allocative inefficiencies among the sesame farmers. This may be due to the fact that good extension contact exposes the farmers to information on input prices which in turn facilitates their choices of rational input combination to reduce allocative inefficiency.

The estimated coefficient of membership of sesame cooperative society is 0.12411 and is significant at $p<0.01$ level. This implies that sesame farmers that belong to sesame cooperative society had more allocative inefficiencies than those that did not belong to any sesame cooperative society. This can be attributed to the fact that membership of sesame cooperative society expose members to expensive agricultural innovations which tend to affect the rationality of their decision as regards to resource input purchase and combination. This finding is contrary to the one obtained by Fleming et al. (2004).

Amount of credit received has a coefficient of 0.00005. The implication of this is that the more credit a sesame farmer receives, the more allocatively inefficient he becomes. This may be due to the fact that credit received by sesame farmers is misused or misallocated in the purchase of farm inputs. This result is corroborated by one of Okike et al. (2000) that showed that receiving credit contributed to farmers' economic inefficiency. They contended that this could be the result of disbursement of credit in cash rather than in kind and loan misapplication endangered by resource poverty.

3.3 Frequency Distribution of Allocative Efficiency Estimates of Sesame Farmers

Allocative efficiency refers to the ability of a firm to use inputs in optimal proportion, given their respective prices (Farrell, 1957). The frequency distribution of the allocative efficiency estimates of sesame farmers in the study areas is also in Table 3. The result revealed that 79% of the sesame farmers had allocative efficiency of 0.61 and above while 21% of the farmers operate at less than 0.61 allocative efficiency level. This implies that the greater majority of sesame farmers were fairly allocatively efficient as 79% of them attained efficiency level greater than 0.60. In other words, the clustering of allocative efficiencies in the region of 0.61 – 1.00 efficiency range implies that the sesame farmers are fairly efficient. That is, the farmers are fairly efficient in producing sesame at a given level of output using the cost minimizing input ratio as about 79% of the sesame farmers have allocative efficiencies of 0.61 and above. The estimated allocative efficiencies differ substantially among the sesame farmers ranging between the minimum value of 0.31 and maximum value of 0.92. This means that the most allocatively efficient sesame farmers operated closer to their cost frontier or minimum cost of 1.00. The mean allocative efficiency was 0.69. This implies that if the average sesame farmer in the study area was to achieve allocative efficiency level of his most efficient counterpart, then the average sesame farmer will realize 25% cost saving i.e. [1-(0.69/0.92)*100]. A similar calculation for the most allocatively inefficient sesame farmer reveals cost saving of 66% [1-(0.31/0.92) x100].

Table 2: Maximum Likelihood Estimates Results of Determinants of Allocative Efficiency of Sesame Production

Variables	Parameters	Coefficients	Standard errors	T- Values
Constant	Z_0	1.53424	0.28753	5.3359*
Age	Z_1	-0.11001	0.01244	-8.8407*
Farming experience	Z_2	-0.07032	0.02121	-3.3156*
Education	Z_3	-0.01307	0.10925	-0.1197
Household size	Z_4	0.15311	0.01831	8.3611*
Extension contact	Z_5	-0.21464	0.03679	-5.8349*
Cooperative society	Z_6	0.12411	0.02109	5.8844*
Amount of credit	Z_7	0.00005	0.00002	2.048**
Diagnostic statistics				
Sigma-squared	($\sigma 2$)	0.15720	0.02084	7.5424*
Gamma	(γ)	0.81247	0.04586	17.7152*
Log likelihood function *L/f*	34.3432			
LR test		52.8198		
Total number of observation		154		
Mean efficiency		0.69		

Significance level: *= p<0.01; **= p<0.05; ***= p<0.1

Table 3: Frequency Distribution of Allocative Efficiency Estimates from the Stochastic Frontier Model

Efficiency level	Allocative efficiency Frequency	%
0.01 – 0.20	0	0
0.21 – 0.40	5	3.25
0.41 – 0.60	28	18.18
0.61 – 0.80	61	39.61
0.81 – 1.00	60	38.96
Total	154	100
Mean	0.69	
Minimum	0.31	
Maximum	0.92	

4. CONCLUSION

Based on the results of this research, it can be concluded that allocative inefficiency exists in the study areas as evidenced in the frequency distribution of the allocative efficiency of the sesame farmers with the best practice farmer having an allocative efficiency of 0.92. The farmers were not judicious in the use of credit facilities for sesame production. The cost of all the independent variables conform to a priori expectation as they monotonically increased with increase in sesame production implying that, if more sesame will be produced, more costs will be incurred.

4.1 Recommendations

It is recommended that cost-saving farming practices (technology) and or techniques should be adopted by the sesame farmers in order to reduce allocative inefficiency. Also, sesame farmers should ensure prudent use of credit facilities and effective utilization of opportunities of cooperative society membership.

Aknowledgement

I sincerely salute Professors Z. Abdulsalam and M. G. Maiangwa for their constructive criticism, assistance and close supervisory support that led to the successful completion of this research work.

Conflict of Interest

Authors have declared that conflict of interest does not exist.

REFERENCES

Aigner, D. J., Lovelt, C. A. K. and Schmidt, P. (1977). Formulation and estimation of stochastic frontier production function models. *Journal of Economics*, 6: 21 -37.

Amaza, P.S., Olayemi, J.K., Adejobi, A.O., Bila, Y. and Iheanacho, I. (2007). Baseline socio-economic survey report: Agriculture in Borno State, Nigeria. International Institute of Tropical Agriculture, Ibadan, Nigeria. p.84.

Battese, G.R. and Corra, G.S. (1977). Estimation of a production frontier model with application to the pastoral zone of Eastern Australia. *Australian Journal of Agricultural Economics,* 21(3): 169 – 179.

Benue State Agricultural and Rural Development Authority (BNARDA). (2000). Agricultural production recommendation for Benue. *Extension bulletin,* 3:1-20.

Chemonics International Inc. (2002). *Overview of the Nigerian Sesame Industry*. The United States Agency for International Development

(USAID)/Nigeria RAISE IQC Contract No. PCE-I-00-99-00003-00.

Elleuch, M., Besbes, S., Roiseux, O., Blecker, C. and Attia, H. (2007). Quality characteristics of sesame seeds and by-products. *Food Chemistry,* 103(2): 641 – 650.

Farrell, M.J. (1957). The measurement of production efficiency*. Journal of the Royal Statistical Society Service A(general.),* 25: 3-81.

Food and Agricultural Organisation Statistics (FAOSTAT).(2013). Food and Agricultural Organisation of the United Nations Statistics Division Database. Faostat.fao.org/site/567/desktop default.aspx. Assessed on 6/09/2014.

Fleming, E.P., Fleming, P., Rogers, H., Griffiten, G. and Johnston, D.(2004). Animal efficiency in an intensive beef production. *Genetic Breeding Unit*, University of New England, Armidale, NSW, Australia.

Ghandi, A.P. (2009). Simplified process for the production of sesame seed (*Sesamum indicum* L) butter and its nutritional profile. *Asian Journal of Food and Agro- Industry.* 2(1):24-27.

Hansen, R. (2011). *Sesame Profile*. Retrieved from http://www.agmrc.org/commodities__products/grains__oilseeds/sesame_profile. cfm. 19/08/11.

Kepede, T.A. (2001). *Farm household technical efficiency: A stochastic frontier analysis of rice producers in Mardi watershed in the western development region of Nepal*. (Unpublished master's thesis), Department of Economics and Social Sciences, Agricultural University of Norway, Norway, p. 57.

Kolawale, O. and Ojo, S.O. (2007). Economic efficiency of small scale food crop production in Nigeria: A stochastic frontier approach. *Journal of social science,* 14(2):123-130.

Lee, J.Y., Lee, Y.S., and Choe, E.O. (2008). Effects of sesamol, sesamin and sesamolin extracted from roasted sesame oil on the thermal oxidation of methyllinoleate. *Food Science and Technology Journal,* 42: 1871-1875.

Mkamilo, G. S. and Bedigian, D. (2007). *Sesamum indicum* L. In:*Vegetable Oils 14*. Vander Vossen, H.A.M and Mkamilo, G.S (Eds.):Plant Resources of Tropical Africa (PROTA) .Pp. 153-158.

National Population Commission (NPC). (2006). *Federal Republic of Nigeria Official Gazette*, 94(24): p.B1 82.

Okike, I., Jabbor, M.A., Manyons, V., Smith, J.W., Akinwumi, J.A., and Ehui, S.K. (2000). Agriculture intensification and efficiency in the West African savannahs: Evidence from Northern Nigeria. *Socio-economics and Policy Research Working Paper* 33, International Livestock Research Institute (ILRI), Nairobi, Kenya, p. 54.

Okoh, C.O., (2009). *Resource use efficiency in tomato production in the Fadama: Implication for poverty reduction in Benue State, Nigeria*. (Unpublished master's thesis). Department of Agricultural Economics, University of Agriculture

Makurdi, Benue State, Nigeria.

Olowe, V.I.O. (2007). Optimum planting date for sesame (*Sesamum indicum* L.) in the transition zone of South West, Nigeria. *Agricultura Tropica et Subtropica,* 40: 153 – 156.

Pham, T.D., Nguyen, T.T., Carlson, A.S. and Bui, T.M.(2010). Morphological evaluation of sesame (*Sesamum indicum* L.) varieties from different origins. *Australia Journal of Crop Science, 4(7): 498-504.*

Salami, A. Kamara, A.B and Brixiova, Z. (2010). Smallholder agriculture in East Africa: Trends, constraints and opportunities. Working Paper Series No. 105. African Development Bank, Tunis, Tunisia.

Singh, R. and Khan, M.A. (2003). Response of clusterbean varieties to fertility levels and cropping systems under arid conditions. In: Advances in Arid Legume Research. Henry, A., Kumar, D. and Singh, N.B. (Eds.). Scientific Publishers and Indian Society of Arid Legumes, Jodhpur, pp. 225-228.

Usman, S., Salisu, H.K. And Makama, S.A. (2010). Technical Inefficiency in Resource Use: Empirical evidence from sesame farmers in Jigawa State, Nigeria. In: *Restrategizing Nigerian Agriculture in Rapidly Changing Climatic Conditions For Sustainable Food Security*: *Proceedings of the 44th Annual Conference of Agricultural Society of Nigeria*, Ladoke Akintola University of Technology, October 18-22. Pp 226-227.

Savanna volume 23, Number 1, June, 2016

Spatial Pattern of Agricultural Development Programmes in Kano State, Nigeria

Hindatu Abdulkadir* and Hadiza A. Sulaiman
Department of Geography Sa'adatu Rimi College of Education Kano state, Nigeria
*hindatuabdulkadir2013@gmail.com

ABSTRACT

This study assessed the spatial pattern of agricultural development programmes in Kano State. Questionnaire and documented materials constituted major sources of data. Twelve Local Government Areas (LGAs) were purposively selected across the three Senatorial districts in the state. Some 384 respondents were randomly selected from these LGAs. The Standardized score (Z-score) analytical technique was employed using the three dimensions and the associated ten variables. The three dimensions namely Infrastructural dimension, Farm output dimension, Farm asset and technology dimension while the ten selected variables are: access to land area, cropping intensity per annum, chemical fertilizer consumption (bags), number of agricultural labourers hired, financial institutions/commercial banks, access to road, modern equipment adopted on farms, number of research extension workers, number of livestock (cow/goat) and number of poultry (chickens). The results of the Infrastructural dimension revealed that Eight LGAs are advantaged while the remaining areas were found to be disadvantaged. Based on the Farm output dimension, it was found that seven LGAs are advantaged while the remaining five LGAs are disadvantaged. The results of the Farm asset and technology dimension revealed that eight LGAs were found to be advantaged while the remaining four LGAs are underprivileged, the LGAs in this category of advantage include Kura with Z-score of 1.00, Rano with Z-score of 0.99, Tofa with Z-score of 0.16, Warawa with Z-score of 0.72, Minjbir with Z-score of 0.66, Danbatta with Z-score of 0.55, Rogo with Z-score of 0.07 and Gwarzo with Z-score of 0.04 in that descending order of performance. However, Tsanyawa, Doguwa, Madobi, Gaya with Z- score values of -0.06, -0.08, -0.18, -1.89 respectively are underprivileged. On the basis of these findings, the study recommends that there is need for the agricultural development to spread across the entire state through agricultural development programmes.

Keywords: Spatial Pattern; Z-score; Agricultural Development Programmes; Kano State.

1. INTRODUCTION

Agricultural development programmes (ADPs) are usually introduced by governments in order to boost agriculture and increase food production. However, there is the need for timely assessment and evaluation of ADPs with a view to understanding their performance, impacts and the challenges affecting the programmes. Therefore, researchers have assessed ADPs in different parts of the world. For xample, Bora, Datta and Barthakus (2009) examined spatial pattern of agricultural development in Sonitpur District, Assam, North eastern India. Suwase (2012) assessed spatial variation in the level of Agricultural development in Phaltan Tahsil of Satara India. Singh and Waseem (2012) examined spatial variation in level of agricultural development programmes in Bulandshahr district of Western Uttar Pradesh India.

The Nigerian agriculture has suffered as a result of the resource curse effect of oil and inappropriate policies and institutions. This coupled with heavy handed and unpredictable government intervention programmes which have led to short term investment decisions and rent seeking behaviour by programmers, has created dysfunctional and disconnected benefit to the poor masses. Clearly, the persisted failures of agricultural development programmes in Nigeria have revealed the inability of the several administrations in Nigeria to solve the basic and fundamental problems of agricultural development (Amalu, 1998).

Several studies have attempted to examine Agricultural Development programmes in Nigeria. For instance, Chukwuemeka and Nzew (2011) investigated World Bank agricultural development programmes in Nigeria. Iwuchukwu and Igbokwe (2012) analysed lessons from agricultural policies and programmes in Nigeria. The World Bank (2012) examined agricultural development programmes in Nigeria. Omonijo et al. (2014) investigated the impacts of ADPs on rural dwellers in Nigeria using Isan area in Ekiti state, Nigeria. These studies identified some of the problems of ADPs in Nigeria which include wrong policy approach, policy inconsistency, poor participation of stakeholders, poor infrastructure, lack of access to agricultural inputs and modern techniques.

Despite all the agricultural development programmes and schemes put in place at various times in history of Kano state, agricultural potentials are not fully developed.The Kano state government has not satisfactorily addressed the issue of how agricultural development programmes could spread spatially so as to maintain a balanced development. The spatial pattern of agricultural development programmes can be represented by the help of maps. The method of mapping of spatial pattern of the level of agricultural development programmes provides a rational base for future orientation of agricultural planning (Singh and Waseem 2012). It is therefore, imperative to assess spatial pattern of agricultural development programmes in Kano State, Nigeria. The aim of this study is to analyse the spatial pattern of agricultural development programmes in Kano State. However, the specific objectives are to: (i) analyse the spatial variation in the distribution of agricultural development indicators in Kano State (ii) examine the spatial pattern of agricultural development programmes in the study area (iii) provide possible solutions to reduce spatial variation of agricultural development programmes in the study area. Hence, the following hypothesis is set to guide the study:

H_{01}: There is no significant difference in the distribution of agricultural development indicators in the study area.

1.1 The Study Area

The study area is located between Latitudes 10°31′ - 12°32′ North of the Equator and Longitudes 7°33′ - 9° 30′East of the Greenwich Meridian (Figure 1). Kano State is one of the seven states that make up the Northwest geopolitical zone of Nigeria. It shares boundary with Katsina in the northwest, Jigawa state in the northeast, Bauchi state in the southeast and Kaduna in the southwest. It has total land area of 21,276.9 square Km. Kano state has a projected population of 12,150.811 according to projected population (2017) population figures report, and this accounts for about 6.7% of Nigeria’s population thereby making it one of the most populous states in Nigeria (Kano state centre of commerce (KSC), 2013).The study area is mostly occupied by the Hausas and Fulanis. Agriculture is one of the most important pillars of the state’s economy with about 75% of the total working population engaged directly or indirectly in this economic activity. The principal food crops cultivated in abundance are millet, cowpeas, sorghum, maize and rice for local consumption while groundnuts and cotton are produced for export and industrial purposes. During the colonial period and several years after the

Nigeria's independence, the groundnuts production in the state constituted one of the major revenue sources of the country. Kano State is a major producer of hides and skins with over 80% of the tanneries located in the industrial estates of the state producing high quality tanned leather ranked among the best in the world, which are exported. Some of the exportable commodities grown in Kano State include sesame, soybeans, cotton, garlic, gum Arabic and chilli pepper. Most of these commodities are available at Dawanau Market about 13 Km from the Kano city centre. Kano State contributes over 20% of Nigeria's non-oil export revenue (Zoml, 2013).

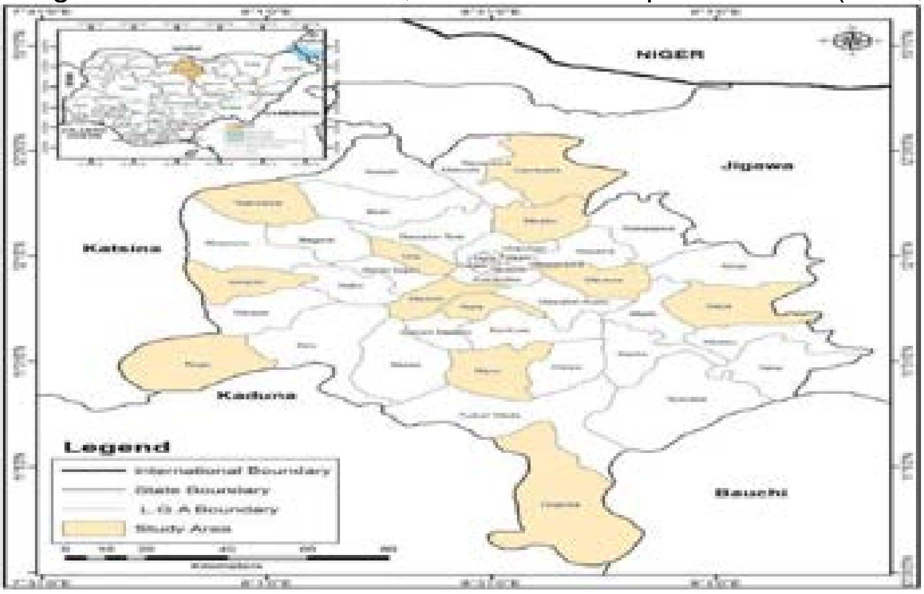


Figure 1: Kano State showing Study Area
Source: Modified from the Administrative Map of Kano State

2. MATERIALS AND METHODS

2.1 Types and Sources of Data

The study has carefully selected a number of Agricultural development indicators required for meaningful results. The following indicators have been considered and they include: - (i) Access to land area (ii) Cropping intensity per annum (iii) Chemical fertilizer consumption (bags) (iv) Number of Agricultural labourers/hired (v) Financial institutions/commercial banks (vii) Access to road (viii) Modern equipment adopted on farms (viii) Number of research extension workers (ix) Number of livestock (cow/goat) (x) Number of poultry (chickens)

The study used both primary and secondary sources of data. Secondary sources included documented materials from official gazettes, annual reports, research reports, journals, unpublished articles and on-line materials. The primary sources of data were collected through administration of questionnaire as a major research instrument for the study. Structured questionnaire was used as an interview schedule to collect relevant data from the respondents in the twelve local government areas in Kano state. Kano state has a projected population of 12,150,811 according to projected population (2017) population figures report. Twelve Local Government Areas (LGAs) were purposively selected across the three Senatorial districts in the state accounting for 2,614,755 as the target population. Some 384 respondents were randomly selected as the sampled population. Considering the sampling techniques, a multi-stage approach was adopted. First, a purposive sampling was used to select the twelve local government areas that are part of the study. Secondly three wards were selected in each local government area, making a total of total of (36) wards for the study. Thirdly, the households were randomly selected. The sample size for each of the twelve LGAs varies with the population size thus, Dambatta 39, Doguwa 29, Gaya 39, Gwarzo 34, Kura 28, Madobi 27, Minjibir 41, Rano 29, Rogo 42, Tofa 20, Tsanyawa 30 and Warawa 26 making a total of 384 sampled population.

2.2 Technique of Data Analysis

The Standardized score (Z-score) technique was employed to get the variation of agricultural development indicators in the study area. It measures the individual observation from the mean of observations, usually expressed in comparative form. The score of each factor on each LGA is standardized into Z-scores by scores into zero mean and unit standard deviation. The zero means form the base line from which scores of each observation on a particular variable was compared. The z-scores were computed from the raw data produced for Kano State. The raw data was first divided by the distribution criterion where population sizes serve as the denominators. The score of each LGA in each variable is then standardized into Z-scores by changing all the scores of all the LGA into zero mean and unit standard deviation. The composite scores are obtained by adding all the standardized scores of the variables for a particular LGA together. This aggregate score or the composite score gives room for the determination of the relative position of LGAs. In fact, all the Local Government Areas that have negative or positive composite scores are tagged disadvantaged and advantaged respectively. There are three major criteria selected for this study namely infrastructural dimension, farm output dimension, farm asset and technology dimension. It must be emphasized that, all the variables in this study were treated equally, that is, they have a weight of unity as far as the study area is concerned

3. RESULTS AND DISCUSSION

3.1 Infrastructural Dimension

The infrastructural dimension indicators for agricultural development are: access by road (km) and number of financial institution. Table 1 shows the data matrix in respect of infrastructural dimension standardized score values for Kano State. It revealed that eight Local Government Areas (LGAs) are advantaged while the remaining areas are disadvantaged.

Table 1: Standard score on LGAs in Kano states on infrastructural dimensions

LGAS	ZI	ZII	Sum Z	Rank
Warawa	0.04	0.89	0.93	1
Madobi	-0.03	0.36	0.33	2
Tsanyawa	-0.02	0.28	0.26	3
Tofa	-0.05	0.28	0.23	4
Gwarzo	0.58	-0.36	0.22	5
Gaya	-0.06	0.27	0.21	6
Rogo	0.02	0.17	0.19	7
Danbatta	-0.06	0.21	0.15	8
Rano	-0.02	-0.09	-0.11	9

Minjibir	-0.10	-0.09	-0.19	10
Doguwa	-0.18	-0.29	-0.47	11
Kura	-0.16	-1.05	-1.21	12

Key: ZI Financial Institution = ZII Access Road

As reflected the scores of the LGAs in the advantage category range from 0.93 – 0.15 while those in the disadvantages category ranges from -0.74 - -0.11. Warawa LGA was found to be most advantage and privileged than other areas. The reason for this could not readily be explained but it is probable that Warawa LGA located close to the central part of the state as such it received much assistance from the agricultural development government.

The disadvantages category include Kura LGA that appeared to be the worst with a composite score value of -1.21 and Rano seemed to be the least advantaged with a score of -0.11 some of the other LGAs in this group include Minjibir and Doguwa in order of hierarchy of disadvantaged. The spatial pattern of the composite scores on infrastructural dimension is presented in Figure 2.

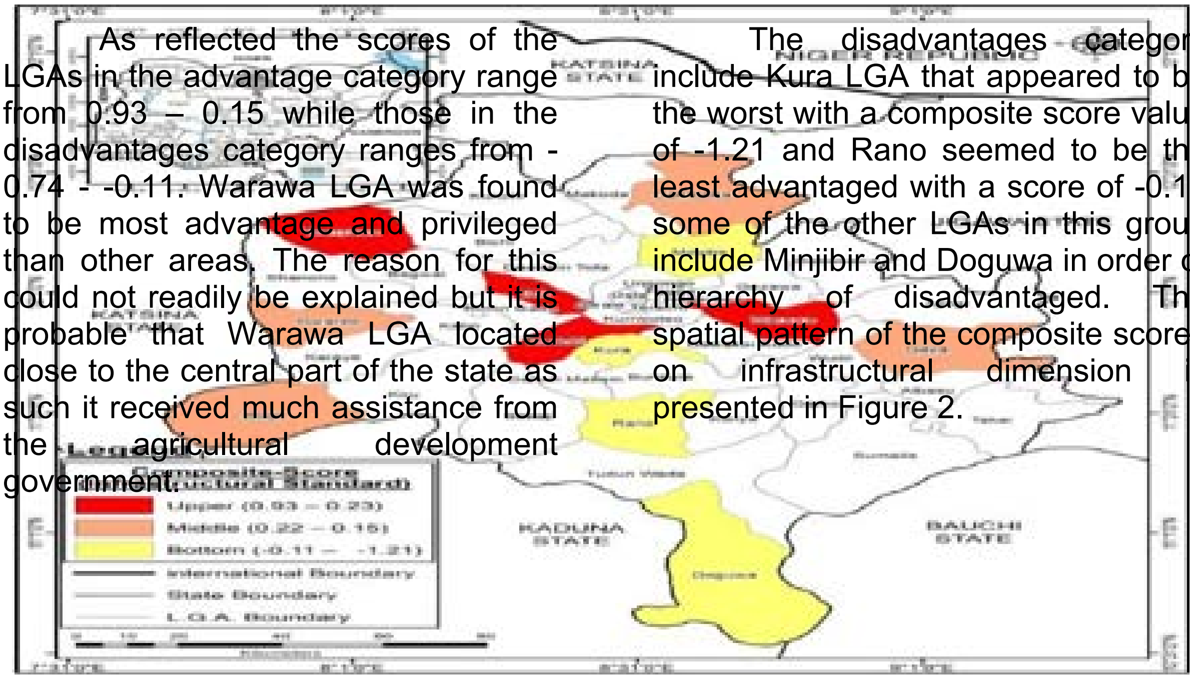


Figure 2: Composite-Score of LGAs in Kano State on Infrastructural Dimension

A close examination of the scores in Figure 2 reveals the fact that eight LGAs are relatively advantaged out of twelve sampled LGAs in Kano state, the advantaged areas include, Warawa, Madobi, Tsanyawa, Tofa, Gwarzo, Gaya, Rogo and Danbatta with scores values of 0.93, 0.33, 0.26, 0.23, 0.22, 0.21, 0.19 and 0.15. On the other hand, Rano, Minjibir, Doguwa and Kura, with score values of -0.11, -0.19, -1.21 and 0.47 are underprivileged respectively. Doguwa LGA appeared to be one of the disadvantaged areas because it is located far from the central part of the state. Looking at the performance of the LGAs under the infrastructural facilities, there are different levels of performance, some LGAs performed better in all the facilities while some did not.

3.2 Farm Output Dimension

Table 2 presents the Z-score values for the twelve local government areas (LGAs) and the farm output dimension indicators for agricultural development are: Crop Intensity Per annum, Extension Workers, Chemical Fertilizer Consumption and the Number of Agricultural Laborers. It can be observed from Table 2 that seven LGAs are advantaged while the remaining five LGAs are disadvantaged under this criterion. The composite score values of the advantaged LGAs range from 0.05 representing the score for Danbatta to 2.1 representing the score for Madobi LGA and it is regarded as the most privileged as far as the farm output is concerned. Some of the other LGAs in this category of advantaged include among others Warawa, Tofa, Rogo, Kura and Danbatta and Doguwa with

Z-score values of 2.1, 0.46, 0.15, 0.07 and 0.06 respectively. It can be noted that non out of the twelve LGAs has positive scores in all the 4 variables. This implies that each of the LGAs is either advantaged or disadvantaged in each of the farm output variables.

Further analysis of Table 2 shows that in the five sampled LGAs in Kano State, within the disadvantaged category, Rano LGA exhibited a high level of deprivation with a composite score of -0.66 followed by Gwarzo -0.64, Gaya -0.35, Minjibir -0.16 and Tsanyawa -0.02 in descending order.

Table 2: Standard scores on LGAs in Kano states on farm output dimensions

LGAS	ZI	ZII	ZIII	ZIV	Sum Z	Rank
Madobi	1.92	0.22	0.12	-0.16	2.1	1
Warawa	0.21	0.04	0.05	0.16	0.46	2
Tofa	-0.41	0.05	-0.06	0.57	0.15	3
Rogo	-0.19	-0.03	-0.03	0.35	0.1	4
Doguwa	0.13	0.01	0.13	-0.17	0.07	5
Kura	-0.01	0.29	0.11	-0.33	0.06	6
Danbatta	-0.19	0.05	0.11	0.09	0.06	6
Tsanyawa	0.01	-0.05	-0.15	0.17	-0.02	8
Minjibir	-0.25	-0.02	0.04	0.07	-0.16	9
Gaya	-0.30	-0.25	-0.22	0.42	-0.35	10
Gwarzo	-0.25	-0.17	-0.15	-0.70	-0.64	11
Rano	-0.25	0.03	0.11	-0.55	-0.66	12

Key: ZI Total crop = ZII Bags of Fertilizer = ZIII Farm labourers = ZIV Extension workers

The spatial pattern of the composite scores on farm output dimension is presented in Figure 3. Further examination of the composite scores of the farm output variables (Figure 3) shows that different LGAs performed differently in the facilities. Some have advantage in some facilities and are disadvantaged in other facilities. Example is Mingibir LGA performed poorly in total crop production per annum (Z1) and fertilizer consumption per annum (ZII) but performed better in ZIII and ZIV facilities. It thus turned out Minjibir ranked 9 in the overall farm output facilities.This points to the fact that some LGAs performed fairly well and some did not in some facilities, but when all the facilities were ranked together, the analysis present a totally different result as revealed by the Figure. For instance, Gwarzo LGA is found to be underprivileged in all the farm output variables with score values of -0.64. It is not surprising therefore, the LGAs ranked 11th respectively. It is interesting to note that some LGAs in Kano state such as Warawa, Tofa and Rogo maintain the status quo of enjoying more of the privilege as the Z-score values confirmed. Surprisingly Madobi ranked 1 as confirmed by Z-score but it is not among the first category of developed areas as confirmed by LQ values.

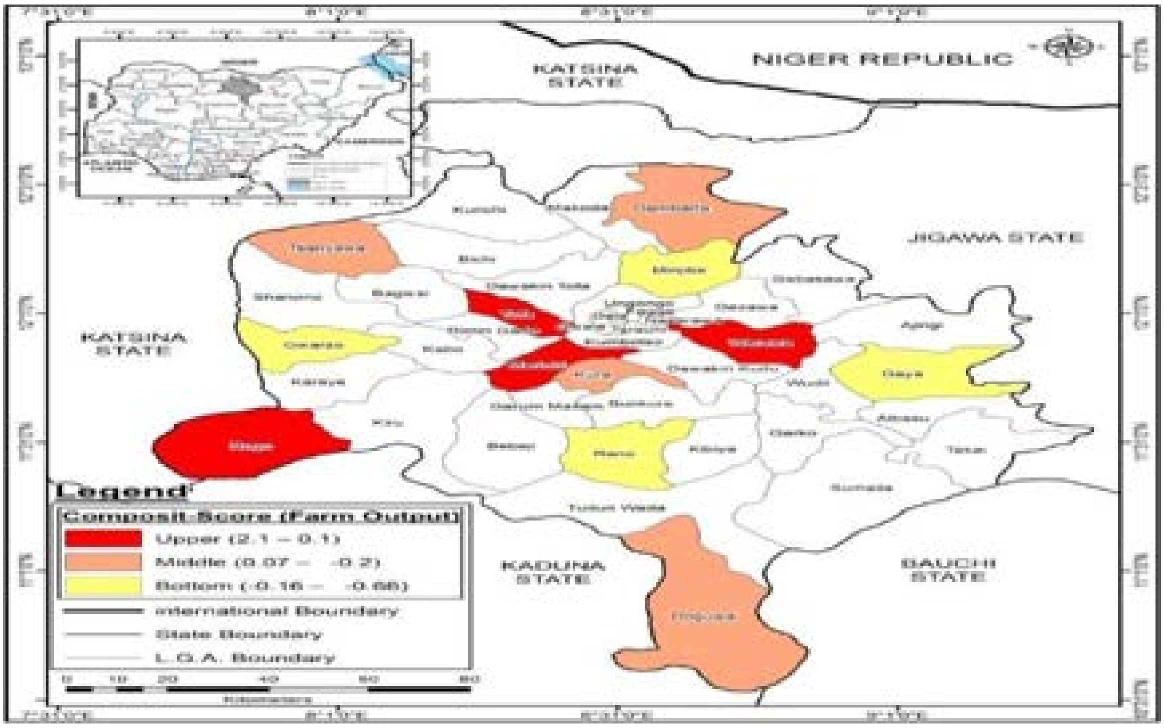


Figure 3: Composite-Score on LGAs in Kano State on Farm Output Dimension

3.3 Farm Asset and Technology Dimension

The farm asset and technology dimension indicators for agricultural development are: Access to Land (hectares), Number of modern equipments, Number of livestock, and Number of poultry. The standard scores of the local government areas (LGAs) on the farm asset and technology dimension are presented in Table 3 while the spatial patterns of the composite scores are presented in Figure 4.

Table 3: Standardized scores by LGAs in Kano States on Farm Asset and Technology Dimensions

LGAS	ZI	ZII	ZIII	ZIV	Sum Z	Rank
Kura	0.00	0.89	0.09	0.02	1.0	1
Rano	0.19	0.45	0.25	0.10	0.99	2
Warawa	-0.16	0.49	0.23	0.16	0.72	3
Minjibir	0.11	0.51	0.03	0.01	0.66	4
Danbatta	0.07	0.09	0.23	0.16	0.55	5
Tofa	-0.07	0.16	-0.04	0.11	0.16	6
Rogo	-0.09	-0.09	0.03	0.22	0.07	7
Gwarzo	-0.07	-0.23	0.20	0.14	0.04	8
Tsanyawa	-0.03	-0.32	0.03	0.26	-0.06	9
Doguwa	-0.19	0.07	0.02	0.27	-0.08	10
Madobi	0.02	-0.04	-0.09	-0.07	-0.18	11
Gaya	0.01	-0.34	-0.83	-0.73	-1.89	12

Key: ZI Assess to Land = ZII Modern Equipment = ZIII Number of goats = ZIV Number of Poultry

A glance at Table 3 revealed the fact that eight LGAs are found to be advantaged while the remaining four LGAs are underprivileged with score values of -1.89 for Gaya and 1.0 for Kura LGAs respectively. Kura LGA has maximum advantage as far as the distribution of farm asset and technology dimension is concerned.

The spatial pattern of the composite scores on farm asset and technology dimension is presented in Figure 4. Figure 4 shows that the factor of close to the central area must have helped to explain the concentration of farm asset and technology facilities in Kura LGA. Some of the other LGAs in this category of advantage include Rano 0.99, Tofa 0.16, Warawa 0.72, Minjbir 0.66, Danbatta 0.55, Rogo 0.07 and Gwarzo 0.04 in that descending order of performance in the distribution. It must be noted that even though these LGAs in the advantaged category have positive scores, they enjoy varying degree of privileges in the farm asset and technology facilities.

Rano LGA ranked second among the category of developed areas which is also affirmed by the findings of FGD that:

> *"One thing that sets Rano apart from other local government areas is farming close to water bodies and dams; this system keeps the soil wet year round. The locals call this method Binaso system of irrigation". Through this method they are supplying huge amount of groundnut during dry season* (FGD, Rano LGAs, 2016).

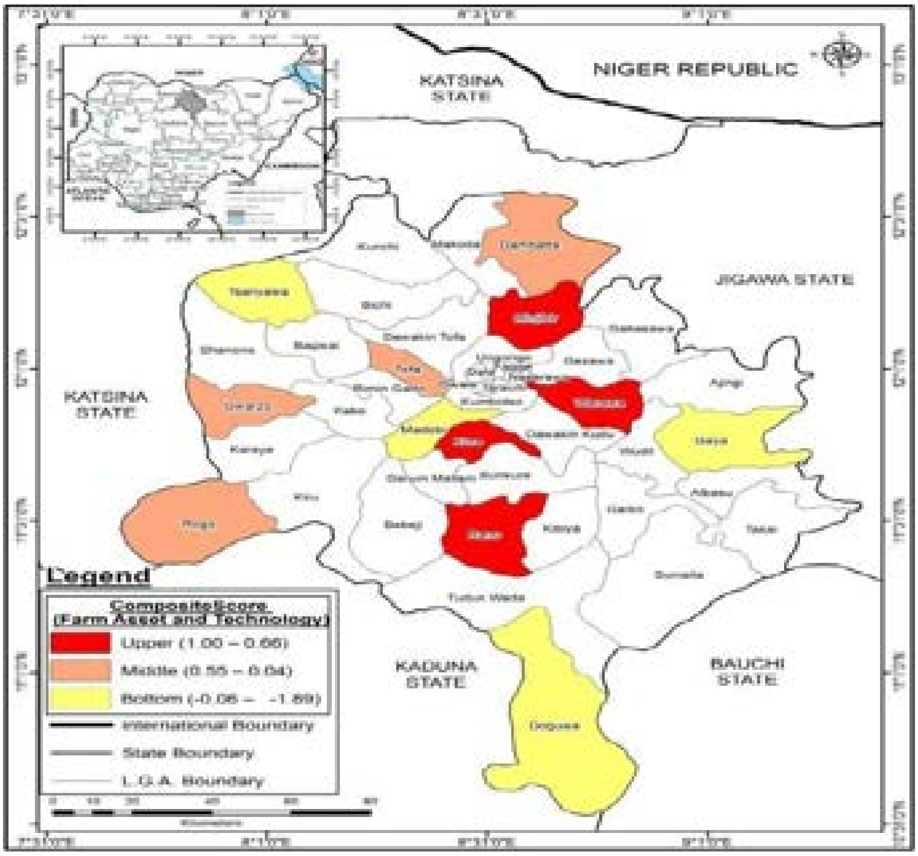


Figure 4: Composite-Score on LGAs in Kano State on Farm Asset and Technology Dimension

4. CONCLUSION

The persisted failure of agricultural development programmes in Nigeria has demonstrated the weakness of the policies coupled with inability of the successive administrations to resolve the fundamental problems of agricultural development. The country has not satisfactorily addressed the issue of how agricultural programmes could spread spatially so as to maintain a balanced development.

The study showed that some areas in Kano state have benefited from agricultural development programmes more than their average shares and this singular factor explains the edge they have over other areas. It is apparently clear that there is existence of varying degrees of variation among the twelve local government areas in Kano state. It is obvious that government at all levels and development partners have not succeeded in giving assistance and creating awareness on the existing agricultural development programmes. The problem of gap- narrowing is one that demands drastic reorientation of policy. It is viewed with all seriousness that after over five decades of independence in Nigeria, there is hardly any excuse for the persistence of the wide gap, except on the ground of lack of sound policies to create the right atmosphere for agricultural development in the backward areas.

A basic challenge in the future of agricultural development programmes process in Nigeria is therefore the narrowing of the gap between the advantaged and disadvantaged areas. Sustainable agricultural development programmes is unlikely to occur without serious attention from the government. Proper channels towards implementing necessary agricultural development programmes strategies should be strictly adhered to in order to deal with the prevailing challenges. It is quite disheartening that certain government policies have compounded the problem because of their non-pragmatic approach.

REFERENCES

Amalu, U.C. (1998). *Agricultural Research and Extension Delivery systems in Sub-Saharan Africa*. University Press, Calabar.

Bora, M. M., Datta, L. and Barthakur, S. (2009). Spatial Pattern of Agricultural Development in Sonitpur District, Assam, India. *North Eastern Geographer*, 36(1 & 2): 6 – 21.

Chukwuemete, E. and Nwewi, H.N. (2011) An Emperical Study of World Bank Agricultural Development Program in Nigeria: *American Journal of Social and Management Science*, 7(8): 2156-5251.

Iwouchukwu, J. C. and Igbokwe, E. M. (2012). Lessons from Agricultural Policies and Programmes in Nigeria. Department of Agricultural Extension. *Journal of Law, Policy and Globalization.* ISSN 2224-3259 (online) Vol 5.

Kano State Agricultural Sector Committee (2015).*Agricultural Sector Performance Review Report.* Ministry of Agriculture, Kano State.

Omoniji etal (2014). Impact of Agricultural Development Program on Rural Dwellers in Nigeria: A Study of Isan Ekiti. *Journal of Finance and Economics,* 128 (2): 41-55.

Singh, G. and Waseem, S. (2012). Spatial Variation in Level of Agricultural Development in Blandisher District of Western Uttar Pradesh (India).

International. *Journal of Development and Sustainability*, 1(1): 47 – 56.
Suwase, K. S. (2015). Spatial Variation in Level of Agricultural Development in Phaltah Tahsil Satara District Mahrashtra, India. *Journal of Research Front,* 2320 – 8341 volume 3000.2.
World Bank (2012). *Independent Evaluation Team.*available@ http://www.google.com/lita.Org.
Zoml (2013). *Kano State Center of Commerce.* Available@ info@zodml.org. 15/06/2016.

The Use of Traditional Adaptation Measures Against Climate Variability among Pastoralists in Katsina State, Nigeria

Idoma K.[1]*, Ashiki, G. M.[2], Ameh, E. B.[3]
[1]*Department of Geography & Environmental Management, Ahmadu Bello University, Zaria*
[2]*Department of Geography, College of Education Akwanga, Nassarawa State, Nigeria*
[3]*Department of Geography, Bayero University, Kano, Nigeria*
**kimidoma@gmail.com*

ABSTRACT

Africa is particularly vulnerable to climate change owing to its low adaptive capacity and high dependence on climate-sensitive resources such as water resources and ecological systems. This has led to myriads of environmental challenges. However, most rural communities have developed various technical solutions and institutional mechanisms to deal with these environmental constraints. This study therefore assessed the indigenous coping strategies employed by pastoralists in response to adverse effects of climate change in Katsina State. A sample of 367 pastoralists was selected for the study. Structured interview and Focus Group Discussion (FGD) were employed for data collection. The data obtained were analyzed using descriptive statistics and Chi-square. Results indicated that a significant proportion (65%) of the respondents adopted various strategies to combat adverse effect of climate change. In addition, the constraints to the effective use of indigenous coping strategies against climate change were identified to be: poverty, poor access to information on climate change, low level of education, land tenure system and inadequate physical and social infrastructure in the rural areas among others. The study concludes that traditional and institutional knowledge accumulated and maintained through practice over countless generations, offers valuable insights into the state of the environment. Consequently, a synergy is needed between local institutions, national and international frameworks for the successful adaptation to climate change.

Keywords: Adaptation; Climate variability; Traditional Adaptation Measures; Pastoralists.

1. INTRODUCTION

Climate change manifestations through extreme climatic events such as changes in mean climate, droughts and floods, have direct impact on crops and livestock as well as local communities' livelihoods (Theobald, 2014). The Intergovernmental Panel on Climate Change (IPCC, 2007) noted that poor communities largely residing in sub-Saharan Africa (SSA) are expected to be most susceptible as a result of their low adaptive capacity and high dependence on climate sensitive resources such as water and ecological systems. Importantly, indigenous communities in SSA, owing to their active involvement in various ecosystems are indispensable to the survival of these ecosystems. The livelihoods of these communities have straight link to nature, therefore, overdependence on natural resources which are greatly constrained by climate change impacts creates lots of pressure on them (Salick and Byg, 2007). Consequently, local communities have evolved various means of adapting to the impacts of climate change in creative ways. This knowledge is gainedthrough observation, premised on cumulative set of experiences passed on from generation to generation (Theobald, 2014).

Regrettably, the growing attention to adaptation to climate change has not come with adequate emphasis on the local nature of climate adaptation and on the role of local institutions and local governance in influencing adaptation practices (Agrawal, Kononen and Perrin, 2009). However, in climate change literature, it is generally held that countries, regions, economic sectors and social groups vary in their level of vulnerability to climate change (Bohle, Downing and Watts, 1993). Hence, it is imperative to note that if adaptation to climate change is to help the most vulnerable social groups, adequate understanding of the role of local institutions in shaping adaptation is germane (Agrawal et al., 2009). It is against this backdrop that this present study is perceived to analyze the use of traditional adaptation measures against climate variability among pastoralists in Katsina state, Nigeria.

In order to construct explanations to the problem statement, the study sought to identify the socio-economic characteristics of the pastoralists, their perception of the climate variability and the coping strategies adopted to mitigate climate change impacts in the study area. The following null hypothesis was tested in this study: Socioeconomic factors do not influence the use of indigenous coping strategies.

1.1 Study Area

The study area is located between Latitudes 11°7′ 49″N, 13°05′22″N, and Longitudes 6°52′30″E and 9°20′40″E with a total area of 24,192 km² (Patrick, 2012). It borders Zazzau Emirate in the south, Kano in the East, Daura in the Northeast, the kingdom of Maradi in Niger Republic in the North and Sokoto Emirate in the West. Katsina state has thirty-four (34) Local Government Areas. See (Fig.1)

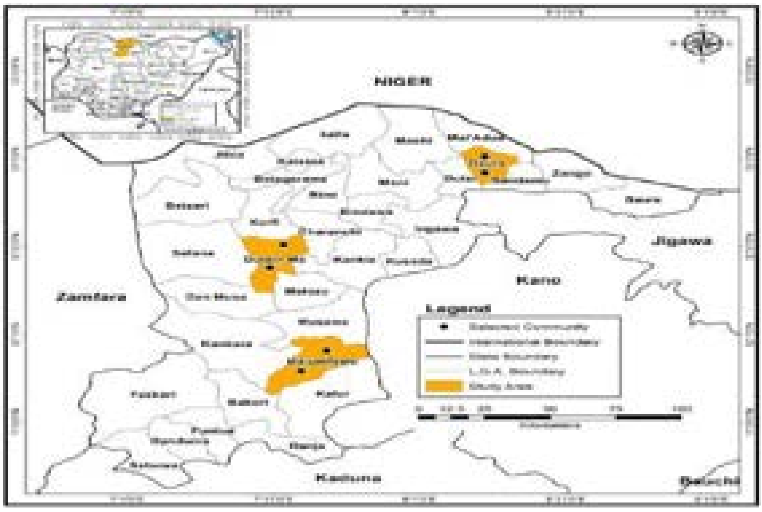


Figure 1: Map of Katsina State showing Study Area

Source: Adapted from the Administrative Map of Katsina State

The climate of Katsina state is fairly that of semi-arid continental zone. It is driven by two principal airmasses: one from the southwest which carries a high degree of moisture and clouds called rainy season and the other from the north bringing cool dry air dust and haze called dry season or Hammatan. The hottest weather occurs between late March and mid-May. The temperature in this period of the year increases daily to maximum of between 38˚C-39˚C (Patrick, 2012). Majority of the population are Hausa/Fulani Muslims and the major economic activities of the people are farming, livestock rearing and marketing of agricultural products (Umar and Musa, 2015; Ikani, 2015).

2. MATERIALS AND METHODS

2.1 Types and Sources of Data

The study used both primary and secondary data. These include socio-economic characteristics of the pastoralists, pastoralists' perceptions of climate variability and the various coping strategies adopted to lessen the adverse effects of climate variability.

Data collection tools included secondary data review, Focus Group Discussion (FGD), Structured Questionnaires, Key Informant Interviews and Personal Observations. The questionnaire was administered by well-trained enumerators supervised by the authors while the FGD was conducted in each community by the authors and assisted by village extension agents. The secondary information was obtained from related books, well researched articles in journals, magazines, seminars and ministries of animal resources on climate change and pastoralism.

2.2 Sampling Techniques

A sample size of 367 based on Krejcie and Morgan's (1970) technique was determined, which is the sample size of a target population range of between 7,000 and 8,000. Multistage (random) sampling technique was used to recruit the sampled respondents. In the first stage, the Local Government Areas (LGAs) in the states were clustered into three senatorial zones of North, Central and West. Secondly, purposive random sampling was employed to select previously identified LGAs with sizeable number of nomads. Hence, one LGA from each of the senatorial zones was selected. This gave a total of three LGAs. See (Tables 1). Thirdly, systematic random sampling was used where the various wards from each of the three LGAs were listed alphabetically and serially numbered. Thereafter, every first and last ward was selected per LGA to give a total of six wards. The fourth stage involved the use of purposive sampling technique to determine the actual settlements from which respondents would be drawn. Consequently, settlements already identified to have the greatest number of nomads were chosen; one from each ward to make a total of six communities for the study. The population of sampled communities from Katsina state is 7, 266 (NPC, 1991); (see Table 1).

2.3 Questionnaire Administration

Households were employed as entities of observation. Hence, open transverse survey was conducted along each path in every selected village to mark every household. Using systematic random method, every third household in each path was selected till the required number of the sample for the community was obtained. The head of each household was chosen as the sampling point and where the head was not available, eldest person was selected to represent the household.

The 1991 Census figures were projected for 2013 for the reason that the population of LGAs was disaggregated into localities according to the 1991 census. The projection of sampled localities' population was based on Katsina state's population growth rate of 3% using the formula: $\mathbf{P_{t+n} = P_t e^{r*n}}$ Where P_{t+n} = Future population (2013), P_t =Base year (1991), e= exponential, r =Growth rate (3%), n =Interval between future population and base year population (2013-1991) =22 years.

Table 1: Selected Settlements and Proportion of Questionnaire administered in Katsina State.

Senatorial Zones	LGAs in Senatorial Zones	Selected LGAs	Selected Wards	Selected Settlements	Population 1991	Population 2013	Proportion of questionnaire
Katsina North	Baure						
	Daura	Daura	Madobi	Tudu	478	925	47
			Sabongari	RumaSanda	717	1387	70
	Kankia						
Katsina Central	Batsari						
	Dutsin-ma	Dutsin-ma	Dabawa	Gamzoka	491	950	48
			Tsauri	Garazawa	850	1645	83
	Katsina						
Katsina South	Bakori						
	Malumfashi	Malumfashi	Malumfashi	Kwarsu	542	1049	53
			UngwaArzuka	Makurdi C	677	1310	66
	Musawa						
Total		**3**	**6**	**6**	**3755**	**7266**	**367**

2.4 Methods of Data Analysis

Descriptive statistics such as frequency, counts, percentages and mean distribution were employed in the data analysis. A fourpoint Likert –type scale with response options of; strongly agree, agree, disagree, strongly disagree, scaled 4 to 1, was used. The values on the Likert type scale were summed to get 10, and then divided by 4, to get a mean score of 2.5. Then respondents' mean scores were obtained for each response item such that any one higher or equal to 2.5 was regarded as significant and vice versa. Chi-square was used to test the hypothesis. The study was carried out between March, 2014 and April, 2015. A total of 367 questionnaires were administered but 300 (96 in Daura, 107 in Dutsin-ma and 97 in Malumfashi LGAs) copies of the questionnaire were retrieved representing 81.74%.

3. RESULTS AND DISCUSSION

3.1 The Socio-Economic Characteristics of the Respondents

Table 2 reveals the distribution of respondents by their socio-economic characteristics. Regarding gender, the majority of the pastoralists were males (90%). This suggests that shepherding as a livelihood is male dominated in the study area.

Table 2: Socio-Economic Profile of Respondents (n=300)

Profile	**Frequency**	**Percentage**$\bar{x}$
Gender: Male	270	90.00
Female	30	10.00
Age <15	18	6.00
15-19	12	4.00
20-24	60	20.00
25-29	30	10.00
30-34	18	6.00
35-39	36	12.00
40-44	42	14.00
45-49	24	8.00
>50	60	20.00
Household Size		
< 5	86	28.67
6-10	112	37.34
11-15	40	13.33
		17
16-20	31	10.33
21-25	18	6.00
>26	13	4.33
Level of Education		
Tertiary	78	26.00
Secondary	67	22.33
Primary	40	13.33
Islamic	109	36.33
Informal	6	2.00
Level of Income		
<100,000	40	13.34
100,000 – 200,000	60	20.00
201,000 – 300,000	100	33.33
301,000 – 400,000	58	19.33
>400,000	42	14.00
Cattle size		
<100	66	22.00
100 -500	75	25.00
501- 1000	100	33.33
1001- 5000	45	15.00
> 5000	14	4.67
Occupation		
Animal rearing	215	71.67
Arable farming	30	10.00
Civil servant	15	5.00
Trading	12	4.00
Artisan	28	9.33

In reality, the tending of cattle requires long distance travelling on daily basis. This is perhaps beyond the scope of the female (Ayanda, Oyeyinka, Salau, and Ojo, 2013). Additionally, Montle and Teweldemedhin (2014) observed that female-headed households might be slow to react to changing climate conditions through the adaptation of diversified strategies due to the challenge posed by their customary household duties (e.g. childcare) and the fact that they are by nature less physically able to perform labour-intensive agricultural work. Therefore, Nhemachena and Hassan (2008) asserted that male-headed households are often considered to be more likely to get information about new technologies and take on risks than female-headed households.

The age distribution of respondents has indicated that 20% of the respondents (i.e. majority) are between the ages of 20-24. This is followed by 14% (40-44 yrs.). This by implication suggests that pastoralists in the study area are within active age. At this age bracket, Falola, Segun, Akangbe and Ibrahim (2012) reported that pastoralists are capable of handling tedious farming activities such as covering long distances to graze animals, fetching water from well for the animals to drink, collection of fodder or hay for the animals during scarcity etc. Also, Onubuogu and Esiobu (2014) asserted that majority of farmers within the age range of 41 to 50 years are still in there active age, more receptive to innovation and could withstand the stress and strain involved in agricultural production and ease adaptation to climate change.

Regarding household Size, Table 2 reveals that the mean household size is 17 persons. By inference, the study area has abundant family labour supply that could be used to carry out herding operations as this would save cost. This investigation is in harmony with Gbetibouo (2009) who noted that large households are more willing to choose labour-intensive adaptation measures. In keeping with his findings, Deressa, Hassan, and Ringler (2010) maintained that household size positively and significantly leads to an increase in the likelihood of adapting to climate change. This is probably because large family size is normally associated with a higher labour endowment, which would enable a household to accomplish various agricultural tasks especially during peak seasons. On the other hand, Yirga (2007) observed a negative relationship contending that household with large families may be forced to divert part of the labour force to off-farm activities in an attempt to earn income in order to ease the consumption pressure imposed by a large family.

On the basis of education, Table 2 has shown that pastoralists in Katsina state were litrate to varying degrees. It has shown that majority (36.33%) had Quranic education. This is followed by secondary education (22.33%) and tertiary education (26%). The high proportion of respondents with Quranic education is indicative of the fact that the study area is Muslim dominated and Quranic education is the basic learning stage in Islam. According to Kehinde (2014), low level in education could prevent farmers from keying into the Agricultural Transformation Agenda of the Federal Government of Nigeria and the Nomadic Education Programme which may thus affect their socio-economic status. Hence, exposure to high level of education is an added advantage in terms of climate change adaptation measures. Consequently, Esiobu, Onubuogu and Okoli (2014) noted that higher education was likely to enhance information access to the farmer for improved technology uptake and higher farm productivity. They reiterated that education is likely to enhance the farmers ability to receive, decipher and comprehend information relevant to making innovative decisions in their farms. Thus, higher level of education determines the quality of skills of farmers, their allocative abilities, efficiency and how well informed they are to the innovations, technologies and awareness levels and adaptation to climate change (Onubuogu and Esiobu, 2014).

With reference to the income level of respondents, Table 2 has illustrated that majority (33.33%) earned between 201,000 to 300,000 annually. This is followed by 19.33% who earned between 301,000-400,000 and 42% whose annual income is greater than 400,000. This investigation discloses that in general, pastoralist communities in Katsina state had medium economic status and hence are bouyant enough to adopt improved adaptation practices. Onubuogu, Chidebelu and Eboh (2013) corroborated this findings by noting that farmers' incomes (whether on-farm or off-farm income) have a positive relationship with the adoption of agricultural technologies since the latter requires sufficient financial wellbeing to be undertaken. In addition, Deressa and Hassan (2009) reported the significant impact of farm income on household choice of conserving soil, using different crop varieties and changing planting date as climate change adaptation strategies.

On the basis of occupation, animal rearing predominates (71.67%). Others include arable farming and trading (15%), artisan (9.33%) and civil servant (4%). The preceding result indicates that pastoralists in the study area are undergoing livelihood diversification. According to Mcbe, Lesile and Deluca, (2010), pastoral peoples in Africa, and in fact in many areas around the world, have been rapidly diversifying their economies. Reasons advanced to explain this change in livelihood strategies have included the alienation of rangelands due to the expansion of parks and protected areas (McCabe, 2003), changes in land tenure and the privatization of land held as common property (Leserogol, 2008),the loss of livestock due to drought and disease (O'Malley, 2000) and the increase in the human population while the livestock population remained steady or declined (McCabe, 2000).

Concerning respondents' cattle size, Table 2 has shown that a larger propotion (33.33%) of the respondents had cattle size between 501 to 1000. Emeka (2015) opined that the number of cattle a man has is considered as a sign of his wealth, therefore, those with 5000 and above herd are considered richest amongst the nomadic famers.This investigation is in deed in tandem with the findings of Osotimehin, Tijani, and Olukomogbon (2006) that the size of herd is traditionally considered a measure of wealth and social status among the nomads; the larger the size of the herd of a nomad, the greater the security such an individual enjoys. Instructively, economic status of pastoralists is critical to climate change adaptation measures. This finding is validated by Deressa and Hassan (2009) who indicated that lack of money, lack of information, inadequate labour, inadequate land and poor potential for irrigation are the major barriers which prevented farmers from adopting various adaptations measures.

3.2 Pastoralists' Perception of Climate Variability

According to Bryan, Deressa, Gbetibouo and Ringler (2009), farmers should perceive first that there is climate change in order to take necessary adaptive strategies. Consequently, the surveyed pastoralists' household heads were asked about their perceptions of changes in various climate variables over the past 40 years. The major components were yearly temperature, rainfall, drought, and pests and diseases. Perceptions on climatic components were divided into four categories: increased, decreased and no change. Farmers' perceptions on each climatic parameter change are presented below:

Figure 1 shows pastoralist perception of changes in rainfall, temperature, drought, pests and diseases incidences in Katsina State from 1996-2013. Majority (83%) of the pastoralists perceived decrease in rainfall, while 89% perceived increase in temperature, above half (69%) observed increase in drought, whereas 54% perceived increase in pests and diseases as effects of climate vaiability in the area.

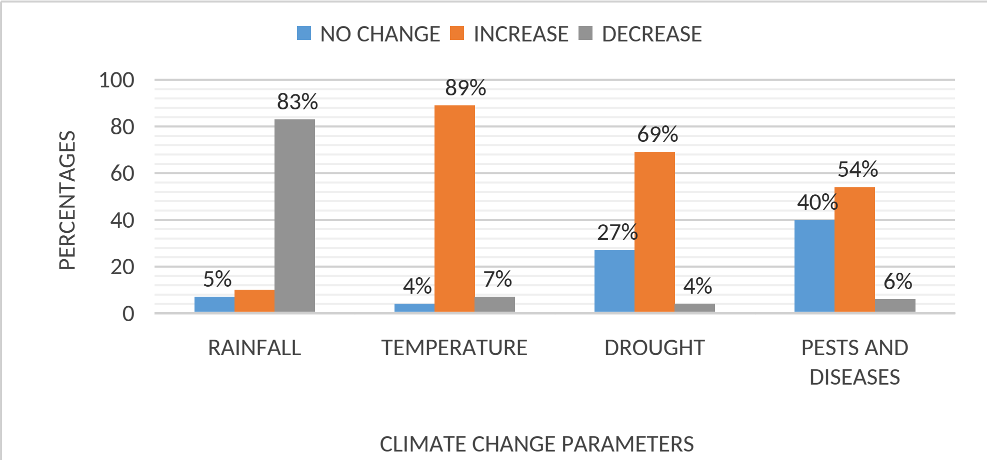


Figure 1: Pastoralist perception of climate variability

The accuracy of farmers' perceptions of climate variability was assessed by comparing their perceptions of long-term changes in temperature and precipitation with climate trends recorded at nearby meteorological stations. This perception was confirmed by the statistical record for Katsina between 1986 and 2013, which showed the increase in temperature occurring mostly in the summer months (October to March) and decreasing trend in rainfall. An analysis of climate data at the regional level shows the same general trend of increasing temperature with some minor variations in terms of the severity of the increase and its timing. Thus, farmers' perceptions are supported by the statistical record. Additionally, the foregoing analysis of pastoralists' observation of climate variability is in harmony with the work of Ishaya and Abaje, (2008) in which 73% of the respondents were of the opinion that temperature has been increasing over the past few decades. This is also in agreement with the study of Oladipo (2011) that the country has been experiencing temperature increase of about 0.2 °C – 0.3 °C per decade in all its ecological zones. However, decrease in rainfall as perceived by the pastoralists is in sharp contrast with similar studies in the region. For instance, Ati, Iguisi, and Afolayan (2007); Odekunle, Andrew and Aremu (2008) and Abaje, Ati, Iguisi, and Jidauna (2013) using recorded rainfall data observed that this zone is now experiencing wetter conditions in recent years. Hence, Odjugo (2009) opined that while rainfall duration and amount is decreasing, the intensity is increasing.

Similarly, pastoralists' perception of increase in drought occurrences is inconsistent with most of the recent studies related to drought occurences in the northern parts of the country using recorded climatic data.These researches include Odekunle, Andrew, and Aremu (2008); Abaje, Ati, and Iguisi (2012) and Abaje, Ati, Iguisi, and Jidauna (2013) who observed that drought occurrences in this zone is decreasing lately.

In view of the importance of rainfall to pastoral economy, the foregoing investigation has demonstrated that pastoralists in the study area are highly constrained. This is because the reduction in rainfall in recent time affects pasture availability, which implies that the pastoralists would wander a longer distance in search of pasture and water. Ward, Saltz, and Ngairorue (2004) and Ayanda et al. (2013) authenticated this result stating that livestock populations generally increase with increasing rainfall due to the importance of rainfall on vegetation production.

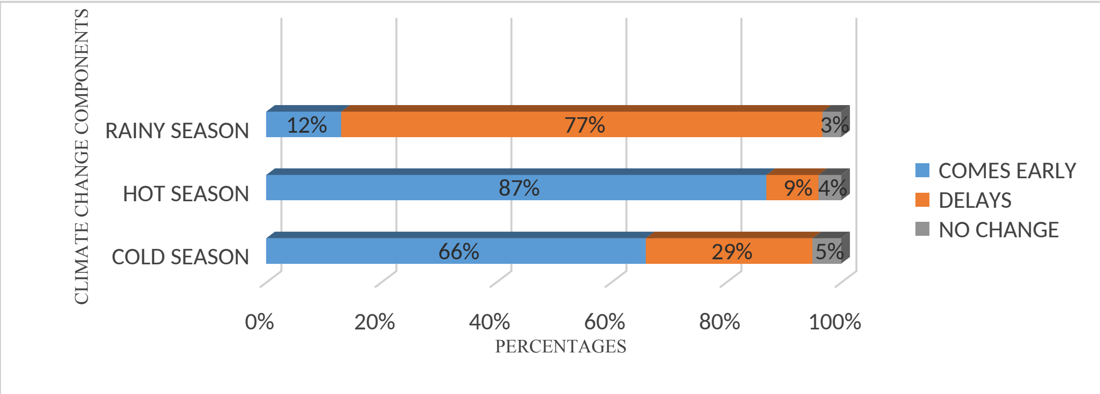


Figure 2: Pastoralists' perception of changes in the onset and cessation of seasons

In terms of onset and cessation of seasons, Figure 2 indicates that a greater proportion of the pastoralists (66%) observed cold season to have come earlier, 87% perceived hot season to have started early, whereas 77% observed rainy season to have delayed. This findings is corroborated by Akponikpe', Johnston and Agbossou (2010) who revealed that onset of the rainy season was perceived by farmers to be later these days. Likewise, Kamruzzaman (2015) noted that majority of the farmers perceived hot season to come early but delays to end, while cold season delays to start and cessation comes early. Conversely, Nyanga, Johnsen, and Aune, (2011) found no change in onset and offset of hot season and no change in onset but delays in offset of cold season in Zambia.

Regarding duration of seasons, Figure 3 demonstrates that larger proportion (73%) of the pastoralists perceived reduction in the duration of cold season, 67% observed increase in the length of hot season, while more than half (60%) perceived decrease in the length of rainy season.

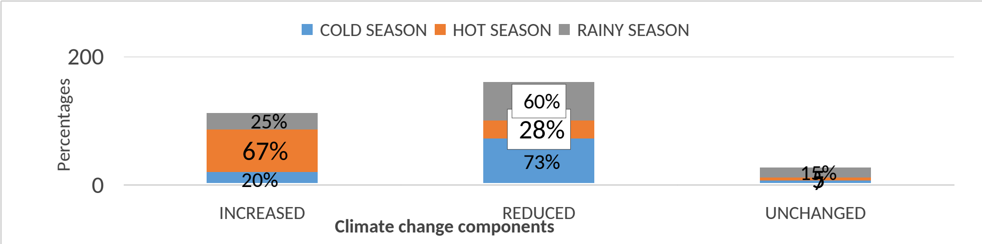


Figure 3: Perception of changes in the duration of seasons

The preceding result is confirmed by Kamruzzaman (2015) who found that greater proportion of farmers (80.7%) believed that duration of rainy season reduced, hot season increased and cold season reduced. Additionally, Mertz, Mbow, Reenberg and Diouf (2009) revealed that in rural Sahel, households generally agreed that cold periods have become shorter, hot periods longer and a reduction in rainy season.

Reduction in the length of rainy season could lead to poor pasture growth, which may also lead to decline in fodder supplies from crop residues,weight less and increased deaths among stock. Whereas, longer hot periods have the tendency to aggravate heat-related diseases and stress impairing growth and reproduction, milk production and lactation length (Singh, Meena, Kolekar and Singh, 2012)

3.3 Pastoralists' Coping Measures to Climate Variability

Pastoralists in the study area were asked to reveal their major adaptive strategies in response to changing climate. These are summarized in Table 3. Hence, from Table 3, the following inferences can be easily drawn. The predominant coping strategies adopted by pastoralists in the study area include; moving long distances to find pasture (2.9), water harvesting (2.9), use of crop residues as animal feeds (2.6), herd splitting (2.7), praying to God (2.7) and concentrate feeding (2.7). These strategies had a mean score above the standard reference mean of 2.5, hence considered the most significant coping strategies implemented in the study area. The submission of Ayanda, Oyeyinka, Salau, and Ojo (2013) is in line with this investigation that more than half the proportion of pastoralists engaged in sinking of open wells for watering cattle, use of crop residue as feed supplements and herd size reduction as measures to ameliorate adverse effect of climate variability on their activities.

Similarly, Kirimi, John and Agnes (2013) opined that migrating to other areas was highly practiced by pastoralists in Kenya during shortage of grasses. According to Heltberg, Siegel and Jorgensen (2009), climate change related challenges have forced many households to change livelihood choices. Other choices included use of traditional fodder especially for the goats, conserving fodder, renting pasture land and to reduce livestock numbers by selling. It is obvious from the foregoing result that the major coping strategy embarked upon by pastoralists was moving long distances to find pasture.

Generally, mobility is a well-known primary risk reduction strategy, particularly in times of drought employed by pastoralists exploiting rangelands. Discussion with key informants confirmed this, as one of them aptly stated:

"We don't stay in one place, any where we notice there is enough grass for

cattle we move there, especially during the dry season we used go far to the southern and middle belt region of the country, where there are enough grasses and water for our animals. Nowadays our movements have been very restricted due to conflicts with crop farmers".

Table 3: Pastoralists' Coping Strategies to Climate Variability

Coping Strategies	1	2	3	4	∑f	∑fx	$\bar{x}$
MLD	30	20	200	50	300	870	2.9
UCR	60	60	110	70	300	790	2.6
DLA	40	120	120	20	300	600	2.0
HDS	10	80	180	30	300	830	2.7
HDK	25	120	130	25	300	725	2.4
HDF	55	110	110	25	300	705	2.4
CTF	20	90	140	50	300	820	2.7
WHT	30	20	180	70	300	890	2.9
PTG	20	60	200	20	300	820	2.7

Note: 4= strongly agree, **3**= agree, **2**=disagree, **1**= strongly disagree. (**Standard Reference mean =2.5**)**Legend: MLD**=Move Long Distances to find Pasture, **UCR**=Use of crop residue as animal feeds, **DLA**=Diversification of livelihood activities, **HDS**= Herd splitting, **HDK**=Herd destocking, **HDF**=Herd Diversification, **CTF**= Concentrate Feeding, **WHT**=Water Harvesting, **PTG**=Praying to God.

Musembi and Kameri-Mbote (2013) confirmed that these movements by herders are often affected by impacts such as violent conflicts, diseases outbreaks and recurrent drought. Researches show that seasonal decisions to migrate guarantee the productivity of herds of households and security of their families. Affirmatively, McCabe (2006) and Niamir-Fuller (2000) maintained that this form of mobility is pursued primarily for livelihood purposes and that movement of livestock to areas with secure water and pasture resources is an effective strategy against droughts, which has remained important for herders in Africa.

Results of the Chi square analysis in Table 4 show that age, marital status, level of education and farmingexperience were significantly related to factors determining adoption of adaptation measures. These findings are similar to that found by other researchers. For instance, Kimani, Ogendi and Makenzi (2014) asserted that as the age of the household head increased, the person was expected to acquire more experience in weather forecasting and that would help to increase in likelihood of practicing different adaptation strategies to climate change. Conversely, Tazeze, Haji and Ketema (2012) submitted that the household age was not significant to choose any types of the climate adaptation strategies. UNESCO (2014) states that education is expected to help people understand and address the impact of global warming, encourage changes in their attitudes and behavior and help them adapt to climate change-related trends.

Similarly, Getachew, Tilahun and Teshager (2014) were of the view that education is an essential element of the global response to climate change. Komolafe, Adesiji and Ajibola (2014) suggest that the older farmer above 50 years will have more experience in farming and exposed to past and present crop varieties that could be planted for maximum output which can shape their decision making as regards adoption of innovation. It is important to note that marital status influences labour supply and labour abundance is critical to climate change adaptation owing to its great labour requirements.

Table 4: Relationship between demographic characteristics of respondents and adaptation strategies to climate change.

Variables	df	X^2 Cal.	X^2 Tab.	Decision
Age	4	19.84	9.49	Significant
Marital Status	3	20.52	7.81	Significant
Level of Education	4	10.31	9.49	Significant
Farm Experience	4	30.65	9.49	Significant

$P< 0.05$

4. CONCLUSION

It is apparent from this study that pastoralists are experiencing change in climate and have been undergoing series of adaptations in response to climate variability already. However, the persistent increase in the magnitude of change is expected to present heightened risk, new combinations of risks and potentially grave consequences, which could stifle their ability to cope effectively. Irregular rainfall pattern affects the availability of water and pasture which is crucial to animal productivity. Hence, reduction in rainfall and its inter-annual variability in the study area necessitate adaptation of pastoralists.

The inconsistency of pastoralists' perception of climate variability with recorded climatic data in the study area indicates low knowledge of climate variability and change among the pastoralists. This could pose a threat to acceptance of new innovations in adaption strategies by pastoralists in the study area.

4.1 Recommendations

Bearing in mind the findings of this study, it is recommended that policy makers, planners, development agencies and donors should initiate the following policy measures to mitigate the adverse effects of climate change on pastoralists: breed Improvement, improvement in livestock health care, improvement in the extension service, improving climate information forecasting and dissemination, making credit available to livestock farmers, enhancement of adaptive capacity, creation of alternative investment opportunities, improvement in ranch management.

REFERENCES

Abaje, I.B., Ati, O.F., and Iguisi, E.O. (2012). Changing climatic scenarios and strategies for drought adaptation and mitigation in the Sudano-Sahelian Ecological Zone of Nigeria. In M. Iliya, and I. Dankani, *Climate Change and Sustainable Development in Nigeria* (pp. 99-121). Ibadan: Crown F. Publishers.

Abaje, I.B., Ati, O.F., Iguisi, E.O., and Jidauna, G.G. (2013). Droughts in the Sudano-Sahelian Ecological Zone of Nigeria: Implications for Agriculture and Water Resources Development. *Global Journal of Human Social Science (B): Geography, Geo-Sciences and Environmental*, 13(2): 1-10.

Agrawal, A., Kononen, M., and Perrin, N. (2009). The Role of Local Institution in Adaptation to Climate

Change . *Social Develpment Working Papers*, Paper No.118.

Akponikpe', P., Johnston, P., and Agbossou, E. (2010). Farmers' Perception of climate Change and Adaptation Strategies in Sub-Saharan West-Africa. *Climate, Sustainability and Development in Semi-arid Regions.* Fortaleza-Ceara,Brazil.

Ati, O.F., Iguisi, E. O., and Afolayan, J. O. (2007). Are we experiencing drier conditions in the sudano-sahelian zone of Nigeria? *Journal of Applied Science and Resources*, 3(12): 1746-1751.

Ayanda, I., Oyeyinka, R., Salau, S., and Ojo, F. (2013). Perceived Effects of Climate Change on Transhumance Pastoralists in Ogun State,Nigeria. *Global Journal of Human Social Science (B)*, 13(1):38-47.

Berkowitz, A.D. (2002). Guidelines for consent in intimate relationships. *Campus Safety and Student Development, 3*, 49-50.

Bohle, H. G., Downing, T., and Watts, M. (1993). Climate Change and Social Vulnerability. *Global Environmental Charge*, 4(1):37-48.

Bryan, E., Deressa, T., Gbetibouo, G., and Ringler, C. (2009). Adaptation to climate change in Ethiopia and South Africa: options and constraints. *Environmental science and policy*, 12(4):413-426.

Deressa, T., and Hassan, R. (2009). Economic Impact of Climate Change on Crop Production in Ethiopia: Evidence from cross-section maesures. *African Journal of Economics*, 18:529-554.

Deressa, T., Hassan, R., and Ringler, C. (2010). Perception of and adaptation to climate by farmers in the Nile basin of Ethiopia. *Journal of Agricultural Science*, 149:23-31.

Emeka, N. (2015). The Effects of Migration by Nomadic Farmers in the Livelihoods of Rural Crop Farmers in Enugu State, Nigeria. *Global Journal of Science Frontier Research: Agriculture and Veterinary*, 15(3):21-28.

Esiobu, N., Onubuogu, G., and Okoli, V. (2014). Determinants of Income from Poultry Egg Production in Imo State, Nigeria: An Econometric Model Approach. *Global Advanced Research Journal of Agricultural Science*, 3(7):186-199.

Falola, A.F., Segun, B., Akangbe, J.A., and Ibrahim, H. (2012). Climate Change Mitigation Activities and Determinants in the Rural Guinea Savannah of Nigeria. *Sustainable Agriculture Research*, 1:(2):170-177.

Francis, O., Wasonga, O., Nyangito, M., Schilling, J., and Munang, R. (2015). Drought Adaptation and Coping Strategies Among the Turkana Pastoralists of Northern Kenya. *International Journal of Disaster and Risk Science*, 6:295–309.

Gbetibouo, G. (2009). *Understanding Farmers' Perceptions and Adaptations to Climate Change and Variability: The Case of the Limpopo Basin, South Africa. .* Washington DC: IFPRI.

Getachew, S., Tilahun, T., and Teshager, M. (2014). Determinants of agro-pastoralist climate change adaptation strategies: Case of Rayitu Woredas, Oromiya Region, Ethiopia,. *Science Alert*.

Heltberg, R., Siegel, P. B., and Jorgensen, S.L. (2009). Addressing human vulnerability to climate change: toward a 'no-regrets' approach. *Global Environmental Change*, 19(1): 89-99.

Ikani, A. (2015). *Households' vulnerability and adaptation to water scarcity in rural areas Katsina state, Nigeria.* PhD Thesis, Department of Geography and Environmental Studies, University of Nairobi, Kenya.

IPCC. (2007, April 21). *IPCC. (2007). Climate Change 2007: Synthesis Report, Contribution of Working Group I, II and III to the Fourth Assessment Report of the intergovernmental Panel on climate change*. Retrieved from http://www.ipcc.ch/pdf

Ishaya, S., and Abaje, I. B. (2008).

Indigenous people's perception on climate change and adaptation strategies in Jema'a Local Government Area of Kaduna State, Nigeria. *Journal of Geography and Regional Planning,*, 1(8):138-143.

Kamruzzaman, M. (2015). Farmers' Perceptions on Climate Change: A Step toward Climate Change Adaptation in Sylhet Hilly Region. *Universal Journal of Agricultural Research*, 3(2): 53-58, 2015.

Kehinde, E. (2014). Conflict Management Strategies to reduce consequences of livelihoods of fulani cattle herds and farmers in Kabba Bunnu,Kogi State,Nigeria. *Nigerian Journal Of Rural Sociology*, 14(2):15-21.

Kimani, E.W., Ogendi, G., and Makenzi, P. (2014). Perceptions of climate change. *Ozean Journal of Applied Sciences* , 7(2):57-74.

Kirimi, N., John, G.M., and Agnes, O.N. (2013). Climate Change Challenges and Adaptation Strategies among the Pastoralits of Laikipia county Kenya. *International Journal of Agricultural Extension*, 1(1):20-30.

Komolafe, S., Adesiji, G., and Ajibola, B. (2014). Determinants of adoption of improved crop practices among women farmers in Ekiti East Local Government Area of Ekiti State, Nigeria. *WebPub Journal of Agricultural Research*, 2(7): 98-105.

Krejcie, R.A. (1970). Educational and Psychological Measurement. *Determining Sample Size for Research Activities*, 30: 607-610.

Leserogol, C. (2008). *Contesting the Commons: Privatizing Pastoral Lands in Kenya.* Ann Arbor: University of Michigan Press.

McCabe, J. (2006). Cattle bring us to our enemies. Turkana ecology,politics, and raiding in a disequilibrium system. *Human Ecology*, 34(1): 147–149.

Mcbe, J., Lesile, P., and Deluca, L. (2010). Adopting Cultivation to Remain Pastoralists: The Diversification of Maasai Livelihoods in Northern Tanzania. *Human Ecology*, 38(3):321-334.

McCabe, J. (2003). Sustainability and Livelihood Diversification Among the Maasai of Northern Tanzania. . *Human Organization.*, 62(3):100–111.

Mertz, O., Mbow, C., Reenberg, A., and Diouf, A. (2009). Farmers' Perceptions of Climate Change and Agricultural Adaptation Strategies in Rural Sahel. *Environmental Management*, 43:804–816.

Montle, B., and Teweldemedhin, M. (2014). Assessment of farmers' perceptions and the economic impact of climate change in Namibia:Case study on small-scale irrigation farmers (SSIFs) of Ndonga Linena Irrigation project . *Journal of Development and Agricultural Economics*, 6(11):443-454.

Musembi, C., and Kameri-Mbote, P. (2013). Mobility, marginality and tenure transformation in Kenya: Explorations of community property rights in law and practice. *Nomadic Peoples*, 17(1):5-32.

Nhemachena, C., and Hassan, R. (2008). Determinats of African farmers' strategies for adapting to climate change.Multinomial choice analysis. . *African Journal of Agriculture and Resource Economics*, 2(1):83-140.

Niamir-Fuller, M. (2000). Managing mobility in African rangelands. In N. McCarthy, B. Swallow, M. Kirk, and P. Hazell, *property rights,risks, and livestock development in Sub-Saharan Africa* (pp. 102–131). Washinton,DC: International Food Policy Research Institute,.

Nyanga, H., Johnsen, F., and Aune, J. (2011). Smallholder Farmers' Perceptions of Climate Change and Conservation Agriculture: Evidence from Zambia. *Journal of Sustainable Development*, 4(4): 73-85.

Odekunle, T., Andrew, O., and Aremu, S. (2008). Towards a wetter Sudano-Sahelian ecological zone in twenty-first century Nigeria. *Weather*, 63(3):66-70.

Odjugo, P. (2009). Quantifying the cost of climate change impact in Nigeria: Emphasis on wind and rainstorms. *Journal of Human Ecology*, 28(2):93-101.

Oladipo, E. (2011). The challenge of climate change for Nigeria: An overview. In E. O. Iguisi, O. F. Ati, R. O. Yusuf, and A. E. Ubogu, *Climate Change Impacts: Risks and Opportunities* (pp. 22-44). Zaria: Proceedings of the International Conference of the Nigerian Meteorological Society held held at Ahmadu Bello University,Nigeria, 13th-17th November,2011.

O'Malley, M. (2000). *Cattle and Cultivation: Changing Land Use Patterns in Pastoral Maasai Livelihoods, Loliondo Division, Ngorongoro District. Tanzania.* PhD dissertation. Department of Anthropology, University of Colorado.

Onubuogu, G., and Esiobu, N. (2014). Trends, perceptions and adaptation options of arable crop farmers toclimate change in Imo State, Nigeria: A logit multinomial model approach . *World Journal of Agricultural Sciences*, 2 (5): 108-122,.

Onubuogu, G., Chidebelu, S., and Eboh, E. (2013). Enterprise Type, Size and Allocative Efficiency of Broiler Production in Imo State, Nigeria. *International Journal of Applied Research and Technology*, 2(6): 10 – 19.

Osotimehin, K.O., Tijani, A. and Olukomogbon, E. (2006). An economic analysis of small scale dairy milk processing in Kogi State,Nigeria *Livestock Research for Rural Development*,18(117)RetrievedNovember14,2015,fromhttp://www.lrrd.org/lrrd18/11/osot18157.htm.

Patrick, S. (2012). *An Assessment of forest Resource Utilization and Management:A study of Katsina fuel wood Plantain Number 2 forest reserve in Katsina Local government Area of Katsina State.*

Salick, J., and Byg, A. (2007). *Indigenous Peoples and Climate change. Report of Symposium 12-13 April 2007.* Oxford, UK.: Tyndall Centre for Climate Change Research.

Schilling, J., Opiyo, F., and Scheffran, J. (2012). Raiding pastoral livelihoods: Motives and effects of violent conflict in north- western Kenya. *Pastoralism: Research, Policy and Practice*, 2(25): 1–16.

Singh, S.K., Meena, H.R., Kolekar, D. V., and Singh, Y.P. (2012). Climate Change Impacts on Livestock and Adaptation Strategies to Sustain Livestock Production. *Journal of Veterinary Advances*, 2(7): 407-412.

Sofoluwe, N.A., Tijani, A.A., and Baruwa, O.I. (2011). Farmers' perception and adaptation to climate change in Osun State, Nigeria. *African Journal of Agricultural Research*, 6(20):4789-4794,.

Tazeze, A., Haji, J., and Ketema, M. (2012). Climate change adaptation strategies of smallholder farmers: The case of Babilie District, East Harerghe zone of Oromia regional state of Ethiopia. . *Journal of Economics and Sustainable Development*, 3: 1-12.

Theobald, F.T. (2014). *Indigenous Knowledge as a base of Climate Change Adaptation: Perspectives from Communities Living along Ngono River Basin, Tanzania.* Retrieved from Responsible Development in a Polycentric World: Inequality, Citizenship and the Middle Classes; 14th EADI General Conference: www.gc2014.org

Umar, S., and Musa, M. (2015). Determinants of the use of Indigenous Coping Strategies against Climate Change among Smallholder Farmers in Katsina State, Nigeria. *Journal of Agriculture and Ecology Research*

International, 3(1): 24-32, .

UNESCO . (2014). *Climate change education for sustainable development.* UNESCO.

Ward, D., Saltz, D., and Ngairorue, B. (2004). Spatio-temporal rainfall variation and stock management in arid Namibia. *Journal of Range Management* , 57: 130–140.

Yirga, C. (2007). *The dynamics of soil degeradation and incentives for optimal management in Central Highlands of Ethiopia.* Pretoria,South Africa: Unpublished PhD. Thesis. University of Pretoria.

Savanna volume 23, Number 1, June, 2016

Physical Planning Inputs in Managing Desertification: A Case Study of Jibia Local Government Area in Katsina State, Nigeria

Mohammad Ahmad Falaki [1]*, Hadiza Tanimu Ahmed[2], Rakiya Haruna Ibrahim[3] and Sani Zainab Ibrahim[3]

[1]*Department of Urban and Regional Planning, Ahmadu Bello University, Zaria*
[2]*Department of Urban and Regional Planning, Nuhu Bamalli Polytechnic, Zaria*
[3]*Department of Architecture, Ahmadu Bello University, Zaria*
**lafalaks@yahoo.com*

ABSTRACT

Jibia Local Government Area falls within the arid zones of the desert. This region is characterized by low amount of rainfall, high temperature, low humidity which has caused frequent drought in the area thereby making the area vulnerable to desertification. This has adversely affected the socioeconomic activities of the inhabitants of the area. This study utilized climatic data to examine the prevailing physical environmental conditions in Jibia, also field survey data was acquired to investigate the present desertification adaptation strategies in the area with a view to making physical planning proposals. Since Jibia falls within the arid zone, it is therefore proposed that in planning a settlement in the area, emphasis should be based on centralizing the residential areas; this should then be followed by an open space for future expansion. Trees should be provided round the residential areas to serve as buffer against the winds and sunrays. Moreover, there should be an expanse of farmland for cultivation by the inhabitants at the outskirts of the residential areas. Narrow routes shaded with trees should also be provided.

Keywords: Desertification; Physical planning; Adaptation; Desertification control.

1. INTRODUCTION

The United Nations Convention to Combat Desertification defines desertification as “land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors including climatic variations and human activities” (UNCED, 1992). Drylands include those land areas of the earth receiving under 600 mm/year of precipitation and for which the ratio of average annual precipitation of potential evapotranspiration is between 0.05 and 0.65 (UNEP, 1992).

Desertification is often caused by the interplay of environmental and socioeconomic factors such as poor irrigation methods, deforestation, and overgrazing resulting to reduced vegetation cover and soil organic matter, decreased infiltration, increased runoff, and increased wind and water erosion. Desertification of drylands is a matter of serious concern as it eventually leads to declining capability of land for crop production, livestock grazing, and thus supporting human populations.

The social consequences of desertification are manifested in the increasing migration of rural populace and shepherds to the cities resulting into increasing pressure on the urban amenities and utilities. Other environmental consequences of desertification include the formation of sand dunes and sand encroachment on urban areas, farmlands, roads and railways (Saad and Shariff, 2011).

Schreiber highlighted how geospatial technologies (including global positioning systems (GPS), satellite imagery, aerial photography, and geographic information systems (GIS)) can be used in monitoring and management of land areas vulnerable to desertification. Likewise, Petta et al. (2005) tested the usefulness of spatial analysis methodologies to capture spatiotemporal heterogeneity from environmental gradients for the assessment of desertification process at Remote Sensing data. They provided spatial and georeferenced information related to the susceptibility to desertification of several areas of the Northeast of Brazil. In addition, they integrated the georeferenced data with other environmental indicators to identify five different levels of susceptibility to desertification (very high, high, moderate, low and very low), and the geographic domain of each class in the area of study.

Haijiang, et al. (2008) employed remote sensing, GIS and field survey to build a dataset for monitoring and analysisof sandy desertification of Otindag Sandy Land in China.Results of their analysis showed that the land has been suffering from sandy desertification since 1987 with 2 different desertified stages. The first stage from 1987 to 2000 was a severe sandy desertification period, characterized by the fixed sand dunes decreasing at a high speed, and the semi-fixed and active sand dunes increasing remarkably. The second stage spanned from 2000 to 2006 and the sandy desertification was weakened greatly (Haijiang, et al., 2008). Also, Gad and Shalaby (2010) integrated remote sensing data (SPOT, Egypt Sat, and SRTM images) with geologic and soil maps in a GIS environment for calculating the Environmental Sensitivity Areas Index (ESAI) for desertification in the inland Sinai and Eastern Desert of Egypt. They discovered that the area is characterized by varying degrees of sensitivity to desertification, ranging from high, moderate to low.

Similarly, Kheiry et al. (2012) applied remote sensing and GIS techniques in relation to socioeconomic and human factors to assess the impacts of desertification process within the agrosilvopastoral system in North Kordofan of Sudan. Their study found a strong link between the process of desertification and landuse/landcover change within the agrosilvopastoral system in the area. Likewise, Edris et al. (2013) employed remote sensing and GIS in assessing and monitoring sand encroachment and vegetation degradation as desertification indicators in Al-Butana area of Sudan (a semi-arid environment). They discovered that most of the study area experienced a significant change due to sand movement and sand encroachment from northerly direction to the southern part of the study area.

Jibia Local Government Area falls within the arid zones of the desert. This region is characterized of low amount of rainfall, high temperature, low humidity which has caused frequent drought in the area. Over time this has affected the socio-economic lives of the inhabitants. The aim of this study is to use climatic data to examine the prevailing physical environmental conditions in Jibia, and also utilize field survey data to investigate the present desertification adaptation strategies in the area with a view to making physical planning proposals.

1.1 Area of Study

Jibia Local Government Area was created in May 1989 in Katsina State of Nigeria. It lies on latitude 11ºO5'N and longitude 7º04'E. It is bordered to the North by Niger Republic, to the South by Batsari Local Government Area, to the East by Katsina Local Government Area and to the West by Sokoto State. It occupies a total land area of about 32177km^2 and has a total population of 169,748 according to 2006 census. It consists of some important towns and villages with the main Jibia town serving as administrative headquarter (See Figure 1).

Jibia lies within the Sudan Savannah composed of short grasses and variety of trees scattered over an expanse of grassland. These trees are characterized with broad canopies and are hardly taller than 20 meters. This area is characterized by sandy soil constituting about three quarter of the soil type while clay and loamy soils constitute the rest of the one-quarter of the soil type. This area falls within the Chad formation of sedimentary rocks of cretaceous origin. The area suffers from strong and direct solar radiation during the day. Absence of cloud cover permits the easy release of the heat stored during the daytime to a form of long wave radiation towards the cold night sky. The annual mean maximum monthly screen temperature in Jibia is between 37.6^{o}C to 39.3^{o}C especially during the hot season (between March and April). The mean minimum temperature in this period is usually 19.6^{o}C to 24.2^{o}C. But during cold season (November to February) maximum mean temperature in the period falls down to about 17.5^{o}C and 10.5^{o}C.

The main occupation of a greater percentage of the people in the area is agriculture, which is estimated to have taken about 85% of the total population. This 85% engage in various agricultural practices ranging from farming, livestock rearing, poultry and fish farming. The rest of the population (15%) is engaged in other occupations such as trading, carpentry, blacksmithing, etc.

Settlements in the area are dispersed over space with the Jibia administrative town towards the North-Western of the area showing that the administrative town is decentralized. There are also some villages located on the boundary of the Local Government Area and most settlements are located closer to the boundary.

There are four types of linkages between the settlements in the area:

i. Major or main road which runs from Jibia administrative town North-West down to Gusau of Zamfara State linking with some villages, and this same road runs from Jibia town North-East to Katsina Local Government Area.
ii. Minor roads linking important villages/hamlets, villages and district headquarters as well.
iii. Footpaths mostly linking villages and hamlets
iv. Rivers and streams linking some of the villages at the South-Western part of the area and serving a purpose of fishing.

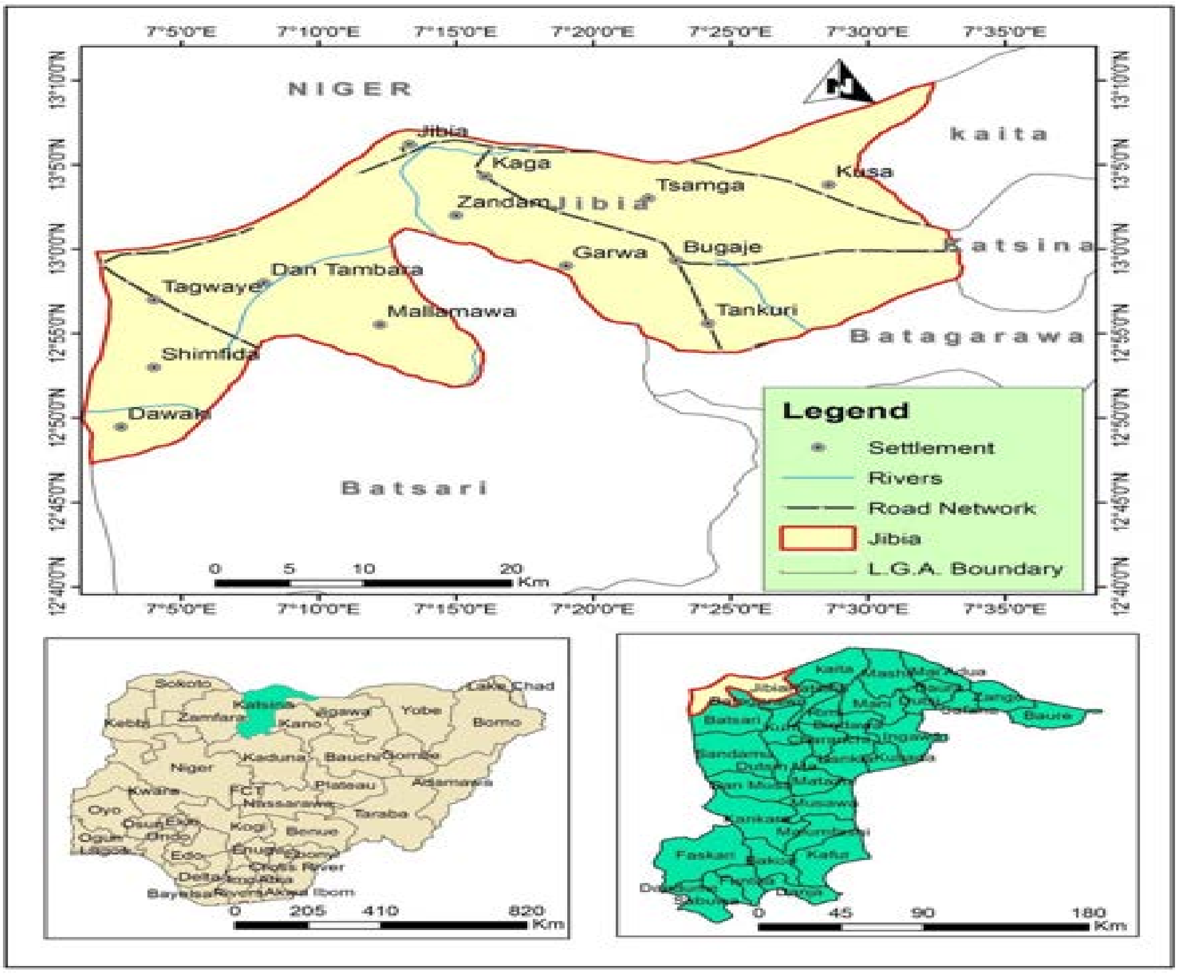


Figure 1: Map of Katsina State showing Jibia Local Government Area
Source: Jibia Local Government Area, 2016

2. MATERIAL AND METHODS

The data for this study was obtained through the following methods:

2.1 Field Survey

This involves trip to the study area where observations were made on the physical environment, spatial organization of activities and the socioeconomic condition of the affected area. This was achieved through discussion with traditional rulers, environment professionals and non-governmental organizations.

2.2 Interviews

Interviews were conducted to obtain information on the factors responsible for desertification, the impact of the encroachment on the physical environment and the lives of the people, as well as adaptation strategies to desertification in the area. A total of 100 respondents were selected which comprises of 80 residents and government officials in the area. A combination of stratified and systematic sampling methods was used across the various wards in Jibia to obtain a representative sample of the whole population. The respondents included 20 officials from Ministries of Land and Survey, Agriculture, Environment, as well as the Environmental Protection Agency. These respondents were selected through purposive sampling technique.

2.3 Secondary Data

This was obtained from Annual Reports of Katsina State Planning

Board, Bulletin of Katsina Afforestation Project Unit and other relevant agencies. Other sources include maps, theses, dissertations and literatures on the area of study.

3. RESULTS AND DISCUSSION

3.1 Physical and Environmental Characteristics of Jibia Area

3.1.1 Temperature

The annual mean maximum monthly screen temperature in Jibia falls between 37.6ºC to 39.3ºC especially during the hot season (between March and April). The mean minimum temperature in this period is usually 19.6ºC to 24.2ºC. But during cold season (November to February), maximum mean temperature in the period falls down to about 17.5ºC and 10.5ºC as shown in Table 1.

Table 1: Variation of the Mean Monthly Temperatures in Jibia between 1994 and 1996

	ºC	J	F	M	A	M	J	J	A	S	O	N	D	(T)
1994	Max.	30.2	31.5	38.2	38.6	39.0	35.5	31.8	29.7	31.3	34.1	32.7	27.3	399.90
	Min.	12.8	13.6	19.6	22.9	24.2	29.2	20.0	19.1	19.8	20.7	13.5	10.5	206.99
1996	Max.	25.0	35.8	37.6	39.3	39.0	34.5	33.1	31.8	32.3	31.9	31.2	31.8	403.3
	Min.	12.1	15.4	18.5	21.8	24.8	30.2	22.0	20.8	21.8	20.6	15.4	14.7	238.1

Source: Agricultural Development Projects, Katsina State

The highest maximum mean monthly temperature is in the month of April of the year 1996 where temperature rises up to 39.3ºC signaling intensive heating of the ground surface. Variation in the mean monthly maximum temperature between the years 1994 and 1996 shows that almost all of the minimum mean temperatures of 1994 rise in 1996, thus indicating increase in heating condition of the ground surface which is an indicator of the advancement of desert like condition in the study area.

3.1.2 Relative Humidity

Relative humidity is rather low during the hot season and the dry season as well with a monthly variation of 36.0% and 7.3%, and a seasonal distribution of about 29.5% up to 75.6% during the rainy season as illustrated in Table 2.

Table 2: Seasonal Variations in Relative Humidity of Jibia in 1992, 1993 and 1994

%	J	F	M	A	M	J	J	A	S	O	N	D	(T)
1992	20.6	21.9	36.0	40.0	52.2	51.0	72.6	75.6	69.3	35.5	21.6	16.0	512.3
1993	19.7	17.1	12.7	20	38.5	49.4	66.0	72.0	66.5	29.5	16.0	17.0	424.4
1994	18.0	8.1	7.3	32.9	39.2	55.7	69.9	78.5	73.8	59.3	20.8	12.6	476.1

Source: Agricultural Development Projects Katsina State

Variation in the monthly relative humidity between the years 1992, 1993 and 1994 shows that there is a drastic fall between the 1992 and 1993 periods especially in the months of January, February and March signaling that the air is dry and dusty. But in the years 1993 and 1994, there were rises in some months and fall in January. In February, there was a drastic fall as much as in March but in the months of October, August and April there was a high rise in the moisture content signaling the arrival of the rainy season.Decrease in the amount of moisture content in the air shows the arrival of desert-like conditions associated with intense heating of the atmosphere.

3.1.3 Rainfall

Rainfall in Jibia usually starts in the month of May lasting to September, covering a period of five (5) months. Annual rainfall in this area is about 600mm per annum as indicated in Table 3. The Table also showed that Jibia experienced low amount of rainfall especially in the year 1964 when mean annual rainfall of 247.09 mm was recorded. In addition, it can be observed from Table 3 that Jibia experienced low amount of annual rainfall between 1934 and 2004. This is one of factors causing desertification in the area as reported by Saad and Shariff (2011) who observed that the low and irregular annual rainfall has increased the severity of the desertification in Arab countries. There was a sudden rise of rainfall in the year 2004 when 506.49mm was recorded. Also, rainfall is associated with strong wind that often affects crop yield in the area.

Table 3: Mean Annual Rainfall in Jibia Area between 1934 and 2004

Year	Rainfall in (mm)
1934	492.13
1944	484.18
1954	467.68
1964	247.09
1974	394.17
1984	341.48
1994	440.00
2004	506.49

Source: Agricultural Development Projects Katsina State

3.1.4 Wind

Jibia is under the influence of two types of local winds: the North-Eastern trade winds or the Hamattan wind, which originates from its neighboring border country, i.e. Niger Republic’s Sahara desert. The wind comes along with it hot and dry weather with dust storms, which usually occurs in the late afternoon when conventional wind stir-up the dry surface of the ground. The second wind is the South-West wind that originates from the Atlantic Ocean bringing cool and warm weather. This wind usually blows during the wet season. Heating of air over the hot ground causes temperature inversion and as the lower warm airmass breaks through the higher cooler air and the Local whirl wind are often created. The average wind speed in the area is shown in Table 4.

It is observed that in the month of March throughout the period of 1992 to 1994, the wind-speed was so high that a maximum of 241.28 km/hr was recorded in the year 1993. Also, in the month of June in the same year, wind-speed rises up to 251.12 km/hr bringing in very hot and dry dusty air. In the month of October of the year 1992, there was a drastic fall in wind-speed to a maximum of 92.24 km/hr which rises to 102.42 km/hr in the year 1994. We can infer from Table 4 that the wind speed in Jibia is generally high. Hence, influences the desertification in the area. This is in line with finding of Schreiber that discovered that degradation process can be aggravated by reduced vegetation cover, increased runoff, and increased wind.

Table 4: Wind Speed in Jibia over the period of 1992 to 1994

Wind (Km/hr)	J	F	M	A	M	J	J	A	S	O	N	D	TOTALS
1992	-	-	-	-	225.39	-	166.31	204.70	121.39	92.24	151.75	145.0	1106.78
1993	-	-	175.95	212.69	241.28	251.12	235.56	187.12	169.56	113.68	95.78	96.4	1179.14
1994	169.65	202.6	173.74	203.47	222.48	231.49	206.98	146.0	97.37	102.42	100.73	186.93	2043.86

Source: Agricultural Development Projects Katsina State

3.2 Present Traditional Adaptation Techniques to Desertification in Jibia

Based on their experience, the residents of Jibia have developed traditional skills in mitigating and adapting to desertification in the area. These are presented in the sections that follow:

3.2.1 Wind Consideration

1. Town form – Though the settlements of Jibia are dispersed over space, the form of its traditional towns are usually compacted. This compaction of houses is necessary in this area so as to reduce the effect of wind. Consequently, narrow passages which are often shaded with trees are provided so as to reduce the easy facilitation of hot and dry wind of the Sahara.
2. Layout of road networks – Roads in the area usually run North-West and South-East and shaded with shelter belts. This is necessary so as to reduce the effect of dusty winds on the eyes of motorists.
3. Green belts – Trees are usually provided within the settlements and along routes so as to check the flow of the dusty wind and serve as a shading device.

3.2.2 Solar Consideration

1. Town form – The compact form of the traditional towns help reduce walking distances within the villages under the hot sun and intensive solar radiation. It also helps to enhance the provision of shades in the villages.
2. Layout of road networks – Location of roads on the North West and South East direction help ease the effect of sun glare on the eyes of motorists.
3. Building materials – Most houses in the study area are usually built with local building materials such as the walls made up of mud and sometimes a combination of both mud and reed grasses, while the roofs are

made up of reed grasses but in some cases corrugated sheet is used. Mud and reed grasses are best known as bad conductors of heat while the corrugated roofing sheet is a good conductor of heat. These houses are often designed with courtyards located centrally within the houses. It provides shades and also serves as a resting place.

3.2.3 Rainfall Consideration

Rainfall plays a vital role in the socio-economic activities of the people of Jibia. Agriculture is the major occupation of over 80% of the inhabitants of the area. Though the annual rainfall in the area varies and is still below the average, but with the help of the Jibia dam, farmers are able to cultivate their farms. Apart from the dam, farmers are only opportune to cultivate their farm deep in the rainy season. Besides, farmers in this area practice a form of shifting cultivation due to low fertility of the soil and are only able to grow grains.

3.3 Physical Planning Approach to Desertification in Jibia

Intensive heat condition in Jibia is associated with the high rate of the mean monthly temperature of the area. Also variation in the amount of the annual rainfall in this area leads to fall in agricultural produce in the area. Furthermore, the high wind speed and low moisture content of the air symbolizes the blowing of heavy dust particles in the area and wearing away of the fertile sub-soil which also reduces the rate of cultivation in this area. All of these climate conditions symbolize the advance of desert-like condition in the area. It was found that climate plays a significant role in the environmental conditions of Jibia. This can be seen in the design of its traditional towns, layout of roads, socio-economic activities of its inhabitants and materials used for building.

The following planning inputs are viable in combating desertification in the area:

1. It is hereby proposed that courtyards should be included in the building design of houses and construction in modern quarters such as those of the traditional houses, for its importance as a shading device. Provision of trees in the courtyards will help enhance ventilation. A typical traditional house with courtyard is shown in Figure 2.
2. Heat transfer can be reduced in the study area by constructing houses with thick walls especially in modern quarters. But the traditional houses should maintain the existing plan.
3. Dense clustered pattern of settlements should be adopted for future layout in the study area. Roads should be relatively narrow and shaded with trees to reduce the effect imposed by direct sun rays and wind.
4. Most inhabitants of the arid zones like Jibia are farmers and animal rearers. Therefore, in planning a settlement in arid zone, emphasis should be based on centralizing the residential areas; it should then be followed by an open space for future expansion. Trees should be provided round the residential areas to serve as buffer against the winds and sun rays. There should also be an expanse of farmland for cultivation by the inhabitants at the outskirts of the residential areas. Furthermore, narrow routes should also be provided, shaded with trees.

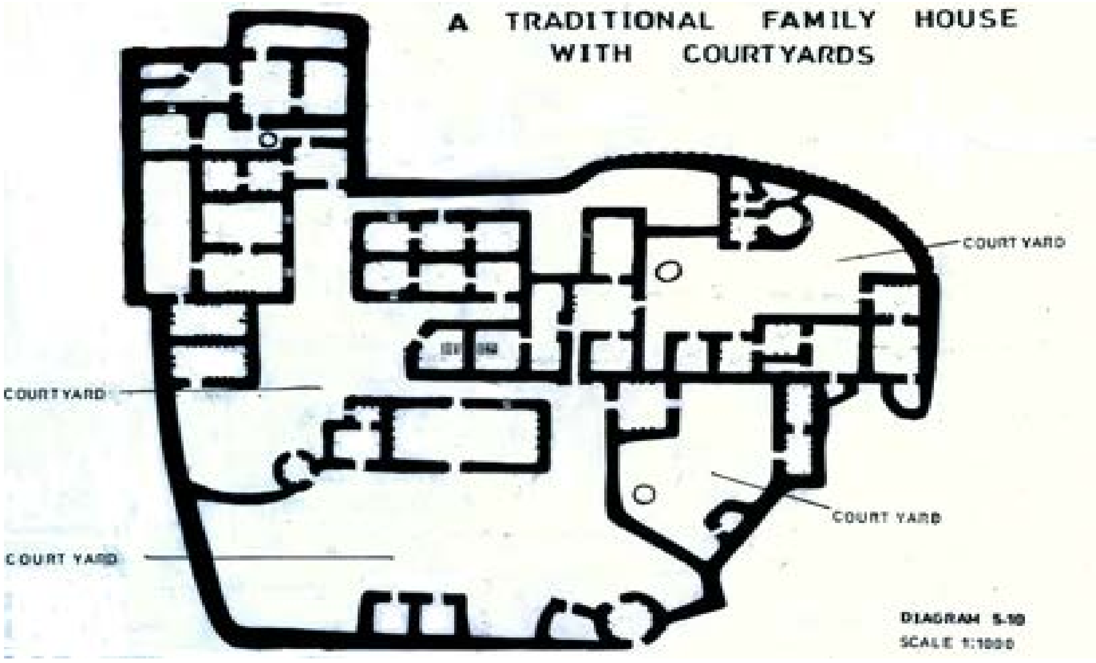


Figure 2: A traditional house with courtyards

4. CONCLUSION

Jibia Local Government Area falls within the arid zones of the desert. This region is characterized by low amount of rainfall, high temperature, low humidity which has caused frequent drought in the area thereby making the area vulnerable to desertification. This has adversely affected the socioeconomic activities of the inhabitants of the area. This study utilized climatic data to examine the prevailing physical environmental conditions in Jibia, also field survey data was acquired to investigate the present desertification adaptation strategies in the area with a view to making physical planning proposals. Findings revealed that some of the traditional techniques in adapting to desertification in the area are viable and could be maintained. For instance, the general compact nature of houses in the study area and nature of building materials used as a result of desert encroachment has affected the layout of infrastructures in the area. This can be maintained in the present settlements but redesigned in new settlements or layouts. Since Jibia falls within the arid zone, it is therefore proposed that in planning a settlement in the area, emphasis should be based on centralizing the residential areas; this should then be followed by an open space for future expansion. Trees should be provided round the residential area to serve as buffer against the winds and sunrays. It is anticipated that if these proposals are implemented and management strategies are well organized, desertification in Jibia shall be reduced to a minimum.

Future studies should review the present desertification control measures in the area. In addition, a study of long term climatic data of the area should be carried out to show if climate change has an impact on the physical and environmental characteristics as well as the severity of desertification in JibiaLocal Government Area.

Acknowledgements

Our gratitude goes to the following people: Mal. Mustapha of Katsina State Land and Survey, Mal. Hussaini Abubakr of KTAPU, Mal.

Hassan of EEC, and Mal Abubakar Usman of KTARDA for the assistance they rendered in conducting this study.

REFERENCES

Agricultural Development Projects (2006). Katsina State.

Edris, O., Dafalla, M., Ibrahim, M. and Elhag, A. (2013). "Desertification monitoring and assessment in Al-Butana area, Sudan, using remote sensing and GIS techniques," *International Journal of Scientific & Technology Research,* 2(3): 181 - 184.

Gad, A. and Shalaby, A. (2010). "Assessment and mapping of desertification sensitivity using remote sensing and GIS, case study: Inland Sinai and Eastern Desert Wadies, *US-Egypt Workshop on Space Technology and Geo-information for Sustainable Development*, Cairo, Egypt 14-17 June, 2010".

Haijiang, L., Chenghu, Z., Weiming, C., En, L. and Rui, L. (2008). "Monitoring sandy desertification of otindag sandy land based on multi-date remote sensing images," *Acta Ecologica Sinica,*2: 627−635.

Kheiry, M., Mahmoud, T. and Mofadel, H. (2012). "Applying remote sensing tools for assessing desertification process within the agrosilvopastoral system, North Kordofan- Sudan. Tropentag," presented at the *Conference on International Research on Food Security, Natural Resource Management and Rural Development* organised by, Georg-August Universität Göttingen and University of Kassel-Witzenhausen, Göttingen, Germany September 19-21, 2012.

Petta, R., Ohara, T. and Medeiros, C. (2005). "Desertification studies in the Brazilian Northeastern areas with GIS database" *anais XII Simpósio Brasileiro de sensoriamento remoto*, Goiânia, Brasil, 16-21 Abril 2005, INPE," pp. 1053-1061.

Saad, A. and Shariff, N. (2011). "Estimating desertification in the Arab world using GIS approach Middle-East," *Journal of Scientific Research,*8: 1046-1053.

Schreiber, *KV an approach to monitoring and assessment of desertification using integrated geospatial technologies*. Millersville, Pennsylvania: Millersville University of Pennsylvania, Millersville.

UNCED (1992). Earth summit agenda 21, programme of action for sustainable development. *United Nations Conference on Environment & Development*, Rio de Janerio, Brazil, June 3 - 14.

UNEP (1992). *Status of desertification and implementation of the United nations plan of action to combat desertification. Report of the executive director*. Nairobi: United Nations Environment Programme.

Savanna volume 23, Number 1, June, 2016

Characterisation of Groundwater Potential Zones for Rural Water Supply in Parts of Kano State, Nigeria

Tasi'u Yalwa Rilwanu[1]*, Mallam Ibrahim[2] and Edwin Osawe Iguisi[3]
[1]*Department of Geography, Bayero University Kano, Nigeria*
[2]*Department of Environmental Management and Toxicology, Federal University, Dutse*
[3]*Department of Geography & Environmental Management, Ahmadu Bello University, Zaria*
**trilwanuyalwa@gmail.com*

ABSTRACT

Delineation and characterisation of groundwater potential zones was undertaken in sixteen rural areas that were selected from eight local government areas of Kano State. Pumping tests were conducted in sixteen open wells in the area. Depths to water levels were obtained from the open wells. Groundwater potential zones were delineated through weighted overlay of the results and six thematic maps of the environmental conditions. Groundwater potential zones were characterised based on environmental conditions and pumping test results. Result showed that five groundwater potential zones were identified which are very high, high, moderate, low and very low. It is established that areas with lower draw down of 7.81m to 9.70m at 30 minutes are areas with higher discharge rates at 30 minutes of between 0.65L/m to 1.11 L/m; and are areas that fall within very high, high and moderate Groundwater Potential Zones (GWPZS). It can be observed that Riruwai, Zainabi, Tumbau, Tudunkaya, Fammar and Tumbau recorded higher draw down of 13.80m to 15.40m at 30 minutes. In these same areas, discharge was found to be 0.5 to 0.7L/m. It was also determined that very high, high and moderate groundwater potential zones are characterised by alluvial soil, hydromorphic soils, and ferruginous soils; and such areas geologically, are associated with pink and white granite, quartzite suits fractured valley fills and older granitic formations of various types. Also, all good prospect areas are characterised by high lineament density, high drainage density, high runoff, high vegetation cover and low relief or low slope values. Lithosols and reddish to reddish brown soil areas are of poor potential. Based on these findings, it can be recommended that groundwater potential map and thematic maps produced can be updated from time to time for water resources development. In addition, study of this nature should be supported by more high resolution terrain data like radar images.

Key words: Groundwater; Potential Zones; Characterisation; Rural areas; Kano.

1. INTRODUCTION

Water is the most abundant solvent on the Earth that supports all forms of life. Over 70% of the earth surface is covered by water in oceans, lakes, rivers, ponds, lagoons and other water bodies (Rilwanu, 2014). Groundwater is part of the available water in the globe for human utilization. Animal and plant bodies contain water for their physiological systems and regulation of body temperature. Food and beverages contain significant amount of water within them. Water serves as coolants in heavy to light industries. Water is very essential to life, which is why people are looking for it at all cost for survival. The physical reality of life is dependent on water; for that water is the essence of man's existence and is therefore the most critical resource supplied by Earth systems (Robert, 2007). If drinking water is scarce or absent, people can spend much time for carrying it to their houses. Water is a medium of life, since man drinks it and utilizes it in many ways. Batmanghelidji (2004) in his book 'Your body's many cries for water' gives a wonderful essay on water and its vital role in health and life.

It was reported by Tanner and Road (2003) that the human body contains from 55% to 78% water, depending on the body size, and to function properly, the body requires between one and seven litres of water per day to avoid dehydration. The intake takes place through drinking, eating of beverages and other foods that contain water. From philosophical point of view, Internet secret text (2010) reports that ancient Greek philosopher Empedocles held that water is one of the four classical elements along with fire, Earth and air, and was regarded as the basic substance of the universe.

Groundwater plays significant role in rural water supply. It was reported by Macdonald and Davies (2000) that groundwater has proved to be the most reliable source for meeting rural water supply demand in sub-Saharan Africa. Search for groundwater has become quite intense in recent times. This is due to the fact that governments at all levels are unable to meet the ever increasing water demand in Nigeria. This can be solved through studies on groundwater potential to explore alternative sources of water supply. Hence, the need for identification and characterisation of groundwater potential is of great significance for water supply and development.

A number of studies on identification and characterisation of groundwater potential are found in the literature, these include that of Sitender (2011) in which he delineated groundwater potential zones of Medwat district of Haryana in India using Multicriterian Evaluation (MCE) and arrived at five groundwater potential zones ranging from very poor to excellent. In addition, he characterised each of the zones based on pumping test data and physical characteristics. Also Saraf and Choundhury (2007) used satellite data to produce artificial recharge zone maps in Jammu District of India by considering the terrain conditions in the area. Also, suitable areas for replenishing groundwater were identified and characterised in the study.

In addition, Shahid et al. (2000) used weighted overlay analysis to study groundwater potential of Bengal in India. Three groundwater potential classes were identified in Bengal, and several factors such as geology, lineament, soil, drainage density and slope were found to be important in determining the groundwater potentials in the area. Likewise, a study of this nature was also undertaken by Khairul Anam, Juharimat and Ibrahim (2000) to delineate groundwater in Langat basin India. Also Goyal, Bharadwaj and Jugran (2009) remarked that factors such as geology, geomorphology, soil, lineament, lithology and vegetation of a selected area can be used together with the interpretation of satellite images to identify groundwater potential of the area. It was discovered that areas of good prospects are areas with low discharge values, drawdown and low slope values.

In another work, Anudu et al. (2011) analysed groundwater potential in Wamba, Nassarawa State of northcentral Nigeria using slope map, drainage density, contour map and lineament density. Their results indicated that lineament and drainage are the most important factors of groundwater identification in the area. They also found that areas with plains, pink and white granite and fractured valley fills, high lineament density, very low slope values and high runoff areas are of good prospects for groundwater potentials. Similarly, Abel and Moshood (2011) used integrated approach to study groundwater potential in Ekiti State of southwestern Nigeria. They used weighted overlay to analyse landsat and thematic maps into various classes of groundwater potential ranges from very good to poor. They discovered poor areas to be around mountain peaks, escarpments with steep cliffs and younger granites. It is established from the foregoing studies that areas can be classified into different groundwater potential zones and several factors influenced the groundwater potential in an area or region. Hence, the aim of this study is to identify and characterise groundwater potential zones for rural water supply and development in parts of Kano State of northwestern Nigeria.

1.1 The Study Area

The study area is within Kano State and it extends from latitudes 10°3ʹ N to 12° 3ʹ N and longitudes 7°35ʹ E to 9°20ʹ E (Figure 1). The total land area of the state is about 20,760sq km (Research and Documentation Directorate Kano, 2009). The total population of Kano State according to 2006 national census is about 9,386,820 people (N. P .C Report, 2009). Rural areas of Kano are located on the high plains of Hausaland which are underlain by the Basement Complex Rocks of Precambrian era. Landforms of the study area include granitic outcrops, hills in form of Ruwares, residual hills, and river valleys, which are distributed within the state. There is a waterfall at Zainabi in Riruwai Doguwa Local Government Area (LGA).

The climate of the study area is described as seasonally arid and in southern Kano, rainy season average is about 150 days from May to October. Mean annual rainfall in the southern parts is about 1000mm and in the north it is 635mm (Sara and Charles, 1988). The climate of Kano is described as Aw by Koppen, with both annual and seasonal variabilities. Wet years and dry years may record between 850 and 750mm (Olofin, 1987). The temperature varies by warm to hot seasons with the occurrence of the Harmattan between November and February. Ahmed (2003) reported that there is a considerable relationship between groundwater and drainage pattern with the highest network of rivers in the Basement Complex areas (Olofin, 1987).

The vegetation of the Study area is Sudan Savannah type that is tropical grassland characterised by scattered trees which hardly exceed 20 metres high. The soil of the region is tropical Ferruginous, rich in sand, while the zonal soils are also influenced by human manipulation to varying degrees (Olofin, 1987).

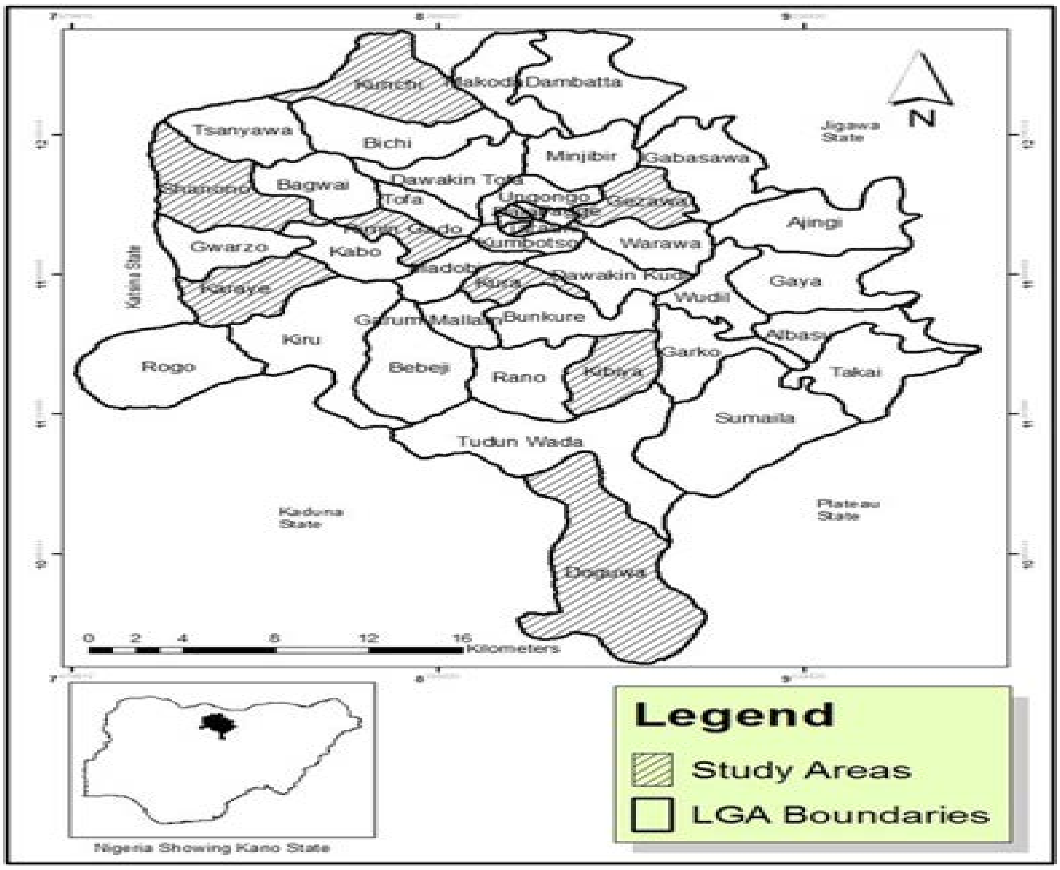


Figure 1: Map of the Study Area
Source: Adopted from Rilwanu, 2014

2. MATERIALS AND METHODS

2.1 Data Collection

Sixteen villages were selected from 8 selected Local Government Areas (LGAs) based on geology making 20% of the 38 rural LGAs. This is based on the fact that for research in Social Sciences, 10% should be selected from a large population, but if the population is small, then 20% may be selected (Krejcie and Morgan, 1970).

Water levels were obtained from pumping tests which were conducted at 16 selected boreholes very close to the sampling points in 2011 and 2012. Landsat ETM+ 2003 with resolution of 28.5m was used to map out the study area using the pumping test data. In order to assess the groundwater potential in the area, the pumping test data were overlaid with the lineament, drainage density, geology, hydrogeology, soil and vegetation which were obtained from the landsat ETM+ 2003 and maps of the study area. The slope of the area was determined from DEM which was developed from the SRTM. This was achieved using weighted overlay method of Analytical Hierarchy Process (AHP) nine point scales as adopted from Carlo (1998), Goyal et al*.,* (2009) and Sitinder (2011).

Pumping tests results were used to characterise the five identified groundwater potential zones as adopted from Kandri, Patil and Rajan (2008). Factors such as geology, soil, hydrogeology, lineament and vegetation were used to characterise the five groundwater potential zones based on differences that exist between them as adopted from Sitender (2011).

2.2 Data Analysis

In the analysis of the groundwater potential zones, the factors were given weight related to groundwater potential weighted overlay method adopted from Goyal et al. (2009) and Gouri et al. (2012). Groundwater potential zones map (GPZM) was obtained through overlaying all the thematic maps, weights were assigned to each according to their relative importance using Spatial Analyst extension of ArcGIS software.

Pumping test results used for the characterisation of the groundwater potential zones were analysed using Numerical method of Singh and Gupta as in Khadri et al. (2008). Where average draw down and discharge at 30 minutes were calculated and tabulated for the 16 villages. Slope data was analysed based on modified standards of Anthony and Doreen (1977) who stated that areas of low slope values are areas of more groundwater prospects and classified conditions of groundwater occurrence based on slope. Tabulation method was adopted to further characterise the groundwater potential zones according to environmental characteristics using ArcGIS software as adopted from Sitender (2011).

3. RESULTS AND DISCUSSION

Groundwater potential of an area is referring to groundwater distribution and quantity in an aquifer of an area or region. Findings of this study indicated that five groundwater potential zones were identified which are very high, high, moderate, low and very low (Figure 2). Pumping tests results were used in the characterisation of the identified GWPZS. This is due to the fact that areas of low draw and higher yield are characterised as been good in terms of groundwater potential as adopted from Goyal et al. (2009) and Stinder (2011). It can be seen from Table 1 that Shuwaki, Yandadi, Dokadawa, K/Yashi, Shakogi, Alajawa, Turawa, Tarai, Babawa, Karfi and Kosawa are areas with lower draw down of 7.81m to 9.70m at 30 minutes and are areas with higher discharge rates at 30 minutes of between 0.65L/m to 1.11 L/m. It can also be seen that these villages fall within very high, high and moderate groundwater potential zones (GWPZS). Areas of very high to high potential can take mechanical boreholes because they are more productive (PBH, M) while areas of low to very low can only take hand pump (HP) (Table 1 and 2).

It can be observed from Table 1 that Riruwai, Zainabi, Tumbau, Tudunkaya, Fammar and Tumbau recorded higher draw down of 13.80m to 15.40m at 30 minutes. In these same areas, discharge was found to be 0.5 to 0.7L/m. It was determined from data analysis that these areas fall within either low or very low groundwater potential zones (GWPZS). This result is substantiated by that of Sitender (2011) in Medwat district Haryana India and that of Abel and Moshood (2011) in Ekiti State in Nigeria. That is because all the areas are underlain by crystalline Basement Complex rocks.

Table 1 Pumping test results and groundwater potential of the 16 villages

S/N	Borehole Loca-	Discharge at 30 mint.(L/M)	Water level (M)	Draw Down	Remark	GWP of the area

	tion/Village			(M)at 30mnt.		
1	Shuwaki	0.70	13.20	9.70	PBH, M	Moderate
2	Yandadi	0.75	14.98	8.98	PBH,M	Very High
3	Dokadawa	0.71	12.13	10.20	PBH,M	Moderate
4	K/Yashi	0.8	16.12	8.25	PBH,M	Moderate
5	Shakogi	0.65	13.81	7.81	PBH,M	Very High
6	Alajawa	0.71	13.22	9.20	PBH,M	Moderate
7	Riruwai	0.5	18.31	15.40	HP	Very Low
8	Zainabi	0.6	17.81	14.81	HP	Low
9	T/Kaya	0.7	17.19	13.80	HP	Low
10	Turawa	1.11	13.30	9.30	PBH,M	Moderate
11	Fammar	0.6	16.70	14.70	HP	Low
12	Tarai	0.75	14.98	8.98	PBH,M	High
13	Babawa	0.70	12.20	8.50	PBH,M	High
14	Tumbau	0.65	17.81	14.82	PBH,M	Low
15	Karfi	0.76	13.30	8.95	PBH,M	Very High
16	Kosawa	0.78	12.48	9.48	PBH,M	High

KEY: PBH, M=Productive Borehole Mechanical; HP = only hand pump

Table 2: Characterization of the groundwater potential zones using Pumping test results

S/N	Groundwater potential Zones (GWPZ)	Characteristics based on pumping test data
1	**Very High**	It is characterised by a discharge of 0.70- 0.76 L/M at 30m and a very low drawdown of 7.81- 8.98m at 30minuts
2	**High**	Areas with discharge of 12.20- 14.98L/M and Drawdown of 8.98- 9.48m
3	**Moderate**	Having a discharge of about 12.3- 13.30L/M and Drawdown of 8.25- 10.20m
4	**Low**	Discharge of about 16.70- 17.81 and Drawdown of 14.70- 14.82
5	**Very Low**	Discharge of 18.31L/M and Drawdown of 15.40m and above

The result of the general characteristics of the groundwater potential zones as presented in Table 4 showed that, very high, high and moderate groundwater potential zones are characterised by alluvial soil, hydromorphic soils, and ferruginous soils. In terms of geology and landforms, they are associated with pink and white granite, quartzite suits, fractured valley fills and older granitic formations of various types (Table 4). These three (3) zones are characterised by high lineament density, high drainage density, high runoff high vegetation cover and low relief or low slope values (Table 3 and 4). This result is in line with that of Anudu et al. (2011) in Wamba Nassarawa State in Nigeria; and Abel and Moshood (2011) in Ekiti State in Nigeria. It is also in line with Khairul

Anam, Juharimat and Ibrahim (2000); and Goyal, Bharadwaj and Jugran (2009) who concluded that areas of good prospects in terms of groundwater potential are areas with low discharge values, draw down and low slope values.

In terms of soils, it can be observed that low and very low groundwater potential zones are characterised by lithosols and reddish to reddish brown soils (Table 4). Areas with younger granite are areas characterised by metamorphic suits, fine granites to medium biotite and Quartz schist (Table 4). This is supported by the work of Shahid et al. (2000) whom studied groundwater potential of Bengal India and concluded that areas of lineament line density with lateritic soils are of poor groundwater potential. These areas are characterised by low lineament lines density, low drainage density, low vegetation cover, low run off concentration and high slope values (Table 3 and 4).

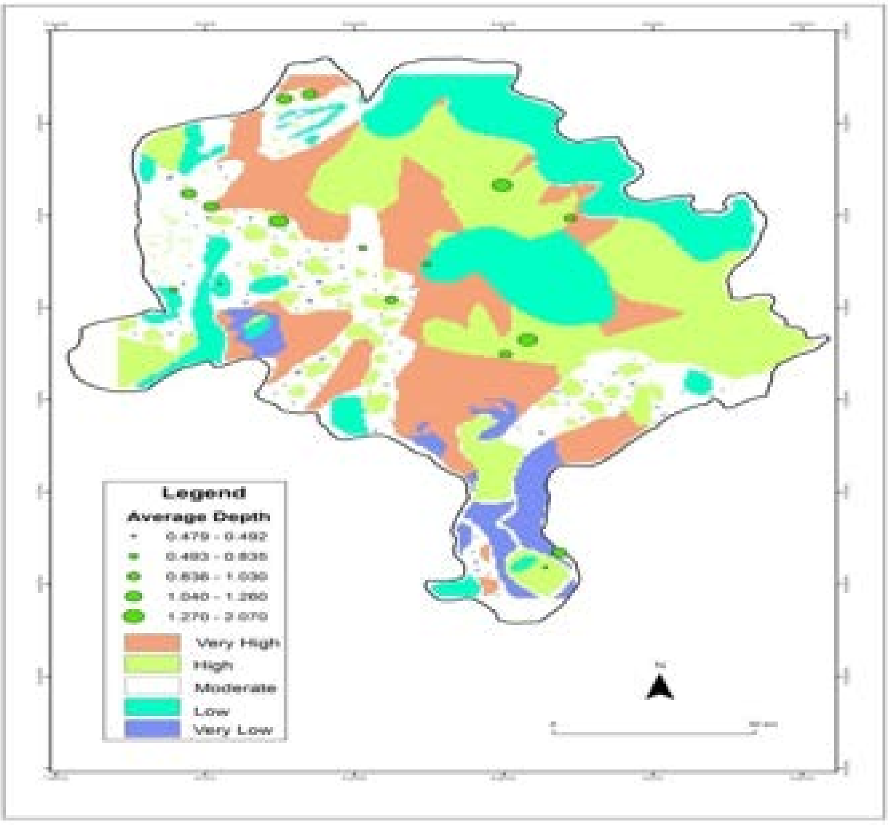


Figure 2: Groundwater potential zones Map

Table 3 Characterising Groundwater Potential Zones Based on Slope

S/N	Slope	Explanation	Relationship with groundwater	Groundwater

				PZ
1	**0º - 2º**	Level or almost	No much runoff, water percolates	Very High
2	**2º - 3º**	Gentle	Infiltration reduces runoff increases	High
3	**3º - 5º**	Moderate	Much run off Low infiltration	Moderate
4	**5º - 18º**	Moderately Steep	Very much Runoff	Low
5	**>18º**	Very Steep	Total Runoff no infiltration	Very Low

Table 4 Characteristics of the five (5) identified GWPZS based on factors

S/N	Groundwater potential Zones (GWPZ)	Characteristics
1	**Very High**	Alluvial plains, pink and white granite, metamorphic coarse, black and white granite, fractured valley fills, high lineament density, very low slope values and high runoff areas.
2	**High**	Hydromorphic soils, Ferruginous soils, Quaternary formations, Quazite areas, fractured valley fills, high lineament density, low slope values and high runoff areas.
3	**Moderate**	Hydromorphic soils, Ferruginous soils Dior granite areas, medium biotite gneiss areas granite gneiss, migmatite, high lineament density, moderate slope values, and moderate high runoff areas.
4	**Low**	Lithosols areas, metamorphic suits, fine grained biotite granite, medium biotite, moderate low runoff, low lineament density areas, moderately high slope values, fairly vegetated areas.
5	**Very Low**	Mountain peaks, escarpments with steep cliffs, younger granite areas, Quartz porphyry, Quartzite massive chist and quartz chist, black and white granite, brown and reddish brown soils and shrub savannah and wood lands with high slope values.

4. CONCLUSION

It is concluded that the study area falls under five groundwater potential zones which are very high, high, moderate, low and very low. Characterisation shows that the five groundwater potential zones are directly controlled by lineament density, drainage density, geology, hydrogeology, soil and vegetation arranged according to their relative importance to groundwater potential. Based on the findings of this study, it is concluded that rural areas in Kano sate with high lineament lines density, high drainage density, low slope values, older granite basement complex, alluvial, hydromorphic and ferruginous soils and high percentage of savanna vegetation are areas with high groundwater potential. It was also found that promising groundwater potential areas are characterised by low draw down from borehole pumping test results.

4.1 Recommendations

With particular reference to the findings of this study, it is recommended among other things that groundwater potential map and thematic maps can serve as sources of vital information and database which can be updated from time to time for development. Since lineament, drainage density, geology, hydrogeology, soil, vegetation and slope are the major factors controlling groundwater occurrence in the study area, analysis of these parameters should be supported by more high resolution terrain data like radar images. Rural areas in the extreme southern part of the study area should be given special treatment regarding water supply since most of them are within the younger granites region characterised by low to very low groundwater potential.

REFERENCES

Abel, O.T., and Monshood, N.T. (2011). Integrated remote sensing and GIS approach to groundwater potential assessment in the basement terrain of Ekiti area south western Nigeria. *Material and Geo environmental Journal,* 58 (3): 303-328

Ahmed, K. (2003) *Kano Environment.* A publication of KanoForum: Retirieved online on 22ndjune, 2014.

Anthony, Y. and Doreen M.Y. (1977). *Slope Development*. Macmillan Education Ltd, London.

Anudu, G.K., Essien, B.I., Onuba, N.L. and Ikpokonte, A.E. (2011). Lineament Analysis and Interpretation for Assessment of Groundwater Potential of Wamba and adjoining areas In Nassarawa State North Central Nigeria. *Journal of Applied Technology in Environmental Sanitation,* 1(2) 185-189

Batmanghelidji, M.D.F. (2004). *Your body many cries for water: You are not sick; you are thirsty don't treat thirsty with medication* (Second Edition): New York time Science Watch.

Carlo, T. (1998). *Groundwater exploration by satellite Remote Sensing in the Syrian Arab Republic:* Part1, General organisation of Remote sensing Syrian Arab Republic.

Gouri, S.B., Sailesh, S. and Babita, P. (2012). Deciphering Prospective Groundwater Zones of Morobe Province, Papua New Guinea. *International Journal of Engineering Research and Applications (IJERA)* ISSN: 2248-9622www.ijra.com 2 (3 May-June 2012, pp752-766

Goyal, S., Bharadwaj, R.S. and Jugran, D.K. (2009). *Multi Criteria Analysis* Using GIS for Groundwater Resource evaluation in U. Rawasen and Pili watershed,P.htt://www.gisdevelopmnt.net/application/nrm/water/ground/watg4pf.ltm

Internet secrete text Archives home (2010) *secrete texts.com Retrieved on* 25 – 05 –2010.

Khairul-Anam, Juharimat, A. and Ibrahim, A. (2000). *Groundwater prediction potential zone in Langat Basin using the integration of Remote sensing and GIS:* Malasian centre for remote sensing (MACRES) No.13 Jalantun Ismail, 50480 Kuala Lumpur 2 University Kebagsaen Malasia.

Khandri, S.F.R., Patil, G.P. and Rajan, Z. (2008). *Estimation of Aquifer Parameters in Basaltic terrain and the Application of wireless sensor Networks, Chikaldhra region, Amravati district, Maharashtra, India:* Centre for statistical Ecology and Environmental Statistics, Pennsylvania State University.

Krejcie, R.V. and Morgan, D.W. (1970). *Determining sample size for research activities, educational and psychological measurement,* 30, pp 607-610.

Macdonald A. M and Davies J. (2000). *A Brief Review of Groundwater for Rural Water Supply in Sub Saharan Africa*. NERC British Geological Survey.

National population Commission (2009). *Annual report year book:* NPC Nigeria.

Olofin, E.A. (1987). *Some Aspect of Physical Geography of Kano Region and Related Human Responses.* Debis Press, Kano.

Research and Documentation Directorate (2009). *About Kano,* in Kurawa I.A (Eds): A Publication of Kano State Government. Kano Printing press Ltd.

Rilwanu, T.Y. (2014). *Assessment of Groundwater potential for Rural water supply in parts of Kano State, Northern Nigeria*. An unpublished Ph.D thesis, Department of Geography ABU, Zaria.

Robert, W. C. (2007). *An Introduction to physical Geography* (8th edition). Prentice Hall Print England Republic.

Sara, B. and Charles, R.C.J. (1988). Combine ETM/VES Geophysical methods for siting Boreholes. *Journal of groundwater development consultant Ltd Cambridge,* 26 (1) Jan, 1988

Saraf, A.K. and Choudhury, P.R. (1998). Integrated remote sensing and GIS for groundwater exploration and identification of artificial recharge sites. *International Journal of Remote Sensing,* 19(10): 1825-1841.

Shahid, S., Nath, S.K. and Roy, J. (2000). Groundwater potential modelling in a soft rock area using GIS. *International Journal of Remote Sensing,* 21 (9): 1919-1924

Sitender, R. (2011) Delineation of Groundwater potential zones in Mewat District Haryana India. *International Journal of Geomatics and Geosciences,* 2 (1): 270-281.

Tanner, G.A. and Road, R.A. (2003) *Medical Physiology* (2nd ed): Lippineott Willions and wilkins Baltimore ISBN 0781719363. OCLC 50554808.

Savanna volume 23, Number 1, June, 2016

An Assessment of the Treatment of Selected Heavy Metals by the Tamburawa Water Treatment Plant in Kano State, Nigeria

Ibrahim Mukhtar*, Garba Samaila, Abubakar Salisu, Abdullahi Jibrin, Hamza Mohammed and Usman Isyaku
Department of Geography & Environmental Management,
Ahmadu Bello University, Zaria
*mukhee2002@gmail.com

ABSTRACT

An analysis of water in the Kano River was carried out to determine the concentration of three selected metals; (Cu, Fe and Mn) before and after treatment by the new Tamburawa plant in Kano, from January to September 2009. This study was situated in the downstream area of the drainage basin, where the Challawa River merges with the Kano River, so as to capture effluents probably not captured by previous studies and to investigate the efficiency of the treatment plant in removing metal pollutants. The concentrations of the metals were determined using the spectrophotometer after digestion of both the raw and treated water samples using the Nitric acid digestion method. The result of the laboratory analysis revealed that the selected metals were present within the basin in varying concentrations across the season. Simple percentages were used to ascertain the level of reduction of the selected metals by the new Tamburawa treatment plant. It was found that the treatment plant was more efficient in reducing the concentration of the metals during the dry season than the rainy season. Cu had a concentration of 0.504mg/l in July of which only 34% was removed, Fe and Mn had 1.870mg/l and 0.520mg/l in August and September, but only 20% and 47% were removed respectively. The study concluded by suggesting proper monitoring of effluent discharge into the river by industries and also the upgrading of the treatment plant with state of the art facilities for better water treatment.

Keywords: Treated water; Raw Water; Pollutants; Spectrophotometer; Kano River.

1. INTRODUCTION

Global water problems are neither homogenous nor constant or consistent over time. Solutions to these problems depend not only on water availability, but also on many other factors such as competence and capacities of institutions that manage them, availability of funds, climatic, social and environmental conditions of the countries concerned. They also depend on the levels and availability of technology, modes of governance and quality of academic research (Biswas, 1998).

Today, the perception about water goes to the very height of the increasing worldwide concern about human health, the environment, and the path towards sustainable development. Of all the natural resources needed for economic development, water is one of the most essential, particularly in arid and semi-arid regions (Bichi, 2000). At the dawn of the 21st century, human kind is faced with multiple challenges of rapid population growth which increases the demand for the quantity of water to satisfy people's needs both in agriculture and in expanding urban centres. Similarly, the failing water quality due to increasing pollution, groundwater depletion and attendant environmental impacts and health risks also pose other major challenges (Butu, 2002).

The impending water crises need both national and international attention. An estimated 1.4 billion people are presently living without access to safe drinking water, about 2.3 billion lack basic sanitation, 7 million die every year from water-borne diseases, and half of the world's rivers and lakes are seriously polluted (Campbell, 2001). Recent assessment conducted for the United Nations and the World Commission on Water (Sekabira et al., 2010) added a sense of urgency to these figures. Currently, almost half a billion people face shortages of water in 29 countries. By 2050, almost two-thirds of the people on our planet are forecast to experience some types of water stress, and for over a billion of them, the shortage will be severe and socially disruptive (Butu, 2002).

Therefore, continuous assessment of the quality of water supplied to the public is very important and necessary, in order to meet the United Nations' campaign for providing good quality drinking water for all by the twenty first century (Knapp et al., 1989). The quality of water plays an important role because its mere availability does not qualify it for use. Biswas (1998) reported that the quality of water defines the extent of the uses it could be put. The better the quality of water the wider the range of uses it could be put.

Research on water quality and pollution is very paramount, particularly in the developing countries like Nigeria where water availability to serve both domestic and industrial demands continues to be a problem of great concern (Tanko, 1996). Water quality control and watershed management would only be possible with adequate information on the water bodies within a given locality, region or a country.

The Tamburawa water treatment plant receives its water supply from the Kano River which has its source from the foot slopes of the Jos Plateau located south of Kano. The water treatment plant supplies about 150million litres of treated water per day to the Kano populace. The plant was established in 2006 to supplement the water supplied by the old Challawa and Tamburawa treatment plants as well as to ease the problems of water scarcity in the state. The water treatment plant is the conventional water treatment system which involves the conventional procedure for water purification. The effectiveness of this conventional purification method to eliminate metal pollutants in the raw water has never been effective (Tanko, 1996). There is a strong possibility that the river water may contain significant amount of metal pollutants because the Kano River drains a substantial part of the industrial section of Kano metropolitan area. Furthermore, much of the drainage basin is under intensive cultivation and as a result receives pollutants through the application of chemical fertilizers, pesticides and herbicides. In addition, industrial and agricultural effluents known to contain metallic pollutants also drain into the river (Bichi, 2000).

In the late 1970's, investigation into the natural drainage system around Bompai industrial zone in Kano indicated that waste water discharge was the major source of pollution of the river (United Nations Development Programme (UNDP), 1978). Bello (1985) and Tanko (1996) reported similar findings in the Sharada industrial estate. A study by Akan et al. (2007a) on the level of pollutants in the effluents discharged by the Mario-Jose tannery in Kano revealed that there were high levels of chromium and iron, which were above Federal Environmental Protection Agency (FEPA) permissible limits. Levels of manganese, copper, zinc, lead and cobalt were also found to be within the minimum permissible limits for effluents discharged into the river. It was also discovered that there was a decrease in concentration of heavy metals with distance from point source up to 400 meters (Akan et al., 2007a).

Furthermore, a similar study by Akan et al. (2007b) within the Kano river drainage basin found concentration of heavy metals to be significantly above United State Environmental Protection Agency (USEPA) and World Health Organization (WHO) permissible limits for drinking water. Levels of oxygen and phosphates were also observed to exceed FEPA tolerance limit for drinking water and water meant for domestic uses. All these studies by Akan et al. were carried out at the upper course of the Challawa River. To extend further on the scope of their works, this study analysed water in the downstream where the Challawa and Kano rivers meet in order to determine the concentration of the three heavy metals (Cu, Fe, Mn) within both rivers and to assess the efficiency of the treatment plant in eliminating the three selected metals.

The aim of this study was to investigate the concentration of Copper, Manganese and Iron owing to their significance to human health at a certain quantity, as well as their potential hazards when present in high concentrations. The conventional treatment plants are usually successful in eliminating the organic pollutants through chlorination, but not the heavy metals because previous researches (Akan et al., 2007a & b; Bichi, 2000) have revealed that such pollutants usually occur in concentrations above the World Health Organization (WHO) permissible limits especially in the upstream area of the river.

1.1 The Study Area

The study focused on the Tamburawa area of the Kano River drainage basin and the new Tamburawa water treatment plant. The Kano river drainage basin occupies the south and western part of Kano State as shown in Figure 1. It is located between latitudes 11°35′ - 12°10′N, and longitudes 7°55′ - 11°35′E of Greenwhich Meridian. The prominent rivers within the basin are the Kano and Challawa rivers which are used extensively for domestic, industrial and agricultural purposes. The climate of the area is typical dry and wet type classified as Aw by Koppen (Olofin and Tanko, 2002). The temperature in the area is averagely warm to hot throughout the year at about 27± 7^0C with annual monthly range of 10 – 15^0C and higher daily ranges (Olofin and Tanko, 2002). Mean annual rainfall ranges from over 1000mm in the extreme south to about 800mm in the extreme north.

The geology of the area is made up of the Basement Complex Rocks which are deeply weathered, resulting in lateritic pans (Olofin, 1987). It is about 430 – 450m above sea level (Olofin and Tanko, 2002). The geology implies predominant surface hydrology; hence the network of rivers and streams (Bichi, 2000), and notable ground storage are common all over, in form of groundwater. The soils of the area are divided in to four main groups. Generally, the ferruginous tropical soils formed on crystalline acid rocks are found in the south, southwest and southeast of the state. The brown and reddish brown soils and latosols occur in the northern part, the northeastern corner is occupied by the brown, reddish, juvenile and hydromorphic soils are found along the alluvial channels (Olofin, 1987). The character, profile, texture, structure and chemical characteristics are altered by the extensive use of manure and chemical fertilizers.

2. MATERIALS AND METHODS

2.1 Methods of Data Collection

Fourty eight (48) water samples were collected for this research, 24 during the dry season (January – April,

2009) and 24 during the rainy season (June – September, 2009). Each of the selected parameters had eight water samples (4 raw and 4 treated) during the dry season and eight water samples (4 raw and 4 treated) during the rainy season. In the laboratory, the water samples were prepared for analysis using the spectrophotometer.

2.2 Laboratory Analysis

To identify the presence of specific metallic elements, the water samples collected were first filtered through a 0.45μm pore diameter membrane filter. The medium used in this study, however, was chosen to avoid contamination as a result of further weathering of solutes due to storage time and handling using decanting or oven drying method. The samples were analyzed in the laboratory of Kano State Ministry of Environment.

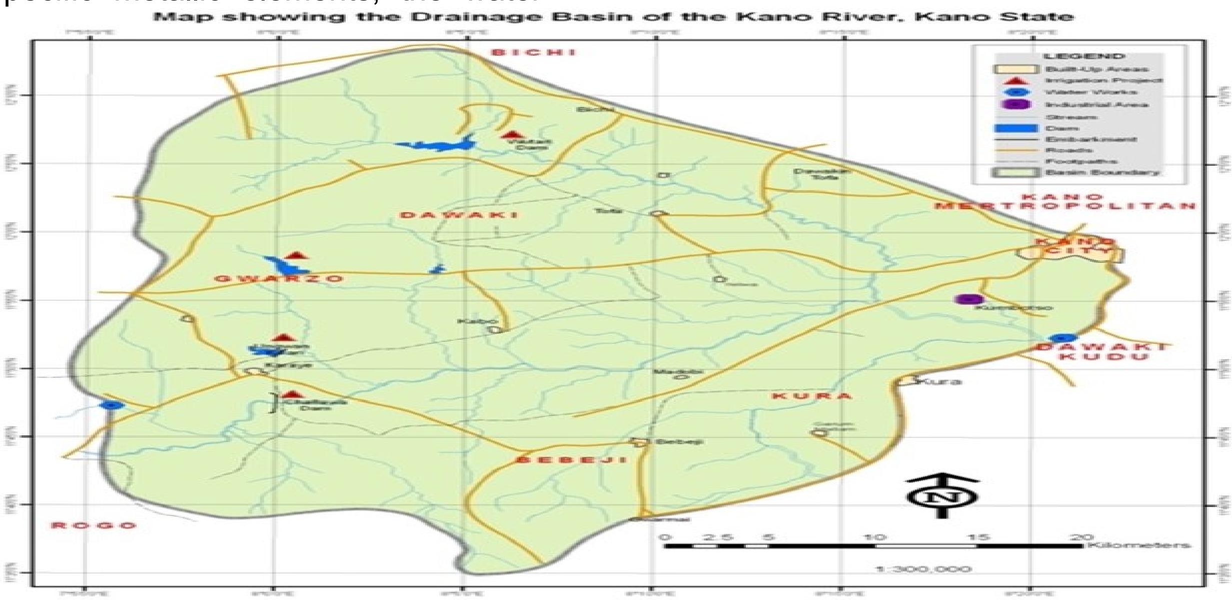


Figure 1: Map Showing the Drainage Basin of the Kano River

The assembled filtering unit was pre-conditioned by rinsing it with 50ml de-ionized water and then with 100ml of the sample and was discarded, but the volume was recorded. This is to avoid contamination of the sample. The remaining sample was filtered and preserved with HNO_3 for further analysis (WHO, 1996).

About 50ml of the acidified sample was stirred and poured into a 100ml glass beaker using a pipette. 5ml of concentrated nitric acid (HNO_3) was added and the solution digested on a hot plate to a volume of 20ml before salting out occurred. 5ml of HNO_3 was again added and covered with a watch glass then heated to obtain a gentler refluxing action. The solution was continuously heated and 2ml of concentrated nitric acid added as necessary until digestion was complete as shown by a clear coloured solution. At no point was the sample allowed to dry completely during digestion. Another 2ml of nitric acid was added and warmed slightly to dissolve the remaining residue. The digested sample was transferred into a 100ml volumetric flask with two 5ml portions of the filtered water after adding the rinsing from the walls of the beaker and watch glass to the volumetric flask. The solution was mixed, marked and allowed to cool.

Portions of the digested solutions of each water sample prepared as described above were taken for identification and their respective concentration levels measured on an Atomic Absorption spectrophotometer (DR/890). The concentration of each metal obtained was expressed in mg/l.

3. RESULTS A ND DISCUSSION

This section presents the concentration of the selected metals in the raw water and the efficiency of the new Tamburawa treatment in reducing the concentration. Percentages of the reduction levels of the selected metals were derived by computing the concentration of the metals in treated water against the raw water, using:

Pr = T/R * 100/1……………. Equation 1

Were:

T = Metal concentration in Treated water

R = Metal concentration in Raw water

Pr = Percentage of reduction in metal concentration

Figures 2 and 3 present concentration of Cu. The untreated water samples ranged from 0.780mg/l in January to a peak concentration of 2.852 mg/l in June. February, March and April had concentrations of 0.872 (mg/l), 0.834 (mg/l) and 0.945 (mg/l) respectively. This shows an increase in concentration from the months of January, July, August and September with concentrations of 0.271mg/l; 0.982 (mg/l) and 0.610 mg/l respectively. These months show a decrease from June, with September having the lowest concentration. The concentration of Cu for treated water samples showed almost the same trend with that of the untreated water samples, but with lower values of concentrations. The concentration ranged from 0.030 mg/l in February to 0.898 mg/l in June. The months of January, March, April, July, August and September had concentrations of 0.061 (mg/l), 0.80 0 (mg/l), 0.131(mg/l), 0.504 (mg/l), 0.083 (mg/l) and 0.232 (mg/l) respectively.

The concentrations of treated water samples fluctuated with February having the lowest concentration of Cu. The monthly reduction in the concentration of Cu by the treatment plant during the study period, ranged from 92% to 4% in January and March respectively. August, February and April had reduced values of 91%, 84% and 81% respectively. The remaining period of the study showed quite low values, with June having a value of 68%, September- 61% and July having a lower value of 34%. Generally, dry season shows a better reduction in the concentration of Cu than the rainy season.

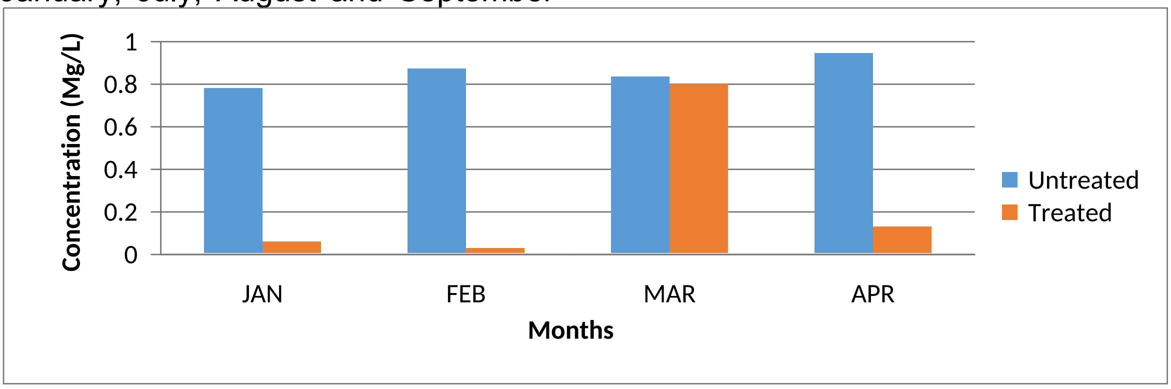


Figure 2: Variation of Cu (Mg/L) concentration between treated and untreated water-Dry Season

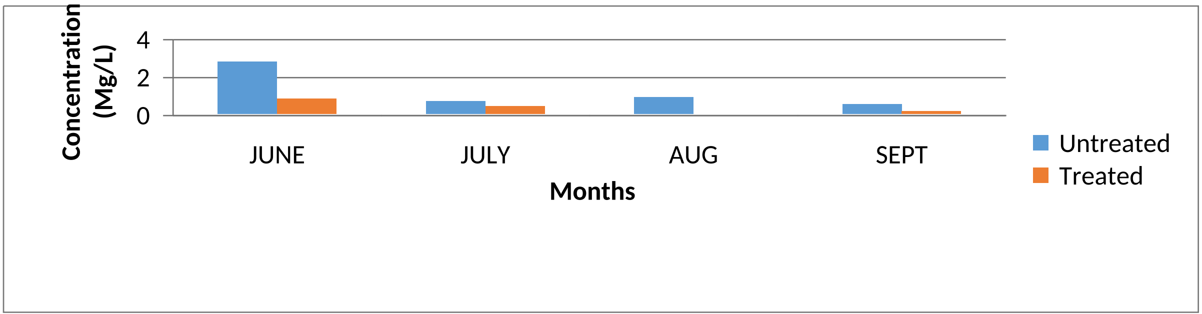


Figure 3: Variation of Cu (Mg/L) concentration between treated and untreated water-Rainy Season

Figures 4 and 5 present the concentration of Fe for the untreated water samples, results showed a higher value compared to that of Cu which ranged from 2.340 (mg/l) in March and August to 3.30 (mg/l) in September. The months of January, February, June and July had values of 2.610 (mg/l), 2.640 (mg/l), 2.450 (mg/l) 3.015 (mg/l), 2.370 (mg/l) and 2.370 (mg/l) respectively. Two months (June and September) had a reasonably high concentration, but March and August had the lowest concentrations. The values for Fe showed almost the same trend as that of the untreated samples in terms of concentration, though with slight differences. August and September had highest concentrations, with the former having the highest value of 1.870 (mg/l) and latter 1.042 (mg/l). January and April had values of 0.961 (mg/l) and 0.923 (mg/l) respectively. Lower values were recorded for the months of February and July with 0.561 (mg/l) and 0.056 (mg/l) respectively, while June had the lowest concentration of Fe with a value of 0.48 (mg/l). The treatment plant reduced the concentration of Fe in water supplied to the Kano city far more than that of Cu. The highest reduction was in the month of June with a value of 98% followed by July, March and February with values of 97%, 96% and 78% respectively. The other months showed considerably lower values of 68%, 63% and 62% for September, January and April respectively. August had the least value in respect to reduction of concentration of Fe by the treatment plant with a value of 20%.

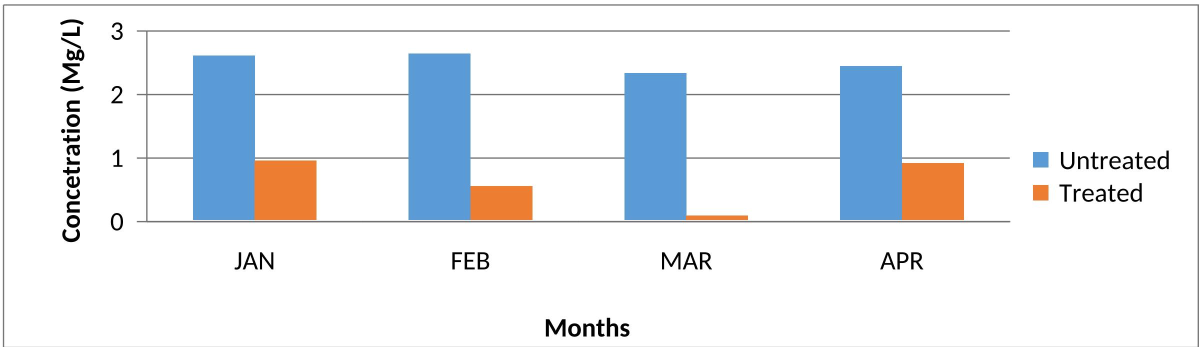


Figure 4: Variation of Fe (Mg/L) concentration between treated and untreated water-Dry season

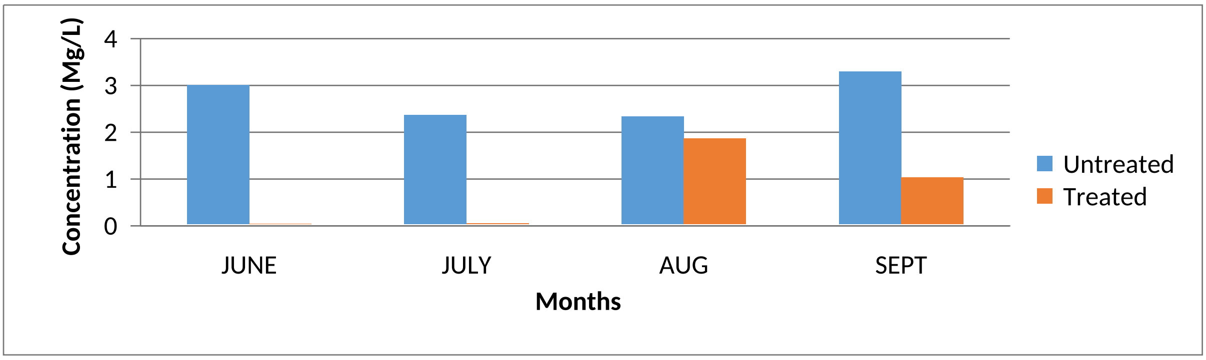


Figure 5: Variation of Fe (Mg/L) concentration between treated and untreated water-Rainy season

Manganese (Mn) had the lowest concentration compared to the other selected metals. Figures 6 and 7 reveals that the untreated water samples had a concentration value ranging from 0.002 (mg/l) to 1.298 (mg/l) in February and August respectively. January values were quite low with a value of 0.005 (mg/l). The concentration of Mn for the months of March, April, June and September are 0.298 (mg/l), 0.143 (mg/l), 0.372 (mg/l) and 0.520 (mg/l) respectively. This shows a much higher value than that of January and February. The highest values of the study were recorded during the months of July and August with the latter having a higher value than the former with a value of 1.182 (mg/l).

The treated water sample had lower concentration values than the untreated water samples. The concentration of Mn ranged from below detection point in February to a value of 0.524 (mg/l) in August. The concentration in January had a considerable low value of 0.001 (mg/l) and a little higher value of 0.024 (mg/l), 0.011 (mg/l) and 0.014 (mg/l) for March, April and June respectively. The much higher values were recorded during July and September with values of 0.170 (mg/l) and 0.275 (mg/l) respectively. The concentration of the metals exhibited almost the same pattern though with different characteristic as observed by Akan et al. (2007). The concentration of Mn was better reduced during the rainy season than in the dry season. March, April and June showed a steady rise in the reduction of concentration of Mn from 91% to 92% and then 96% respectively. There was a decline in the value from July with 85%, August with 59% and September 47%. The first two months of the dry season had values below detection.

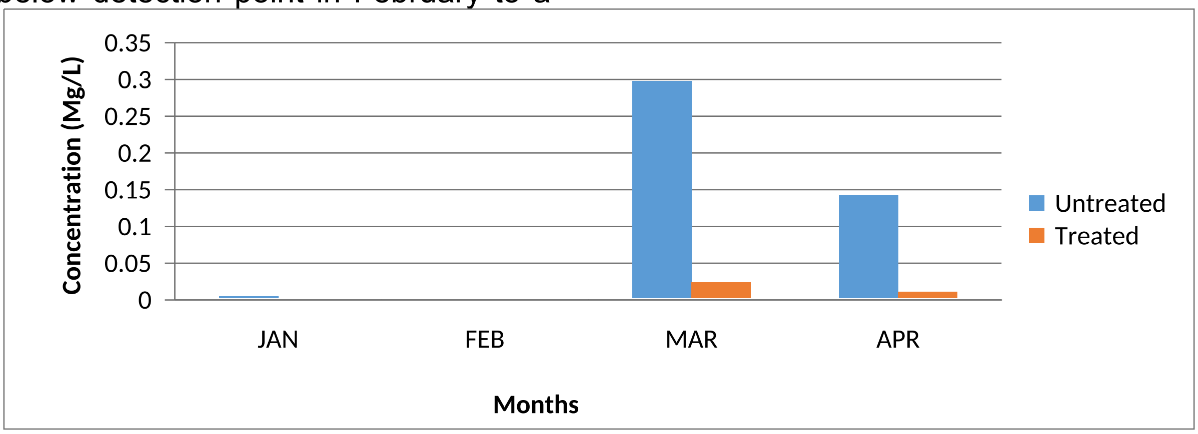


Figure 6: Variation of Mn (Mg/L) concentration between treated and untreated water-Dry season

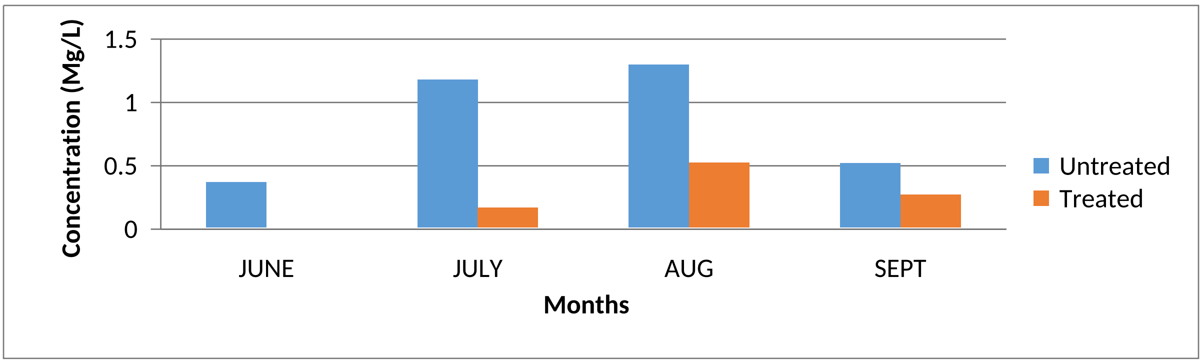


Figure 7: Variation of Mn (Mg/L) concentration between treated and untreated water-Rainy season

Generally the efficiency in treatment of the selected metals during the rainy season is less effective than that of the dry season due to higher concentration of the metals during the rainy season as a result of runoffs and high river discharge of dissolved and particulate effluents in to the river channel as observed by Butu (2002) in a study on the Galma river.

4. CONCLUSION

The study has shown that Cu, Fe and Mn do have high concentrations in the raw water due to increasing human activities and contemporary uses within the basin. This study has also revealed that the raw water is better treated by the new Tamburawa treatment plant during the dry season than the rainy season. Even though the treatment plant reduces the concentration of these metals, they are still not always within the desirable limits of the WHO standards for drinking water. Therefore, continuous accumulation over time by consumers could result in serious health complications.

4.1 Recommendations

Proper orientation should be given to rural farmers on the effect of chemical inputs on surface water and possible alternatives given. The local authorities should provide waste management disposal systems that would take care of waste and refuse dumps within the basin.

There should be proper monitoring of effluents discharge by industries and effluent receiving water by the concerned authorities. There should be proper orientation and re-orientation of all communities within the basin on the impacts of indiscriminate waste discharge and use agricultural pesticides on water quality, health and environment.

The water treatment plants should be well equipped with state of the art facilities that will ensure proper removal of pollutants from the raw water especially the heavy metals so as to keep it within safe drinking water standards.

REFERENCES

Akan, J.C. Ogugbuaja, V.O., Abdulrahaman, F.I. and Ayodele, J.T. (2007a). Determination of pollution levels in Mario-Jose Tannery Effluents from Kano metropolis, Nigeria. *Journal of applied sciences,* 7(4): 527-530.

Akan, J.C., Ogugbuaja, V.O., Abdulrahaman, F.I. and Ayodele, J.T. (2007b). Determination of pollutant levels in water of river Challawa and in tap after from Kano indusial area, Kano state, Nigeria. *Research journal of environmental sciences,* 1(5): 211-219.

Bichi, M.H. (2000). Surface Water Quality in Kano Industrial Areas. In Falola J.A (ed) *Issues in Land Administration and Development in Northern Nigeria.* Department of Geography BUK. Pp. 305-313

Biswas, A. K. (1998). *Water Resources: Environmental Planning Management and Development*. McGraw Hill Publication Comp.

Bello, B.M. (1985). *The Impact of Industrial waste on sharada, Settlement.* Unpublished B.Sc. Project, department of geography, Bayero University Kano.

Butu A.W. (2002). *Variations in the concentration of Selected Heavy Elements in the Lower and Upper Regions of Galma Dam, Zaria*. Unpublished M.Sc. Thesis Geography Department, Ahmadu Bello University, Zaria.

Campbell, L.M. (2001). *Mercury in lake Victoria (East Africa). Another emerging issue for beleaguened lake.* Ph.D Dissertation. Waterloo Unversity, Ontario, Canada.

Knapp, B., Ross, S. and McCree D., (1998). *Challenges of the Natural Environment.* Longman Group Essex.

Olofin, E.A. (1987). Some Aspects of the Physical Geography of Kano Region and Human Response. Lecture Note Series No. 1. Geography Department, BUK.

Olofin, E.A. (1991). *Surface Water Pollution. Menace to the Quality of life in Urban Area*. Paper presented at 34th Annual conference of the Nigeria Geographical Association (NGA) Owerri 11th April 1991.

Olofin, E.A. and Tanko, A. I. (2002). *Metropolitan Kano in Geographic Perspective; Laboratory of Areal Differentiation.* Department of Geography, BUK Field Studies Series 1.

Sekabira, K., Oryem Origa, H., Basamba, T. A., Mutumba G., Kakudidi, E. (2010). Assessment of heavy metal pollution in the Urban stream sediments and its tributaries *international, Journal of Environmental Science and Technology,* 7 (3), 435-446.

Tanko, A.I. (1996). The relevance of Water Quality and Population Hazards Assessment. *Journal of NGA Bayero University Kano Chapter,* 2(3). 5-11.

UNDP (1978). *Kano Sewage and Drainage project Master Plan Report*, Annex A, UNDP project NIR/75/102.

WHO (1996). *Guideline for drinking water quality recommendations,* second ed. WHO, Geneva.

Savanna volume 23, Number 1, June, 2016

Analysis of Water Quality of Selected Wells in Gonin-Gora, Kaduna State, Nigeria

Abduljalal Abdulsalam[1]*, Sule Muhammad Zubairu[2] and Abdullahi Hussaini[3]
[1]*Department of Geography, Kaduna State University, Kaduna*
[2]*Department of Geography & Environmental Management, Ahmadu Bello University, Zaria*
[3]*Nigerian Meteorological Agency, Mallam Aminu Kano International Airport, Nigeria*
*aabduljalal@gmail.com

ABSTRACT

Groundwater is considered to be safe for drinking, but increasing evidences have revealed that, its chemical composition or physical characteristics may render it unsafe for human consumption. As a result, this study was undertaken to analyse the water quality of selected wells in Gonin-Gora Kaduna State. Water samples were randomly collected from nine (9) different wells at strategic positions, the source and levels of concentration were determined to ascertain the water samples for human consumption. Magnesium, Calcium, Alkalinity, BOD, Chloride, Colour, Nitrate, Total Hardness, Turbidity and pH parameters (variables) were generated from each of the nine (9) analysed water samples for statistical analyses. The regression analysis was used to compare the relationship between distance of dumpsites and level of pollution, while chi-square was used todetermine a significance difference between empirical values and WHO standards for drinking water. Therefore, the results have shown that, there is a significant difference between the levels of concentration of the well water and W.H.O standards for drinking water. The study recommended that water from open wells should be treated before humanconsumption.

Keywords: Water quality; WHO Standard; Groundwater; Wells; Gonin-Gora.

1. INTRODUCTION

Water is a common substance that is essential for the survival of all living things. Adewale (2001) opines that water is the “matrix of life”. He observes that the progress of any development in a community, a state and a nation at large lies on the availability of potable water. Indeed, human beings cannot be in existence without water.

Groundwater is an important resource that exists almost everywhere on the landscape. In fact, it is one of the sources of fresh water and constitutes about 0.03% of usable water for many parts of the world. In Africa, many cities, towns and villages depend almost entirely on groundwater for their domestic, agricultural and industrial needs (Jidauna et al., 2013). Groundwater perhaps accounts for the largest sources of dug well water. It is located below the soil surface and largely contained in the interstices of bedrocks, sand, gravels and other interspaces through which precipitation infiltrates and percolates into the underground aquifers due to the gravity (Wilson, 1990 cited in Ajibaje et al., 2014). In Nigeria, over 70% of the population use hand-dug wells to meet their water needs especially for household drinking purposes (Ashano and Dibal, 2006 cited in Jidauna et al., 2014). The hand-dug wells are in most cases sited in unsanitary locations (close to abattoirs, refuse dumps, pit latrines or suck-away systems) (Jidauna et al., 2013). Consequently, this can become a health risk to the immediate society.

Various shallow wells have been sunk in the study area (Gonin-Gora) due to inadequate potable water supply. Water consumed plays a key role in determining the physical, mental and social health of any society

(Yakubu and Baba, 2010). While human senses can only analyse the aesthetic quality of water, it cannot go beyond that to ascertain the chemical quality of drinking water. As a result, the overall process of evaluating the physical characteristics and elemental concentration of heavy metals contained in drinking water is expedient to promote awareness of risk of consuming unhygienic water in our society.

Analysis of water for quality and suitability is one of the most significant aspects in the study of groundwater. Water that is suitable by its quality for drinking is revealed through its chemical study (Sadashivaiah et al., 2008). The chemical parameters of groundwater play a significant role in classifying and assessing water quality. Groundwater consists of major, minor and trace dissolved constituents. Constituents with concentration greater than 5mg/l, 0.01 – 10.0mg/l and less than 0.01mg/l are classified as major, minor and trace respectively (Davis et al., 1966). Water quality is not static over time, rather, it varies in both time and space and requires routine monitoring to detect spatial patterns and changes over time.

Therefore, the objectives of this study are to determine some physical and chemical characteristics of well water consumed consumed in Gonin Gora area; to examine the relationship between distance of dumpsites and level of pollution in the area; and to compare the parameters with the WHO standards in order to evaluate any possible health effect on the consumers in the area.

1.1 The Study Area

The study area is located along Kaduna-Abuja express way in Kaduna State. Gonin-Gora is located betweenLatitude 10°24′24.54″N and 10°26′30.15″N and Longitude 7°24′45.12″E and 7°28′51.22″E (Figure 1). It is bordered to the south by “Ligari”, to the east by “Ungwan-Romi”, and to the north by Garka. The study area is situated in the Basement Complex, the permeability and storability of the groundwater system are dependent on structural features such as the extent and volume of fractures together with the thickness of weathering (Clark, 1985 and Eduvie, 1998). It has also been discovered that below the veneer of regolith, the Fresh Basement rock is highly fractured at shallow and even at great depth. This, according to Eduvie (1998) makes the basement complex rock, and their derivative to constitute large reservoir of groundwater. Relative high annual rainfall (1270mm) and temperature of 32°C in the study area have resulted in the formation of deep weathered zones.

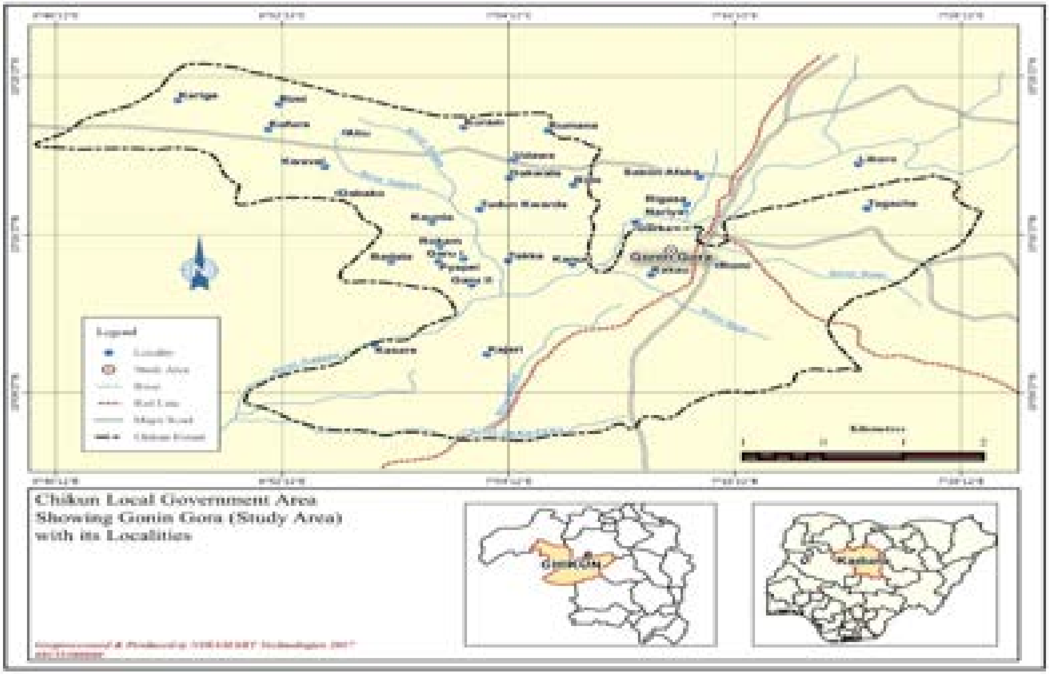


Figure 1: Chikun Local Government Area showing the study Area

Geophysical investigation and borehole drilling report have clearly established two major aquifers. These are the Overburden weathered aquifer and the Fractured Crystalline aquifer. These aquifers are characterized by thick overburden found within basement depressions with maximum value of 65m and resistivity values between 10Ωm and 756Ωm (Abdullahi et al., 2014). The Overburden weathered aquifer holds a great quantity of groundwater, hence, most of the hand-dug wells are sunk into it for domestic water supply. At some locations, these aquifers are interconnected and form a hydrological unit of water table surface.

2. MATERIALS AND METHODS

2.1 Data collection and Analysis

Water samples were randomly collected from nine (9) different wells (W1-W9) at strategic positions, the source and levels of concentration were determined using standard laboratory techniques set by ALPHA 1971 and 1986 in order to ascertain the water samples for human consumption. A small plastic bottle of one (1) litre capacity rinsed with distilled water was used to collect water samples. Water sample collected from each well was taken to the laboratory for analysis the same day for the following Physico-chemical parameters: Magnesium, Calcium, Alkalinity, BOD, Chloride, Colour, Nitrate, total hardness, turbidity and pH using standard laboratory techniques. The aforementioned parameters are among the key indicators determining the quality of drinking water.

The analysis was carried out at the Central laboratory of Kaduna State Water Board, Kaduna. The regression analysis was used to compare the relationship between distance of dumpsites and level of pollution, while Chi-square was used to determine whether there is significant difference between empirical values and WHO standard for drinking water (see Table 1).

Table 1: List of some Physico-chemical Parameters

Parameters	**WHO Guidelines (mg/l)**

Magnesium	50.00
Calcium	200.0
Alkalinity	-
BOD	-
Chloride	250
Color	5.0
Nitrate	50.0
Total Hardness	150.0
Turbidity	0 - 5.0
pH	6.5 - 8.5

Source: WHO, 2006

3. RESULTS AND DISCUSSION

3.1 Physico-Chemical Concentration in the Sampled Wells

This section presents results of laboratory analysis from the nine (9) water samples. It was carried out in order to find out conformity between the water use in the study area and WHO standard for drinking water. From the analysis of the samples, variations in the levels of both physical and chemical concentration were observed. The values of each of the parameters examined from well 1 to well 9 are tabulated in Table 2. However, Figure 2 shows a variation in terms of range, mean level of concentration of each parameter examined as well as WHO standard limits.

Figure 2 shows the variation in terms of range, mean level of concentration of each parameter examined and WHO guideline for drinking water. It was discovered from the sampled water wells that, the study recorded magnesium values that ranged from 56.6 to 507.00Mg/l with a mean value of 281.8mg/1. Therefore, magnesium values of the hand-dug wells were above the WHO limits for drinking water. The presence of magnesium ions makes water hard. However, the calcium values recorded ranged between 12.00 and 107.0 mg/l with a mean value of 59.5 mg/l were less than WHO standards of 200 mg/l for drinking water. Generally**,** there is no evidence of adverse health effects specifically attributable to magnesium and calcium ions in drinking water (Oyerlude, 2013).

Alkalinity and BOD values recorded ranged between 6.00 to 40.00 mg/l and 0.40 to 3.70 mg/l with mean values of 23.00 mg/l and 2.05 mg/l respectively. However, the WHO Standards for drinking water were virtually unavailable for proper comparison. Chloride content of the hand-dug wells samples ranged from 0.47 to 63.84 mg/l with a mean value of 32.16 mg/l. These values are less than WHO desirable limit of 250 mg/l for drinking water. The colour of the hand-dug wells samples ranged from 5.00 to 5.00Unit with a mean value of 5.00Unit. These values are within the WHO desirable limit of 5.00Unit for drinking water.

Table 2: Levels of Physico-Chemical Concentration in the Sampled Wells

Parameter	Unit	Well 1	Well 2	Well 3	Well 4	Well 5	Well 6	Well 7	Well 8	Well 9
Magnesium	Mg/l	242.00	315.00	271.00	507.00	160.00	56.00	96.00	88.00	224.00
Calcium	Mg/l	22.00	46.00	42.00	77.00	24.00	107.00	12.00	24.00	54.00
Alkalinity	Mg/l	15.00	6.00	40.00	24.00	7.00	12.00	24.00	20.00	17.00
BOD	Mg/l	0.90	1.00	0.96	0.40	0.70	1.80	2.30	3.70	1.40
Chloride	Mg/l	5.53	8.76	3.65	60.27	2.20	63.84	0.47	0.70	2.89
Color	TCU	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Nitrate	Mg/l	92.00	315.00	100.00	72.00	95.00	67.00	95.00	91.00	66.00
T/hardness	Mg/l	264.00	360.00	312.00	548.00	184.00	272.00	108.00	152.00	484.00
Turbidity	NTU	15.00	25.00	17.00	22.00	25.00	18.00	24.00	11.00	16.00
pH	pH-Unit	7.54	7.19	7.49	7.54	7.55	7.60	7.60	7.68	7.45

Source: Laboratory Analysis, 2016

No. 15, Bagudu road near railway (Well 1); No. 6, New Hospital Road (Well 2); No. 10, Sabon Gari Yayin Doyo (Well 3); Behind 1st Baptist Church Yoruba Road Gonin-Gora (Well 4); No. 11, Lagri Road (Well 5); No. 22, Cemetery Road (Well 6); No. 10, Ungwan Bije Road (Well 7); No. 15, Yayin Katafawa (Well 8); No. 8, Lamigyi Road (Well 9).

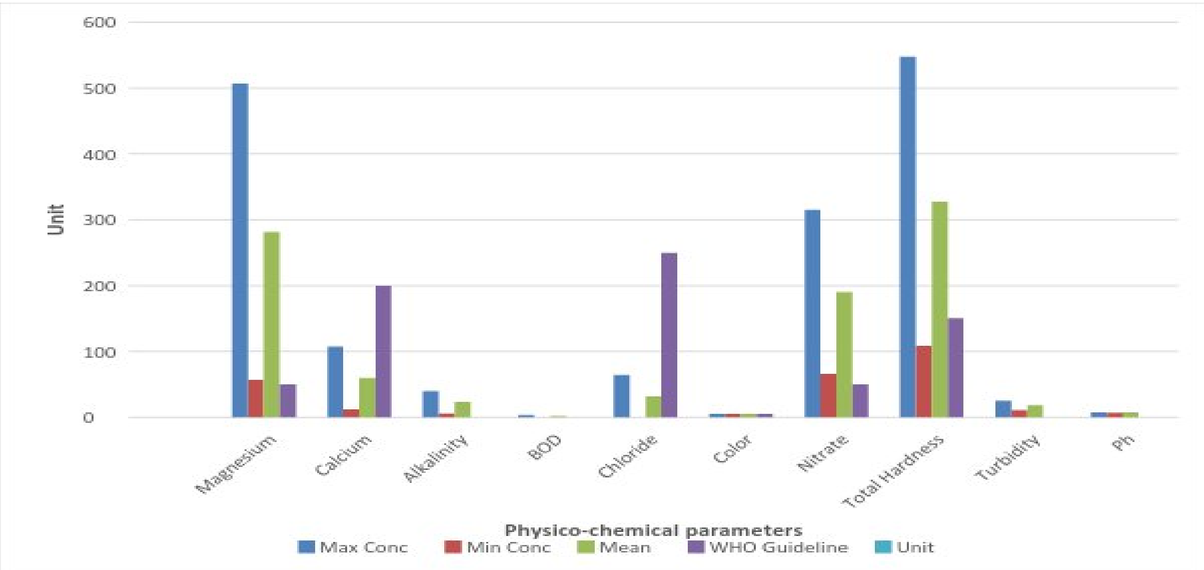


Figure 2: Comparison between Results of Water Parameters of the Study Area and WHO Standard

The Nitrate values recorded ranged from 66.00 to 315.00 mg/l with a mean value of 190.00 mg/l. Nitrate values of the hand-dug wells were above the WHO limits of 5.00mg/1 for drinking water. This implies that, the high concentration of nitrate from the sampled water may cause cyanosis which is due to methamoglobinemia especially in infants, also the occurrence of gastric cancer (Spalding and Exner, 1993). Source of nitrate contamination could be attributed to runoff from human and animal wastes during heavy rain. Total hardness values recorded ranged between

108.00 to 548.00 mg/l with a mean value of 328.00 mg/l were greater than WHO standards of 150.00 mg/l for drinking water. This was virtually attributed to the Solution of alkaline earth minerals from soil and rocks in most of the sampled water wells. High record of total hardness from water is harmless to humans, although possible related to urinary concentrations.

Turbidity values recorded ranged between 11.00 to 25.00 NTU with a mean value of 18.00 NTU. In general, the turbidity of the wells was predominantly above WHO recommended guideline value of 5.0 NTU. This was due to the Solution of alkaline earth minerals from soil and rocks in most of the sampled water wells. High turbidity can stimulate bacteria growth, which causes problems with treatment processes. The present study recorded turbidity values that are a bit higher that of Bakobie et al. (2015) who reported turbidity values that ranged from 2.0 to 9.0 NTU in dug well water samples in Janga, Ghana. The study recorded pH values that ranged from 7.19 to 7.68 pH-units with a mean value of 7.44 pH-units. Generally, pH values of the hand-dug wells were within WHO limits for potability. The hand-dug wells studied were not acidic for potability and cannot cause health problem like acidosis.

Table 3: Relationship between Observed and Expected Value of Physico-Chemical Concentration in the Water Samples

Parameters	Results	WHO Guidelines	Unit
Magnesium	281.8	50.00	Mg/l
Calcium	59.5	200.0	Mg/l
Alkalinity	23.0	-	Mg/l
BOD	2.05	-	Mg/l
Chloride	32.16	250	Mg/l
Color	5.00	5.0	Unit
Nitrate	190.5	50.0	Mg/l
Total Hardness	328.8	150.0	Mg/l
Turbidity	18.00	0 - 5.0	NTU
pH	7.44	6.5 - 8.5	pH-unit

The results from Table 5 were computed for verification, the observed values are the results from the analysis, while the expected values were WHO Guidelines for drinking water. Chi-square was used in determining the relationship between the empirical values and the WHO standards (see Table 4). The significant level used is 0.05%, while the computed Degree of freedom is 7. The calculated value from the table [x^2] = Chi Square value is 1,906.23. Thus, the D.f of 7 under the significant level of 0.05% is 14.07.

Decision: The computed value x^2 is greater than our tabulated value and implies that the alternative hypothesis be accepted (see Table 4). Thus, there is a significant difference between the levels of concentration of the wells and W.H.O standards. This simply means that, the sampled water wells from the Gonin-Gora area is not in any way suitable for direct consumption.

Table 4: Computed Chi-square Values

S/No	**Parameters**	**Observed Values (O_i)**	**Expected Values(E_i)**	**(O_i - E_i)^2**	**(O_i - E_i)^2/ Ei**
1	Magnesium	281.8	50.00	5373124	1074.6
2	Calcium	59.5	200.0	19740	98.7
3	Alkalinity	23.0	-	-	-
4	BOD	2.05	-	-	-
5	Chloride	32.16	250	47454.2	189.8
6	Color	5.00	5.0	0	0
7	Nitrate	190.5	50.0	19740.2	394.8
8	Total Hardness	328.8	150.0	31969.4	213.1
9	Turbidity	18.00	5.0	169	33.8
10	pH	7.44	8.5	11236	0.13
	Total				**1,906.23**

3.2 Relationship between Distance of the Refuse Dump Sites and Levels of Physico Concentration in the Wells

This sub-section sets to examine relationships between distance (m) of refuse dumpsites and levels of pollutants in the water wells from the study area using a correlation analysis ($r = \frac{S.xy}{Sx.sy}$). This research hypothesized that, there is no significant difference in terms of distance variation and levels of physico-chemical concentration in the wells located in the study area. This variation was examined using individual wells (W1-W9). In addition, each parameter was analyzed individually as shown in Table 3.

Using the correlation formula $r = \frac{S.xy}{Sx.sy}$

Where $S.xy = \frac{[?][?][?](x - x[?][?][?][?])(x - y[?][?][?][?])}{N}$

$\overline{x} = \frac{\sum X}{n}$, $\overline{y} = \frac{\sum Y}{n}$

Where $S\,x = \frac{\sqrt{[?][?][?]x - \overline{x})^2}}{N}$

$S\,y = \frac{\sqrt{[?][?][?]y - \overline{y})^2}}{N}$ **S**

Table 5: Relationship between Distance of the Dump Sites and Levels of Physico-Chemical Concentration in the Water Wells

Distance from Dump sites		**7.5m**	**26.5m**	**6.9m**	**17.3m**	**5.3m**	**8.7m**	**20.0m**	**3.2m**	**22.m**
Parameter	Unit	Well 1	Well 2	Well 3	Well 4	Well 5	Well 6	Well 7	Well 8	Well 9
Magnesium	Mg/l	242.00	315.00	271.00	507.00	160.00	56.00	96.00	88.00	224.00
Calcium	Mg/l	22.00	46.00	42.00	77.00	24.00	107.00	12.00	24.00	54.00
Alkalinity	Mg/l	15.00	6.00	40.00	24.00	7.00	12.00	24.00	20.00	17.00
BOD	Mg/l	0.90	1.00	0.96	0.40	0.70	1.80	2.30	3.70	1.40
Chloride	Mg/l	5.53	8.76	3.65	60.27	2.20	63.84	0.47	0.70	2.89
Color	Unit	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Nitrate	Mg/l	92.00	315.00	100.00	72.00	95.00	67.00	95.00	91.00	66.00
T/hardness	Mg/l	264.00	360.00	312.00	548.00	184.00	272.00	108.00	152.00	484.00
Turbidity	Unit	15.00	25.00	17.00	22.00	25.00	18.00	24.00	11.00	16.00
pH	Mg/l	7.54	7.19	7.49	7.54	7.55	7.60	7.60	7.68	7.45

Table 6 Summary of r values obtained from the individual sample analysis

Parameters	**R Values**
Magnesium	0.4
Calcium	0.2
Alkalinity	-0.2
BOD	-0.2
Chloride	0.1
Color	0.1
Nitrate	0.5
Total Hardness	0.5
Turbidity	0.5
pH	-0.4

4. CONCLUSION

The study was carried out on the analysis of water quality of selected wells in Gonin-Gora in Kaduna State. It was discovered from most of the sampled well water that, the physico-chemical parameters examined were virtually above the WHO guideline for drinking water. Hence, there is a significant difference between the levels of concentration of the wells and W.H.O standards for drinking water. This may pose health threats to the inhabitants of the study area.

4.1 Recommendations

To enhance the quality of hand-dug well water, the following recommendations are made from the various findings in this work:

- There is urgent need to create awareness about the present situation of these wells among the people in the area.
- Government agencies and other stakeholders should develop methods of waste management which would have little or no impact on hand-dug well water.
- The peope should ensure that water from the open wells in the study area are treated before human consumption.

REFERENCES

Abdullahi, N. K., Udensi, E.E., Iheakanwa, A. and Eletta, B.E. (2014): Geoelectrical Method Applied to Evaluation of Groundwater Potential and Aquifer Protective Capacity of Overburden Units. *British Journal of Applied Science & Technology,* 4(14): P. 20-26.

Adewale, G. (2001): Global Water Shortage may widen, *Guardian Newspaper*, pp.2. Retrieved on November 13, 2001

Bakobie, N., Awal, F.M., and Duwiejuah, A.B., (2015). Water Quality Assessment of Hand-Dug Wells in Janga, Ghana. *International Research Journal of Public and Environmental Health,* 2(12): 197-205.

Clark, L.M. (1985): Groundwater Abstraction from the Basement Complex Areas of Africa. *Quarterly Journal of Engineering Geology*, 18(2): 25-34.

Davis, S. N., and De Wiest, R. J. M (1966): *Hydrogeology*. John Wiley & Sons, New York 463p.

Eduvie, M.O. (1998): *Exploration, Evaluation and Development of Groundwater in Southern part of Kaduna State, Nigeria*: PhD thesis: Department of Geology, Ahmadu Bello University, Zaria, Nigeria.

Jidauna, G.G., Dabi, D.D., Saidu, J.B., Abaji, B., and Ndabula, C. (2013): Assessment of Well Water Quality in Selected Location in Jos, Plateau State. *International Journal of Marine, Atmosphere and Earth Science,* 1: 38-46.

Oyelude, E.O., Densu A.E., and Yankey, E. (2013). Quality of Groundwater in Kassena-Nankana District, Ghana and its Health Implications. *Advances in Appl. Sci. Res.,* 4(4): 442- 448.

Sadashivaiah C., and Ramakrishnaiah C. R. (2008). Hydrochemical Analysis and Evaluation of Groundwater Quality in Tumkur Taluk, Karnata State, India. *International Journal of Environmental Research and Public Health,* 5(3): 158-164.

WHO (2006): *Guidelines for Drinking, Water quality: First Addendum to Third edition*. Volume 1: Recommendations, World Health Organization, Geneva, 515.

Wisson, E. M. (1990): *Engineering Hydrology* 4th ed. Macmillan, London, PP. 83-94

Yakubu, S., and Baba, B. (2010). Assessment of Water Quality Consumed by Students and its Health Implications on their Academic Performance. *Journal of Studies in Science and Mathematics Education,* 1(1): 103-111.

Analysis of the Biophysical Quality of Domestic Water in Toro Local Government Area, Bauchi State, Nigeria

Abdu Ali[1]*, Ahmed Abubakar Jajere[1], Ibrahim Mukhtar [2], Nafisa, M.N.[3]
[1]Department of Geography, Federal University, Kashere, Gombe State, Nigeria
[2]Department of Geography & Environmental Management, Ahmadu Bello University, Zaria
[3]Department of Microbiology, Kaduna State University, Kaduna
*aliabdu1044@fukashere.edu.ng

ABSTRACT

Water quality analysis of surface and groundwater was carried out in Toro Local Government Area of Bauchi state located on the central highlands of northern Nigeria. Samples were collected from streams, rivers, ponds, wells and boreholes. The area was stratified into three districts and six samples were collected from each district (a total of 18 samples). The samples were subjected to laboratory analysis to taste for the physical and biological parameters in the water, and the results were compared with the World Health Organization (WHO) standard. The results of the analysis showed that only 3 of the 18 samples fell below the WHO standard in terms of biological fitness. The result of the physical parameters showed that the temperature of all the samples fell below the WHO standard; while turbidity of 11 of the samples fell below the WHO standard. In the case of appearance and taste, 5 samples are objectionable as set by WHO. The odors of all samples are unobjectionable as set by WHO. Based on these findings, recommendations were made on how to improve the quality of water in the study area.

Keywords: Biological quality; Physical quality; Surface and underground water; WHO standard.

1. INTRODUCTION

Water is very essential for socioeconomic activities. McGhee (1991) noted that in recent times, the provision of adequate potable water for domestic and other uses is becoming a serious problem as the dynamics of human-water relationship becomes more complex. However, the demand for potable water is increasing rapidly as population grows and becomes more urban and as water need per capita also increases. Therefore, the demand for clean, good and safe drinking water is attracting much more water planning attention (Population Report, 2000) and the interests of stakeholders in water resource management.

Access to safe and adequate supplies of portable water is essential for human health and well-being. Countries in the Pacific Region are constantly faced with drinking water supply problems (Mirti and Davies, 2005) and also many countries in Sub-Saharan Africa. This is attributed to variations in water resource availability, inadequate supply and treatment systems, increasing pollution and lack of proper institutional frameworks and resources for water quality monitoring thereby affecting the water quality (Mirti and Davies, 2005).

In Nigeria, water for domestic activities is obtained from various sources which include taps, boreholes, rivers, streams and lakes. But in most cases, these water sources are not being treated before used hence the quality of water cannot always be guaranteed. Rainfall is one of the factors affecting water quality by washing dissolved nutrients into the water sources thereby increasing organic carbon level and lowering alkalinity levels in the water. The dry season can also result into high levels of dissolved minerals or nutrients in a particular water source (Napacho and Manyele, 2010).

Domestic water quality relates the effects of natural processes and anthropogenic activities on the composition of water. A quality standard sets the acceptability levels of concentration for pollutants in water to be used for various domestic and socioeconomic activities (Napacho and Manyele, 2010). The quality of surface water (rivers and streams) is dynamic and can change within the catchments area.

Gamedze et al. (2012) assessed water quality levels of sources used by rural communities in the lowveld region of Swaziland. Their assessments were based on household perceptions about water quality and laboratory water quality analyses which were carried out on selected water quality parameters. The parameters considered were physical factors including pH, colour, taste and odour. They concluded that water quality remains a sustainable development challenge in the rural areas of Swaziland (Gamedze et al., 2012).

Isah et al. (2015) analyzed the water quality of Hand dug wells (HDWs) from Hardo ward, in Bauchi metropolis, Nigeria for the physical, chemical and bacteriological parameters. The results of water quality from the wells were found to fall within or below or in excess of the safety limits of drinkable water based on the benchmark standard set by the WHO and the Nigerian Standard of Drinking Water Quality (NSDWQ). The study concluded that the quality of water from HDWs in Hardo ward were not suitable for drinking. Therefore, the study recommended regular monitoring of ground water quality and a further research to determine the sources of ground water pollution in the study area.

Toro Local Government Area of Bauchi State in northern Nigeria is experiencing rapid population growth brought about by persistent influx of in-migrants from neighboring Plateau State, consequently, water is not only becoming scarce in the area but its quality is also degraded. The major sources of water in the area are rivers, streams, ponds, earth dams, and groundwater tapped from wells and boreholes. Unfortunately, most of the surface water sources dry off immediately or few months after the rainy season, while the few sources that withstand the dry season become contaminated by domestic and agricultural uses. Most people therefore, rely on hand dug wells and boreholes as the ultimate sources of water during the dry season. Thus, this study seeks to examine the physical and biological characteristics of both surface and groundwater in Toro, with a view to find answers to the following research questions:

- What is the biophysical quality of water for domestic activities in the area?
- Does the quality of both surface and groundwater in the area conform to the WHO standard for drinking water?

1.1 The Study Area

Toro local government area is one of the twenty local government areas of Bauchi state in northeastern Nigeria. It was created in

August 1976 with an area of 6,932square kilometers. It is located between Latitudes 9º45′N and 10º49′N and Longitudes 8º44′E and 9º50′E (Information Office Toro) as shown in Figure 1. It is politically divided into three districts of Toro, Jama'a and Lame with seventeen electoral wards. They are Toro, Tulai, Ribina West, Ribina East, Tilden Fulani, Mara, Palama, Jama'a, Zaranda Rauta Geji, Wonu North, Wonu South, Rahama, Lame, Rishi, Tama and Zalau.

The area is located on the basement complex of the northcentral Nigeria (Chollom, 2006). The area is composed of several complexes notable among which are the Toro complex which contain three types of granites of concentric rings surrounding a core of hypersthenes diorites (Aigbodion, 1991). Toro is located on the central highlands of Northern Nigeria. The terrain is generally undulating with isolated hills, ridges and insebergs. The highest peak is the zaranda hill (1450m). Temperatures are relatively very low with an annual mean of 22°C. Rainfall is very high through diminishes as we go north wards. The annual mean rainfall is about 1368mm (Aigbodion 1991).

The area is located within the Guinea Savanna grassland of northern Nigeria. The dominant land use in Toro is farming and grazing. Different crops are cultivated with maize, guinea corn and rice being the major crops. One important occupation is the tin mining which is still carried out in small scale across Toro and Lame districts. It is noteworthy that the first tin mining in Nigeria was in Tilden Fulani area of Toro. Most of the villages around Tilden Fulani are built on soils that were distorted by tin mining in the colonial era notable among them is the Sabon Garin Narabi village.

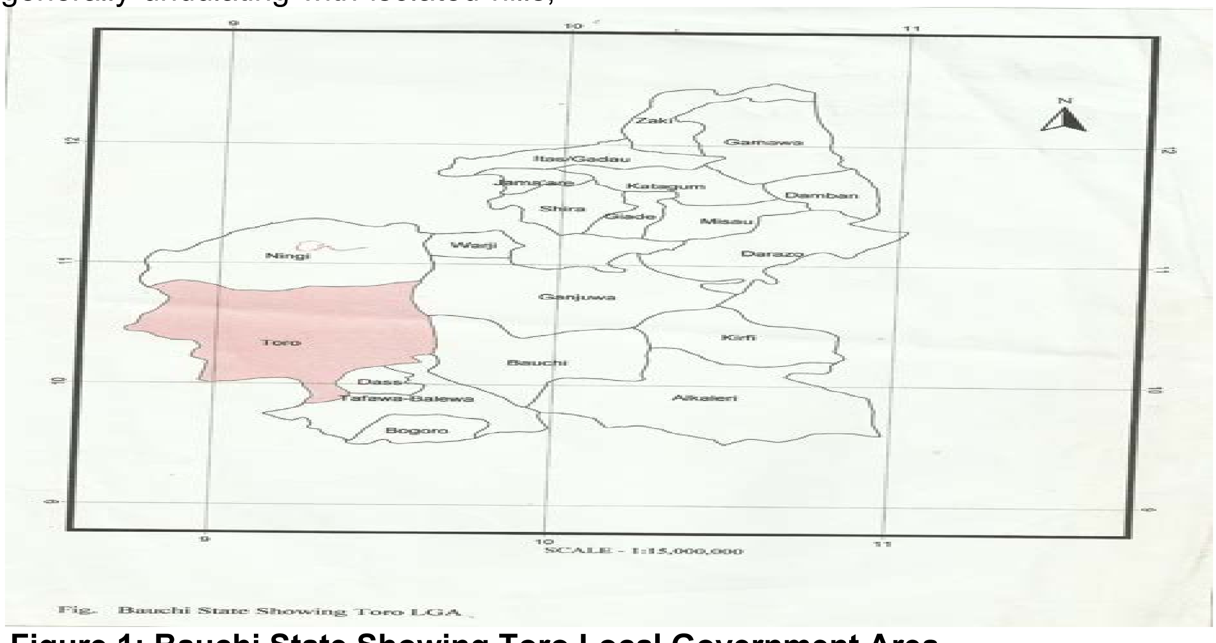


Figure 1: Bauchi State Showing Toro Local Government Area

2. MATERIALS AND METHODS

2.1 Types and Sources of Data

The nature of the data needed depend on the requirements of the study. The data used for this study were obtained from primary and secondary sources. These are:

a. Data on the physical and biological quality of both surface and groundwater was obtained from laboratory analysis.

b. Maps of Bauchi and Toro showing the sampling points.
c. Data describing the location in terms of latitude, longitude and heights of the position of the samples using Global Positioning System (GPS).

2.2 Methods of Data Collection

Several methods and procedures were employed for the collection of the data required for the study. A reconnaissance survey was carried out in the month of June. The three districts of the local government area were visited. This helps the researchers in developing their sampling techniques. The sources of domestic water identified were: wells, boreholes, ponds, streams/rivers and earth dams. Rainwater was also identified as a major source of domestic water during the rainy season.

2.3 Sampling Procedure

In locating the water sample points, the following factors were considered: mainly population concentrated areas, landuse and the relief. Numbers of samples were distributed across the three districts and between the surface and the underground waters irrespective of the sources.

The local government area was divided into three based on its districts. A combination of purposive, stratified and random sampling techniques were used. The researchers used the districts as the basis of stratification. A total of six (6) samples were taken randomly from each district comprising of three (3) surface and three (3) (underground) samples as shown in Table 1. The researcher used purposive sampling to include a sample from Toro town being the headquarters of the local government area.

Table 1: Sample Size

S/N	Location	Number Of Samples
1	Toro	6
2	Lame	6
3	Jama'a	6
Total		**18**

2.4 Water Sample Collection Techniques

The procedure for the collection of samples and the location of the various samples points are outlined below:

1. Sterilized 75cl plastic Swan bottles were used for the collection of water samples.
2. The caps of the bottles were removed after the water had been extracted from the sources, the bottles were rinsed with the water extracted before been filled, leaving air space in each bottle. The bottles were covered immediately after filling.
3. Provision was made for a cooler containing ice to regulate the water temperature in order to prevent excessive growth or death of bacteria. The points where samples were collected were arrived at by random selection in each district from a list of major towns identified as sample points. Figure 2 shows the locations of the sample points.
4. The water samples were fairly distributed across the local government area and coded S_1, S_2, S_3, G_1, G_2, G_3, where S = surface water source and G = ground water source as illustrated in Table 2. To distinguish between surface and ground water source among the

three districts, the first letter of each district was written at the beginning of the codes to give what is in the below Table 2. The geographic coordinates of the sampled points is shown in Table 3.

Figure 2: Toro LGA Showing the Sampled Locations

2.5 Laboratory Analysis of the Water Samples

The eighteen (18) samples collected were analyzed at the Bauchi State Rural Water Supply and Sanitation Agency (BAURUWASSA) Laboratory to investigate the biophysical parameters. The results of the analysis are presented in Appendices I and II.

2.5.1 Physical Parameters

Five variables involving physical characteristics of the water quality were tasted in the laboratory, namely; temperature, turbidity, appearance, taste and odor as shown in Table 4. Colometric method was used to measure the physical parameters using spectrophotometer. This is a very powerful laboratory instrument capable of performing tests using different reagents. It has four digits for different parameters. Liquid crystals display and provide three operator selectable read out modes of absorbance, percent transmittance or concentration.

2.5.2 Biological Parameters

The biological parameters involving total coliform, faecal coliform and *E. coli* were tested using delagua field water testing kit. A summary of biological parameters determined for the present study is presented in Table 5.

Table 2: Name of Sampling Locations and their Codes

S/N	District	Sample Code	Name of Location
1	Toro	TS_1	Upper Dilimi River
		TS_2	Ribina Stream
		TS_3	Balarabe River
		TG_1	S/Garin Narabi borehole
		TG_2	Jajuwa borehole
		TG_3	Toro District Pallace well
2	Lame	LS_1	Lower Dilimi River

		LS_2	Rishi River
		LS_3	Dokan Auwalu mining pond
		LG_1	Gumau Public well
		LG_2	Tulu Public well
		LG_3	S/Garin Tulu borehole
3	Jama'a	JS_1	S/Garin Nabordo Earth Dam
		JS_2	Nyela Bongo River
		JS_3	Dori Stream
		JG_1	Nabordo well
		JG_2	Tashan Durumi Well
		JG_3	Biciki borehole

Table 3: GPS Values of Sampled Points in the Study Area

Sample	Latitude	Longitude	Elevation	Name of Place
TS_1	10^0 02' 51N	8^0 58' 51E	859m	Upper Dilimi River
TS_2	10^0 04' 55N	9^0 05' 12E	910m	Ribiner River
TS_3	10^0 06' 09N	9^0 17' 35E	729m	Balarabe River
TG_1	10^0 01' 31N	9^0 57' 16E	890m	S/Garin Narabi borehole
TG_2	10^0 01' 15N	9^0 02' 41E	855m	Jajuwal borehole
TG_3	10^0 03' 25N	9^0 04' 13E	980m	Toro well
LS_1	10^0 12' 24N	9^0 02' 56E	783m	Lower Dilimi River
LS_2	10^0 28' 13N	8^0 56' 31E	893m	Rishi River
LS_3	10^0 45' 22N	9^0 02' 00E	836m	Dokan Auwalu Mining Pond
LG_1	10^0 15' 20N	9^0 01' 10E	833m	Gumau well
LG_2	10^0 34' 30N	9^0 01' 32E	844m	Tulu Public well
LG_3	10^0 40' 18N	9^0 00' 32E	796m	S/Garin Tulu borehole
JS_1	10^0 12' 27N	9^0 20' 45E	732m	S/Garin Nabordo Earth dam
JS_2	10^0 19' 08N	9^0 29' 27E	670m	Nyela Bongo River
JS_3	10^0 11' 25N	9^0 02' 00E	672m	Dori Stream
JG_1	10^0 13' 20N	9^0 32' 08E	717m	Nabordo Public well
JG_2	10^0 13' 25N	9^0 35' 08E	682m	Tashan Durumi Public well
JG_3	10^0 14' 25N	9^0 38' 18E	666m	Biciki borehole

3. RESULTS AND DISCUSSION

A total of 18 samples were taken from the study area and 29 parameters were tested for each of the samples. This section analyzes the levels of various elements from all the samples and the obtained results were compared with the recommended standard for drinking water quality given by the World Health Organization (WHO). This was done to determine the degree of portability of both surface and groundwater in Toro, Lame and Jama'a districts. Data collected were first aggregated individually and compared against each other to see if there were any similarities or variations in the quality levels.

The results of the analysis are discussed using the following methods:

i. The descriptive analysis of the laboratory results obtained from the field.
ii. The graphical representation of the test results showing comparison of the parameters among the districts and the mean values against the WHO standard.
iii. Statistical analysis which include ANOVA for the mean variations of biological parameters among the districts to compare with the WHO standard.

3.1 Results of the Laboratory Water Quality Analysis

The data from the laboratory tests of physical and biological parameters examined from the water samples are contained in Tables 4 and 5 respectively.

3.1.1 Physical properties of the water temperature

The result of the analysis indicated that the temperature values ranges between 25.9°C and 27.3°C. This shows that the values are within the acceptance limits set by WHO which is 29°C as the maximum level.

3.1.1.1 Turbidity

The turbidity of the surface water is influenced by the rain. This is because the runoffs carry soil particles into surface water sources and render them more turbid. The result of the analysis shows that with the exception of River Ribina whose turbidity value is 4, all other surface water sources show values above 5 set by WHO. In the case of the groundwater sources, all of them fell below the WHO maximum limit except those of the well at Toro, borehole at Sabon Garin Tulu and borehole at Biciki whose values are 6, 11 and 17 respectively.

3.1.1.2 Appearance

The appearance of water must be unobjectionable for such water to be potable. From the results of the analysis, five samples show an objectionable water appearance. They are river Balarabe, River Richi, Sabon Garin Nabordo earth dam, River Nyela Bongo and River Dori.

3.1.1.3 Taste

Five samples also revealed objectionable taste. They are Toto well, Tulu well, Sabon Garin Tulu well, Naborodo well and Tashan Durumi well. This represents 27.8% of the sampled waters.

Table 4: Values of Physical Parameters of water samples in the Study Area

Sample	Temperature	Turbidity	Appearance	Taste	Odour
TS_1	27.0	232	Obj	Unobj	Unobj
TS_2	27.0	4	Unobj	Unobj	Unobj
TS_3	25.9	23	Obj	Unobj	Unobj
TG_1	26.0	2	Unobj	Unobj	Unobj
TG_2	27.0	4	Unobj	Unobj	Unobj
TG_3	26.5	6	Unobj	Obj	Unobj
LS_1	26.7	22	Unobj	Unobj	Unobj
LS_2	27.3	23	Obj	Unobj	Unobj
LS_3	26.0	6	Unobj	Unobj	Unobj
LG_1	26.0	5	Unobj	Obj	Unobj
LG_2	26.7	4	Unobj	Obj	Unobj
LG_3	26.0	11	Unobj	Unobj	Unobj
JS_1	26.3	54	Obj	Unobj	Unobj
JS_2	27.0	38	Obj	Unobj	Unobj
JS_3	26.3	34	Obj	Unobj	Unobj
JG_1	26.7	3	Unobj	Obj	Unobj
JG_2	27.0	3	Unobj	Obj	Unobj
JG_3	26.1	17	Unobj	Unobj	Unobj
WHO	29	5	Unobjectionable	Unobjectionable	Unobjectionable

The concentration of the individual elements in the water sample is presented in Figure 3.

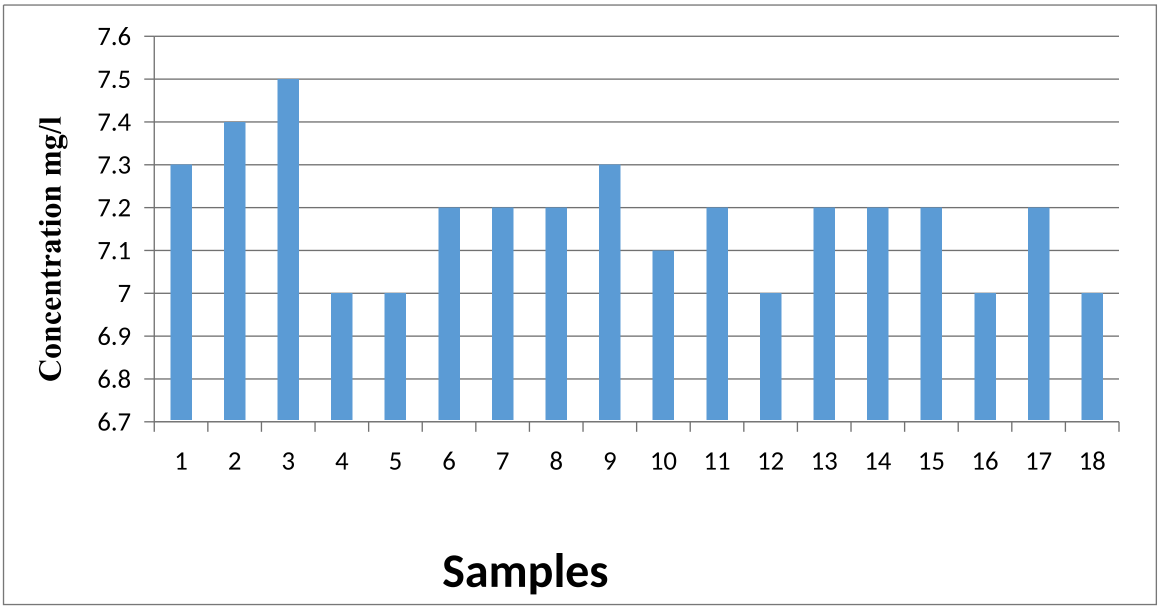


Figure 3: Graphical representation of individual elements in the water samples

3.1.1.4 Odor

This is also an important physical parameter that influenced the portability of water. From the results of the laboratory analysis, all samples show unobjectionable odor indicating that otherwise the water is fit for domestic purposes.

3.1.2 Biological Properties of the Water Sample

Gray (1994) observes that there are several reasons why a specific individual isolation and identification of pathogenic organisms is impracticable, these include; the fact that it is time consuming and that it is misleading as each species can tolerate different environmental conditions. This has led to the development of the use of indicator organism to determine the likelihood of contamination by faeces. The most widely used forms of indicators are the non-pathogenic bacteria in particular coliforms, *faecal streptococci* and sulphate reducing *clostridia*. *Escherichia coli* can survive for several weeks under ideal conditions and are far more easily detected than the other indicator bacteria. Because of this, it is the most widely used test organisms, although others are often used to confirm faecal contamination if *E.coli* is not detected. The (EC) directive specifies that total and faecal coliforms are to be measured by way of a count, it also set that safe water must be free from faecal coliform (*Escherichia coli*) and has about 3 x 10^{-1}mg/l of total coliform.

Our data from the laboratory test shows about 83.3% of contamination in the total number of samples from both surface and groundwater in the study area. Flanagan (1988) summarized the interpretation of coliform results as follow:

a. Where *E.coli* are present in large numbers, the interference is that heavy, recent pollution by human or animal wastes has occurred. This can be observed in all the samples except TG_1, TG_2 and LG_3.
b. If the *E.coli* numbers are low, it is inferred that pollution from the same source(s) is either recent or less severe. This is not observed in any of the samples.
c. If coliforms not including *E.coli* are observed, the indication is that either the pollution is recent and non-faecal in origin or of

remote origin such that the intestinal coliforms have not survived. This is not observed in any of the samples.

d. The remaining samples showed no evidence of contamination.

There is need for caution in the above interpretation as noted by Gray (1994) that in tropical region *E.coli* in particular is known to multiply in warm waters and there is increasing evidence that *E.coli* is able to reproduce in enriched waters generally, indicating an increase health risk.

Possible source of coliforms contamination of water in the study area is obviously bad sanitation. The geological structure of some of the rocks aids groundwater contamination especially where wells and boreholes are situated in close proximity to pit latrines, septic tanks or gutters containing sewage. Intensive grazing in the study area is another likely source of contamination of water.

Faecal coliforms are dangerous to human life. This is because ingestion of water that is contaminated with human or animal faeces is a source of pathogenic bacteria, viruses, protozoa and helminthes. Short term peaks in pathogen concentration may increase diseases risks and may trigger outbreaks of water born diseases (WHO, 1993).

Table 5: Values of Biological Parameters of water samples in the Study Area

Sample	Faecal Coliform	Total Coliform	E.Coli	WHO Limit
TS_1	56	102	13	0
TS_2	75	145	12	0
TS_3	84	104	24	0
TG_1	0	0	0	0
TG_2	0	0	0	0
TG_3	47	94	15	0
LS_1	84	154	24	0
LS_2	65	105	34	0
LS_3	49	84	11	0
LG_1	61	104	12	0
LG_2	66	132	14	0
LG_3	0	0	0	0
JS_1	54	210	32	0
JS_2	89	200	13	0
JS_3	133	300	76	0
JG_1	56	95	12	0
JG_2	7	20	0	0
JG_3	133	300	76	0

3.1.3 Statistical Analysis

In order to determine the degree of variation in the mean biological parameters among the districts of Toro local government area, the analysis of variance (ANOVA) was used. Consequently, the followingresearch hypotheses were formulated:

H_0: There is no significant variation in the mean biological parameters among the districts of Toro local government area.

Rejection Level: $\alpha = 0.01$

The result of the analysis is presented in Table 6.

Table 6: One-way ANOVA on the Biological parameters in the study area

	Source of variation	Sum of squares	df	Mean Square	F-calculated	f-tabulated $\alpha = 0.01$
Mean Biological parameters	Between Group Variation	11196.99	2	5598.495	2.94	6.23
	Within Group Variation	30482.172	16	1905.1359		
	Total Group Variation	41679.165	18			

Group = Districts of the local government area

The result shows that there is every reason to accept the null hypothesis at α=0.01 significant level. In conclusion, there is no significant variation in the mean biological parameters among the districts of Toro local government area.

4. CONCLUSIONS

The result of the physical analysis of groundwater in the study area shows that the water in the study area is potable. On the other hand the surface water revealed a contrary result.

In the case of the biological parameters, with the exception of water from boreholes, all the other sources showed feacal contamination. This implies that waters from rivers, streams and shallow wells are of poor quality in Toro Local Government Area.

4.1 Recommendations

Water of poor quality has serious implications on human health and the environment. Therefore, the following recommendations are put forward in order to improve the water quality in the area:

i. There is the need for government intervention in providing boreholes in the remote villages and hamlets in addition to improving what exists in larger villages and towns. Where possible, dams should be constructed with treatment plants to make portable water available to the teaming population of the area.

ii. There should be an enlightenment campaign on where and how to locate wells to avoid contamination from pit latrines, septic tanks and waste dumps.

iii. There should be intensive awareness campaign and education through schools, environmental protection agency and the ministry of health on the dangers of consuming water of poor quality (untreated water).

4.2 Suggestion for Further Study

In order to have a comprehensive understanding of the overall water quality of Toro local government area, analysis of the chemical parameters in the water is necessary. It is also recommended that future studies should use more than 18 samples to cover a wider area of Toro.

Appendix I

Water Quality Control and Protection Unit Laboratory Result Sheets

S/N	Parameters	S/g Narabi	bichiki	R. ibana	Nabardo Well	Dokan Auwalu M.P	Tasha Durmi	Jajuwal Borehole	L. Delml River	NSDWQ*MPL
1.	Temperature(^{0}C)	26.0	25.9	27	26.7	26.0	27	27	26.7	-
2.	pH	7.0	7.5	7.4	7.0	7.3	7.2	7.0	7.2	6.5-8.5
3.	Appearance	Unobl	Object	Unobj	Unobj	Unobj	Unobj	Unobj	Unobj	Unobjectionable
4.	Test	Unobj	Unobj	Unobj	Object	Unobj	Object	Unobj	Unobj	Unobjectionable
5.	Odour	Unobj	Unobj	Unobj	Unobj	Unobj	Unobj	Unobj	Unobj	Unobjectionable
6.	Turbidity (NTU)	2	22	4	3	6	3	4	22	5
7.	Total coli form (cfu/100ml)	0	104	145	95	84	20	0	154	0
8.	Faecal coli form (cfu/100ml)	0	84	75	56	49	7	0	84	0
9.	*E. Coli* (cfu/100ml)	0	24	12	12	11	0	0	24	0

Appendix II

S/N	Parameters	Bichiki	Bongo river		Doris stream	Ung. Gumau	Dillimi river	Tulu well	Toro dist. Well	N. earth dam	Rishi river	NSDWQ*MIND
1.	Temperature(^{0}C)	26.0	27	26	26.0	26	27	26.7	26.5	26.3	27.3	-
2.	pH	7.0	7.2	7.0	7.2	7.1	7.3	7.2	7.2	7.2	7.2	6.5-8.5
3.	Appearance	Unobl	Object	Unobj	Object	Unobj	Obj	Unobj	Unobj	Obj	Obj	Unobjectionable
4.	Taste	Unobj	Unobj	Unobj	unobjt	Obj	Unobj	Obj	Obj	Unobj	Unobj	Unobjectionable
5.	Odour	Unobj	Unobj	Unobj	Unobj	Unobj	Unobj	Unobj	Unobj	Unobj	Unobj	Unobjectionable
6.	Turbidity (NTU)	17	38	11	34	5	232	4	6	54	23	5
7.	Total coli form (cfu/100ml)	0	200	0	300	104	102	132	94	210	105	0
8.	Faecal coli form (cfu/100ml)	0	89	0	133	61	56	66	47	54	65	0
9.	*E. Coli* (cfu/100ml)	0	13	0	76	12	13	14	15	32	34	0

REFERENCES

Aigbodion I.C. (1991). Geology of the Area North of Zaranda Younger granite Ring Complex Bauchi State Department of Geology and Mining, University of Jos, Nigeria.

Chollom, T. (2006). Groundwater Quality Assessment in the North Central Basement Complex of Nigeria. Department of Geology and Mining, University of Jos, Nigeria.

Flanagan PJ (1988). Parameters of Water Quality, Interpretation and Standards' Environmental Research Unit, Dublin.

Gamedze, K., Tevera DS, Fadiran A.O. (2012). Water Quality Assessment of Various Sources in Rural Areas in the Lowveld Region of Swaziland. Current Research Journal of Social Sciences, 4(2): 99-102.

Gray N.F. (1994). Drinking Water Quality Problems and Solutions. John Wiley and Sons, England pp 43-63.

Isah M.A., Salau O.B.E., Harir AI, Chiroma MA, Umaru AA (2015). Parameters of Water Quality in Hand Dug Wells (HDW) from Hardo Ward, Bauchi Metropolis, Nigeria. ARPN Journal of Engineering and Applied Sciences, 10(16): 6804-6810.

Mcghee (1991). Water Resources on Environmental Engineering. McGraw Hill Series.

Mirti A.V., Davies S. (2005). Drinking Water Quality in the Pacific Island Countries: Situation Analysis and Needs Assessment. South Pacific Applied Geoscience Commission (SOPAC) Joint Contribution Report 181. WHO & SOPAC, Fiji.

Napacho Z.A., Manyele S.V. (2010). Quality Assessment of Drinking Water in Temeke District (part II): Characterization of Chemical Parameters. African Journal of Environmental Science and Technology,4(11): 775-789.

Population Report (2000). The Environmental Population Growth, Decade for Action Series in No. 10 pp18.

WHO (1993). International Standards for Drinking Water. Geneva pp 36-45.

WHO (1971). Health Hazards of Human Environment, WHO Geneva pp 36-64.

WHO (1976). Surveillance of Drinking Water quality, WHO Monograph Series, No. 63, Geneva.

WHO (1983). Guidelines for Drinking Water Quality, Vol. 1 Recommendations WHO, Geneva pp 1-2.

WHO (1984). "Guidelines for Drinking Water Quality, Vol. 1 Health Criteria and Other Support WHO, Geneva pp 130.

WHO (1985). Guidelines for Drinking Water Quality, Vol. 2 Recommendations WHO, Geneva pp 1-2.

WHO (1984). Guidelines for Drinking water quality, Vol. 2 Recommendations WHO, Geneva pp 130.

WHO (1985). Guidelines for Drinking Water Quality, Vol. 2 Health Criteria and other Support Information, WHO, Geneva, pp 327.

WHO (2004). Guidelines for Drinking Water Quality, vol. 1 third edition. Recommendations. World Health Organization Geneva.

Savanna volume 23, Number 1, June, 2016

Assessment of the Living Conditions of Internally Displaced Persons in Yola, Adamawa State, Nigeria

Abubakar M.[1]*, Maiwada A.[2] and Bako A.R.[3]
[1]*Department of Geography & Environmental Management, Ahmad Bello University, Zaria*
[2]*Department of Geography, Kaduna State University, Kaduna*
[3]*Department of Geography, Federal University, Gashua, Yobe State*
*****maryamabubakar08@gmail.com

ABSTRACT

Internally Displaced persons (IDPs) are mostly victims of various kinds of injustices or violent confrontations, perpetrated by either their own government against them or by others. The study assessed the living conditions of IDPs in Yola, Adamawa State, Nigeria. The objectives were to examine the living conditions of IDPs and assess the coping strategies IDPs have developed to survive. Questionnaire was the main instrument for collecting data which was complemented by in-depth interviews. A total of 335respondents were sampled for the study. Descriptive statistics was used to analyze the data collected using SPSS version 20. The results were presented in form of tables, frequencies and percentages. The result showed that St. Theresa Cathedral and Malkohi camps had more females (66%) than males. A high percentage of the respondents were widows (46%) and all respondents were displaced as a result of insurgency in Northeastern Nigeria. The major needs of IDPs on the camps were food, hygiene, health and psychosocial support as these were all lacking. The coping strategies adopted by the IDPs to survive include: reliance on food aid from government; non-governmental organizations, and individuals (49%); moving out of the camps for emergency health care (49%); organizing sanitation activities (100%), engaging in recreational activities for psychosocial therapy (63%). Thus, all government agencies responsible for protecting and assisting IDPs and other local and international humanitarian actors must therefore ensure effective measures are put in place to provide suitable accommodation, livelihood assistance, medical facilities and psychotherapy to improveon the deterioration conditions IDPs are living in.

Keywords: Internally Displaced Persons; Camps; Living conditions; Coping strategies; Yola.

1. INTRODUCTION

Internal displacement has emerged as one of the great human tragedies of the 21st century (Norwegian Refugee Council, 2009). The plight of displaced persons has in recent years become a formidable problem of global significance and implications (Ladan, 2001). The United Nations (UN) Guiding Principles on Internal Displacement have a given precise and internationally accepted definition of internally displaced persons (IDPs); as persons or groups of persons, who have been forced or obliged to flee or to leave their homes or places of habitual residence, in particular as a result of or in order to avoid the effects of armed conflict, situations of generalized violence, violations of human rights or natural or human-made disasters, and who have not crossed an internationally recognized State border (UN OCHA, 1999). This definition gives us a broad framework to recognize IDPs, thus helping to bring forth the diverse issues and problems they have been facing (Niroula, 2008).

In 2015, there were about 40.8 million IDPs worldwide as a result of conflict and violence– an increase of 2.8 million on the figure for 2014. Three quarters of the global total of IDPs or 30 million people, were located in just 10 countries and 5 of these are in sub-Saharan Africa (SSA). There were 8.6 million new displacements associated with conflict and violence in 28 countries in 2015.

Nearly 4.8 million of those newly displaced are in the Middle East and North Africa (MENA). Outside this region, the countries with the highest numbers of people fleeing the effects of conflict and violence in 2015 were Ukraine, Nigeria, Democratic Republic of the Congo (DRC), Afghanistan, Colombia, Central African Republic (CAR) and South Sudan. Globally, 5 countries (Colombia, DRC, Iraq, Sudan and South Sudan) alone accounted for almost 40% of the world's IDPs, or nearly 16 million people in the same year (Internal Displacement Monitoring Centre {IDMC}, 2016a). Likewise, in 2015, SSA had 2.2 million people who were newly displaced by conflict and violence in 14 countries, making this region second only to MENA. Of the total new displacements in SSA, Nigeria accounted for more than 30% and the DRC-25% (IDMC, 2016b). There is a risk that these conflicts will become stubborn, leaving the people they have displaced to face a future of protracted and possibly multiple displacements (IDMC, 2016a).

Nigeria in the recent years has witnessed a sudden upsurge of a population of people forced to move into temporary settlements or camps due to protracted internal conflicts (Joshua et al., 2016). The Northeastern part of Nigeria has witnessed an increase in violence since the beginning of 2014, causing a major humanitarian crisis. The intensification of attacks by *Boko Haram* along with the counter-insurgency activities of the Nigerian Government have resulted in chronic insecurity and violations of human rights and humanitarian standards, exacerbating the plight of vulnerable civilians and triggering waves of forced displacement(IOM, 2016). In April 2016, IOM identified a total of 2,155,618 IDPs in Adamawa, Bauchi, Benue, Borno, Gombe, Kaduna, Kano, Nasarawa, Plateau, Taraba, Yobe, Zamfara states and Abuja, the Federal Capital Territory in Nigeria. Adamawa is the second state hosting the largest proportion (6.9%) of the IDPsin Nigeria. About 86.1% of the total IDPs' population have been displaced by insurgency in the Northeast with the highest numbers recorded in Borno, Yobe and Adamawa states (International Organization for Migration/National Emergency Management Agency {IOM/NEMA}, 2016). Despite the fact that some IDPs have started to return home, the situation on the ground remains dire and most of the affected populations have yet to receive humanitarian assistance (IOM, 2016).

People who live in or outside camps receive some assistance, but often not enough to meet their food and other basic needs. They also tend to live in cramped and unhygienic conditions. The most vulnerable IDPs – the young, women, older people and those with disabilities are most at risk. There is a lack of strategy guiding humanitarian assistance and only limited discussion of durable solutions at both the national and local level (IDMC, 2015). Displacement and humanitarian needs are mounting, but assistance is not, leaving both IDPs and their host communities without access to the basic necessities of life (IDMC, 2014). The poor living conditions in IDPs' camps has become of great concern. Report from both domestic and international agencies have shown that IDPs' camps since 2009 have lacked adequate facilities in addition to their poor sanitation and increase in the rise of diseases such as malaria, acute watery diarrhea, measles and pregnancy related issues (International Regional Information Networks, 2013).

Most studies on IDPs in Nigeria so far have focused on specific issues related to IDPs. Durosaro and Ajiboye (2011) studied problems and coping strategies of internally displaced adolescents in Jos Metropolis, Nigeria. The study revealed that educational and emotional problems are most prominent among internally displaced adolescents; with the emotional problems being characterized by memory of fearful events and nightmare. The major coping strategy employed by respondents is repression because they often avoid thinking about their present condition. Joshua et al (2016) investigated the social characteristics and risk factors for diseases among IDPs in Stefano's foundation camp in Jos, Nigeria. Results showed that there were several morbidities from malaria, diarrhea, and cholera due to inadequate water supply, poor refuse and fecal disposal, and the presence of disease vectors in the camp. Also, majority of the IDPs obtained medical treatment at the ill-equipped camp clinic. Kabir (2016) studied the living conditions of IDPs in Abuja and found that displaced persons are living in dire conditions such as overcrowding, poor hygiene and sanitation, health problems and psychological trauma. Thus, IDPs have employed negative mechanisms to cope with some of these situations.

Despite the increasing numbers of IDPs in Northeastern Nigeria and the burden of poor living conditions in these populations, these prior studies have, however, not really provided a complete picture of the living conditions of IDPs in Adamawa state. This information is essential for the proper planning and management of IDPs' camps.This present study therefore considered it pertinent to investigatethe living conditions of IDPs in Yola of Adamawa State, Nigeria.

1.1 The Study Area

Geographically, Yola is located between Latitudes 9°5′29″-9°26′42″North of the Equator and Longitudes 12°5′2″-12°36′33″East of the Greenwich Meridian. Yola town consists of two Local Government Areas (L.G.As), which are Yola North and Yola South.Yola shares borders with Demsa L.G.A to the west, Fufore L.G.A to the east and south and Girei L.G.A to the north. It occupies a land area of about 7,604 square km. Yola is the capital city and administrative centre of Adamawa state.

It is Yola's commercial, educational, recreational, and industrial functions that attract people from various parts of the country in search of greener pasture. The 2006 National Population and Housing Census gave a total population of 395, 871 in Yola (NPC, 2010). The 2016 projected population of Yola is 644, 639 people. The Fulbe (Fulani) make up an estimated 60% of Adamawa's population. The Muslim Fulbe form the major ethnic group, though Bororo, Tikar, Gbaya, Bitare, Dii, Mambila and other peoples are present in lesser numbers. Christians are in a distinct minority, many of the tribes in Adamawa State retain animist or pagan beliefs, particularly in the mountains near the Nigerian border (Wikipedia.org, 2016). Agriculture is by far the most important activity of the working population in Yola. Rain fed agriculture is the activity that takes place in the rainy season on upland fields supporting crops such as millet, maize, groundnut, guinea corn and many more. Irrigation activities take place on the low lands which support labor-intensive higher value crops per hectare such as sugarcane, onion, tomato, pepper, spinach, and other garden vegetables (Adebayo and Tukur, 1999).

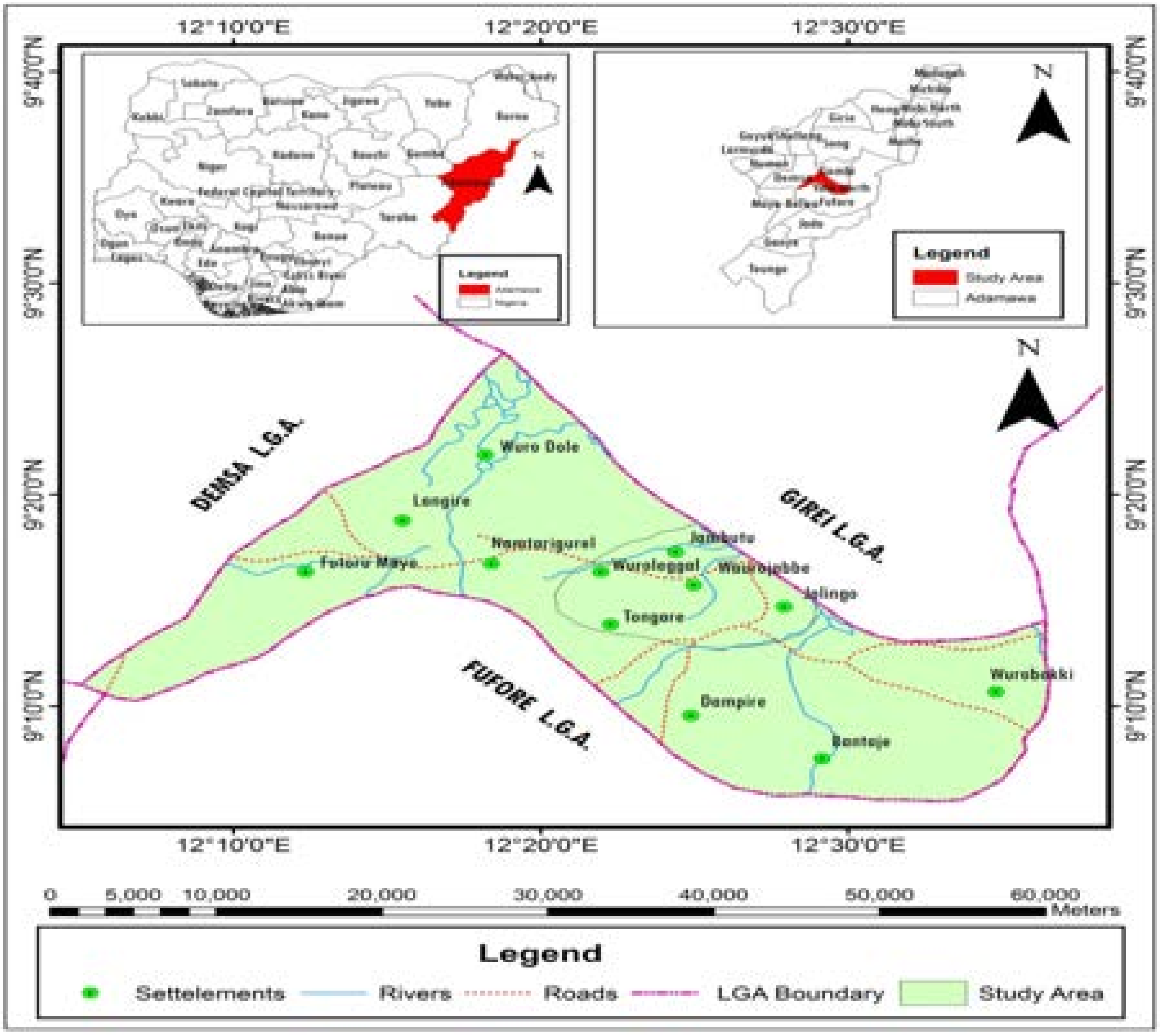


Figure 3.1: Adamawa State showing the Study Area
Source: Adapted from the administrative map of Adamawa State (2016)

2. MATERIALS AND METHODS

Following the closure of 6 out of the 10 IDPs' camps in Adamawa State by NEMA in April 2016, only four remained namely: Fufore, Malkohi, National Youth Service Corps (NYSC) and St. Theresa Cathedral camps. These camps had a total of 6, 937 IDPs (NEMA, 2016). The total number of IDPs in Malkohi and St. Theresa Cathedral camps was 2,698, with the former having 465 IDPs and the latter 2,233 IDPs (IOM/NEMA, 2016). Using Kredcie and Morgan (1970) table of determining sample size for finite population, the sample size for a population of 2,698 is 335. Thus, the total number of respondents for this study is 335.

The main instrument for sourcing data was through questionnaire administration which was complemented by 2 in-depth interviews (IDIs) with IDPs' leaders. Of the 335 copies of questionnaire administered, 200 were found valid for analysis, indicating a success rate of 60%.The study adopted the multistage sampling method. St. Theresa Cathedral and Malkohi camps were purposively selected for the study because they are the only two formal camps located in the study area. The 335 copies of questionnaire were administered based on the total number of IDPs in each of the camps. Respondents were selected from the two camps using purposive sampling. The study population comprised IDPs including males and females of 12 years and above who have found themselves in these formal IDPs' camps in Yola. The researchers only considered IDPs from 12 years and above because they are the most appropriate to provide the required information on this study. Descriptive statistics was used to analyse data obtained. In-depth Interviews were tape recorded, after seeking consent from the participants and were transcribed and translated into Fulfulde (the major language spoken by IDPs) and thereafter back translated into English

.

3. RESULTS AND DISCUSSIONS

3.1 Socio-demographic and Economic Characteristics of Respondents

This section presents the bio-data of respondents. Table 1 reveals the characteristics of respondents. Findings revealed that females with 66% constitute the majority of the respondentsin Malkohi and St Theresa cathedral camps; and males (34%). This is similar to the results of Joshua et al. (2016) in Stefano's Foundation camp at Jos, Plateau State where there were more females (60.9%) than males (39.1%). A possible explanation why men are fewer than the female folks can be that most of the displaced men stayed back to guard their properties at home, lost their lives while fleeing or are out there trying to fend for their families.

Results showed that 50% of the respondents are between 30-35 years, followed by children who are between 12-17 years with 19% as shown in Table 1. It can be deduced that children make up a great proportion of IDPs in the study area, hence greater dependency ratio. It was also found that 46% of the respondents are widowed which is not surprising because most of the IDPs have lost their spouses to insurgent attacks as indicated in Table 1. However, this does not concur with the results of Imaseun (2015) in IDPs' camps of Northeastern Nigeria where 51.3% and 29.5% of the respondents are married and widowed respectively. The result was also reaffirmed by an IDI camp leader who reported that:

> *"Most of the women have lost their spouses to insurgency or all hopes of finding their spouses have been shattered since they cannot confirm whether they are alive or dead because contacts have been lost for long" (female camp leader, Malkohi camp).*

Table 1 also indicates that 50% of the respondents have only Secondary education followed by 29% who have Primary education. This does not concur with the findings of Kabir (2016) in IDPs' camps of Abuja which revealed that most of the respondents (30%) had no formal education.The implication of this is that high level of illiteracy or lack of knowledge could greatly influence hygiene and sanitation in camps, which can ultimately increase the risk of infection as well as its spread. Findings also revealed that 39% of the respondents are farmers by profession. This is followed by trading or business with 30%, however, 25% of the IDPs are unemployed as shown in Table 1. This is similar to the results of Imaseun (2015) where 58.3% and 28.3% are farmers and traders respectively. The implication of this is that the lack of land to cultivate while in the camp may likely add to the worries of IDPs if they do not have alternative means of livelihood. It can also create discord between IDPs and community members who are struggling to obtain employment in a new settlement.

Table 1:Socio-demographic Characteristics of the IDPs in the Study Area

Sex	Frequency	Percentage
Male	68	34.0
Female	132	66.0
Total	**200**	**100.0**
Age (years)		
12-17	38	19.0
18-23	14	7.0
24-29	36	18.0
30-35	100	50.0
36 and above	12	6.0
Total	**200**	**100.0**
Religion		
Islam	136	68.0
Christianity	64	32.0
Total	**200**	**100.0**
Marital Status		
Single	42	21.0
Married	64	32.0
Widowed	92	46.0
Divorced/Separated	2	1.0
Total	**200**	**100.0**
Highest educational attainment		
No formal education	28	14.0
Primary	58	29.0
Secondary	100	50.0
Tertiary	14	7.0
Total	**200**	**100.0**
Occupation		
Farming	78	39.0
Trading/business	60	30.0
Civil servant	12	6.0
Unemployed	50	25.0
Total	**200**	**100.0**

Table 2 shows that all respondents (100%) in both camps were displaced by insurgency. This corroborates the results of Kabir (2016) where 98% of the respondents attested to being displaced by insurgent attacks in Northeastern Nigeria. Findings revealed that respondents from Adamawa State constitute the highest proportion with 85.5%, followed by those from Borno State (6%) as indicated in Table 2.

This is likewise similar to the results of Imaseun (2015) where 50.3% and 35% of the respondents were displaced from Borno and Adamawa states respectively. The fact that all of the respondents in this study are displaced within Northeastern Nigeria is a testimony of the severity of the humanitarian crisis in this region. It was also found that 54% of the respondents were displaced in 2014 as shown in Table 1. This agrees with the results of Joshua et al. (2016) where 96.1% of the respondents have been in the camp since 2014. The implication here is that most IDPs camps are planned on short term basis and this exerts enormous pressure on existing facilities often yielding tension among IDPs.

Table 2: Displacement Characteristics of the IDPs

Reasons for Displacement	Frequency	Percentage
Insurgency	200	100.0
Total	**200**	**100.0**
State of Residence		
Adamawa	171	85.5
Bauchi	6	3.0
Borno	12	6.0
Taraba	4	2.0
Yobe	7	3.5
Total	**200**	**100.0**
Years of Residence (years)		
Before 2014	6	3.0
2014	108	54.0
2015	66	33.0
2016	20	10.0
Total	**200**	**100.0**

3.2 Living Conditions of the IDPs

Table 3 reveals the sources of food for the IDPs. It was found that 50%of the respondents in both camps got their food supply from non-governmental organizations (NGOs) and individuals, and 34% from government agencies such as NEMA and Adamawa State Emergency Management Agency (ADSEMA). Although the IDPs receive 'food supplement' rations for extended periods of time, supplies can be sporadic and often insufficient for the changing location patterns of displaced population groups (United Nations High Commissioner for Refugees (1999) in Hines and Balletto (2002). Furthermore, results showed that 86% of the respondents reported food inadequacy in the camps. This concurs with the results of Singh et al. (2016) in Kenya where three quarters of displaced persons' households assessed had severe food insecurity and 23.9% of the respondents were underweight. The health implication of this situation is that it can lead to hunger and starvation as well as different forms of malnutrition especially among children, pregnant women and the aged.

It was found that 49% of the IDPs is sheltered in well ventilated government buildings with large halls. However, 33.5% of the respondents live in tents due to inadequate shelter especially in St Theresa Cathedral camp where the rooms and halls could not accommodate all the IDPs as shown in Table 3. As observed by the researchers, even the tents are insufficient and temporary tents of poor quality materials (such as sacks, corrugated zinc and polythene) were erected. This has made IDPs vulnerable to the prevailing weather conditions especially during the rains where blown-off roofs leak water.This can lead to high risk of infection from cold and pneumonia. Table 3 also shows that 37% of the respondents have up to 19 or more occupants in a tent or room; indicating overcrowding which is a risk factor that easily facilitates the spread of infectious diseases in camps due to the proximity of infected persons to uninfected persons. This can likewise lead to disease outbreak.

The importance of potable water in any community cannot be overemphasized. It was found that 92.5% of the respondents obtain water mainly from boreholes within the camps and 7.5% from wells as shown in Table 3. Government-run IDPs' camps have higher numbers and better functioning taps and boreholes with accompanying water points than informal settlements and host communities (IRC, 2016). Results revealed that burning is the main method of disposing waste for 60% of the respondents and 40% dump garbage in the open field as indicated in Table 3. This could serve as a source of fire outbreak or lead to environmental pollution which is detrimental to the health of IDPs since these are risk factors for the transmission of diseases such as malaria, diarrhea, cholera and so on. This was emphasized by an IDP male camp leader who reported that:

> *"Some of the IDPs here dispose waste indiscriminately sometimes very close to their shelters or cooking space which causes foul smell and serve as breeding ground for flies, mosquitoes, rodents and other harmful disease vectors. The sight is detestable and discomforting" (male IDPs camp leader).*

Findings also revealed that all (100%) of the respondents reported having pit latrines with slabs as shown in Table 3. Although both camps had separate toilets for males and females, there was evidence of open defecation as most of the latrines were not functioning or appeared very unhygienic and untidy for use. Results showed that 87% of the respondents reported having a bathroom, nevertheless, 13% do not have as indicated in Table 3. This is because the numbers of bathrooms are not sufficient for the large population of IDPs living on both camps. The health implication of poor hygiene and sanitation is that communicable diseases could spread quickly in the camps due to exposure to these identified risk factors.

Table 3: Living Conditions of IDPs

Source of Food	**Frequency**	**Percentages**
Government	68	34.0
NGOs and individuals	100	50.0
Personal	32	16.0
Total	**200**	**100.0**
Food adequacy		
Yes	28	14.0
No	172	86.0
Total	**200**	**100.0**
Type of Shelter		
Tents	67	33.5
Makeshift huts	35	17.5
Government Building	98	49.0
Total	**200**	**100.0**
Occupants per room/tent		
4-8	58	29.0
9-13	58	29.0
14-18	10	5.0
19 and above	74	37.0
Total	**200**	**100.0**
Source of Water		
Borehole	185	92.5
Well	15	7.5
Total	**200**	**100.0**
Waste Disposal Method		
Burn	120	60.0
Dump in Field	80	40.0
Total	**200**	**100.0**
Toilet facility		
Latrine with cement slab	200	100.0
Total	**200**	**100.0**
Bathroom facility		
Yes	174	87.0
No	26	13.0
Total	**200**	**100.0**

Table 4 shows that all the respondents (100%) reported having health facilities within the camps which include government-run clinics managed by NEMA and mobile clinics run by humanitarian organizations such as United Nations Children's Fund (UNICEF). However, 44% of the respondents reported unavailability of some drugs in the clinics and 10% reported inability of the health facilities to handle emergency cases as indicated in Table 4. The implication of this is that serious health damage may occur or lives of IDPs could be lost. It was also found that all respondents (100%) have experienced some sort of psychological trauma. This corroborates the results of Kim, Torbay and Lawry (2007) in Sudan which revealed a high prevalence of depression (31%) among Sudanese IDPs in South Darfur.This is very common because conflict-induced displacements are associated with painful ordeals that live 'indelible marks' in the hearts of displaced persons. Findings also revealed that 89% of the IDPs have observed psychosocial problems since arriving in the camps. Of the problems, the most common was isolation (30.3%), followed by nightmares and sleeplessness (26%), sadness (21.3%). These results concur with that of Roberts et al. (2008) where 54% of the respondents had symptoms of post-traumatic stress disorders and 67% had symptoms of depression. The psychological distress occurring in post-conflict environment contributes to harmful health behaviours such as hazardous drinking and increased smoking. Such behaviours are linked to an increased burdenof non-communicable diseases such as hypertension, chronic obstructive pulmonary disease and cancers (Robert, Patel and McKee, 2012).

Table 4: Health and Psychosocial Problems of IDPs	**Frequency**	**Percentage**
Presence of clinic	**200**	**100.0**
Total	**200**	**100.0**
Healthcare problems		
Emergency cases	20	10.0
Non availability of drugs	88	44.0
No problem	92	46.0
Experienced psychological distress	**200**	**100.0**
Total	**200**	**100.0**
Psychosocial problems on camps		
Yes	178	89.0
No	14	7.0
No response	8	4.0
Total	**200**	**100.0**
Type of problem		
Nightmares/sleeplessness	46	26.0
Children's refusal to attend school	16	9.0
Isolation	54	30.3
Sadness	38	21.3
Disrespectful behaviour	6	3.3
Excessive playing	16	9.0
Substance abuse	2	1.1
Total	**178***	**100.0**

*Total number with psychosocial problems

3.3 Coping Strategies of the IDPs

Table 4 reveals the coping strategies IDPs employ to adapt to the situation they have found themselves in. It was found that 49% of the respondents cope with food insecurity by relying solely on food gifts from government or NGOs. To cope with water scarcity, results showed that 42% of the respondents prioritize water usage by forfeiting other domestic needs for water such as frequent washing of clothes, bathing once or more daily, and other sanitation needs. To keep the camps clean, all the respondents (100%) reported organizing environmental sanitation occasionally. Whereas, 73% of the respondents manage the available latrines in the camps, the remaining 27% answer the call of nature in the surrounding bush as shown in Table 4. The effect of such negative coping strategies is that epidemics of infectious diseases can be quite common in the IDPs' camp settings due to inadequate water and sanitation facilities. Findings revealed that 63% of the respondents engage in recreational activities to cope with psychosocial distress and 19% resort to reading their Holy Scriptures from which they derive hope, strength and encouragement to move on with life as shown in Table 4.Table 4 also shows that 70.4% of the respondents go out of the camps to access drugs and medical services in cases of emergencies or unavailability of drugs or medical equipment. Displaced persons may likely face hardships due to the in-efficiency of camp medical facilities especially for the fact that most of them lack fund for treatment outside the camps.

Table 4: Coping Strategies of the IDPs

Food Insecurity	**Frequency**	**Percentages**
Reliance on government/NGOs/individuals	98	49.0
Borrow food from/rely on friends and relatives	42	21.0
Reduce quantity /skipping of meals	36	18.0
Regulate food consumption by adults	24	12.0
Total	**200**	**100.0**
Water Scarcity		
Move out of the camp in search for water	74	37.0
Wait until it arrives	42	21.0
Prioritize water use	84	42.0
Total	**200**	**100.0**
Sanitation		
Organize environmental sanitation	200	100.0
Total	**200**	**100.0**
Hygiene		
Manage the available toilets	146	73.0
Go to the bush	54	27.0
Psychosocial distress		
Engage in recreational activities	126	63.0
Reading Holy Scriptures	38	19.0
Avoid thinking	26	13.0
Substance abuse	10	5.0
Total	**200**	**100.0**
Health problems		
Access drugs/medical services outside	76	70.4
Herbal remedy	25	23.1
Spiritual remedy	7	6.5
Total	***108**	**100.0**

***Total number of IDPs facing health problems**

4. CONCLUSION

Consequent upon the findings of this study, it could be concluded that IDPs are living in very difficult conditions. The major cause of displacement is insurgency. As a result of the displacement, a large number of people face various problems of livelihood, such as unemployment, food insufficiency, health and sanitation problems. There is difficulty in the camp essentially due to the lack of basic facilities such as adequate potable water, good shelter; sanitary methods of sewage and refuse disposal, equipped medical facility and treatment among others. Displaced persons mainly rely on assistance from NGOs, individuals and government. In order to survive, some of the IDPs have resorted to negative coping strategies which can worsen the already deteriorated living conditions.

4.1 Recommendations

i. Government at all levels and humanitarian agencies must improve on the provision of basic necessities for survival such as food, water, healthcare and shelter.
ii. ADSEMA and other stakeholders should make appropriate plans to provide suitable accommodation to meet the physiological and psychosocial needs of the IDPs fleeing to camps due to the humanitarian crisis in northeastern Nigeria.
iii. NEMA and ADSEMA must ensure the provision of efficient medical facilities in camps to meet the health needs of IDPs; specialized mental health services, counselling and support services should also be provided to deal with the psychological distress of IDPs.
iv. Health personnel from the relevant stake ministries should offer health education to IDPs on hygiene, environmental sanitation, proper disposal of refuse and sewage, avoiding indiscriminate burning of refuse among others.
v. All government agencies should provide livelihood assistance through psychosocial programmes which will serve as a form of community support to promote positive coping strategies and reduce psychosocial problems among displaced persons.

REFERENCES

Adebayo, A.A and Tukur, A.L. (1999). *Adamawa State in Maps*. Yola, Nigeria: Paraclete Publishers.

Durosaro, I.A. and Ajiboye, S.K. (2011). Problems and Coping Strategies of Internally Displaced Adolescents in Jos Metropolis, Nigeria. *International Journal of Humanities and Social Science,* 1(20): 256-262, Retrieved on 12/7/2015.

Hines, D. and Balletto, R. (2002).*Assessment of Needs of Internally Displaced Persons in Colombia. Working Paper 189.* London, United Kingdom: Overseas Development Institute.

Imaseun, E. (2015). Insurgency and Humanitarian Crises in Northern Nigeria: The case of Boko Haram. *African Journal of Political Science and International Relations*, 9(7): 284-296.http://www.academicjournals.org/AJPSIR,Retrieved on /5/2016.

Internal Displacement Monitoring Centre {IDMC} (2014). *Nigeria: Multiple Displacement Crises Overshadowedby Boko Haram.*Geneva, Switzerland: Norwegian Refugee Council. www.internal-displacement.org, Retrieved on 27/05/2015.

IDMC (2015*). The Global Overview 2014: People Internally Displaced by Conflict and Violence.* Geneva, Switzerland: Norwegian Refugee Council. www.internal-displacement.org. Retrieved on 21/05/2016.

IDMC (2016a*). Global Report on Internal Displacement: GRID 2016.* Geneva, Switzerland: Norwegian Refugee Council. www.internal-displacement.org. Retrieved on 21/01/2016.

IDMC (2016b). *Africa Report on Internal Displacement: New Displacements associated with Conflict and Disaster in 2015.* Geneva, Switzerland: Norwegian Refugee Council. www.internal-displacement.org. Retrieved on 21/01/2016.

International Organization for Migration {IOM}(2016). *Nigeria Emergency Operations: Situation Report-April 2016.*http://www.nigeria.iom.int/, Retrieved on 25/05/2016.

IOM/NEMA (2016). *Displacement Tracking Matrix (DTM) Round IX Report - April, 2016.* http://www.nigeria.iom.int/ Retrieved on 3/6/2016.

International Rescue Committee (2016, April). *Borno and Adamawa State. Nigeria Multi-sectoral Rapid Assessment Report XIII.*http://www.humanitarianresponse.info/nigeria-multi-sectoralrapid-assessment-report-adamawa-and-borno. Retrieved on 27/02/2016.

Integrated Regional Information Networks (IRIN), 2013. *Boko Haram Crises Throw Internally Displaced Persons in North East Nigeria.*http://allafrica.com/stories/200806260489.html, Retrieved on 20/01/ 2015.

Joshua, I.A., Biji B.D., Gobir A.A., Aliyu A.A., Onyemocho A., Nmadu A.G., Makama J.G., Bobai M., Olayemi A.G., and Andrew K. (2016). *Social Characteristics and Risk Factors for Diseases among Internally Displaced Persons: A study of Stefano's Foundation camp in Jos, Nigeria.Arch Med Surg* 1(2):42-49. http://www.archms.org/text.asp?2016/1/2/42/204798, Retrieved on 23/06/2017.

Kabir (2016). *Living Conditions of Internally Displaced Persons in Abuja*. An Unpublished B.Sc. Project, Department of Geography, Faculty of Science, Ahmadu Bello University, Zaria.

Kim, G., Torbay R., and Lawry L. (2007). Basic Health, Women's Health, and Mental Health among Internally Displaced Persons in Nyala Province, South Darfur, Sudan. *Am J PublicHealth*, 97(2):353-361.*https://www.ncbi.nlm.nih.gov/pubmed/17138925,* Retrieved on 11/07/2017.

Krejcie, R.V and Morgan, D.W., (1970). Table for Determining Sample Size for Research Activities. *Educational and Psychological Measurement,* 30(3): 607-610 https://home.kku.ac.th/sompong/guest_speaker/KrejcieandMorgan_article.pdf Retrieved on 11/07/2016.

Ladan, M.T. (2001). *Introduction to International Human Rights and Humanitarian Laws*. Ahmadu Bello University Press, Zaria.

National Emergency Management Agency {NEMA} (2016). *1,934, 765 IDPS Live in Formal Camps, Host Communities and Satellite Camps.*http://nema.gov.ng/1934-765-idps-live-in-formal-camps-host-communities-and-satellite-camps/, Retrievedon June 15, 2016.

National Population Commission (2010). *2006 Population and Housing Census: Priority Table Volume IV.* Abuja: National Population Commission.

Niroula, S. M. (2008). *Voiceless Citizens: A case study ofInternally Displaced Persons in Nepal.*http://www.un.org.np/pdf/interimconstitution/170106_InterimConstitution_Eng_Nep_ Merged.pdf, Retrievedon June 5, 2016.

Norwegian Refugee Council (2009). *Nigeria: No end to Internal Displacement.* Geneva: IDMC Global Project. www.internal-displacement.org, Retrieved on 21/01/2015.

Olukolajo, Ajayi and Ogungbenro (2014).Crisis Induced Internal Displacement: the Implication on Real Estate Investment in Nigeria.*Journal of Economics and Sustainable Development.* 5(4): 39-48. www.iiste.org Retrieved on 12/7/2015.

Roberts, B., Ocaka K.F., Browne J., Oyok T., Sondorp, E. (2008). Factors Associated with

Post-traumatic Stress Disorder and Depression amongst Internally Displaced Persons in Northern Uganda. *BM Psychiatry*, 8:38. *https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2397420/* DOI:10.1186/1471-244X-8-38, Retrieved on 11/07/2017.

Roberts, B., Patel, P., McKee, M. (2012) Non-communicable Diseases and Post-conflict

Countries. *Bulletin of the World Health Organization*, 90(1):2-2A. *https://researchonline.lshtm.ac.uk/24612/1/BLT.11.098863.pdf.* DOI:10.2471/BLT.11.098863. Retrieved on 11/07/2017.

Singh, K.P., Bhoopathy, S.V., Worth, H., Seale, H. and Richmond, R.L. (2016). Nutrition among Menand Household Food Security in an Internally Displaced Persons' Camp in Kenya. *Public Health Nutr,* 19:723-31. *https://www.ncbi.nlm.nih.gov/pubmed/17138925* Retrieved on 11/07/2017.

United Nations Office for the Coordination of Humanitarian Affairs (1999).*Guiding Principles on Internal Displacement.* New York: Office for the Coordination of Humanitarian Affairs.

Wikipedia.org (2016). *Free Encyclopedia: Adamawa Region*

https://en.wikipedia.org/wiki/Adamawa_Region. Retrieved on 10/07/2016.

Savanna volume 23, Number 1, June, 2016

An Analysis of Catastrophic Health Expenditure on Non-Communicable Diseases by Households in Kaduna State, Nigeria

Yetunde, A. Arigbede
Department of Geography & Environmental Management,
Ahmadu Bello University, Zaria
ytarigbede@gmail.com

ABSTRACT

Non-communicable diseases (NCDs) are fast becoming major causes of morbidity and mortality around the world, affecting the well-being of numerous individuals at an alarming rate. The NCDs examined in this research were Cancer, Diabetes and Cardiovascular disease (Hypertension) which were selected purposively because they are among the most common NCDs in the world.Some households face catastrophic health expenditure and impoverishment as a result of spending on medical bills of the NCD patient. Catastrophic spending is the situation whereby healthcare expenditure is greater than or equal to 40% of household income. Some 384 copies of questionnaire were systematically administered among patients or their caregivers in systematically selected hospitals in Kaduna State. Descriptive qualitative statistical techniques were used for analysis. ANOVA was used to test the statistical difference of catastrophic spending between households managing each of the NCDs. The results showed that households with Cancer patients have the highest percentage of involvement in catastrophic spending (40.6%), followed closely by households with hypertensive patients (37.5%), and lastly households with diabetic patients (11.7%). Also, the quantitative analysis showed a statistically significant difference (0.001) in catastrophic spending between the households managing NCDs. The economic effects of the NCDs have particularly pushed families into catastrophic spending, thus plunging them further into impoverishment and a vicious cycle of poverty and disease. In conclusion, there is a significant difference in the economic effect of NCDs on households in Kaduna State. The economic burden on households managing NCD patients can be alleviated by institutional interventions aimed at sharing the cost of treatment with the family. The insurance schemes should also be expanded to accommodate NCDs and non-government workers.

Keywords: Catastrophic spending; Non-Communicable Diseases; Households; Morbidity.

1. INTRODUCTION

Non-Communicable Diseases (NCDs) also referred to as degenerative or chronic diseases, are ailments that affect an individual for a long duration, and are usually slow in progression (World Health Organisation (WHO), 2015). They affect the structure, physiology and function of body tissues thus making the affected organs deteriorate with time (WHO, 2014a). Non-communicable diseases (NCDs) are fast becoming major causes of morbidity and mortality around the world, affecting the well-being of numerous individuals at an alarming rate. Presently, NCDs are the active triggers of human morbidity and disability globally and the trend is progressively on the increase (WHO, 2014b). The four most prominent forms of NCDs include cardiovascular disease (CVD), type 2 diabetes, Cancer and chronic obstructive pulmonary disease (WHO, 2015). It is projected that about 17 million people die untimely each year as a result of the worldwide epidemic of chronic NCDs (WHO, 2005; WHO 2014a).The NCDs examined in this research are Cancer, Diabetes and Cardiovascular disease (Hypertension) which are selected purposively because they are among the most common NCDs in the world.

Individuals that suffer from NCDs belong to households, which are invariably saddled with the responsibility of caregiving to the chronically ill persons. Managing chronic diseases within a household affects several aspects of the household. A household is a domestic unit consisting of the members of a family who live together along with non-relatives such as servants (American Heritage Dictionary, 2009). Laah (2003) defined household as a unit consisting of individuals who live together, share living quarters and their major meals. Individuals who cohabit as a household unit tend to be supportive of each other. With the natural organisational structure of a home, every individual has a role to play. Among the varied effects chronic diseases can have on households, economic consequences of managing a chronically ill family member can adversely affect the household expenditure. Ill-health can contribute to impoverishment, broadly defined as processes of household asset depletion and income loss that cause consumption levels to fall below minimum needs (Russel, 2004). Oerun (2008) stated that health problems, particularly those related to life-long or chronic diseases are becoming major issues for households. The tendency of a chronic disease to plunge a household into poverty was studied by Engelgau, Karan and Mahal (2012). They coined the term ‘catastrophic spending’ as the expenditure on non-communicable disease treatment that is 40% more than the ability to pay. This catastrophic spending is a situation that many households managing a chronically ill member may be challenged with, hence the poverty trap. Apart from economic consequences, chronic diseases in their varying forms can lead to death.

Although there appears to be a heavy representation of healthcare services in Kaduna State, the health indicators in the State are poor, and non-communicable diseases are becoming public health concerns (Kaduna State Ministry of Health (KSMoH), 2010). With the problem of NCDs becoming more obvious particularly in the study area, this research therefore focuses on Kaduna State of Nigeria, with a view to further investigating the possible etiology and prevalence of NCDs that seem to be on the increase in the State. Contrary to general perception that most cases of NCDs are found in the developed nations of the world, 80% of chronic disease deaths occur in low and middle income countries and these deaths occur in equal numbers among men and women (WHO, 2005).

NCDs, which have been referred to as the ‘silent killer’ in Nigeria have been a major cause of sudden death among the able bodied in the population. Kaduna State has been labelled to have an unacceptably high mortality rate and burden of disease profile (PATHS, 2008). Unfortunately, Kaduna State has a poor record keeping practice; hence State specific data on morbidity and mortality are lacking (KSMoH, 2010). Inferring from studies such as Onyemelukwe (2004), the mortality rate due to NCDs in Kaduna State is 44%. The aim of this research is to analyse the economic effects of NCDs on households in Kaduna State. This will be actualized by the following objectives:

i to examine catastrophic spending among the households with Cancer patients in Kaduna State;

ii to examine catastrophic spending among the households with Hypertensive patients in the State

iii to examine catastrophic spending among the households with Diabetes patients in the State.

HypothesisH_0 – there is no significant difference in catastrophic spending among households managing each NCD in Kaduna State.

1.1 Study Area

Kaduna State is located in Northern Nigeria and lies between Latitudes 9°01′ to 11°34′ North of the Equator and Longitudes 6°11′ and 8°49′ East of the Greenwich Meridian as shown in Figure 1. The State comprises of 23 Local Government Areas (LGAs) with 255 political wards (NPC, 2009). Kaduna State shares its boundary with Katsina State to the north, Niger State and Abuja to the west, Plateau State to the south and Kano State to the east.

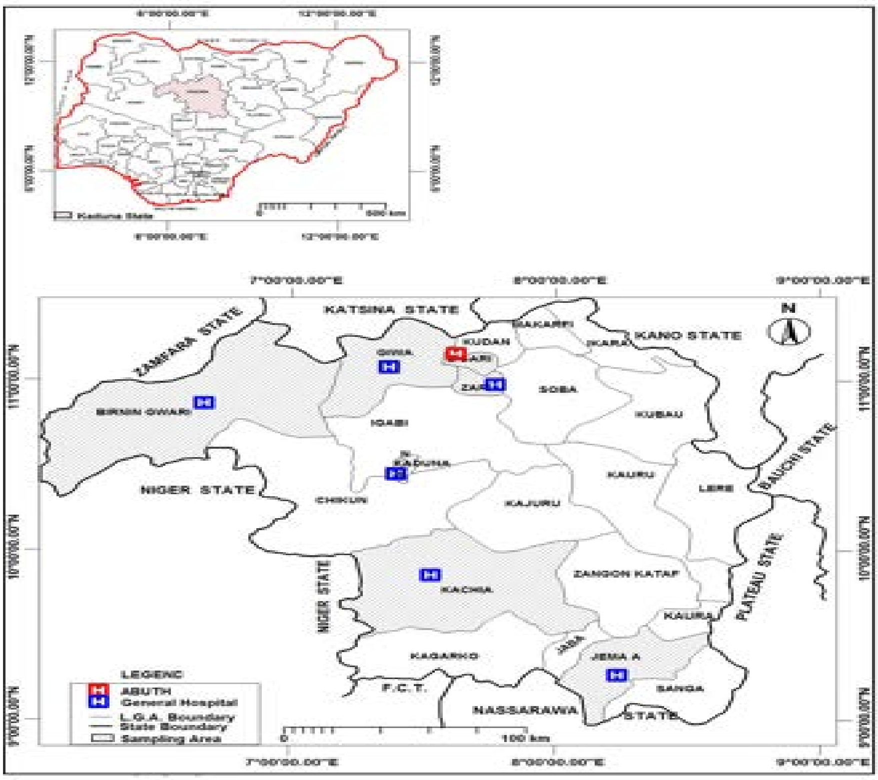


Figure 1: Kaduna State showing the Study Area Source: Adapted from Administrative Map of Kaduna State, 2016

2. MATERIALS AND METHODS

2.1 Types and Sources of Data

The study used both primary and secondary data. The primary data utilised was obtained from a semi structured questionnaire administered to the chronically ill or their caregivers who are members of the same household. These were administered in hospitals where the sick were being cared for. In-depth interviews (IDIs) involved interviewing experts (Doctors and Nurses) on the peculiarities of some cases of NCDs to enrich the research, were done. Focus Group Discussions (FGDs) were conducted, to obtain attitudinal data and information on culture, myths and other sensitive issues relevant to the research, which the questionnaire may not capture. Secondary data was systematically obtained from medical records in secondary and tertiary healthcare centres and the Ministry of Health. Population figures from the National Population Commission (NPC), hospital records from the Ministries of Health (Federal and State), world morbidity and mortality figures from World Health Organisation (WHO), and other significant data from agencies and institutions were used for this study.

2.2 Sample Size and Sampling Technique

Kaduna State has a population of 6.1 million (NPC, 2009), and projected to 7.3 million in 2017. It comprises of twenty three LGAs grouped into three senatorial districts. Six Local Government Areas were selected for the study as shown in Table 1. The selection of these LGAs was based on the following criteria:

i. Their location in each of the senatorial districts. Two LGAs were chosen from each of the three senatorial districts, to ensure adequate spatial spread.
ii. The LGAs with the two biggest general hospital or tertiary health institution and/ or with the highest patronage was chosen in each of the senatorial districts. These hospitals were selected for the purpose of obtaining richer and more comprehensive data.

With reference to Table 1, based on the criteria stated above, the hospitals in the following Local Government Areas were selected for the study: Sabon Gari, Zaria, Giwa, Kaduna South, Jema'a and Kachia. A total of 384 copies of questionnaire were administered in the ward of sick patients who were on admission, and also during clinic days for outpatients who came for treatment. This number of questionnaire is justified using the Krejcie and Morgan method (1970), which states that a sample size of 384 is adequately representative of a population of 1,000,000 and above. Kaduna State has an approximate population of 7.3million people (projected), so this sampling method fits adequately. Equal copies of questionnaire were administered in the selected hospitals, except in cases where there were no cancer cases, because not all the hospitals handle cancer cases (mostly general hospitals). In such a situation, the proportion of questionnaire meant for cancer patients in a hospital they are not present, were redistributed among the other selected hospitals that had cancer patients.

2.2 Data Analysis

Descriptive statistics was used to examine catastrophic spending in households with NCD patients. ANOVA was used to test the difference among the catastrophic effect of NCDs on households in Kaduna State.

Table 1: Location and selected Tertiary and General Hospitals in the Local Government Areas of Kaduna State

Senatorial zone	LGA	The Hospital(s) location	No of Hospitals
North	Ikara	General hospital Ikara	1
	Kubau	General hospital, Pambegua	1
	Kudan	General hospital, Hunkuyi	1
	Lere	General hospital, Saminaka	1
	Makarfi	General hospital, Makarfi	1
	Sabon gari	ABUTH*	1
	Soba	General hospital,Maigana	1
	Zaria	Gambo Sawaba General hospital, Zaria*	1
Central	Birnin Gwari	General hospital, Birnin Gwari	1
	Chikun	General hospital, Kujama	1
	Giwa	General hospital, Giwa*	1
	Igabi	General hospital, Turunku	1
	Kaduna North	Dantsoho Tudun Wada and Nursing hospitals	2
	Kaduna South	Gwamna Awon General hospital Makera*	1
	Kajuru	General hospital, Kajuru	1
South	Jaba	General hospital, Kwoi	1
	Jemaa	General hospital, Kafanchan*	1
	Kachia	General hospital,Kachia*	1
	Kagarko	General hospital,Doka	1
	Kaura	General hospital,Manchock	1
	Kauru	General hospital,Kauru	1
	Sanga	General hospital,Gwantu	1
	Zangon Kataf	St Louis hospital, Zonkwa	1
	Total		**24**

Source: Reconnaissance Survey (2014) (*) = Selected hospital

3. RESULTS AND DISCUSSION

3.1 Catastrophic Spending on NCDs

Economic effects of NCDs on households are quite glaring and easily quantifiable. Some households face catastrophic health expenditure and impoverishment as a result of spending on medical bills of the NCD patient. In addition, some households' longer-term financial status is also adversely affected through the accumulation of debt and other risk mitigating strategies. The economic effect of interest is a concept called catastrophic spending, which is measured among households in the study area.

Catastrophic spending is the situation whereby healthcare expenditure is greater than or equal to 40% of household income (WHO, 2005). WHO (2005) refers to three factors that have to be present for catastrophic payments to arise: the availability of health services requiring out-of-pocket payments; low household capacity to pay; and lack of prepayment systems for risk pooling. Prepayment however, refers to the situation where funds for health are collected through taxes and/or insurance contributions. The subsequent Tables (2-4) describe the pattern of medical expenditure.

3.1.1 Percentage of Healthcare Expenditure on Diabetes

With reference to Table 2, out of the 128 diabetic respondents, 30.5% spent 10% of household income on managing the disease monthly. About 13.3% and 19.5% spend 11-20% and 21-30% on healthcare expenditure respectively, while 25% of the households with diabetes patients spent between 31-40% of household income on managing diabetes; which is on the verge of catastrophic spending.

Table 2: Household healthcare expenditure on diabetes

% of income on healthcare expenditure	Frequency	Percentage
10	39	30.5
11-20	17	13.3
21-30	25	19.5
31-40	32	25.0
>40	15	11.7
Total	**128**	**100**

A total of 11.7% of households with diabetic patients spent greater than 40% of their income on managing the disease monthly. This category of households spent catastrophically on healthcare services, ranging from consultations, to purchase of drugs, running of laboratory tests and following prescribed diets. These findings are similar to that of Chinenye et al. (2012), which concluded in their study that Diabetes constitutes a significant health and socioeconomic burden for patients, their families and the health care systems.

3.1.2 Household Healthcare Expenditure on Cancer

Table 3 shows the percentage of healthcare expenditure on cancer by households.

Table 3: Household healthcare expenditure on Cancer

% of income on healthcare expenditure	Frequency	Percentage
10	12	9.4
11-20	19	14.8
21-30	17	13.3
31-40	28	21.9
>40	52	40.6
Total	**128**	**100**

Cancer is medically recognised as a terminal illness and families managing the disease have had to grapple with the escalating costs of treatment. About 9.4% of the cancer respondents spent 10% of household income on healthcare; 14.8% and 13.3% of households spent 11-20% and 21-30% of income on healthcare services. A total of 21.9% of the respondents spent close to catastrophic expenditure, with a total of healthcare spending of 31-40%. Almost half of the respondents that were managing cancer spent catastrophically, with an expenditure of over 40% of household income. These findings are similar to studies by Delavari, Keshtkaran and Setoudehzadeh (2014) who inferred in their research that most families (67.9%) managing a household member with cancer, spend catastrophically due to the high cost of treatment. ACTION Study Group (2015) also got similar results from their study of cancer patients in Iran; it was revealed that as much as 48% of the households with cancer patients experienced financial catastrophe.

3.1.3 Household Healthcare Expenditure on Hypertension

Hypertension which is a cardiovascular disease, and is also a risk factor to heart disease is becoming a more common condition, not only among the elderly, but increasingly more among young adults. Table 4 shows the amount households managing their hypertensive members spend on healthcare services in the study area.

Table 4: Household healthcare expenditure on Hypertension

% of income on healthcare expenditure	Frequency	Percentage
10	21	16.4
11-20	13	10.2
21-30	11	8.6
31-40	35	27.3
>40	48	37.5
Total	**128**	**100**

About 16.6%, 10.2%, 8.6% and 27.3% spent 10%, 11-20%, 21-30% and 31-40% of their household income on healthcare respectively. About 37.5% incur catastrophic spending by making payments greater than 40% of household expenditure on hypertensive healthcare. Daniel et al. (2013) and Kankeu, Saksena, Xu, and Evans (2013) are among the scholars that have established catastrophic spending in relation to household expenditure in their research.

3.2 Catastrophic Spending of Households on NCDs in Kaduna State

Among all the households in the study area, the households of concern are those who spent greater than 40% of household expenditure on medical bills. Extracting this information from Tables 2, 3, 4 and Figure 2 reveals the comparison of catastrophic spending within the households with cancer, diabetes and hypertension patients.

With reference to Figure 2, 11.7% of households with diabetics were involved in catastrophic spending. Almost half of the households with cancer patients were involved in catastrophic spending, with as high as 40.6%. This may be attributable to the high costs of medical investigation, surgery and treatment cancer patients have to go through. Households with hypertensive patients also had a high percentage (37.5%) involved in catastrophic spending. Other studies on NCDs that have documented catastrophic spending within households include: Thakur et al. (2011), Van and Tran (2012), Mwai (2013), Alam and Mahal (2014a) and Mwai and Muriithi (2016). In summary, Figure 2 shows that households with cancer patients have the highest percentage of involvement in catastrophic spending, followed closely by households with hypertensive patients, and lastly households with diabetic patients.

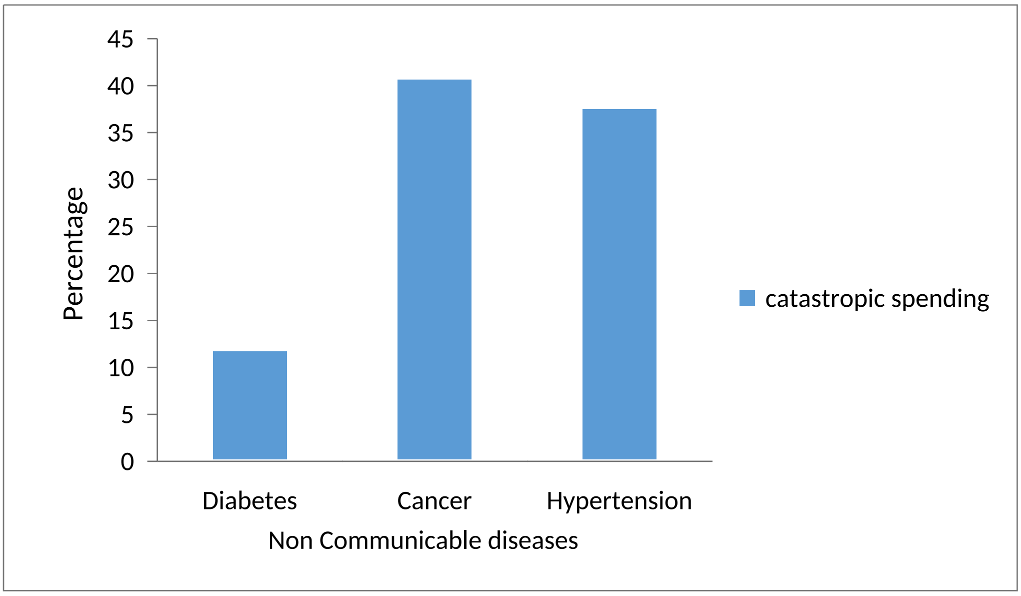


Figure 2: Catastrophic spending by households on NCDs

Table 5: Difference on catastrophic spending among households in Kaduna State

Catastrophic spending	NCD type	Numberof respondents	Mean	Significance
	Cancer	128	5	0.0001
	Diabetes	128	1	
	Hypertension	128	4	
	Total	384	3	

The percentage of income used for treatment shows how much of a financial burden the NCD is to the household. Table 5 shows that the mean value of cancer is 5, 1 for diabetes and 4 for hypertension. This result is closely linked to Figure 2, where households that spend 40% and above (catastrophic spending) in managing the NCD are analysed. The results showed that cancer households spend catastrophically the most, as represented by 40.6% of the respondents. Of all the analysis, a clear fact that keeps emerging is that cancer households experience the greatest economic impact of the NCDs. This may be explained by the enormous amount of money it takes to manage a cancer patient such as laboratory analysis, surgery, chemo/radiotherapy, cost of medication and hospitalisation and other miscellaneous expenses. All these and more, sum up to making cancer treatments very expensive, to the point of the households being plunged into catastrophic spending.

In testing the difference in percentage of income used for treatment by households, the ANOVA result shows that the difference in the percentage of income spent monthly on the NCDs by households is statistically significant, with a p-value of 0.0001, at 0.05 significance level, hence the rejection of the null hypothesis, which states that there is no significant difference in the effect of NCDs on households.

4. CONCLUSION

It can be deduced from this paper that Non-Communicable Diseases indeed have serious economic effects on households. The economic effects of the NCDs have particularly pushed families into catastrophic spending, thus plunging them further into impoverishment and a vicious cycle of poverty and disease.

Households with cancer patients are leading in catastrophic spending (40.6%), followed by households with hypertension (37.5%) and lastly households with diabetes patients (11.7%). There is a significant difference in catastrophic spending among households managing each NCD in the study area, hence a rejection of the null hypothesis.

4.1 Recommendations

The economic burden on households managing NCD patients can be alleviated by institutional interventions aimed at sharing the cost of treatment with the family. The insurance schemes should also be expanded to accommodate NCDs and non government workers. The cost of treatment and medication of especially cancer, may be shared by the government to ease the burden on affected households.

REFERENCES

ACTION Study Group. (2015). Catastrophic health expenditure and 12-month mortality associated with cancer in Southeast Asia: results from a longitudinal study in eight countries. *BMC medicine*, *13*(1), 190.

Alam and Mahal, (2014). Economic impacts of health shocks on households in low and middle income countries: a review of the literature. *Global Health*, 10, 21.

American Heritage Dictionary (2009). (Ed) USA: Houghton Mifflin Company

Chinenye, S., Uloko, A.E., Ogbera, A.O., Ofoegbu, E.N., Fasanmade, O.A., Fasanmade, A.A., Ogbu, O.O. (2012). Profile of Nigerians with diabetes mellitus –*Indian J Endocr Metab*16:558-64. Retrieved on 16-07-2014, fromhttp://www.ijem.in/text.asp?2012/16/4/558/98011

Daniel, O.J., Adejumo, O. A., Adejumo, E. N., Owolabi, R. S., & Braimoh, R. W. (2013). Prevalence of Hypertension among Urban slum dwellers in Lagos, Nigeria*Journal of Urban health, 90(6),* 1016-1025

Delavari, H., Keshtkaran, A., & Setoudehzadeh, F. (2014). Catastrophic health expenditures and coping strategies in households with cancer patients in Shiraz Namazi hospital. *Middle East Journal of Cancer*, 5(1), 13-22.

Engelgau, M.M., Karan, A., and Mahal, A. (2012). The Economic impact of Non- communicable Diseases on households in India. *Globalization and Health*, Retrieved on 06-11-2014 from http://www.globalizationandhealth.com/content/8/1/9.

Kankeu, H.T., Saksena, P., Xu, K., and Evans, D.B. (2013). The financial burden from non-communicable diseases in low- and middle-income countries: a literature review. *Health Res Policy Syst*, *11*, 31.

KSMoH (2010).Kaduna State Government strategic health development plan. Retrieved on 13-12-2014 from www.mamaye.org.

Krejcie, R.V. and Morgn, D.W. (1970.) Determining sample size for research Activities. *Educational and psychological measurement* 30, 607-610.

Laah, J.G. (2003). *The demographic and socioeconomic effect of HIV/AIDS in Kaduna State.* Unpublished Ph.D. Thesis, Ahmadu Bello University, Zaria.

MNCH2(Maternal, Newborn and Child health programme(2014). Retrieved on 14-07-2016 from http://www.mnch2.com/kaduna-state/

Mwai, D.N. (2013) *Non-communicablediseasesinKenya:economic effects andriskfactors*. An unpublished Ph.D dissertation, University of Nairobi, Kenya

Mwai, D.& Muriithi, M. (2016). Catastrophic Health Expenditure and Household Impoverishment: A Case of NCDs prevalence in Kenya. *Epidemiology, Biostatistics and Public Health*. 13(1).

National Population Commission (2009), Population and housing census of the Federal Republic of Nigeria. Kaduna State priority tables. Vol 1.

Oerun, K.S. (2008*). Impacts of chronic diseases on household's economic development in rural Cambodia: a comparative study on household suffering from HIV/AIDS and diabetes in Takeo province*. An Unpublished Dissertation submitted to the Royal University of Cambodia, Cambodia.

Onyemelukwe, C.G. (2004). *Role of Medical Women Association of Nigeria in non-communicable diseases*. Retrieved on 03-01-2015 from http://www.profgconyemelukwe.com/publications/national-reports.

PATHS, Partnership for Transforming Health Systems (2008). *Final programme report, supporting Kaduna's health reform agenda*. Kaduna.

Russel, S. (2004). The economic burden of illness for households in developing countries: a review of studies focusing on malaria, tuberculosis, and human immunodeficiency virus/acquired immunodeficiency syndrome. *American journal of tropical medicine.* 71 (2).147–155

Thakur, J., Prinja, S., Garg, C.,Mendis, S., and Menabde, N. (2011). Social and Economic Implications of Noncommunicable diseases in India. *Indian Journal of Community Medicine,* 36(Suppl 1): S13-22.

Van Minh, H., & Tran, B. X. (2012). Assessing the household financial burden associated with the chronic non-communicable diseases in a rural district of Vietnam. *Global health action*, *5*.

WHO (2005). *The impact of chronic disease in Africa*. Retrieved on 17-02-2014 from http://www.who.int/chp/chronic_disease_report/media/afro.pdf

WHO (2014a). C*hronic diseases*. Retrieved on12-02-2014 from http://www.who.int/topics/chronic_diseases/en/

WHO (2014b). *Chronic diseases and health promotion*. Retrieved on 12-02-2014 from http://www.who.int /chp/en/.

WHO (2015). *Non Communicable disease factsheet*. Retrieved on 12/01/2015 fromhttp://www.who.int/mediacentre/factsheets/fs355/en/

Savanna volume 23, Number 1, June, 2016

Spatio-Temporal Distribution of Polio Cases in Kaduna Central Senatorial Zone, Kaduna State, Nigeria

Giwa, S.M.[1]*, Abdullahi, H.S.[2], Ahmad, A.A.[2], Haliru, S.M.[3], Muhammed, A.Y.[3], Suleiman, U.B.[3] and Shehu, B.[4]

[1]Department of Geography & Environmental Management, Ahmadu Bello University, Zaria
[2]Department of Geomatics, Ahmadu Bello University Zaria, Nigeria
[3]Department of Geography, Federal College of Education Zaria
[4]Sardauna Memorial College, Kaduna
**shamdat123@gmail.com*

ABSTRACT

This study analysed the spatio-temporal distribution of polio cases in Kaduna Central Senatorial Zone, which comprises of BirninGwari, Chikun, Giwa, Igabi, Kaduna North, Kaduna South and Kajuru. Records of polio cases from the year 2006 to 2016 were collected from Primary Health Care Development Agency and State Ministry of Health. This includes addresses of the infected children and the healthcare centres visited by the infected children. Mobile topographer was used to take the home coordinates while ArcGIS 10.1 was used to analyse the data. The result of the analysis showed that significant numbers of polio cases were recorded in settlements along the major roads linking so many towns and villages most especially in Birnin Gwari Local Government Area. It was recommended that robust security patrol team should be deployed in these areas so as to tackle the security problems thereby making these areas accessible to health workers.

Keywords: *Poliomyelitis*; Mapping; Spatial distribution; Immunization.

1. INTRODUCTION

Health is one of the most fundamental pillars of human life. Health supports life and health is the state of being free from physical or psychological disease, illness or malfunction. Many diseases are more common to a specific age group of people, among which are poliomyelitis and measles among children. Poliomyelitis lead to irreversible paralysis and the best way to prevent children from it is through polio vaccine immunization (Atkinson et al., 2007). According to Free Medical Dictionary (2016), poliomyelitis is defined as an acute viral disease usually caused by a poliovirus and it could be developed into the minor illness or the major illness with a central nervous system involvement ranging from stiff neck, affecting spinal fluid, paralysis; to contraction in the muscle groups and permanent deformity.

Human is the only receptor of the polio virus. Virus dissemination is made by the fecal-oral and oral-oral routes. Faeces could contaminate the water, milk, or food with the virus and houseflies could also transfer the poliovirus. Poor sanitation could ease the virus dissemination (Polio 2014). The global polio eradication (GPEI) was launched in 1988 so much so that no any child suffers with paralytic polio. Thus the need to study polio distribution in the study area is very vital (GPEI 2013).The best way to prevent poliomyelitis is the immunization with the polio vaccine. Attitude of people and traditional beliefs are the most influential factors that determinethe success of innovation and adoption of programs like polio immunization. Survey in Zamfara state of Nigeria has shown that 55.3% of the respondents were found to have a positive attitude while 44.7% have negative attitude toward accepting polio immunization programs (Ogwumike et al., 2012).

Also, survey data from Enugu, southeast of Nigeria indicate that the majority of the respondents (80%) would not continue immunization if the child suffered adverse effects (Nnenna et al., 2013). Similarly, in another survey, it was found that 50% of the respondents from southwestern Nigeria believe not to immunize their children if the child was taking antibiotics (Ekure et al., 2013; Itimi et al., 2012). It was also reported that the meagre 17.23% of the respondents that received immunization in Bayelsa, south-southern Nigeria was due to rumours on adverse effects of the vaccine; and the 17.4% of the respondents covered in Enugu was due to the ill condition of their children during the vaccination (Tagbo et al., 2012). However, 37.2% of the respondents in a study in Lagos believed that long distance travelled for the vaccination is contributing factor to poor immunization turn over. Oyefara et al. (2014) reported that 60% of the respondents from polio endemic northern states; Katsina, Kano and Kaduna reject polio immunization programme due to religious and cultural ethics (Baba and Ayivor et al., 2012).

However, due to rapid population growth coupled with poor sanitation condition, the study area is associated with high disease profile. Under-five mortality rate was also high in some parts of the State. The main causes of infant and child deaths in some parts of the study area are pneumonia, diarrhoea and malaria compounded by under-nutrition and vaccine-preventable diseases (Kaduna Initiative, 2014). Oladipo and Ejembi (2013) pointed out that the socioeconomic status of the Hausa women, forming the larger population of women in Kaduna central Senatorial zone, is one of the contributing factor to continuing maternal mortality, and by extension, child diseases particularly poliomyelitis. However, Kaita (2003) believed and propagated that Muslims should doubt the sincerity of the Americans, World Health Organisation and Britain in view of forced conduct of immunization in Niger Republic which was unethical and illicit. Many other factors also help in explaining the level of immunization in Nigeria. While safety concerns and suspicion are central factors in immunization programme implementation, quite a number of factors unrelated to these may affect its rate of coverage (Mongono, 2013).

Many leading public health organizations have endorsed the use of Geographic Information System (GIS) in public health practice and research. The Centre for diseases control and prevention (CDC, 2009) revealed that GIS plays an important role in epidemiology; health promotion and protection. According to CDC (2011), the use of GIS in diseases control cannot be overemphasised, it is highly suitable for analysing epidemiological data, revealing trends and interrelationships that would be more difficult to discover in tabular format. It allows policy makers to easily visualise problems in relation to existing health and social services and the natural environment. Also, GIS provides an ideal platform for gathering of disease-specific information and their analyses in relation to population settlements, surrounding social and health services and the natural environment (WHO, 2014).

These give rise to so many epidemiological researches conducted using GIS. For example, Roul (2009) examined polio cases around River Congo using GIS; the researcher concluded that wild polio virus cases seemed to follow the course of the Congo River. Usman, Sajid and Muhammad (2015) studied polio disease in Pakistan using GIS approach to examine the spatiotemporal patterns and areas of hotspot from 2011 to 2014, the results depicted spatially clustered pattern of polio disease in the study area. Sakiru and Ayoola (2013) used GIS to model the spread of Tuberculosis in Ibadan; his findings revealed that the pattern of Tuberculosis in the study area was significantly clustered. Felix and Animam (2013) used GIS-based approach to model Cholera occurrence in Nigeria; this was achieved using Geographically Weighted Regression, and the study revealed that the pattern of cholera spread over time is non-clustered not random.

Kaduna Central Senatorial zone is the most populous among the 3 senatorial districts of the state, namely; Kaduna North and Kaduna South. The study area comprises of remote settlements which are very difficult to access in mostly Birnin Gwari and Igabi Local Government Areas (LGAs), due to security and accessibility challenges. Resistance to immunization was strongly observed due to socioeconomic status of the dominant tribe in the study area.

1.1 Study Area

The study area is Kaduna Central Senatorial Zone, it comprises of the following LGAs: Giwa, Birnin Gwari, Kaduna North, Kaduna South, Igabi, Chukun and Kajuru. The area is located between Latitudes 9°41′36″N-11°25′4″N and Longitudes 4°30′41″E-8°37′39″E as shown in Figure 1.

Maternal mortality in Nigeria is ranked second in the world after India and Nigeria is part of a group of six countries in 2008 that collectively accounted for over 50% of all maternal deaths globally. About 53,000 women die every year, which means one woman dies every 10 minutes (Kaduna State Government, 2015). A number of 277 maternal deaths occurred among 38,058 deliveries in the hospitals. Considering geographical distribution, Kaduna North hospitals recorded 233 maternal deaths with MMR of 979/100,000 live births; while Kaduna South hospitals recorded 44 maternal deaths with maternal mortality rate(MMR) of 309/100,000 live births (Kaduna State Government, 2015).

According to the Köppen's classification of climate, the study area belongs to the Aw which is marked by distinct wet and dry season. The mean daily temperature in the area can be as high as 34 °C between months of March and May. Temperature could be as low as 20°C during the December to January. This low temperature is intensified by humidity due to the dry harmattan wind (Kaduna physical settings, 2003). The climate of the area is dry sub-humid with annual rainfall of about 1200-1500mm. The mean monthly temperature is about 27°C but higher between the month of March and May, representing the hot dry season (Oguntoyinbo, 1998).

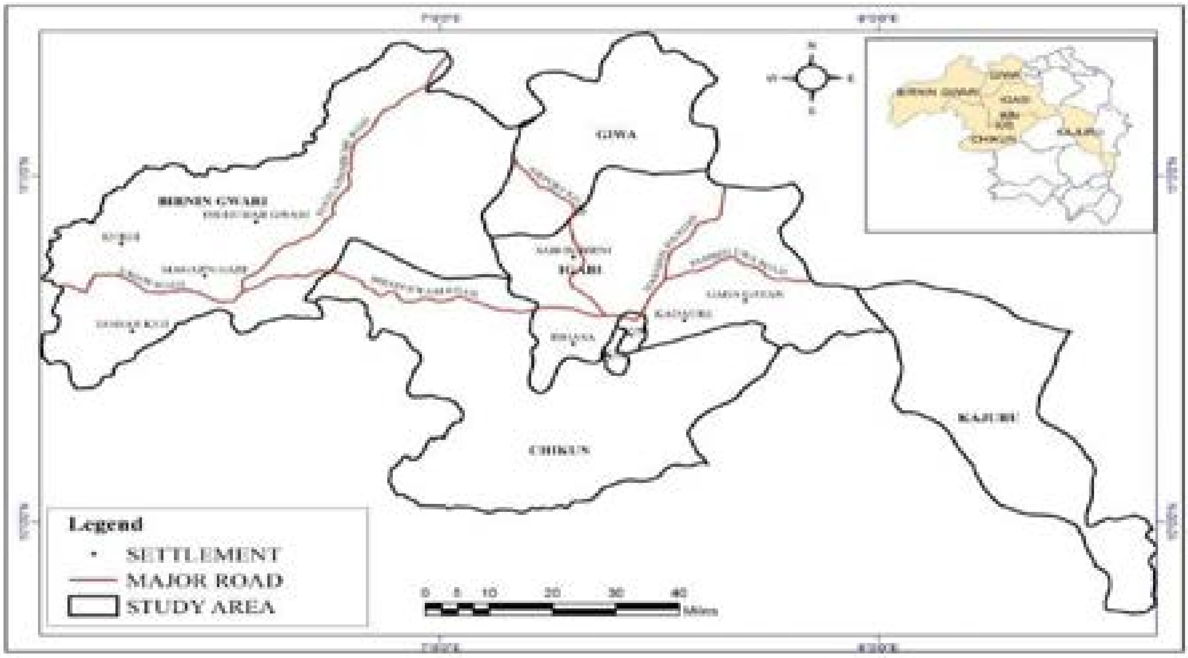


Figure 1: The Study Area

2. MATERIALS AND METHODS

This research utilized both primary and secondary data. The secondary data includes: topographic map of the study area (1; 50,000) extracted from the topographic map of Kaduna State. The primary data includes; Poliomyelitis record was obtained from Kaduna State Ministry of Health and as well as from Primary Health Care Development Agency. The data obtained were: home addresses of the infected persons, local government and ward of the infected persons, sex, as well as age and onset date of the infected persons for the study period (2006-2016), this period was selected because Polio cases record were not documented prior to 2006.

The Houses of the infected children were visited by the researchers in order to collect the geographic coordinates of the address of each polio case in the study area; Android Global Positioning System software called Mobile Topographer was used. Also, the coordinates of the primary health care centres where the infected children attend for vaccination were taken. The recorded coordinates of the polio cases were recorded in an Excel delimited text file format and the file was imported into ArcMap software as XY data, then the map of the study area was georeferenced and then imported into ArcMap, then, a new layer showing the distribution of polio cases over space was produced. This layer allowed the identification and visualization of polio cases in the study area. The table of content shows the identified layer.

Graph was also used in showing the number of cases on yearly basis over the study period. This was achieved by using the attribute table of the map of polio cases developed above; then a graph of polio cases against the study period was floated.

3. RESULTS AND DISCUSSION

3.1 Mapping the Distribution of Polio Cases in the Study Area

This section discussed the distribution of polio cases during the study period with the aid of maps and graph. Polio cases were found to be spatially distributed in the three local government areas (LGAs), namely Birnin Gwari, Igabi and Chikun. It was further observed that the polio cases were spatially distributed in settlements along major roads linking so many towns and villages in the western and eastern part of the study area (see Figure 2). It can be understood that, based on the distribution of the polio cases on Figure 2, the nature of distribution of the cases are very close to each other. This can be attributed to lack of immediate confirmation and intervention of the new infected child by the health authorities which led to the immediate spread of the virus to other children. The result of this study also found that, on one hand 4 cases were located in western region of the study area in settlements along Niger/Lagos Road, on the other hand some polio cases were also distributed in eastern region of the study area; 2 cases in Sabon Birni Village alone Giwa road, 1 case in Kerawa Village along Rigachikun/Kaduna road and another case in Mararaban Jos Town. The findings also revealed that another 2 close together cases were found at Gadar Gayan Village which is located along Pambeguwa Way, while the last two cases were reported in Rigasa District.

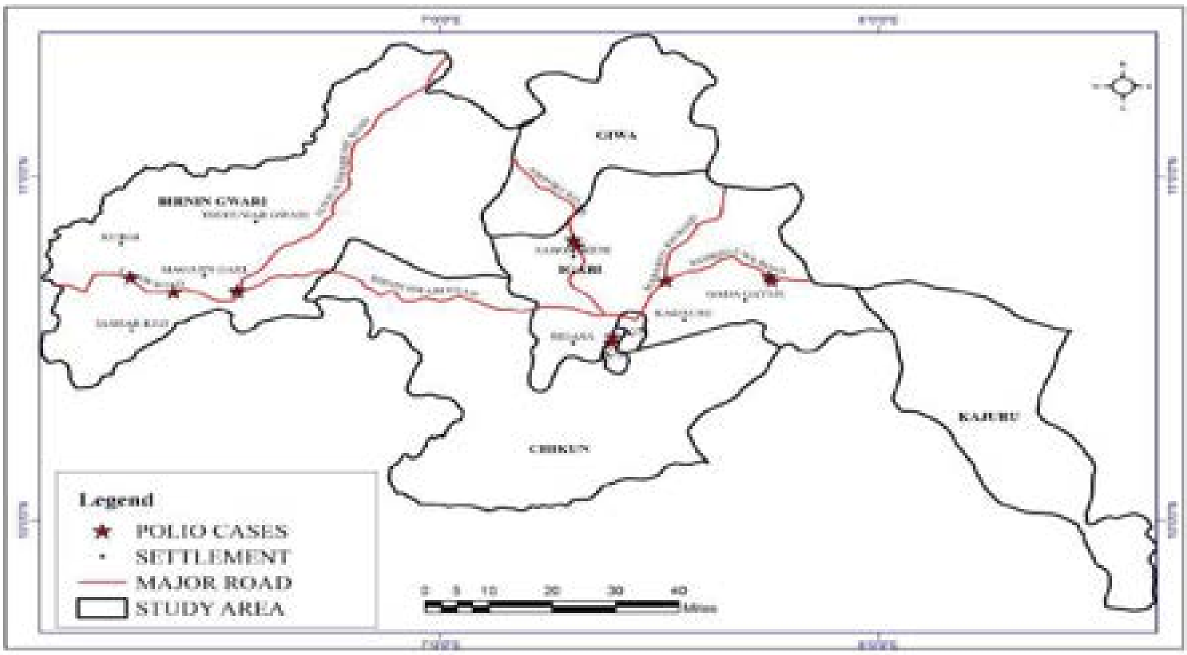


Figure 2: Distribution of polio cases for 2006

It was also found that the number of polio cases in the eastern part of the study area are more in number than that in the western part, namely Birnin Gwari and Igabi LGAs respectively. In Birnin Gwari, the incidence of higher polio cases in settlements along Niger/Lagos road can be attributed to poor immunization coverage in the area due to the security challenges, particularly armed robbery, murder and cattle rustling which occurred during both day and night time especially in the settlements along Lagos roads within Birnin Gwari and its neighborhoods. This makes the concerned area inaccessible by vaccination team. Figure 2 shows the distribution of polio cases in the study area for the year 2006.

In the year 2008, there were a total of 9 reported polio cases, out of which only 1 case was mapped using the home addresses of the infected child, this was spatially located in Tsuhuwar Gwari settlement along Kuyyalo Dandime road in the western part of the study area, as shown in Figure 3. The remaining 8 cases were spatially distributed in PHCs Birnin Yaro, Gwaraji, Gadar Gayan, Kuyallu, Tabanni and Miyatti Allah across the study area.

Out of the 8 cases, 2 cases were located in geographically north of the study area, 1 at Model PHC Kuyallu and the second case at PHC Tabanni, while the other 6 cases were spatially distributed in PHCs at eastern region of the study area namely Igabi, with 1 case in each of the listed PHCs: PHC Gada Gayan and PHC Gwaraji. PHC Birnin Yaro and PHCs Miyatti Allah, Rigasa has two polio cases each. Significant number of polio cases in the year 2008, were located in eastern part of the study area, while only few cases (3 cases) were recoded in the western part. This signifies that more prevention measures against polio virus transmission were taken in western and the northern part of the study area than the eastern part. The higher cases of polio in Igabi were attributed to the socio-economic background of the people (low level of education).

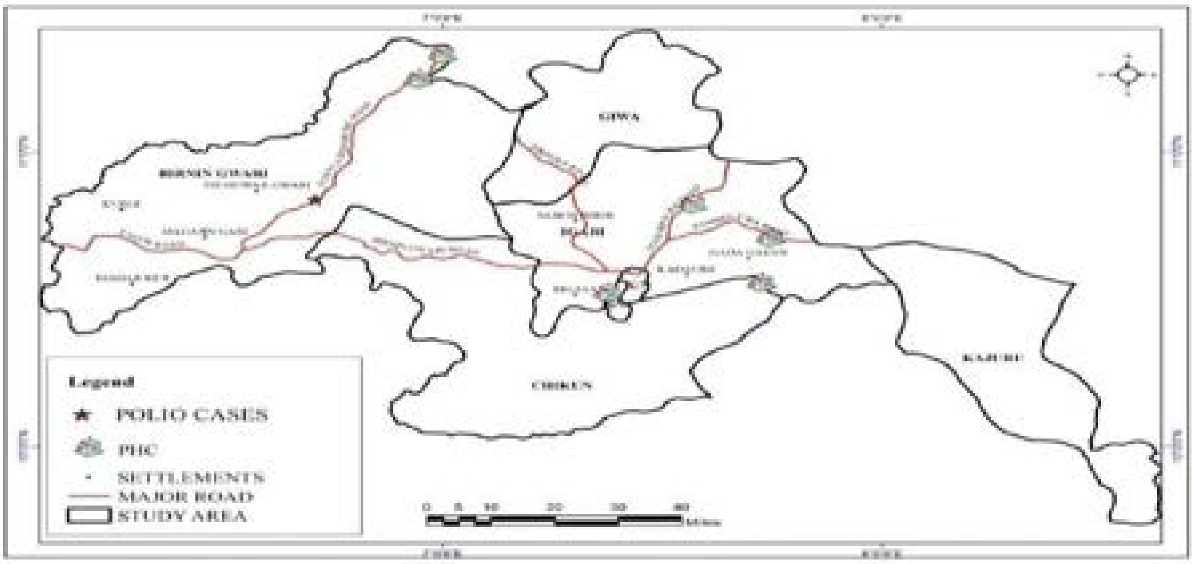


Figure 3: Distribution of polio cases and PHCs where infected children attend for treatment in 2008

In the year 2009, there were only 3 reported polio cases in the study area. Two cases overlapping each other in the western part of the study area that is in Magajin Gari settlement of Birnin Gwari LGA and the other single case in Rigasa settlement. This is shown in Figure 4. The overlapping case is as a result of direct transmission of the virus by the first infected person to the other since the two cases occurred in the same location. The second infection occurred due to failure to confirm and report the first infected person on due time.

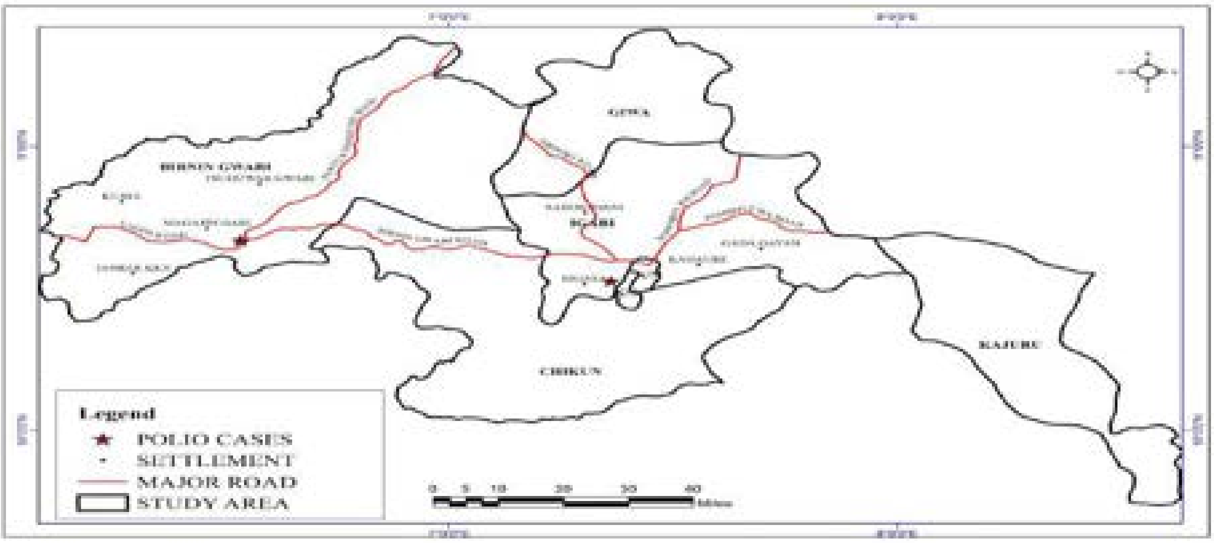


Figure 4: Distribution of polio cases for the year 2009

In the year 2012, there were 6 reported polio cases out of which only 2 cases were mapped using home addresses of the infected children. The two (2) cases were spatially distributed in eastern settlements of the study area namely Kadaure and Sabon Birni. Sabon Birni is a town bordering Giwa LGA as shown in Figure 5. The remaining 4 cases were spatially distributed in two PHCs, 3 cases in PHC Unguwan Nachibi in the northern part of the study area, which is a village prone to cases of robbery and murder activities. The last case for the year was spatially located in PHC Sabon Birni. Therefore, it can be concluded that in the year 2009, more cases were spatially located in the eastern settlement of Sabon Birni and Kadure, but of great concern is three (3) polio cases were spatially located in Unguwan Nachibi, signifying poor immunization coverage resulting from security challenges in the area.

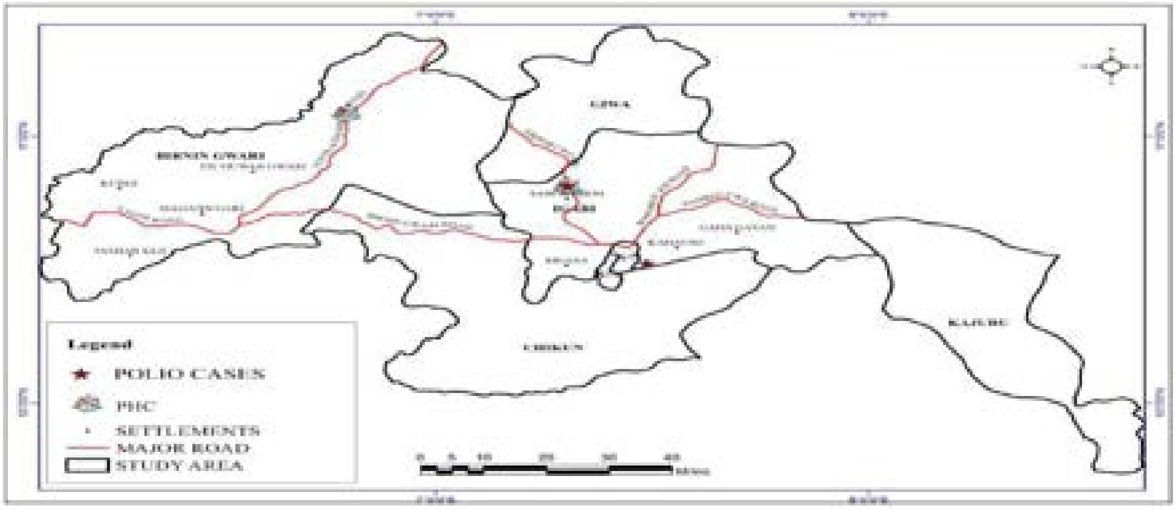


Figure 5: Distribution of Polio cases and PHCs where infected children attend for treatment for the 2012

In the year 2013, only 1 polio case was reported which was mapped using home address. This case was located in the western part of the study area in Magajin Gari area of Birnin Gwari LGA. Many polio cases were spatially located in Magaji Gari area. This may probably be as a result of not taking necessary action by the concerned authority on the emergence of the disease.

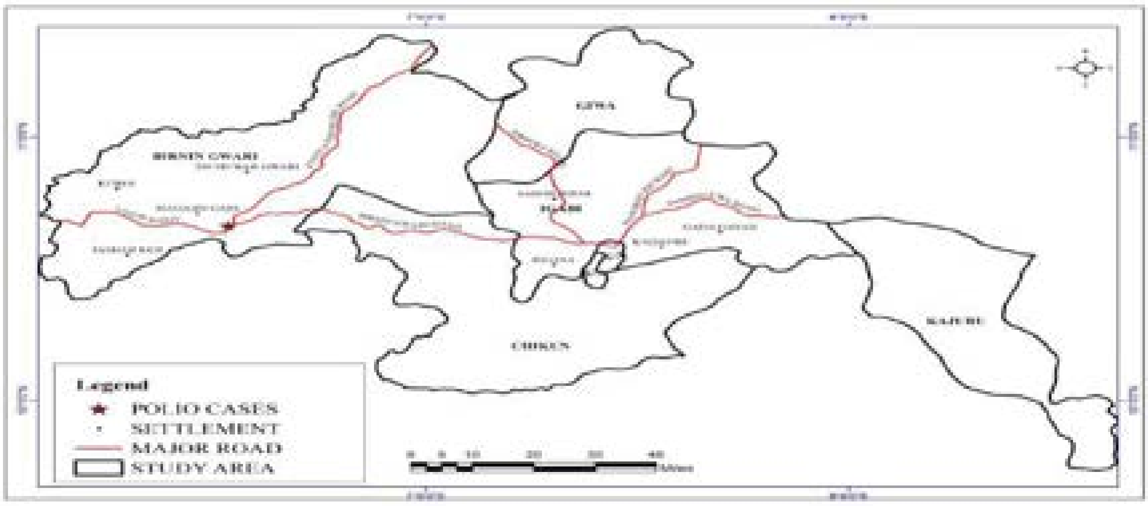


Figure 6: Distribution of polio cases for the year 2013

Indeed, the year 2006 witnessed the highest number of attacks, which affected 14 children. Studies of Poliomyelitis over a period of 2006 to 2016 showed that there was only occurrence of the epidemic in three local government areas of the Senatorial Zone. Although the number of poliomyelitis cases reported has decreased since 2007 to only zero, it was slightly erratic as follows: 2006 (14), 2007 (0), 2008(9), and 2009 (3), 2010 (0), 2011 (0), 2012 (6), 2013 (1), 2014(0) 2015 (0) and 2016 (0); this is shown in Figure 7. It can be seen from the graph in Figure 7 that polio infection reach its peak in the year 2006, subsequently in 2007, there was a drastic reduction of polio cases to zero which may be attributed to mass immunization campaign during that period. Polio cases rise reaching up to slightly above average in the year 2009 which may be possibly due to reluctance by the concerned authority considering the success gained in the year 2006. Then, there was a reduction of polio cases from 2009 to zero in 2010 and 2011. However, due to success recorded in the year 2010 and 2011 the authorities relaxed, and negligence of the concerned authorities led to the infection of six (6) children in the year 2012. In the year 2013, there was a decline of reported polio cases to one (1), and lastly to zero in the year 2014, 2015 and 2016.

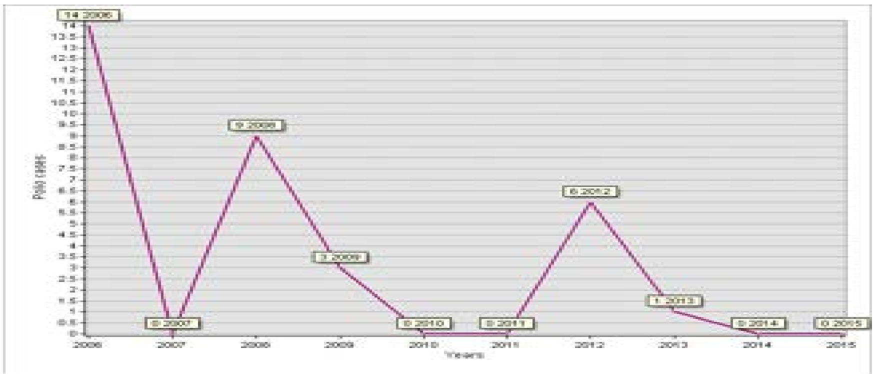


Figure 7: Number of polio cases in each year from 2006 to 2014

4. CONCLUSION

Poliomyelitis cases were spatially distributed only in Birnin Gwari, Chikun and Igabi local government areas. The eastern part of the study area had more number of polio cases which were more clustered in nature. The study identified failure to report suspected polio infected persons to the relevant authorities, and also in whole the study area. However, the western part of the study area has fewer polio cases spatially distributed. These cases are less clustered in nature unlike in the eastern part of the study area. The spread of polio cases in Birnin Gwari was as a result of many factors; the most important one was poor immunization coverage. Security challenges are considered as factors which hindered the movement of the vaccinators in the area.

Therefore, the study recommended that robust security patrol team should be deployed in Birnin Gwari area so as to tackle the security problems in the area. This will make the area more accessible to the health workers (vaccination team). Also, suspected polio infected child should be immediately reported to the relevant authorities.

REFERENCES

Atkinson W., Hamborsky, J., McIntyre, L. and Wolfe, S. (2007). *Poliomyelitis*. *Epidemiology and Prevention of Vaccine-Preventable Diseases*.The Pink Book 10th edition. Washington D.C: Public Health Foundation.pp.101-114.

Baba and Ayivor, J. (2012). AntivirAntiretrovir [Review Article Open Access *Antivirals& Antiretrovirals Polio Vaccination in Nigeria: The 'Good', the 'Bad' and the Ugly*] WHO National /ITD Polio Laboratory, University of Maiduguri Teaching Hospital, Nigeria 2 Nigeria National Polio Plus Committee, Rotary Centre, Nigeria S15http://dx.doi.org/10.4172/jaa.S15-004

Betts, K. (1997). Mapping the Environment. Environmental Health Perspectives 105, no. 6. Retrieved March31, 2009, http://www.ehponline.org/docs/1997/1056/innov.html.

CDC (2011). Tracking Progress Toward Global Polio Eradication Worldwide, 2009 2010. *MMWR,* 60(14): 441-445.

CDC (2009). *National Environmental Public Health Performance Standards: LocalEnvironmental Public Health Self-Assessment Instrument*. Retrieved April 8, 2009,http://www.cdc.gov/nceh/ehs/EnvPHPS.

Ekure E.N. Esezobor C.I., Mukhtar Y.M, Ojo O.O., Bamiwuye O.S., Adejuyigbe E.A.,Omoigberale, A.I., Ezechukwu, C., Olowu, A.O., Ogala, W.N. and Esangbedo, D.O.(2013). Community knowledge, attitude and practice of childhood immunization in Southwest Nigeria: Data from a Paediatric Association of Nigeria town hall meeting. *Niger Journal of Paediatric,* 40(2): 06-11.

Felix, N.N. Animam B.O. (2013). Department of Geography and Regional Planning, University of Benin, Benin City, Nigeria

Free Dictionary. Available: http://medical-dictionary.thefreedictionary.com/Acute+poliomyelitis [Accessed: March 12, 2016].

Global, P.E.I. (2013). *Polio eradication and endgame strategic plan global polio Eradication initiative draft* : pp11.

Itimi, K., Dienye, P.O. and Ordinioha, B. (2012). Community participation and childhood immunization coverage: a comparative study of rural and urban communities of Bayelsa State, south-south Nigeria. Niger *Med Journal,* 53(1):21–25.

Kaduna physical settings (2003). Retrieved 02/01/2015 fromhttp://www.onlinenigeria.com/links/kadunaadv.asp?blurb=295#ixzz3j0r7.

Kaita, H.A. (2003) Interview with WHO advocacy team. *Weekly Trust Newspaper*, pp 4 10.

Mongono, M. (2013). *Factors influencing Immunization coverage in Borno State, Nigeria.*

Nnenna, T.B., Davidson, U.N. and Babatunde, O.I. (2013). Mothers' Knowledge and

Oguntoyinbo, J. (1998). *Geography of Nigeria Development*. Heineman, Nigeria Limited

Ogwumike, O., Bashir, K. and Ade, F.A. (2012). *Children with paralytic poliomyelitis: a cross-sectional study of knowledge, attitude sand beliefs of parents in Zamfara state, Nigeria*. BMC Public Health.888

Oladejo, O. P., Nwobu, G.O., Omosigho, O. P., Baba, M., S. Oderinde, S., Emumwen, E. G., Otojareri, K.A., Ndako, J., O gedengbe, S.O. and Onoja, A.O . (2013). Neutralization Antibodies in Oral Poliovirus Vaccine (OPV) Vaccinated Children and Young Adult in Bida North Central, Nigeria. *International Journal of Epidemiology and Infection,* 10: 19-24.

Oladipo, A. and Ejembi, C.L. (2013). Socioeconomic status of women and Immunization Status of under five children in Northern Nigeria- a case study of poliomyelitis in Kaduna state. *Annual international interdisciplinary conference, AIIC. 24 26 April, Azores, portugal proceeding.* pp 785-788.

Oyefara, J.L. (2014). Mothers' Characteristics and Immunization Status of Under-Five Children in Ojo Local Government Area, Lagos State, Nigeria. *SAGE Journals* Perception of Adverse Events Following Immunization in Enugu, South-East, Nigeria. *Journal Vaccines Vaccination*.Vol.4. pp20 2. doi: 10.4172/21577560.1000202

Polio (2012). *Bio Farma*.Available: website.http://www.biofarma.co.id/eng/vaccination5. Html [Accessed: February 22, 2014]

Raoul, K. (2009). Tracking The Polio Virus Down The Congo River. *International Journal of Health Geography.*

Sakiru, O.O. and Ayoola, A.A. (2013). *Geospatial Modelling of Tuberculosis Spread in Ibadan, Nigeria.*

Tagbo, B., Uleanya, N., Nwokoye, I., Eze, J. and Omotowo, I. (2012). Mothers' knowledge, perception and practice of childhood immunization in Enugu. *Nigerian Journal of Paediatrics,* 39(3): 90-96.

Usman, A., Sajid, R.A. and Muhammad, L. (2015). Study of Polio Disease In Pakistan Using GIS Approach. *International Journal of Scientific and Technology Research,* 4: 315-321

Usman, L.G. (2012). *Mapping of Spatial Distribution of Tuberculosis Cases in Kebbi State, Nigeria*. Department of Geography, Adamu Augie College of Education, Argungu, Kebbi State, Nigeria. Pp 3-9

WHO (2009). http://www.who.int/health_mapping/en/.Retrieved 10/04/2014

Savanna volume 23, Number 1, June, 2016

Effects of Beliefs and Economic Status on Family Size in Kano Metroplis, Kano State, Nigeria

Ibrahim Badamasi Lambu
Department of Geography, Bayero University Kano
iblambu@yahoo.com

ABSTRACT

This study examines the effects of cultural beliefs on gender preferences and family size in Kano Metropolis of Kano State in Nigeria. The study used questionnaire and interviews to obtain data on family size, income and ages of parents; the preferences and choices of certain sexes. Descriptive statistics like measures of central tendency, graphs and charts were used for the analysis. The findings showed high birth rate or fertility among couples due to desire to attain certain gender combination. It was also found that traditional title holders, businessmen and lower income earners in the study area beget more children than the educated elites because of the belief that the children are assets. There is also a belief that certain sex is better than others even among wealthy individuals who abhor more children with preference to sons than daughters. Some of the reasons attached to this preference include the assistance sons render at home and market; they serve as source of security at old age as well as heirs of family continuity. It was also found that many families tend to give birth to large number of children in the quest of getting a son(s) especially if the early children are females. Another factor is the cultural belief that encourages polygamy, one of the co-wives may have many males, hence, this triggers competition trying to have modal set. Socio-economic and socio-cultural status show some variations in these trends. Preferences of sex and many children are more common to polygamous couples than in monogamous family. The study recommended the need for enlightenment among the people to consider both sexes as complementary to one another to reduce the degree of preferences.

Keywords: Culture; Preferences; Family Planning; Gender; Competition.

1. INTRODUCTION

Cultural beliefs differ from one society to another and are varied in how they divide the geographical space of Earth creating different perceptions and preferences (Lambu 2014). There is a close relationship between culture and the environment to the extent that human beings exercise significant level of control in how the latter looks like (Lambu, 2011). Culture that encompasses beliefs defines a relationship between nature, humans and spaces that allows for interaction, assimilation and diffusion (Paden, 1973). Simple change of life system produces a complex behaviour that may differ with reality, though cultural beliefs (religion) that guide people to obey the society's norms, values and code of operation may be stable at certain time.

Adoption of family planning i.e. the planning of when to have children, and the use of birth control and other techniques to implement such plans faces one form of restriction based on differing beliefs. Family planning is sometimes used as a synonym for the use of birth control; however, it often includes a wide variety of methods, and practices that are not birth control. It is most usually applied to a female-male couple who wish to limit the number of children they have and/or to control the timing of pregnancy (also known as *spacing children*). Family planning may encompass sterilization, as well as abortion. Family planning services are defined as educational, comprehensive medical or social activities which enable individuals, including minors, to determine freely the number and spacing of their children and to select the means by which this may be achieved (ibid).The beliefs are contentious over some techniques commonly used which include sexuality education, prevention and management of sexually transmitted infections, pre-conception counselling and management, and in fertility management (Ahmad, 2017).

The success for couples and individuals to decide freely and responsibly the number and spacing of their children, and to have the information and means to do so are affected by the society's beliefs and values (Lambu, 2012). People decide to have families at both younger and older ages, and contraceptive technology is enabling them to do so. It is important that these decisions be made not only freely but also with full information about the long-term consequences for both the parents and the children in conformity with the beliefs (Ahmad, 2017).

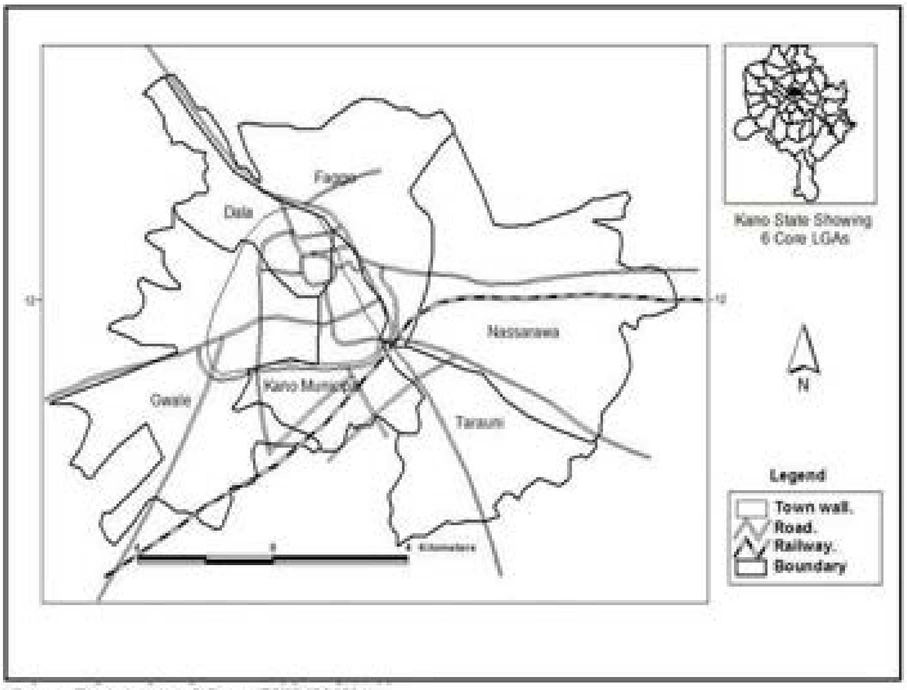
Culture dictates the strong sense of individual identity in every society irrespective of its state of development. Whether it is concerned with preferences, choices or decision, family affairs are too complex due to distinctive attributes and goals. Many studies show a strong preference for sons than daughters; prominent among them is that of Musa (2008) who conducted a study on sex preferences in Rano Local Government Area. He reported that a significant number of respondents opined that couples with daughters sustain child bearing quite longer than those with male offspring. Studies on the relationship between sex preference and number of children in a given household shows parity progression ratios or transitional probabilities as a function of the existing sex composition of the family. The basic argument is that if sex preference influences family decisions, then at any parity, those couples with undesirable sex compositions should be more likely to have another child than those who already have achieved their desired sex composition (Musa, 2008). Children and sex preference relates to the number of children in many instances because of the fact that if the actual sex set is not in line with the preferred sex set of a couple, the couple may continue to reproduce, until the desired sex set is achieved, leading to an increase in the number of children of a couple.

Culture (especially religion) is an important variable which regulates human behaviour, including marriage and reproduction. Sometimes, some cultures favour having a particular sex of children over the other (Ibrahim, 1989). There may be a conflict between a strong sex preference and preference for a small family, and in this case the problem of which will dominate arises, this is because if couple did not achieve their preference, they may continue to have birth beyond their desired number (Ahmad, 2017). This type of conflict in many cases leads to adoption of polygamy when the couple cannot settle at a point amiably. The existence of sex preference leads naturally to the question of to what degree such preference influences people to either marry another wife, or divorce wife who could not deliver the preferred sex. The treatment given to a wife who always produces a son may be different from that of the other wives because of the belief that certain sex is superior to other (Ahmad, 2017). Similarly, a wife who could not bear a son may face serious pressure to the extent that she would keep trying to have another birth with the hope of achieving the preferred gender. Many women face intimidation and harassment from husband's relatives simply because she couldn't deliver a male offspring.

The social roles and behaviour of males and females have differed in all known human societies due to varied beliefs system. Research on tribal societies indicates that men have tended to be the warriors, hunters, and processors of hard raw materials used for weaponry and tools, whereas women have tended to do the cooking and preparation of vegetable foods (Musa, 2008). As a result of this gender differentiation in the division of labor and the social inequality between sexes, men have been in a better position to acquire and control the valuable resources of their societies. Resources, position of power, privilege, and status have seldom, if at all been shared across males and females on equality basis which in many times rooted from cultural beliefs (Lambu 2014). This study will bring to light the cultural beliefs and economic status that influence family planning adoption in Kano metropolis. In many times, even the educated elites are made to produce high number of children unwillingly

1.1 The Study Area

Kano metropolis is located between latitudes 10°30′ to 12°30′N and longitudes 7°30′ to 9°25′E, about 840km from the edge of the Sahara desert as shown in Figure 1. It is located on a height of 472.45m above sea level with average temperature range between 15.8-33°C. Its mean the average rainfall in a normal situation is about 1000mm in southern Kano and 800mm around the metropolis (Olofin, 1987). The Kano metropolis in this study consists of six local government areas (LGAs) namely; Dala, Fagge, Gwale, Municipal, Nassarawa and Tarauni as shows in Figure 1 below. It has an estimated population of over 2,166,179 people (projection). Kano metropolis is the second largest industrial and commercial centre in Nigeria. The early settlers settled around Dala hill (in the walled city of Kano) from where expansion began. Hausa and Fulani otherwise known as Hausa-Fulani are the predominant tribe in the state.



Souce: Department of Geog. BUK (2012)

Other ethnic groups in Kano include the Yorubas and Igbo (accounting for the large segment of the non-indigenous population), Nupe, Tiv, Idoma and many others (Adamu 2012). The dominant religion in the area is Islam. Islamic faith was brought to Kano through the Arab traders and preachers among others though the beliefs were mixed with traditions. The boundary of Hausa ethnicity and Hausa culture are language, religion, social values, dress and historical status. On religious perspective, to identify Hausaculture in places far away from Hausa land is the Islam (Paden 1973). Islam becomes an important identity of the people virtually in everything.

Figure 1: Map of the study area (six metropolitan LGAs)

2. MATERIAL AND METHODS

2.1 Data Collection

Interview sessions were conducted with some households in the study area. Similarly, questionnaire was designed to capture the number of children per households. The former gathered qualitative information on their preferences and the beliefs behind such decisions. The latter provided quantitative indices such as number of children and corresponding economic parameters like income. Males dominated the entire sessions as many husbands cannot allow discussion with their wives. Only questionnaires were filled successfully by educated wives since direct contact is not necessary.

2.2 Sample Size and Sampling Technique

It is a qualitative research investigating cultural forces (beliefs) accentuating gender preferences visas its effect on family size. Interviews and questionnaire are the key instruments used in this study. The population of interest to this study consists of males and females who are married and fall within child bearing age. Multi-stage sampling was used because the study was employed in assessing the preference of one sex over another and how the attitude affects the subsequent decision toward the number of children in the households. The study in the next stage sampled the Hausa people, a dominant ethnic group in northern Nigeria. The choice of this ethnic group was largely predicated on the traditional character of this patriarchal group and its high fertility within extended family set up. The Hausa people constitute a significant proportion of the population in Nigeria, the largest country in Africa. The Hausa people are undergoing rapid socioeconomic changes manifesting in various transformations especially in expansion of education and urbanization (Adamu, 2012). Some samples of one thousand one hundred and sixty (1,160) respondents were drawn from the eight LGAs. About 145 respondents from each LGA were purposively sampled. The purposive sampling was necessitated by the fact that the types of information required from the respondents are unique and peculiar to married adults of the society. It is considered adequate because of homogeneity of the population as opined by Adamu (2012) and Lambu (2014).

3. RESULTS AND DISCUSSIONS

Results from both interviews and questionnaires are discussed in this section. Opinion of respondents on the effects of various cultural beliefs and socio-economic status were captured. Competitions from co-wives in polygamous homes to have modal sets of children were discussed. Variation in family size and how it is affected by socio-economic class of the head of household is also discussed.

3.1 Effect of Polygamy on Family Size

The rivalry and jealousy in polygamous family accentuate the need for wives to have control of their marital home through having more children, in essence, this intensifies the preference for son among the female respondents. As such, *Mai Babban-Daki* is the name given to a woman with higher prestige (i.e. richest, noble or number of male children among co-wives), while *Dauki-Bisu* is referred to as woman who does not have a son. Though it is assumed that men are more likely to express strong sex preference than females, this research found that females express stronger preference than the males. About 67.3% of the women that were interviewed agreed strongly that competition for having more issues affect their initial decision to adopt family planning.

Only an educated lady controlled her birth at only four children while her partner counting seven. Less than 23% of the respondents opined that it is their husband that decided on their number of children which is part of cultural belief. The submissive behaviour of females to their husbands on decision making has strong rooting with religion. Issue of polygamy is more cherished by Islam as can be observed from Table 1 where 58% of the respondents have polygamous homes as against 42% of the respondents with monogamous families. This finding is in line with that of Lambu (2014) who discovered that polygamy is cherished in Islam. The more religious a Muslim is the more likely he would engage in polygamy. In fact, even the desire to have more children among co-wives is geared toward gaining or winning husband's attention and concern. In other religions such as Christianity, polygamy is discouraged to the extent that this study and other studies conducted such as Lambu (2012, 2013 and 2014) have not discovered polygamy among any Christian respondents. The study area being a Muslims dominated society, there is tendency to observe the impact of such belief.

Table 1: Types of family and average number of children per wife

Types of family	Average children per wife	Percentage
Monogamous home	5	42
Polygamous home	8	58
Total	12	100

3.2 Economic Status, Gender Preferences and Family Size

Economic status shows some peculiarities where highly placed business class and low income farmers give birth to more children than the middle class people (see Table 2). The main reason for this is that even among those with medium and higher income, there is the need to have a son who can continue the family name, and even to inherit his family income and assets, because there is the general belief that a girl can transfer her inheritance to another family. This study found that wealth with many children is regarded as highest esteem to the family as confirmed in (Lambu, 2015 and 2016). Low income farmers beget more children to help in farming activities by provision of cheap labour. Most elites are restive if their wives didn't issue male children because their belongings may be inherited by other relatives if only females are their offsprings.

Findings revealed that both males and females parent prefer giving birth to son than daughter due to the cultural beliefs as dsicovered by Lambu (2015). However, it is observed from Table 2 that a reasonable percentage of the respondents showed preference for combined sons and daughters. This type of decision has serious implication on cultural values which may trigger gender abuse and corresponding women neglect.

Table 2: Status and gender preferences on family planning decision

Status	Males preferred	Female preferred	Combine (Male/female)	Total
Educated elites	57.5%	12.5%	30%	100%
Business class	59%	20%	21%	100%
Masses	78%	5%	17%	100%

3.3 Gender Preference between Couples

The gender preference between couples in the study area is shown in Figure 2. Many couples expressed that their desire for attaining certain gender combination distorted their family planning agenda. Many males decided to adopt polygamy when the only wife cannot produce a male child or children. Even the wives opined that they cannot stop giving birth if they don't have a right combination of sexes. Over 90% of educated husbands are in support of family planning but expressed caution that '*planning of family is after attaining the right sex combination'.* Many wives are of the opinion that their marriage security is higher after attaining certain number of both males and females offspring. To both husbands and wives, marriage without many children is just like casual parting. The study discovered that stability of marriage is associated with number of children between the couple which concur strongly with Lambu (2016) who found that women looks for more livelihood options to support husbands if they have many issues (children) with the husband because the two (husband and Wife) are partners in the upbring of the siblings.

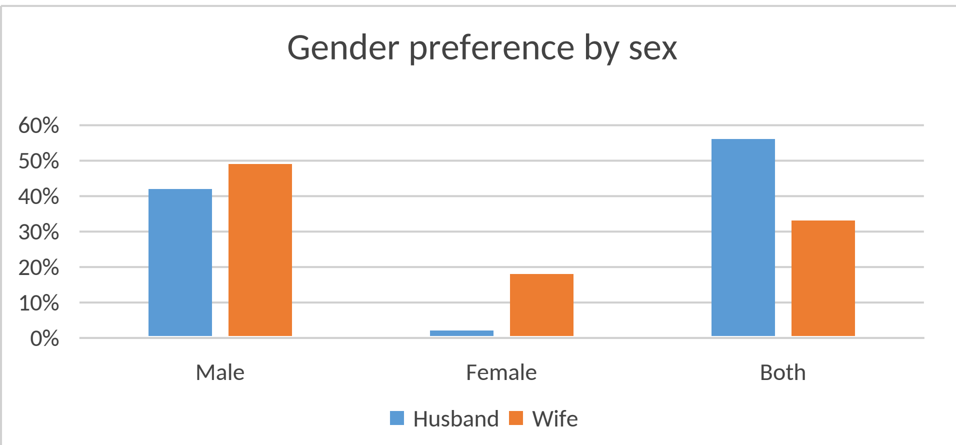


Figure 2: Showing gender preference among couples in the study area

The findings of this study suggest that the cultural set up of the people (beliefs) affect preference of children and practice of family planning. The culture recognizes males as the head of household irrespective of age and economic status. They also have twice share of their females' counterpart (in inheritance). This accentuates the need for son(s) than daughter(s). The issue pertaining security at old age among people is a definite reason for son preference among many people in the area. Preservation for family name is also a reason for son preference among the people. The research found that there is preference for particular sex among the respondents irrespective of their sex and economic status.

4. CONCLUSION

This study revealed that majority of the people in the area believed that male are superior to females hence, gender preferences accentuate higher fertility and or birth rates among the couples before certain desire are met on the right set of children. It was found that preservation of family name and security in old age are factors for sex preference, there is also a definite preference among all the respondents, with variations based on income, sex, education, and number of the sex of children present. Based on the findings of this study, there is lack of adequate orientation among the people especially on the patriarchal belief giving more attention to one sex over the other.

4.1 Recommendations

Families need to raise an appropriate number of children qualitatively (with good education, sound moral training and skillful mind) irrespective of sex for the betterment of the entire society. Men and women are complementary, supplementary and congruent to one another. In other word, life of one is meaningless without the other due their roles and hence the need for mutual respect.

Proper orientation on the gender roles and responsibility are needed by the society so as to appreciate the complementarity of both sexes so that the degree of segregation, marginalization, seclusion and preference may be lowered to minimum.

REFERENCES

Adamu, M. U. (1999). *Confluences and influences: The emergence of Kano as a city state.* Munawwara Book Foundation, Kano.

Adamu, M.A. (2012). *Analysis of vital registration centers in Kano metropolis*, a PhD unpublished thesis submitted to Department of Geography, Bayero University, Kano.

Ahmad, B.Y. (2017): *Geographical analysis of maternal mortality in Gombe state, Nigeria;* a PhD unpublished thesis submitted to Department of Geography Bayero University Kano

Ibrahim, J. (1989). The politics of religion in Nigeria: The parameters of the 1987 crisis in Kaduna State. *Review of African Political Economy,* 45(6), 65–82.

Lambu, I. B. (2011). Culture and nature: The co-actors in climate change. Paper presented at *the 52nd Association of Nigerian Geographers (ANG) Conference*. Usmanu Danfodio University, Sokoto.

Lambu, I.B. (2014): *A Geographical analysis of Religious Landscape of Kano metropolis, Kano state Nigeria,* a PhD unpublished thesis submitted to Department of Geography, Bayero University Kano.

Lambu, I.B. (2014): Socio-Cultural responses to inequality between Rural and Urban environment in Kano State; *Publication of Department of Geography: Book of proceedings,* University of Maiduguri, Borno state.

Lambu, I.B. & Dan, Y. (2015): Sensing the Birth preferences among spouses in Kano metropolis, Kano state, Nigeria. *Advance in Social Sciences Research Journal, 2(12).*

Lambu, I. B. (2016). The Cultural Forces and Women Livelihood Options in Rural Areas of Kano State, Nigeria. *Advances in Social Sciences Research Journal,* 3(2): 146-156.

Musa, A. M. (2008): *Assessment of child preferences in Rano Local Government Area, Kano state,* M.Sc. Dissertation submitted to Department of Sociology, Bayero University Kano.

Paden, J. N. (1973). *Religion and political culture in Kano.* University of California Press, Berkeley/Los Angeles.

Olofin, E.O (1987): *Some aspect of the physical Geography of Kano region and some related responses*.

Savanna volume 23, Number 1, June, 2016

An Explanation of the Factors Responsible for Fuelwood Consumption in Zaria and its Region, Kaduna State, Nigeria

Dabo A. A.[1]*, Shehu A.[2], Shehu A. U.[3] and Abdulmumin L.[4]
[1]*Department of Environmental Health, School of Environmental Health Sciences, Shehu Idris College of Health Sciences and Technology, Makarfi, Kaduna State-Nigeria*
[2]*Department of Geography, Kano College of Arts, Science and Remedial Studies, Kano*
[3]*National Agricultural Extension, Research and Liaison Services (NAERLS), A.B. U. Zaria*
[4]*Department of Geography & Environmental Management, Ahmadu Bello University, Zaria*
**aminudabo01@gmail.com*

ABSTRACT

This study aimed at examining the factors responsible for fuelwood consumption by households in Zaria and its regions. A systematic (probability) sampling technique was employed in selecting the wards from each Local Government Area (LGA) that make up the study area. The study used questionnaire to collect data from 384 respondents that constitute households and commercial fuelwood vendors. On average, most of the commercial fuelwood vendors (50%) and the households (39%) have spent over 30 years in fuelwood production and consumption respectively. The respondents for the main survey were selected randomly (by visiting as many households as possible in the sixteen electorate divisions) with no regard to any probability in the selection process to determine the factors influencing fuelwood consumption and the preferred tree/shrub species for firewood in the households. Results showed that majority (77.3%) of the respondents used fuelwood as their major source of energy, it further showed that cheapeness (64%), affordability (8.8) and availability (5%) of fuelwood were found to be the factors responsible for fuelwood consumption in the area. The most preferred tree and shrub species for fuelwood were *Isobalina doka* (85%), *Eucalyptus* (83%), *Prosopis Africana* (73%), *Agnogeissus leicarpus* (68%), and *Parkia biglobosa* (63%) among others. Most of the species were reported to have good combustion characteristics. The study recommends that there is urgent need for government to provide cheap, reliable and sustainable sources of energy at affordable prices. Cultivation of fast growing tree species needed to accelerate the regeneration of forests.

Keywords: Household energy; Fuelwood; Consumption; Zaria and its Region.

1. INTRODUCTION

According to International Energy Association (IEA) report in 2014, 50-70% of the population of Nigeria does not have access to electricity while according to another report by IEA in 2013, the population and per capita energy demand of Nigeria is 141 Mtoe. As the energy mix in 2014 shows that bio-energy constitute (70%), gas (10%) and oil (20%). The oil product demand growth in Nigeria exceeds the whole of sub-Saharan Africa demand from 2000-2012 which is about 6000Mt of gasoline, 2000Mt of kerosene and 800Mt of diesel (World Bank, 2014).

Fuelwood is a renewable form of energy that has continued to be the only energy option (especially for cooking) for most people in the Developing Countries (DC) (Ali and Benjaminsen, 2004; Shackleton et al., 2006; Ghilardi et al., 2007 and 2009 and Maconachie et al., 2009). Results from recent studies of the Nigerian fuelwood situation suggest that the majority of the population has been moving back to the use of fuelwood in recent times. For example, a study conducted in Kano city in Northern Nigeria by Maconachie et al. (2009) which investigated the consumption pattern of fuelwood among households over at least two decades, revealed that most families, despite using other cooking fuels in the past, are now reverting to the use of fuelwood. There are various reasons for this, including among others, poverty and inconsistency in the supply of fossil fuels in the region. Increasing poverty has ever been reported in the developed countries as a driving factor in the use of fuelwood.

In Nigeria, the demand for fuelwood is very high because more than 80% of households use fuelwood for their cooking; making it the most used form of cooking energy (Sambo, 2008). The over-dependence on fuelwood in the country has been attributed to its availability and affordability compared to the other sources of energy (Maconachie et al., 2009). From the perspective of the consumer, the availability and affordability of the energy source matters as well as the type of energy (Sambo, 2008).

Overall, Olise and Nria-Dappa (2009) emphasised that the energy situation in Nigeria is actually worse than has been revealed to the outside world. They presented their arguments on the basis of the household income ratio to their spending on energy and revealed that the poorest households earn about 1-2 US dollars per day and spend about 0.4 dollars per day on energy. This represents about 20-40 percent of the household's income spending on energy alone.

Even though this figure seems to be high, the fact remains that the availability and acquisition of fossil fuel products in Nigeria is highly erratic due to the corruption that has become endemic in the Nigerian National Petroleum Corporation (NNPC) (Ogbonnikan, 2012; Tsan and Odemwingie, 2013). Hence, a major alternative to fossil fuel in Nigeria is the use of fuelwood for commercial and household activities. The aim of this study is to examine the factors responsible for fuelwood consumption in Zaria and its region.

1.1 Study Area

According to Mortimore (1970), Zaria and its Regions comprise of eight Local Government Areas (LGAs) including Zaria, Igabi, Sabon Gari, Giwa, Kudan, Makarfi, Ikara and Soba. It is located between Latitudes 10°20′ - 11°40′ North and Longitudes 7°00′ - 8°40′ East as shown in Figure 1. It is bordered by Kano State to the north and northeast, to the east by Kubau LGA, to the south by Kauru LGA, to the southeast by Kajuru LGA, to the west by Birnin Gwari LGA, to the southwest by Chikun, Kaduna South and Kaduna North LGAs, and to the northwest by Katsina State (Figure 1). Zaria and its regions is located in northern part of Kaduna State. The plain of Zaria and its Regions is an undulating one, which is gently rolling and has numerous valleys and streams (Wright and McCurry, 1970).

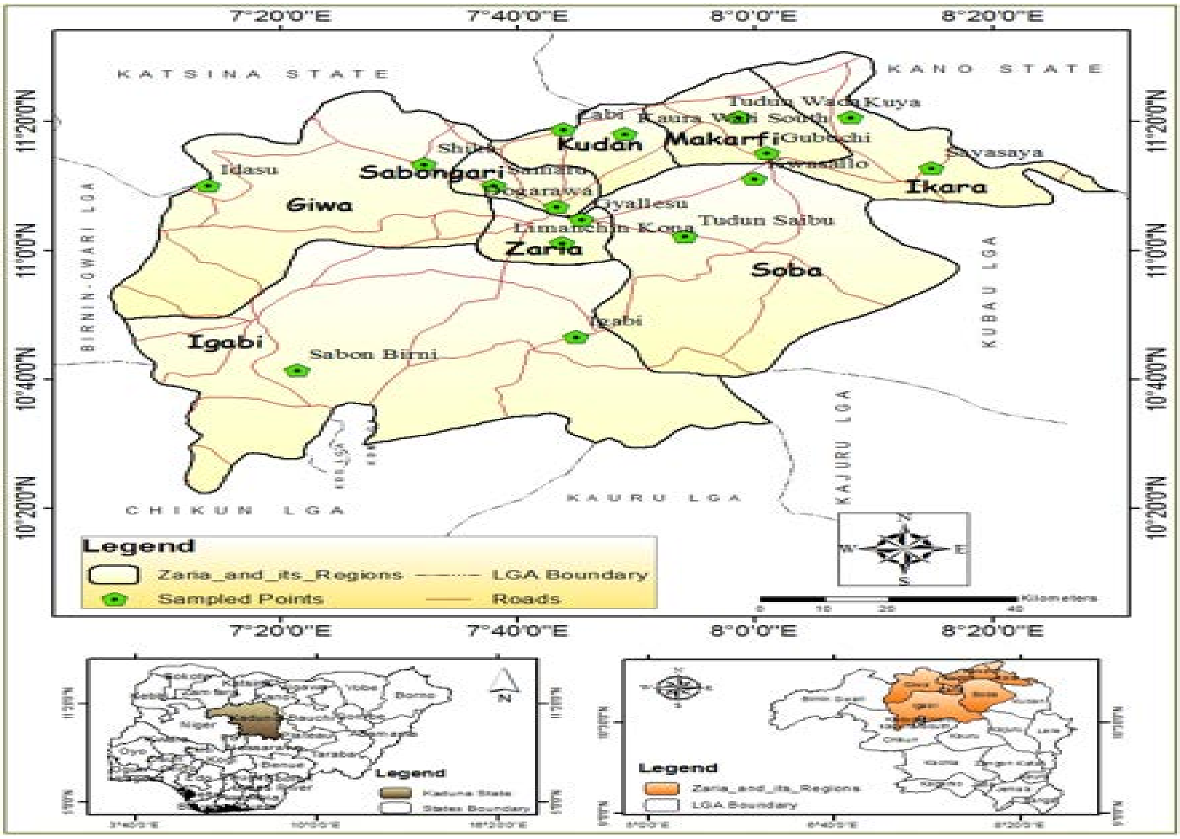


Figure 1: Study area showing the sampling points
Source: Adapted from administrative map of Kaduna State

Zaria and its Regions belongs to the tropical continental type of climate corresponding to Koppen's tropical savannah or tropical wet and dry climate zone (Aw), characterized by strong seasonality in rainfall and temperature distributions. It has two distinct seasons: the dry or harmattan season (October to March) and wet season (April to September) (Kowal and Kassam, 1978). The geology of the study area is part of the basement complex geology of central Nigeria. It is composed of older high grade metamorphosed gneiss interspersed by belt of young metasediment of mainly quartzite and schist. The region is underlain by older granitic crystalline, metamorphic rocks of Precambrian to low Paleozoic age (Oguntoyinbo, 1978). The soil type of Zaria and its Regions is reddish ferruginous in nature. The lower part of the soil is derived in situ from underlying weathered gneiss and still contains pieces of quartz and mica (Klinkenberg, 1970).

The natural environment in which Zaria and its Regions lies is termed by plant-geographers the Northern Guinea Savannah zone, a designation which implies a woodland vegetation type characterized by the presence of *Isoberlinia doka*, *Isoberlinia tomentosa* and *Upaca togonensis*, with well developed grass layer of tufted and low ground cover of *Andropogoneae* (Jackson, 1970). According to the National Population Census (NPC) (2006) Zaria and its Regions has population of 2,184,172 people and this was projected to 2014 which gave total figures of 2,767,343 people using a geometric method of population projection as presented below (see Table 2) for the type of trees use in the study area (Zaria and its regions):

$$Pt = Po\ (1 + r)^{n}$$

Where: **Pt** = population of the year i.e. 2016

Po = previous population i.e. 2006

r = growth rate i.e. 3%

n = interval between **Pt&Po** i.e. 10years

2. MATERIALS AND METHODS

In-depth interview was conducted to target concerned end users and sellers of fuelwood. Questionnaire was administered to respondents across the area that is Zaria, Sabon Gari, Giwa, Kudan, Makarfi, Ikara, Soba and Igabi using the Krejcie and Morgan (1970) method of determination of the sample size who recommended that for a population size of between 1,000,000 and above, a sample size of 384 should be taken. The proportion of questionnaire was administered to respondents based on the population size (the higher the population, the higher the sample size allocated to each area) using a formula below and presented in Table 1.

The number of questionnaire to be administered will be proportionate to the population of each area. Thus: Proportion $=\frac{n}{N} \times 384$

Where: **n** = population of the area

N = total population of the areas

A systematic sampling technique was employed in selecting the wards from each LGA that make up of the study area. List of wards of every LGA were arranged alphabetically and every fifth ward was chosen as a sample for the questionnaire administration and a total of sixteen wards were chosen i.e. two wards from each LGA's (See Table 2 and Figure 2).

Table 1: Population Size by Local Government Area

Areas	Population (2006)	Projected population (2016)	Sample Size	Percentage (%)
Giwa	286,427	383,812	50	13
Igabi	430,229	576,507	76	20
Ikara	193,926	259,861	34	9
Kudan	138,992	186,249	24	6
Makarfi	146,259	195,987	26	7
Sabon Gari	286,871	384,407	50	13
Soba	293,270	392,982	52	14
Zaria	408,198	546,985	72	19
Total	**2,184,172**	**2,926,790**	**384**	**100**

Source: National Population Commission, 2006

Table 2: Study Population Showing the Selected Wards

LGA	S/No	WARD	LGA	S/No	WARD
GIWA	1	Danmahawayi	**MAKARFI**	1	Dan Damisa
	2	Galadimawa		2	Dan Guzuri
	3	Gangara		3	Gazara
	4	Giwa		4	Gimi
	5	**Idasu**		5	**Gubuchi**
	6	Kadage		6	Gwanki
	7	Kakangi		7	Makarfi
	8	Kidandan		8	Mayere

	9	Panhauya
	10	**Shika**
	11	Yakawada
IGABI	1	Apaka
	2	Birnin Yero
	3	Gadangayan
	4	Gwaraji
	5	**Igabi**
	6	Kerewa
	7	Kwarau
	8	Rigchikun
	9	Rigasa
	10	**Sabon Birni**
	11	Turunku
	12	Zangon Aya
IKARA	1	Auchan
	2	Ikara
	3	Janfalan
	4	Kurmin Kogi
	5	**Kuya**
	6	Paki
	7	Pala
	8	Rumi
	9	Saulawa
	10	**Sayasaya**
KUDAN	1	Doka
	2	Garu
	3	Hunkuyi
	4	Kauran Wali North
	5	**Kauran Wali South**
	6	Kudan
	7	Likoro
	8	Sabon Garin Hunkuyi
	9	Taba
	10	**Zabi**
	9	Nasarawan Doya
	10	**Tudun Wada**
SABON GARI	1	Ang. Gabas
	2	Basawa
	3	Bomo
	4	Chikaji
	5	**Dogarawa**
	6	Hanwa
	7	Jama'a
	8	Jushi
	9	Muchia
	10	**Samaru**
	11	Zabi
SOBA	1	Gamagira
	2	Garu
	3	Gimba
	4	Kinkiba
	5	**Kwasallo**
	6	Maigana
	7	Rahma
	8	Richifa
	9	Soba
	10	**Tudun Saibu**
	11	Turawa
ZARIA	1	Ang. Fatika
	2	Ang. Juma
	3	Dambo
	4	Dutsen Abba
	5	**Gyellesu**
	6	Kauran Sarki
	7	Kufena
	8	Kwarbai A
	9	Kwarbai B
	10	**Limancin Kona**
	11	Tudun Wada
	12	Tukur Tukur
	13	Wucicciri

Due to the absence of reliable population data/figures for the electoral wards in the study area, the number of questionnaires allocated to each LGA is shared equally among the selected two wards as shown in Table 3. The respondents for the main survey were selected randomly (by visiting as many households as possible in the sixteen electorate divisions) with no regard to any probability in the selection process. Therefore, the selection of the respondents was by chance, and only households that showed interest in responding to the questionnaire were interviewed. This kind of sampling was referred to as "convenience sampling" which Robson (2011) described as the most widely used, but the least satisfactory method of sampling.

Table 3: Selected Wards Showing Sample Size

ZARIA AND ITS REGIONS	S/No.	SELECTED WARDS	SAMPLE SIZE
GIWA	1	Idasu	25
	2	Shika	25
IGABI	3	Igabi	38
	4	Sabon Birni	38
IKARA	5	Kuya	17
	6	Sayasaya	17
KUDAN	7	Kauran Wali South	12
	8	Zabi	12
MAKARFI	9	Gubuchi	13
	10	Tudun Wada	13
SABON GARI	11	Dogarawa	25
	12	Samaru	25
SOBA	13	Kwasallo	26
	14	Tudun Saibu	26
ZARIA	15	Gyellesu	36
	16	Limancin Kona	36

3. RESULTS AND DISCUSSION

3.1 Socio-economic Characteristics of the Respondents

The socio-economic characteristics of the respondents were examined with respect to their age marital status, educational background, position in marriage, family size, primary occupation and income. Majority of the respondents (fuelwood buyers) were males while few of them were females constituting 84% and 16% respectively as indicated Table 4. This greater variation is in line with the religious and cultural ethics in the study areas where males serve as heads of the household except in some localities where females serve as household heads (either as widows or divorcee)s. This is also in line with the work of Abdul-Hadi (2009) who found that majority (75.8%) of the users/buyers of fuelwood during his survey where males. Age plays a critical role in the business of fuelwood because adult people are more likely to engage in the issues than dependent age group and the result confirm that age group between 40-49 years mostly partake in fuelwood utilization in Zaria across the regions.

Figure 2 illustrated that majority (77.3%) of the households in the area rely on fuelwood regardless of their economic or social status. However, economic status of the family and increasing family size was seen as an important indicator of fuelwood use in this study. In contrast, those households with less than 6 people have choices they can make.

Table 4: Socio-economic Characteristics of the Respondents

	REGIONS																	
	GIWA (N=50)		**IGABI (N=76)**		**IKARA (N=34)**		**KUDAN (N=24)**		**MAKARFI (N=26)**		**S/ GARI (N=50)**		**SOBA (N=52)**		**ZARIA (N=72)**		**CUMMULATIVE DATA**	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
Sex																		
Male	47	94	63	83	27	79	24	100	19	73	41	82	41	79	61	85	**323**	**84**
Female	3	6	13	17	7	21	-	-	7	27	9	18	11	21	11	15	**61**	**16**
Age																		
20 – 29	6	12	14	18	6	18	3	12.5	4	15	9	18	16	30.7	23	32	**81**	**20**
30 – 39	13	26	18	24	9	26	6	25	7	27	11	22	12	23	19	26	**95**	**25**
40 – 49	21	42	31	41	15	44	9	39.5	11	42	19	38	16	30.7	23	32	**145**	**38**
50 – 59	7	14	10	13	2	6	3	12.5	3	12	7	14	5	9.6	5	7	**42**	**11**
60 above	3	6	3	4	2	6	3	12.5	1	4	4	8	3	6	2	3	**21**	**5**
Literacy level																		
Adult literacy	15	30	12	16	10	29	8	33	5	19	7	14	17	33	10	14	**84**	**21.9**
Primary	15	30	20	26	9	26	4	17	7	27	19	38	13	25	23	32	**110**	**28.6**
Secondary	5	10	27	36	6	18	3	13	3	11	11	22	8	15	21	29	**84**	**21.9**
Tertiary	7	14	17	22	4	12	2	8	2	8	9	18	3	6	13	18	**57**	**14.8**
No formal	8	16	-	-	5	15	7	29	9	35	4	8	11	21	5	7	**49**	**12.8**
Occupation																		
Farming	23	46	21	28	14	41	16	67	17	65	9	18	21	40	17	24	**138**	**36**
Business	11	22	20	26	7	21	4	17	3	12	19	38	19	37	27	37	**110**	**29**
Civil service	9	18	28	37	9	26	3	12	5	19	15	30	9	17	23	32	**101**	**26**
Others	7	14	7	9	4	12	1	4	1	4	7	14	3	6	5	7	**35**	**9**
Income (₦)																		
< 18, 000	19	38	13	17	15	44.1	7	29	9	35	13	26	11	21.2	15	21	**102**	**27**
18,000-27,000	9	18	11	14.5	4	11.8	9	38	5	19	14	28	13	25	15	21	**80**	**21**
28,000-37,000	11	22	8	11	3	8.8	5	21	5	19	7	14	9	17.3	11	15	**59**	**15**
38,000-47,000	7	14	30	39.5	7	20.6	-	-	3	12	2	4	8	15.4	15	21	**72**	**19**
48,000 above	4	8	14	18	5	14.7	3	12	4	15	14	28	11	21.2	16	22	**71**	**18**
Family size																		
1 – 5	7	14	14	18	5	15	3	12	4	15	11	22	11	21	12	16.7	**67**	**17**
6 – 10	13	26	9	12	3	9	7	29	3	11.5	9	18	9	17	9	12.5	**62**	**16**
11 – 15	11	22	23	30	10	29	9	18	9	35	12	24	23	44	25	34.7	**122**	**32**
16 – 20	9	18	17	22	13	38	4	17	7	27	9	18	4	8	9	12.5	**72**	**19**
21 above	10	20	13	17	3	9	1	4	3	11.5	9	18	5	10	17	23.6	**61**	**16**

It was also found that level of education was significant and had positive relationship with quantity of fuelwood demanded. The positive relationship is consistent with a prior expectation which implies that an attainment of higher level of education might make an individual consume less of fuelwood as a result of accepting alternatives energy sources such as kerosene and cooking gas etc. The results further showed that majority (28.6%) of the respondents (buyers of fuelwood) were primary school leavers.

Table 4 also showed that in most cases, occupation determines the level of income of a person though there is a link between occupation of people and type of energy they use. That is, the higher the occupation the higher the income and thus affects the types of energy used. The result also shows that majority (36%) of the fuelwood buyers/users were farmers and does not have any kind of activity apart from it. Income which is a major factor determining the living standard, hence household energy has correlation with standard of living as indicated in Table 4. The Zaria and its regions comprise of eight LGAs in which their income level varies across the LGAs from ₦18,000 to ₦48,000. The 18% of the respondents found with very high income are basically government officials. Table 4 also explains that majority (27%) of the respondents earn less than ₦18,000 monthly which is below the national minimum wage. Only 18% of the respondents earn above ₦48,000 monthly and this is due to the nature of their employment, as most of them were farmers and business men and women.

However, it can be observed from Table 4 that lack of capital, inadequate support from the government, unemployment coupled with poor economic and commercial spirit discourages major investments which eventually affects income level and standard of living of most of the respondents in the study area; which also make them to rely solely and as well expend reasonable amount of their income on purchase of fuelwood. Naibbi (2013) also had a similar finding in Northeastern Nigeria where majority of the respondents are below the minimum wage earners.

Table 4 revealed that the cumulative household size among the majority in Zaria and its Regions is 11-15 people which constitutes 32%, followed by 19% of the respondents which had a size of between 16-20 people per household; then 17% with a size of between 1-5 people per household; and lastly households with sizes of 6-10 and above 21 people per household which constitute 16% each respectively. It is observed from Table 4 that, there is an association between fuelwood use and larger households, this is because the larger the size of the house, the larger the quantity of fuelwood used in a particular household.

The implication of the large household size is that the family might spend more on conventional energy sources and this would make them go for fuelwood, the one that is considered cheaper and as such it was confirmed that all household with family sizes of less than 6 people in the households do not use fuelwood for their cooking. In contrast, all households with more than 6 people use fuelwood for their cooking. This is in line with the finding of Naibbi (2013) even though it is expected because is different geographical area.

3.2 Fuelwood as a Major Source of Energy

The rate at which trees are felled is by far more than the rate at which they are planted, and this is due largely to high demand for the commodity brought about by soaring prices of kerosene and gas used for domestic energy. Many households remain subsistently dependent on fuelwood due to socio-economic (e.g income and wealth), demographic (e.g. family size, household composition, lifestyle and culture) and location attributes (e.g. proximity to sources of modern and traditional fuels) in addition to fuelwood availability (Dovie et al., 2004; Onoja, 2012). The over dependence on the use of fuelwood in the study area was the product of numerous issues concerning fossil fuel supply and affordability as well as income and size of the of the household.

Results of this study showed that fuelwood is the major energy used by the households which account for 77.3% of the total respondents, followed by kerosene with 10.4%, and coal with 6%, while others (saw dust, crop residue, and animal dung), electricity and gas accounted for 4%, 1.3% and 1% respectively. Even though the use of charcoal for cooking was reported by only a few households (6%) who cook for less than 6 people, the majority have indicated that they use it in conjunction with fuelwood. Alabe (1996) reported a similar findings within the study area about two decades ago, where he noted that charcoal was extensively used among households during the harmattan season for heating, while some few households (with small families) also use it to cook. Although the use of charcoal for cooking among the majority of its users in the study area was for complementary purpose, it is also worth noting that charcoal use in the area is now gaining popularity among the small households. This is likely due to the size of the charcoal cooking stoves used among households in the study area as highlighted by a few households that uses it (normally small in size and can only be used with small cooking pots).

Similarly, a few households in this study also reported that they use animal dung and the stalks from their crop residues during the dry season to complement fuelwood supply. It can be argued that its use is more confined to the rural areas. Apart from using fuelwood for cooking, most households also use modern cooking fuels such as kerosene-10.4%, gas-1% and electricity-1.3% in conjunction with fuelwood. The majority of the households (77.3%) indicated that they use kerosene for starting the fire (when cooking with fuelwood) especially in the rainy seasons. Other items such as polythene bags, scraps of plastic pieces and papers are also used for starting the fire by the same 77.3% of the respondents. The use of electricity was next to kerosene in the study area in terms of importance followed by gas as showed earlier which account for 1.3%, 10.4% and 1% respectively. However, the provision of these fuels in Nigeria is insufficient, which is part of the reasons why none of the fossil fuels were used in isolation without complementing it with fuelwood in the study area (see Figure 2).

Also, fuelwood appeared to be the only form of cooking energy that can serve the needs of even the poor and households with large population, as demonstrated by many households in the study area. Additionally, with the recent withdrawal of fuel subsidy in Nigeria in January 2012, the prices of fossil fuel soared; this has the implication of committing more people to depend even more on fuelwood. Therefore, in the future, if the situation does not change, it is likely that the vegetation in the study area would decline further and the adverse effect of this is borne by the environment in the form of deforestation.

3.3 Reasons for the Choice of Fuelwood

Findings revealed that the majority (77.3%) of households relied on fuelwood for two main reasons: the economic situation in the country, and; unreliability in the supply of modern cooking fuels. The result further showed that cheaper; affordability and availability were the major factors responsible for fuelwood consumption in the regions which are represented as 64%, 8.8% and 5% respectively as shown in Figure 2.

Given the current status of the country's weak infrastructure, economic development (Eroke, 2012) and lack of alternative energy sources (Maconachie et al., 2009), the price of fuelwood is far less than that of the alternative energy sources of kerosene, gas and electricity which is why most people depend on fuelwood as their only cooking fuel option (Casse et al., 2004). Although, some authorities have argued that the use of fuelwood is largely found in lower income families in the developing countirs (Adelekan and Jerome, 2006; Kowsari and Zerriffi, 2011 and Sovacool, 2011), which contrasts with the ways fuelwood is being used in the developed countries. Couture et al.'s (2012) study of the use of fuelwood for heating among families in France shows a reverse relationship between fuelwood use and income, because affluent families use fuelwood for pleasure rather than for necessity. The present findings contrast with both these studies, because the difference between the rich and the poor in terms of fuelwood use is negligible, especially in the northern states of Nigeria, where even the affluent families, have to rely on fuelwood for their cooking, due to the shortage of modern fuel supply (Maconachie et al., 2009). As observed earlier by Cline-cole et al. (1987); Mortimore (1990); Alabe (1996); Casse et al. (2004); Maconachie et al. (2009); and Arabatzis et al. (2012).

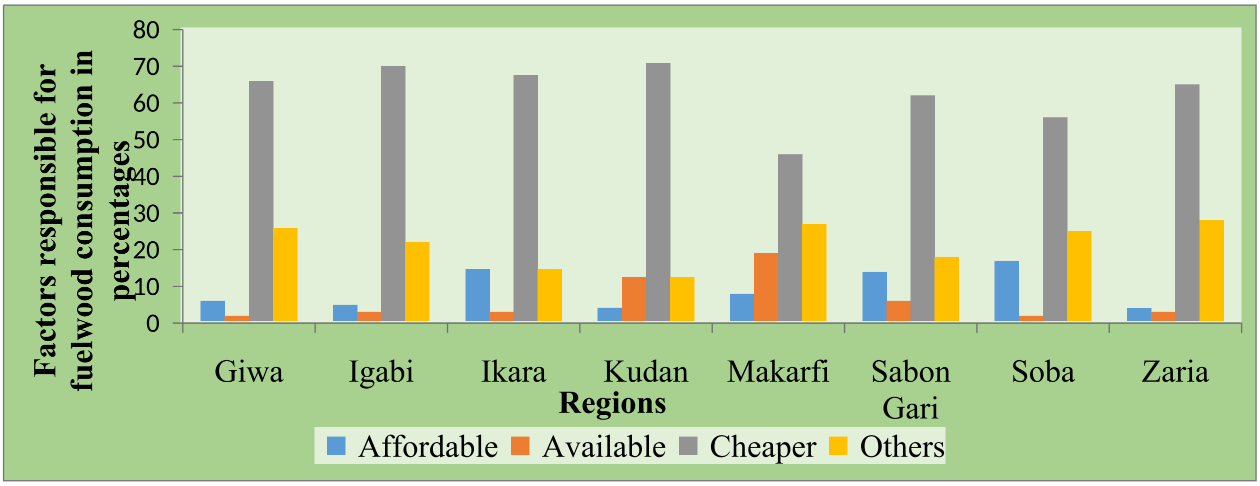


Figure 2: Reasons for the choice of fuelwood

The economic situation lies with the

fact that the majority of households are low and minimum wage earners (see Table 4) which places them in a vulnerable economic situation given that the prices of modern cooking fuels are always on the rise, with no substantial improvement in the economic situation of the households. The economic situation of households together with the irregular supply of fossil fuels in the northern part of Nigeria due to many factors, were among the reasons for the high dependence on fuelwood in the study area (Cline-cole et al., 1987 and 1988; Nichol, 1990; Hyman, 1994; Alabe, 1996; Odihi, 2003 and Maconachie et al., 2009). The unreliability in the supply of fossil fuel to the study area is similar to that of Kano and many other northern parts of Nigeria.

3.4 Species of Preference in Fuelwood Business

The prefered type of wood species used for fuelwood are presented in Table 5, although the households have no choices of their preferred fuelwood type, the most preferred species of tree among others are: *prosopis Africana, Anogeissus leicarpus, Guiera senegalensis, Piliostigma reticulatum, Combretum and Bauhinia rufescens.* These species are preferred because of their high quality in terms of heat output, good combustion and their potential to produce less smoke even when they are wet (during rainy season) (Alabe, 1996). However, amongst some households in Idasu village (Giwa LGA) and Sabon birni (Igabi LGA), there are those who believed that neem tree, referred to as "Dogon yaro" by the Hausa people, is a tree in the mahogany family with broad dark brown stem and widely spread branches, "*it can easily be established without irrigation in Northern Nigeria and grows rapidly, providing fuel and timber in just about 5-7 years..... and unlike most other native trees and shrubs in Africa, the neem trees are seldom damaged by wandering animals*" (Radwanski, 1969). The tree was introduced to Northern Nigeria through the government afforestation programme in order to prevent desertification and to provide shades in the towns (Odihi, 2003).

Table 5: Species preference for use and sell

Hausa Name (Local Name)	Botanical Name	English Name
Adduwa	*Balanites aegyptiaca*	Desert date
Baushe	*Terminalia spp*	-
Chediya	*Ficus thonningii*	-
Doka	*Isobalina doka*	
Dorawa	*Parkia biglobosa*	Locust tree
Gawo	*Faidherbia albida*	Winter thorn
Kanya	*Diospyros mespiliformis*	West African Ebony
Kargo	*Piliostigma reticulatum; p.thonningii*	-
Kirya	*Prosopis Africana*	False locust
Dogon yaro	*Azadirachata indica*	Neem tree
Madachi	*Khaya senegalensis*	Mahogany
Makarho	*Daniella olivera*	-
Malga	*Mangnifera*	-
Mangoro	*Magnefera indica*	Mango tree
Marke	*Anogeissus leiocarpus*	Chewstick tree
Sabara	*Guiera senegalensis*	-
Taura	*Datarium microcarpum*	-
Tsamiya	*Tamarindus indica*	Tamarind
Wuyan damo	*Combretum molle; c.glutinosum*	-

Source: Field Survey, 2016; Names confirmed from Naibbi (2013)

However, given its high potential of growing very fast in the arid areas, neem tree is now gaining much popularity among households who mentioned it as being an important fuelwood source. It is worth mentioning that the neem tree also has other economic benefits among households in Nigeria through its numerous potential by-products (medicines, factory chemicals, oil etc) (refer to Radwanski, 1969 and Salako et al., 2008, for more details on the economic potential of the neem tree).

3.5 Number of Years Spent in Fuelwood Usage

The variations in the number of years spent on fuelwood use among households were presented in Figure 3. It shows that 5% of the households (fuelwood users) have been using the wood as a fuel between 1-10years, 14% of them said they spent about 11-20years, 12% of them said they spent about 21-30years, 46% of them said they have been using for the period of over 30years while 23% were others (those using either gas, charcoal, electricity etc). However, the increasing use and the large number of fuelwood users is an indication that by the next few decades, the entire vegetation cover will be exhausted. This is so because population is increasing while demand for fuelwood is also increasing without adequate replacement of the wood. A similar finding was reported by by Naibbi (2013) in Northwestern Nigeria.

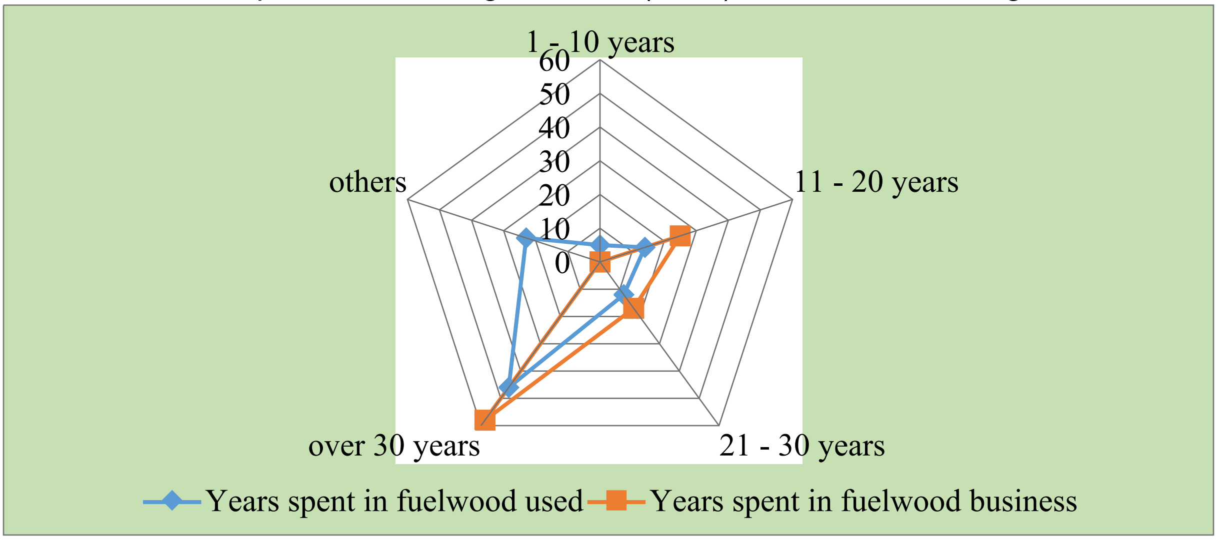


Figure 3: Number of Years Spent in Fuelwood Usage as Well as Business

3.6 Number of Years Spent in Fuelwood Business

It was found that those in the business constitute 25% vendors who spent about 11-20years in selling fuelwood, 17% and 58% of them (vendors) said they were in the business for 21-30 and over 30 years respectively. Some of these vendors claimed that they found themselves in this business just because of the rate of unemployment, which made it their primary activities so that they will take care of themselves and their families as well. Others claimed that they inherit the business directly from their fathers and they also mentioned that they were in the business since their childhood. However, they also reported that because of the availability and cheap rate of fuelwood as well as the increasing population which lead to increase in fuelwood consumption, they had to travel far distance in procuring the wood compared ot the situation in the past few decades where fuelwood can be found within a short distance.

4. CONCLUSION

Majority of the people in the study area predominantly use fuelwood for their cooking. The major factors that determine the demand for fuelwood by the majority of the people is cheaper, affordable and available which coupled with the economic status of households (income, size of household and levels of education) having strong influence on the propensity to demand for fuelwood. Other factor is related to the low supply of fossil fuel in the region.

4.1 Recommendations

There is urgent need for government to provide cheap, reliable and affordable sources of energy like kerosene, electricity, solar energy and cooking gas at affordable prices so as to avert the reliance on fuelwood with its related negative effects on the environment. Also, cultivation of fast growing tree species is needed to accelerate the regeneration of forests.

REFERENCES

Abdul-Hadi, A. D. (2009). Examine *the Household Consumption Rate of Woodfuel in Zaria City Township.* Unpublished B.Sc Project, Department of Geography, Ahmadu Bello University, Zaria.

Alabe, M. (1996). Household Energy Consumption Patterns in Northern Nigeria. *Energy for Sustainable Development. Vol II*. No.5.

Adelekan, I.O. & Jerome, A.T. (2006). Dynamics of Household Energy Consumption in a Traditional African City, Ibadan. *Environmentalist, 26:* 99–110.

Ali, J. and Benjaminsen, T. A. (2004). Fuelwood, Timber and Deforestation in the Himalayas - The case of Basho Valley, Baltistan Region, Pakistan. *Mountain Research and Development, 24*(4): 312-318.

Casse, T., Milhøj, A., Ranaivoson , S. & Randriamanarivo, J.R. (2004). Causes of Deforestation in Southwestern Madagascar: What do we know? *Forest Policy and Economics, 6:* 33–48.

Cline-Cole, R. A., Falola, J. A., Main, H. A. C., Mortimore, M. J., Nichol, J. E. and O'Reilly, F. D. (1987). Wood Fuel in Kano, Final Report of the Rural Energy Research Project. Bayero University, Kano, Nigeria. Report Submitted to the United Nations University Development Studies Division.

Couture, S., Garcia, S. & Reynaud. A. (2012). Household Energy Choices and Fuelwood Consumption: An Econometric Approach Using French Data. *Energy Economics,* 34:1972–1981

Dovie, D. B. K; Witkowski, E. T. F. and Shackleton, C. M. (2004). The fuelwood crisis in Southern Africa: relating fuelwood use to livelihoods in a rural village, *Geo- Journal. 60:* 123-139.

Eroke, L. (2012). 20.3 Million Nigerians Currently Unemployed, Statistics Reveal. *Thisday Newspaper*, 8/10/2012 edition.

Ghilardi, A., Guerrero, G., & Masera,O. (2007). Spatial analysis of residential fuelwood supply and demand patterns in Mexico using the WISDOM approach. *Biomass & Bioenergy, 31*(7), 475-491.

Ghilardi , A., Guerrero, G. and Masera ,O. (2009). A GIS-Based Methodology for Highlighting Fuelwood Supply/Demand Imbalances at the Local Level: A Case Study for Central Mexico. *Biomass Bioenergy, 33*(6-7): 957-972.

Hyman, E. L. (1994). Fuel Substitution and Efficient Woodstoves - Are they the Answers to the Fuelwood Supply Problem in Northern Nigeria. *Environmental Management, 18*(1): 23-32.

International Energy Agency (IEA) (2013). Energy for all: Financing Access for the Poor – Special Early Excerpt of the World Energy Outlook 2013. OECD/IEA, Paris.

International Energy Association (IEA) (2014). World Energy Outlook In- International Energy Agency, Paris, Pp. 533 http://www.iea.org/textbase/nppdf/ free/2000/weo2002.pdf.

Jackson, G. (1970), "Vegetation" In Mortimore, M.J. (Ed.)*Zaria and Its Region: A Nigerian Savannah City and Its Environs*. Occasional Paper No. 4, Department of Geography, Ahamdu Bello University, Zaria.

Klinkenberg, K. (1970). "Soils" In Mortimore, M.J. (Ed.) *Zaria and Its Region: A Nigerian Savannah City and Its Environs*. Occasional Paper No. 4, Department of Geography, Ahamdu Bello University, Zaria.

Kowal, J. M. and Kassam, A. H. (1978). *Agricultural Ecology of Savanna: A Study of West Africa.* Oxford University Press. London.

Kowsari, R. & Zerriffi, H. (2011). Three Dimensional Energy Profile: A Conceptual Framework for Assessing Household Energy Use. *Energy Policy, 39:*7505–7517.

Kreijcie, R. V. and Morgan, D. W. (1970). Determining Sample Size for Research Activities. *Journal of Educational and Psychological Measurement.* Pp 607-610.

Maconachie, R., Tanko, A. and Zakariya, M. (2009). Descending the Energy Ladder? Oil Price Shocks and Domestic Fuel Choices in Kano, Nigeria. *Land Use Policy, 26* (4): 1090-1099.

Mortimore, M. J. (1970). *Zaria and its Region:* Ahmadu Bello University, Zaria. Department of Geography, Occasional Paper, No 4: Pp. 132.

Mortimore, M. J. (1990). *Policy issues.* In R. A. Cline-Cole et al. (Eds.), Wood Fuel in Kano. Tokyo: United Nations University Press.

Naibbi, A. I. (2013). *Fuelwood and Vegetation Change in Northern Nigeria: An Exploration Using Remote Sensing (RS), Geographical Information Systems (GIS) and Field Reports.* Unpublished Ph.D. Thesis Submitted in Partial Fulfillment of the Requirements for the Award of the Degree of Doctor of Philosophy of the University of Portsmouth, UK.

National Population Commission (NPC) (2006) *Census Report. Nigerian Statistics Annual Report.*

Nichol, J. E. (1990). Dynamics of Indigenous Fuelwood Production Systems - An Analysis of Kano, Nigeria. *Singapore Journal of Tropical Geography, 11*(1): 43-55.

Odihi, J. (2003). Deforestation in Afforestation Priority Zone in Sudano-Sahelian Nigeria. *Applied Geography, 23:* 227-259.

Ogbonnikan, F. (2012). *6 More Marketers Arrested Over N23.6bn Fuel Subsidy Scam.* Leadership newspaper, 17/11/2012 edition.

Olise M. and Nria-Dappa, T. (2009). *Overcoming Nigeria's Energy Crisis: Towards Effective Utilisation of Associated Gas and Renewable Energy Resources in the Niger Delta.* Social Development Integrated Centre Social Action Briefing No. 2. Port Harcourt, Nigeria. www.saction.org - accessed 10/07/ 2011.

Onoja, A. O. (2012). Econometric Analysis of Factors Influencing Fuelwood Demand in Rural and Peri-Urban Farm Households in Kogi State, Nigeria. *The Journal of Sustainable Development, 8*(1):115 – 127.

Radwanski, S. A. (1969). Improvement of Red Acid Sands by the Neem Tree (*azadirachta indica*) in Sokoto, North- Western state of Nigeria. *Journal of Applied Ecology, 6(3):* 507-511.

Robson, C. (2011). *Real World Research: A Resource for Users of Social Research Method in Applied Settings.* 3rd Edition, Chichester, UK , John Wiley & Sons Ltd.

Salako, E. A., Anjorin, S. T., Garba, C. D. & Omolohunnu, E. Z. (2008). A review of Neem Biopesticide Utilization and Challenges in Central Northern Nigeria. *African Journal of Biotechnology, 7 (25)*: 4758-4764.

Sambo, A. S. (2008). *Renewable Energy Options for the Environment and Sustainable Development in Nigeria.* Paper Presented at the National Workshop on Energy Investment and Private Sector and Participation at the Petroleum Training Institute, Warri.

Shackleton, C.M.; McConnachie, M.; Chauke, M. I.; Mentz, J.; Sutherland, F.; Gambiza, J. and Jones, R. (2006). Urban Fuelwood Demand and Markets in a Small Town in South Africa: Livelihood Vulnerability and Alien Plant Control. *International Journal of Sustainable Development and World Ecology, 13*(6): 481-491

Sovacool, B.K. (2011). Security of Energy Services and uses Within Urban Households. *Current Opinion in Environmental Sustainability, 3:*218 – 224

Tsan, A. & Odemwingie, E. (2013). Ministries, CBN Boycott House SURE- P Probe. *Leadership Newspaper*, 23/01/2013 edition.

Wright, J. B. and McCurry, P. (1970). Geology of Zaria. In Mortimore, M. J. (Ed), *Zaria and its Regions*. Occasional Paper 4, Department of Geography, A.B.U., Zaria.

World Bank (WB) (2014). Nigeria Economic Report: Document of the World Bank.

Savanna volume 23, Number 1, June, 2016

Quantifying Household Energy Consumption in Kano Metropolis, Nigeria

Abdul-Hakim Ibrahim Kiyawa[1]*, Ibrahim Yakubu[1] and Muhammad Nuraddeen Danjuma[2]
[1]*Department of Environmental Management, Bayero University Kano*
[2]*Department of Geography, Bayero University Kano*
*aikiyawa.em@buk.edu.ng

ABSTRACT

This study quantified household energy consumption in Kano metropolis. Clustered sampling technique was employed to categorise the study area into different residential zones on the basis of socio-economic status and residential density, while systematic sampling technique was used to select households at specific intervals, resulting to 528 sampled households. Wood fuel, charcoal and gas were measured in kilogram, while kerosene was measured in litres. At household level, questionnaire was used to get information on the quantity of energy consumption. The study estimated a mean monthly consumption of wood fuel per household at 83.8 kg, with a mean expenditure of 1528 Naira (NGN). Kerosene was estimated at 22.7 litres with an expenditure of 3519.2 Naira per household. The quantity of charcoal consumption and expenditure was found to be 19.02 kg and 1389.1 Naira respectively, while gas consumption and expenditure was estimated at 12.97 kg and 3093 naira. The findings therefore showed a major decrease in the quantity of wood fuel consumption over the period of study. However, the expenditure on it has risen due to the declining value of the Naira. The study concluded that, although, the consumption of wood fuel has decreased drastically, the amount of consumption is still significant, and this might result to the continuous depletion of forest resources and indoor air pollution, which can lead to health problems. Therefore, the study recommends: the use of the newly designed charcoal and wood fuel efficient stoves (capable of saving up to 40 to 60% of energy with less smoke), especially among the very low income earners who cannot afford cleaner sources of energy, and the use of renewable energy.

Keywords: Household; Energy Consumption; Quantity; Expenditure.

1. INTRODUCTION

Energy is central to nearly every major challenge and opportunity the world faces today. Be it for jobs, security, climate change, food production or increasing incomes. Access to energy for all is essential (United Nations Convention to Combat Desertification, 2015). According to International Energy Agency (2008), the residential sector accounts for 36% of global energy consumption. However, the amount of energy consumed in the various sectors of the economy varies from country to country and according to level of development (Yakubu, 2014). For instance, Enger and Smith (2004) reported that the industrialized nations used energy equally within three sectors: residential, transportation and industrial, as against the predominant use of energy for residential purpose (cooking and heating) by the less developed countries. They gave example of 30% of the energy used in North America going to the residential and commercial sector as against the 90% in India going to the residential sector. Similarly, Dzioubinski and Chipman (1999) stated that household sector is responsible for about 15 to 25% of primary energy use in Organization for Economic Cooperation and Development (OECD) countries; while the European Environmental Agency (EEA) in 2008 revealed that households consume 25% of the total energy in the European Union (EU). In the same vein, Faiella (2011) carried out a research on the pattern of household energy consumption using the Italian Household Budget Survey (HBS) and revealed that Italian households use about 20% of the energy available for final use in the country, excluding private transportation, 0.472 tons of oil equivalent (toe) per individual.

In contrast, residential sector in developing countries accounts for 80% of total energy consumption, with cooking energy accounting for about 95% of this (Yakub et al., 2012). This consumption includes high rates of biomass fuel use on a relatively inefficient basis in rural regions, but even in highly urbanised settings, the residential sector can still account for over half of the total energy use (Bensel and Remedio, 1995). While biomass demand comes mostly from the power generation and industrial sectors in OECD countries, in developing countries, these sectors represent only 12% (IEA, 2006). According to Bensel and Remedio (1995), the largest portion of residential sector energy use in developing countries goes towards food preparation, which accounts for 85% of the total in Brazil, 91% in India, and 97% in Kenya. Household use of biomass in developing countries alone accounts for almost 7% of the world's primary energy demand (IEA, 2006). According to available figures, household energy use in developing countries totalled 1 090 Mtoe in 2004, almost 10% of world primary energy demand, and it is projected to rise from 771 Mtoe in 2004 to 818 Mtoe in 2030 (IEA, 2006).

An analysis of energy composition and consumption in Nigeria is more revealing. For example, Isah et al., (2016) reported that on household wood fuel consumption by country, Nigeria ranks 4th with 129,944,069.4 m^3 consumed annually. Due to varying factors, the country for instance is reported to be using 80 million m^3 (43.4 x 109kg) of woodfuel annually (Isah et al., 2012; Na'ibbi and Healey, 2014). In Nigeria, per capita energy consumption is about 0.284 t/person/year, that is, about 0.776 kg/day (Zaku et al., 2013). In Kaduna State, Zaku et al., (2013) reported a consumption of 1,722,904 t/year. In neighbouring Katsina State, Hassan and Yakubu (2010) reported the use of wood fuel and charcoal in large quantity despite modernisation of the city.

Kano state as the most populous state in northern Nigeria has been identified as the most commercial and industrial hub of the region, as well as having the most diversified energy market (Cline-Cole et al., 2016). Attempts have been made by some previous studies to quantify the consumption level of household energy in the study area. For instance, Cline-Cole et al. (1990) estimated a mean monthly consumption of wood fuel in 80 households to be 332 kg by weight, with a mean monthly cost per household being ₦24.66. According to Yakubu (2014) wood fuel consumption per person has been estimated to be 372 kg per year, with a total consumption of metropolitan Kano estimated to be 383,000m^3 in 2010. Although these studies have made attempt to estimate the level of household energy consumption (particularly wood fuel) in the study area, continuous increase in population (resulting from the increasing number of immigrants and expansion of the metropolis) would mean more amount of energy to be consumed. Therefore, this study examined the current level of household energy consumption in Kano metropolis with a view to making comparison with the study by Cline-Cole et al. (1990), which estimated the consumption level of the major forms of household energy in Kano Metropolis. This is done with a view to providing necessary information for policy intervention in the sector.

1.1 Study Area

Kano Metropolis is located between latitudes 12° 25′ and 12° 40′N and between longitudes 8° 35′N and 8° 45′E as shown in Figure 1. It is the largest, and among the fastest growing cities in Nigeria with an estimated population of 3.5 million (Nabegu, 2010). Comprising of eight (8) Local Government Areas (LGAs), it has a population density of about 1000 inhabitants per km² within the Kano close-settled zone compared to the national average of 267 inhabitants per km² (Nabegu, 2010). It is bordered by Minjibir LGA to the northeast and Gezawa LGA to the east, Dawakin Kudu LGA to the southeast, Madobi and Tofa LGAs to the southwest. The densely-populated metropolis also has the largest and most spatially-concentrated wood fuel consuming population market in northern Nigeria. The metropolis has long been seen to be socially and economically heterogeneous. In this regard, Cline-Cole et al., (1990) categorised the different socio-economic clusters that existed in the Metropolis which are highly relevant to energy use. These are: Birni (walled city), Gwagwarwa, Tudun Wada, Sabon-Gari, Gyadi-Gyadi, No man's land, Nassarawa, Institutions and Suburban neighbourhoods. To date, all of these exist and therefore used in this study in addition to others.

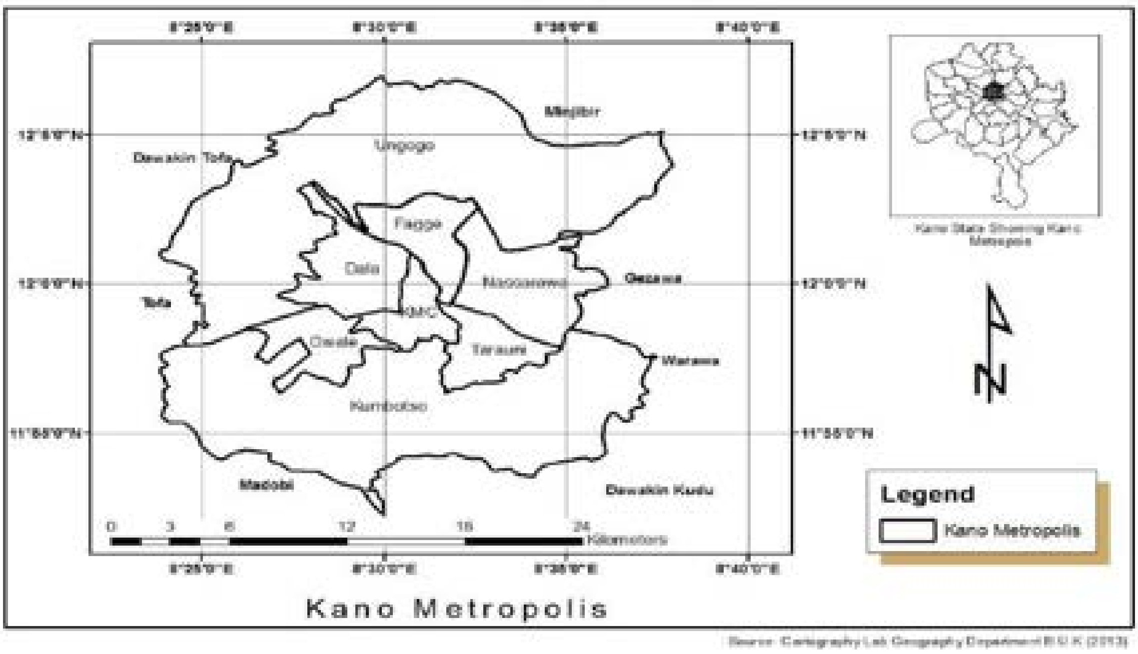


Figure 1: The Study Area

2. MATERIALS AND METHODS

The study is a field survey research as it involves sampling individual households on the field from a population, and quantifying the amount of their household energy consumption. It is also a comparative research as it involves making a comparison with a similar study conducted about thirty years ago.

2.1 Sampling Techniques

2.1.1 Procedure for Sampling of Study Locations

This work has partly adopted the method used by Cline-Cole et al.

(1990) in categorising the study area into different residential zones based on socio-economic factors. These divisions are still believed to persist, although with some few changes taking place over time. For example, Nassarawa Government Reservation Area, formerly a zone of Expatriates, is now dominated by the northern elites and few foreigners, but still retains its feature as a zone of high income earners, and as such, it is considered for this study. Also, those areas that were considered as sub-urban and or peri-urban villages such as Kurna-Asabe, Giginyu, have all been incorporated into the metropolis. Other areas such as: Mariri, Danbare, Dawanau and Challawa are now considered as the sub-urban areas. Here, Mariri was statistically selected to represent them. Additionally, Birni which was mainly a zone of Kano indigenes and other northerners was predominantly an unplanned settlement in the 1980s. Presently, this zone has evolved some planned settlements (e.g. portions of Gadon-Kaya, Sani Mainagge and Goron-Dutse) comprising of people with higher income than their neighbours in the unplanned areas. On the part of educational and other institutions, Bayero University Kano (staff houses) was purposely chosen to represent all institutions because it comprises the middle-class from almost every part of the country, with some foreigners as well.

Following these clustered divisions, Quickbird image of Kano metropolis with spatial resolution of 0.61m was utilised to define the locations and boundaries of each of these residential zones. Thereafter, grid cells of equal sizes were imposed on the image, which were given unique identifiers (numbers), giving a total of 156 grids for all the zones. Raosoft online software (2014) was used to determine the number of sample grids to be selected at a marginal error of 10% and confidence level of 90% from a grid population of 156. The result of sample calculation gave 48 grids (Table 1). The number of the sample grids (i.e. 48) was then distributed proportionally between the residential zones (clusters) (i.e. based on cluster size) using the formula below:

Number of samples for each cluster

$$= \frac{\text{number of grids for each cluster}}{\textit{total number of grids}} \times 48$$

Table 1: Grid Population and Sample per Location

Cluster	Grid Population	Grid Sample
Mariri	4	1
Gyadi-Gyadi	22	6
Sabon-Gari	16	5
No Man's Land	1	1
Gwagwarwa	2	1
Nassarawa	39	11
Institution (SSQ)	3	1
Tudun Wada	11	3
Birni (unplanned)	50	16
Birni (planned)	7	2

Institution (I and J)	1	1
Total	**156**	**48**

Random grid numbers were generated for each cluster using Microsoft Excel Office (2007). Thereafter, 10% of the households within each of the selected grids were selected for interview using a systematic random sampling, where each street (which cuts across residential areas) was given a number which was picked randomly and thereafter, the sample households were selected at an interval of 6 households in the high-density areas (due to the large number of households) and 3 in the other locations. With this, a total of 528 households were sampled. Thereafter Google Earth Software version 5 (2014) was used to get the relative locations of the households, thereby making it easier to locate them on the ground.

2.1.2 Procedure for Sampling of Respondents

Table 2 shows the number of sampled households for each of the residential zones. The selected residential zones, as well as their residential density and the sampled points are shown in Figure 1. For every household, the head was selected for interview due to the tradition of the Hausa land where housewives are prohibited from contact with strangers. In a case where the household head was not available, a male family representative was chosen. Also, in a situation where a single residential building contains multiple households, one of them was conveniently chosen.

2.2 Data Collection

A reconnaissance survey was first carried out to identify some locations of wood fuel, charcoal and gas sellers in the study area. Thereafter, weights of wood fuel, charcoal and coal were measured using scale at point of sale. This was used in getting the quantity of energy consumed by households. The quantity of woodfuel, charcoal and coal consumption was measured in kilogram, while kerosene was measured in litres. For the purpose of measuring wood fuel, this study selected the depot at Rijiyar Zaki. This is because the depot has three different wood bundle sizes, which were considered as; small, medium and big, unlike other major wood depots example Nassarawa GRA which has uniform sized wood bundles (Table 3 gives a summary of the types of wood bundles, as well as their prices, weight and quantity per bundle). For the charcoal, the size of the measuring can is uniform across all selling points. For this study, the 'Diga' charcoal selling point was selected. Similarly, same size gallon (4 litres) was used for measuring kerosene across all sellers. With regards to gas, measurement was taken from one of the most popular gas sellers in the metropolis (ultimate gas), whereby, about 6 different categories of gas cylinders were identified based on their weight (Table 4).

Table 2: Number of Sampled Households per Location

Location	Number of sampled households
Institution (I and J)	3

Mariri	27
Gyadi-Gyadi	95
Sabon-Gari	72
No Man's Land	27
Gwagwarwa	25
Nassarawa	53
Institution	8
Tudun Wada	40
Birni (planned)	37
Birni (unplanned)	141
Total	**528**

To determine the quantity and expenditure on energy types at household level, questionnaires were directly administered to the 528 households (respondents). Questions here were asked on how much cooking fuel is consumed on monthly basis. For instance, if a household uses woodfuel, the data sought was the number of wood bundle(s) used monthly (converted to kilogram). Households were also asked on the number of pieces per bundle and present a sample of the woodfuel used. This was done to know the category of woodfuel used. If a household uses kerosene, the data sought was the number of gallon(s) used daily (converted to litres). If a household uses gas, the information sought was the size and number of gas cylinders used monthly (converted to kilogram). Also, if a household uses charcoal/coal, the question asked was the size and number of charcoal/coal container "mudu" consumed monthly (converted to kilogram). Questions were asked in this manner for the convenience of the respondents. Also, a question regarding the amount spent on household energy was included with options given in range of amounts.

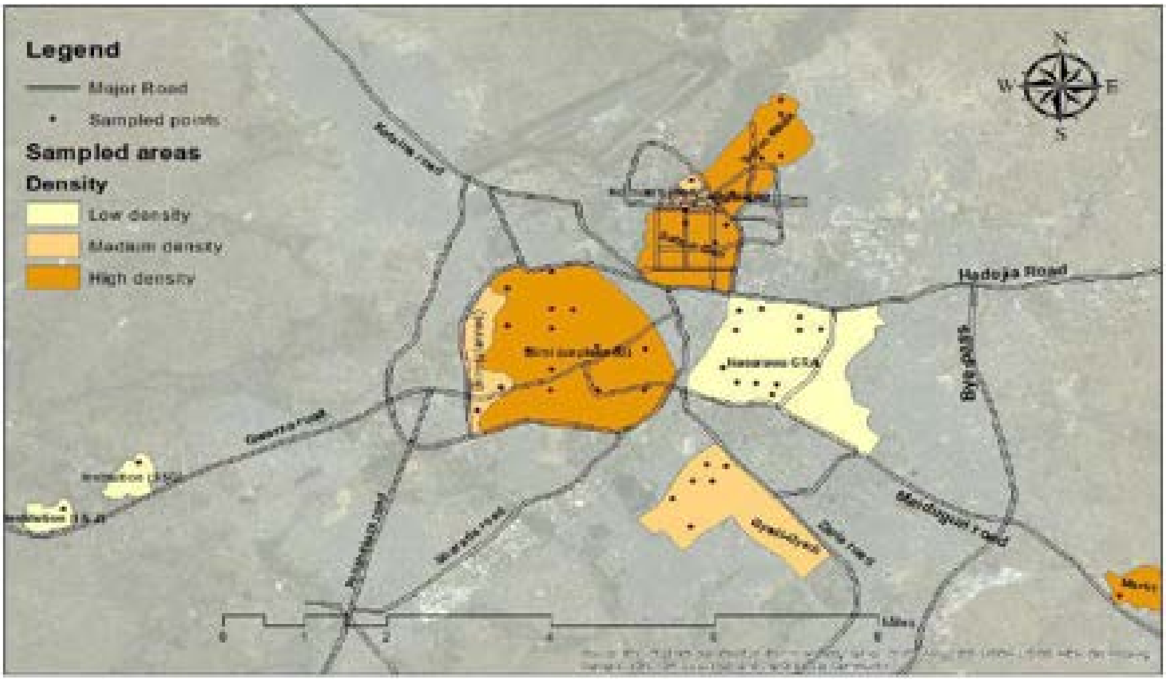


Figure 1: Selected Residential Zones in Kano Metropolis
Source: Google Earth/Fieldwork, 2014

3. RESULTS AND DISCUSSIONS

3.1 Level of Household Energy Consumption in Kano Metropolis

In this study, the mean monthly consumption of woodfuel for 185 households (including those who use it in conjunction with other forms of energy) was found to be 83.8 kg. Compared to the work of Yakubu (2014) who estimated a mean monthly consumption of woodfuel at 372kg, this study observed about 77% reduction in its usage and 74% reduction compared to the work of Cline Cole et al. (1990) which reported 332 kg. The mean monthly cost for woodfuel per household in this study was estimated at 1,528 Naira. This gives an increase in the mean monthly cost of expenditure in 1980s, which was estimated at 24.66 Naira. The reduction in the kilogram of wood consumed may be related to the increased use of kerosene and gas presently, while the increase in the expenditure estimated in this study might also be related to the rise in the cost of wood (and energy in general) and the depreciating value of the currency. Therefore, computing household's mean monthly cost on woodfuel with the government's minimum wage (₦18,000) implies that the low-waged households (which constitute the largest percentage of wood fuel users) spend 8% of their monthly income on woodfuel for cooking.

Table 3: Types of Woodfuel Bundles

Type of Wood Bundle	Weight	Cost	Quantity
Small	1.8 kg	₦20	5
Medium	3.3 kg	₦50	5
Big	6.6kg	₦200	5

This result corroborates the findings of Prasat (2008) who reported that today, wood used as fuel still accounts for around 10% of the global energy supply. Over 90% of the population in sub Saharan Africa relies on wood-fuels (Jones, 2015).

In contrast, a rise in kerosene consumption was observed in this work, as the mean monthly consumption for the 267 households was estimated at 22.7 litres as against 24.09 litres for 339 users in the work of Cline Cole et al. (1990) for both cooking and lighting. With regards to household's expenditure on kerosene, a mean monthly expenditure for this work was estimated at ₦3,519.2 per household compared to the ₦3.74 - ₦3.99 in 1987. Likewise, this can also be explained from the rise in the costs of energy and the falling value of the Naira. Since, a greater proportion of households earning the national minimum wage and even below, use more kerosene (44.8%) than wood (40.6%), the percentage of a household's (earning the minimum wage) monthly income being spent on purchase of kerosene was estimated at 19.6%.

The rise in the quantity of kerosene consumption is likely to be related to the high number of households using kerosene currently as compared to 28 years back. For charcoal, a mean monthly consumption for 81 users was estimated at 19.02 kg and the monthly household expenditure was ₦1,389.1 as against ₦5.75 in 1987 that mostly use it for heating and ironing. Although the reference study did not estimate the consumption level of charcoal in kg, however, a decrease in the number of households using the energy was observed. This present study recorded only 15.3% of households using charcoal (this includes households using it in conjunction with other types of energy) as against 29% in 1987. The increase in the expenditure for charcoal could however be explained from the above for the other types of energy.With continuous urbanisation, the demand for charcoal in recent years has increased. This has been observed in sub-Saharan Africa in particular where average annual consumption of charcoal grew by 3% from 2000 to 2010 (UNCCD, 2015).

With regards to gas consumption, a mean monthly consumption for the 181 users was estimated at 12.97 kg while the mean monthly expenditure for 177 households (4 households working with the emirate council stated that they are given free gas refill every month) was estimated at ₦3093.89. This corroborates the result of Unwah (2007) in Maconachie et al. (2009) who reported that in Nigeria a 12.5kg cylinder of cooking gas refills for ₦3000. The reference study did not quantify the consumption of gas in terms of both the kilogram and price, probably because it was rarely used according to the study.

Table 4: Cost of Gas Cylinders

Cylinder Sizes	Cost
6kg	₦5500
9kg	₦7000
13kg	₦8000
26kg	₦13500
60kg	₦18800
95kg	₦35600

A drastic increase in the number of households using gas was observed, as this study recorded 31.6% of households using gas (although 9.3% of them use it in conjunction with other types of energy) as against the 12% in 1987. This might be related to the increasing availability of gas retail points in the study area, giving the example cited earlier, whereby households in the last two to three decades had to go to Zaria road, Unity road, Galadima road, or major gas company and some few filling stations in order to get a gas refill or purchase a new one (interview with a gas seller during field work). This can also be attributed to the emergence of can cylinders which cost less and can be easily carried for refill. Presently, along Gwarzo road alone (precisely from Kabuga to BUK new site), about 15 gas outlets were counted. Although, none of the households earning the national minimum wage use gas as their most frequently used energy, however if they were to use it, 17% of their monthly income would be spent on it.

The quantity of coal consumption was however not measured because it is out of stock in the study area as at the time of this survey. The information was sought from the major wholesalers at railway and 'Yankura market respectively, and confirmed from all the 9 households (1.7% of the sampled household) that were found to be using it as their most frequent type of energy. All of them reported that they purchase it from the South-eastern part of the country due to its unavailability in the study area. The scarcity of coal in the study area might be related to the increased awareness on its serious health implications, as Burt et al. (2013) stated that, it is a major cause of respiratory infections and cancer when used indoors for cooking or heating.

4. CONCLUSION

This study discovered a major decrease in the quantity of woodfuel consumption from a mean monthly consumption of 332 kg to 83.8 kg, which translates to about 25% of those using woodfuel in the metropolis thirty years back. However, the expenditure on it has risen significantly, from 24.66 Naira to 1528 Naira. This has been attributed to the declining value of the Naira. On the other hand, an increase in both the consumption and expenditure on kerosene was observed in this study. This was attributed to the fact that more retail points emerge around neighbourhoods despite its periodic scarcity which might increase the number of its users. Expenditure on it is high may be because people are aware of the health implications of woodfuel and therefore used kerosene more. This study concluded that the consumption of wood fuel users has decreased drastically but is still significant. And this might result to the continuous depletion of forest resources and indoor air pollution, which leads to health problems. This study found that charcoal is preferred in Kano metropolis and this may be because of its higher energy density and relatively low emissions.

4.1 Recommendations

i. This study recommended the use of the newly designed charcoal and woodfuel efficient stoves (capable of saving up to 40 to 60% of energy with less smoke), especially among the very low income earners who cannot afford cleaner sources of energy. To achieve this, government can invite or seek collaboration with private and foreign investors such as the C-Quest Capital (CQC) – a private business company that works to reduce humanity's carbon footprints and help the poor to improve their lives in an affordable climate-friendly way.
ii. The use of renewable forms of energy should also be promoted in the study area. Nigeria has a huge potential for renewable energy. There is need for government at all levels to look into the existing policies on renewable energy and take full advantage of it to boost her power generating capacity. This will serve as an effective measure in both reducing the amount of energy consumption and ensuring cleaner use of energy.

REFERENCES

Bensel, T.G. and Remedio, E.M. (1995). Residential energy use patterns in Cebu City, Philippines. *Energy*, 20(3): 173-187.

Burt, E., Orris, P. and Buchanan, S. (2013). Scientific Evidence of Health Effects from Coal Use in Energy Generation. *Chicago and Washington: School of Public Health, University of Illinois and Health Care Without Harm.*

Dziobinski O. and Chipman R. (1999). Trends in Consumption and Production: Household energy consumption. *DESA discussion paper Number 6*.

Cline-Cole, R.A., Falola, J. A., Main, H. A. C., Mortimore, M. J., Nichol, J. E., andO'reilly, F. D. (1990). *Woodfuel in Kano*. Tokyo: United Nations University Press

Cline-Cole, R.A. and Maconachie, R. (2016). Wood energy interventions and development in Kano, Nigeria: A longitudinal, 'situated 'perspective. *Land Use Policy*, 52:163-173.

Enger, E.A. and Smith, B.F. (2004). *Environmental Science – A Study of Interrelationship.* New York: McGraw hill

Faiella, I. (2011). The demand for energy of Italian households. *Bank of Italy Temi di Discussion (Working Paper)* No, 822

Hassan, A. and Yakubu, I. (2010). An analysis of per capita household energy consumption in Katsina, Nigeria. *Biological and Environmental Sciences Journal for the Tropics*, Vol. 7 Number 3 (6 -9).

International Energy Agency (2006). Paris, France:World Energy Outlook.

International Energy Agency (2008). Paris, France: World Energy Outlook

Isah A.D, Yakubu A.A, Babangida A and Musa S. (2012). *Woodfuel resource exploitation and energy demand in selected local government areas of*

Sokoto state. A paper presented at an International Conference on the Future of Energy Use in Nigeria's Drylands: Challenges and Opportunities, Mambayya House, Kano 12th-15th, 2012

Isah A.D., Shamaki S.B., Yakubu A.A., Babangida A. and Musa S. (2016). Fuelwood Resource Exploitation and Energy Demand in Selected Local Government Areas of Sokoto State, Nigeria. *Asian Journal of Environment & Ecology,* 1(1): 1-7, 2016

Jones, B. (2015). *Social and Environmental Impacts of Charcoal Production in Liberia*. A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science (Natural Resources and Environment) at the University of Michigan

Maconachie, R., Tanko, A. and Zakariya, M. (2009). Descending the energy ladder? Oil price shocks and domestic fuel choices in Kano, Nigeria. *Land Use Policy*, 26 (4): 1090-1099.

Naibbi, A.I. and Healey, R.G. (2014).Using Geographically Weighted Regression to Estimate the Spatial Patterns of Fuelwood Utilization in Nigeria. *American Journal of Geographic Information System*, 3(3): 109-121 DOI: 10.5923/j.ajgis.20140303.01

Prasad, G. (2008). Energy sector reform, energy transitions and the poor in Africa. *Energy Policy*. 36(8): 2806–2811.

United Nations Convention to Combat Desertification (2015). *Fuel for Life: Securing the land-Energy Nexus.* Bonn, Germany

Yakubu, I. (2014). Household Energy in Kano Region. InTanko, A.I. and Momale, S.B. (ed.).*Kano Environment, Society and Development.*Abuja, Nigeria: Adonis and Abbey Publishers Ltd.

Zaku, S.G., Kabir, A., Tukur, A.A., and Jimento, I.G. (2013). Woodfuel consumption in Nigeria and the energy ladder: A review of fuel wood use in Kaduna State. *J Pet TechnolAltern Fuels*, 4(5):85-9.

Analysis of the Chemical Quality of Domestic Water in Toro Local Government Area, Bauchi State, Nigeria

Ahmed Abubakar Jajere*, Abdu Ali, Adam Modu Abbas and Sulaiman Abdulhamid Sulaiman
Department of Geography, Federal University,
Kashere, Gombe State, Nigeria
**ahmedabubakarjajere@yahoo.com*

ABSTRACT

Analysis of the surface and groundwater water in Toro Local Government Area of Bauchi state was conducted in order to test the chemical quality of the water in the area. Samples were collected from wells, boreholes, ponds, streams and rivers in the area. The area was stratified into three districts and six samples were collected from each district making a total of 18 samples. The samples were analyzed in the laboratory to taste for the chemical parameters in the water, and the results were compared with the World Health Organization (WHO) standard. The results of the analysis showed that chemically, the pH, calcium, magnesium, copper, fluoride, zinc, nitrite, manganese, chromium, cyanide, arsenic, and electrical conductivity of the water all fell below the WHO standard. On the other hand, the Total Dissolved Solids (TDS), total hardness, total alkalinity, iron, nitrate, lead, sulphate, chloride, and barium in the water had 1, 8, 4, 13, 3, 1, 2, 1 and 11 samples respectively above the WHO standard. Based on these findings, recommendations were given on how to improve the quality of water in the study area.

Keywords: Chemical quality; Surface water; Underground water; WHO standard.

1. INTRODUCTION

The provision of potable water is perhaps the most difficult problem facing many developing countries today (Oni, 1997). However, the quality of water needs to be ascertained before it is considered potable. Water quality is used to describe the chemical, physical and biological characteristics of water usually in respect to its suitability for a particular purpose. Although scientific measurements are used to define the quality of water, it is not quite simple to declare water 'good' or 'bad'. One of the factors that render water bad is pollution.

Water pollution is the contamination of water bodies such as groundwater usually caused by human activities, which can be harmful to human, aquatics, organism and plants that live or use these water bodies. Water is said to be polluted when it is impaired by anthropogenic contaminants and does not support a human use, like drinking water and or undergoes a shift in its ability to support its constituent biotic communities (Rubin, 2006). Plants and animals require water that is moderately pure, and they cannot survive if their water is loaded with toxic chemicals or harmful microorganisms (Hart, 2009).

Domestic and municipal sewage contain decomposable organic matter that exerts a demand on oxygen resources of the receiving water. The World Health Organization (WHO, 1971) has demonstrated that organic matter consists primarily of carbohydrates, proteins from animal waste matter, fats and oils. Other studies have shown that dissolved salts in the form of ions such as Sodium, Potassium, Calcium, Manganese, Ammonium, Chloride, Nitrate, Bicarbonate Sulphate and Phosphate are main constituents of some drinking water and waste waters (Shuval, 1986; Okoronkwo, 1998, Okoronkwo and Zoakah 1998).

There are certain substance or chemical characteristics that may affect the acceptability of water for drinking purposes. They include substances causing odor and taste (WHO, 1985); and naturally occurring salts of magnesium and iron as well as sulfate and chloride ions (Okoronkwo, 1998). Both national and international criteria have been established to provide a basis for the control of human exposure to many of those substances (WHO, 1983; 1985).

The health hazards from chemical pollutants are of two kinds, namely: Hose, which are due to the presence of toxicity, for example, lead, Arsenic, mercury, chromium, cadmium, nitrate, nitrite and fluoride. Other water constituents such as iodine and fluoride may be beneficial and may be essential to health if present in small concentrations, though toxic if taken in large amounts (Okoronkwo, 1998).

Chemical elements in water have been classified into essential and non-essential based on their apparent metabolic functions (Underwood, 1971). Concentration of traced elements whether essential or non-essential at elevated levels can cause morphological abnormality, reduced growth and increased mortality and mutagenic effects in human (Pie et al., 1980). While the need to provide pathogen free water to prevent the spread of acute water borne diseases is acceptable by all, same is not true for chemicals found in water. The question of long term or even short term effects of some chemicals still remain a strong bone of contention bedeviled by claims and counter claims (Shuval, 1980; Holdsworth, 1991).

Isah et al. (2015) analyzed the physical, bacteriological and chemical parameters of water in Hand dug wells from Hardo ward, in Bauchi metropolis, Nigeria. The results of the water quality from some of the wells in Hardo were found to fall below or in excess of the safety limits of drinkable water based on the benchmark standard set by the WHO Standard.

Toro Local Government Area of Bauchi State in northern Nigeria is experiencing rapid population growth which exerts pressure on the available water sources in the area. The major sources of water in the area are rivers, streams, ponds, earth dams, and groundwater tapped from wells and boreholes. Most of the water sources in the area are seasonal because they usually dry off during the dry season. Therefore, most people rely on hand dug wells and boreholes as the ultimate sources of water during the dry season. Hence, this study seeks to examine the chemical quality of both the surface and groundwater in Toro, with a view to ascertaining whether the water in the area is potable based on the WHO standard for drinking water.

1.1 The Study Area

Toro local government area is one of the twenty local government areas of Bauchi state in northeastern Nigeria. It was created in August 1976 with an area of 6,932square kilometers. It is located between Latitudes 9°45′N and 10°49′N and Longitudes 8°44′E and 9°50′E (Information Office Toro) as shown in Figure 1. It is politically divided into three districts of Toro, Jama'a and Lame with seventeen electoral wards. They are Toro, Tulai, Ribina West, Ribina East, Tilden Fulani, Mara, Palama, Jama'a, Zaranda, Rauta, Geji, Wonu North, Wonu South, Rahama, Lame, Rishi, Tama and Zalau.

The area is located on the basement complex of the northeastern Nigeria (Chollom, 2006). Temperatures are relatively very low with an annual mean of 22°C. Rainfall is very high through diminishes as we go north wards. The annual mean rainfall is about 1368mm (Aigbodion 1991). The area is located within the Guinea Savanna grassland of northern Nigeria.

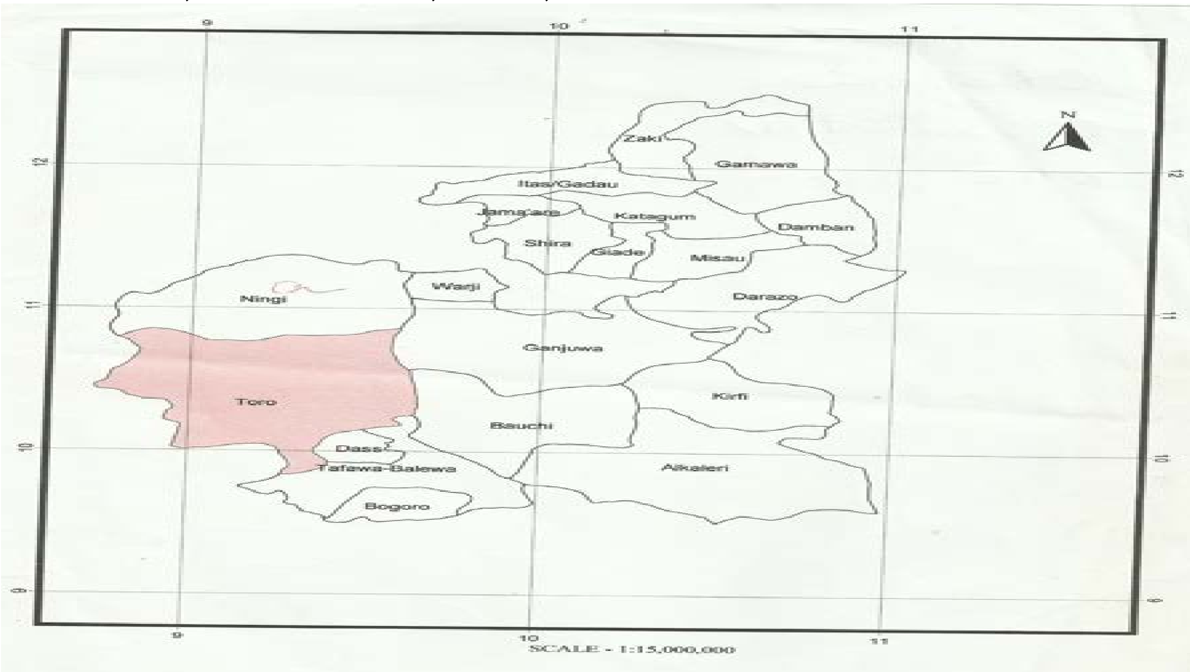


Figure 1: Bauchi State Showing Toro Local Government Area

2. MATERIALS AND METHODS

2.1 Types and Sources of Data

The data used for this study were obtained from primary and secondary sources such as:

d. Data on the chemical properties of both surface and groundwater was obtained from laboratory analysis.

e. Maps of Toro Local Government Area showing the sampling points.

f. Location data in terms of latitude, longitude and heights of the samples obtained using Global Positioning System (GPS).

2.2 Methods of Data Collection

Several methods were employed for the collection of the data required for this study. A reconnaissance survey was carried out in the month of June. The three districts of the local government area were visited. This helped the researchers in developing their sampling techniques. The sources of domestic water identified were: wells, boreholes, ponds, streams/rivers and earth dams.

2.3 Sampling Procedure

In locating the water sample points, the following factors were considered: mainly population concentrated areas, landuse and the relief. Numbers of samples were distributed across the three districts and between the surface and the underground waters irrespective of the sources.

The local government area was divided into three based on its districts (Toro, Lame and Jama'a). A combination of stratified, random and purposive, sampling techniques were used. The researchers used the districts as the basis of stratification. A total of six (6) samples were taken randomly from each district comprising of three (3) surface water and three (3) groundwater samples. The researcher used purposive sampling to include a sample from Toro town being the headquarters of the local government area.

2.4 Water Sample Collection Techniques

The procedures used for the collection of samples and the locations of the various sampling points are outlined below:

5. Sterilized 75cl plastic Swan bottles were used for the collection of water samples.
6. The caps of the bottles were removed after the water had been extracted from the sources, the bottles were rinsed with the water extracted before been filled, leaving air space in each bottle. The bottles were covered immediately after filling.
7. Provision was made for a cooler containing ice to regulate the water temperature. The points where samples were collected were chosen through random sampling in each district from a list of major towns identified as sample points.
8. The water samples were fairly distributed across the local government area and coded S_1, S_2, S_3, G_1, G_2, G_3, where S = surface water source and G = groundwater source as illustrated in Table 1. To distinguish between surface and ground water source among the three districts, the first letter of each district was written at the beginning of the codes to give what is in the below Table 1.

2.5 Laboratory Analysis of the Chemical Parameters

Twenty-one parameters were analyzed for each of the eighteen samples (see Table 2). These include pH, Total Dissolved Solid (TDS), total hardness, total alkalinity, electrical conductivity, calcium, iron, copper, manganese, nitrate, nitrite, zinc, fluoride, sulphate, lead, chloride, chromium, barium, cyanide, arsenic, and magnesium. Hardness, chloride, calcium, magnesium and total alkalinity were measured using the volumetric method. The instrument used was the digital titrator. The analysis was conducted at the Bauchi State Rural Water Supply and Sanitation Agency (BAURUWASSA) Laboratory.

3. RESULTS AND DISCUSSION

3.1 Laboratory Analysis of the Chemical Properties of the Water

Results of the chemical parameters analyzed in the water samples are presented below:

3.1.1 Analysis of pH

The results showed a pH range between 7.0mg/l and 7.4mg/l. This shows that the values are within the WHO guideline of 6.5-8.5. pH is related in several different ways to almost every other water quality parameter as aqueous chemical equilibria invariably involve hydrogen and hydroxyl ions (Beka, 2007).

3.1.2 Nitrate

The laboratory result showed that nitrate levels of the three samples are above the maximum permitted level of 50mg/l. The samples are LS_1, LS_2 and JG_3 whose values are 54, 64, and 60 respectively. Concentration of nitrate above the 50mg/l (SON) leads to blue baby syndrome in infants under 3 months.

3.1.3 Nitrite

The laboratory results showed that there are traces of nitrite detected in all the samples, but in very insignificant levels. It ranged between 0.008mg/l to 0.57mg/l. All the samples show concentration levels below the WHO maximum limit of 3mg/l. On the other hand, if we compare the nitrite level of the Nigerian Standard of Drinking Water Quality (NSDWQ) whereby the maximum permitted level is 0.2mg/l, then two samples revealed values above the limit. They are LS_1 (0.57mg/l) and JS_1 (0.22mg/l).

3.1.4 Zinc

This is an important element in the body of human beings once it does not exceed the maximum recommended level of 5mg/l. It serves as Co-factor in enzymes activities in the body (WHO, 1993). From the results of the laboratory analysis, all the samples showed values below the maximum limit set by the WHO. This shows that, in terms of zinc, all samples are in the right proportion for a given potable water.

3.1.5 Fluoride

The results showed that fluoride ranges between 0 and 0.32. All the samples therefore fall below the maximum permitted limit of 1.5mg/l (NSDWQ, 2007). This indicates that the water is fit for drinking.

3.1.6 Copper

Copper was detected in 13 samples but were all below the acceptance limit of 2mg/l recommended by the WHO. The concentration ranges from 0.0mg/l – 0.62mg/l. Copper at high concentration affects person suffering from copper metabolism disorder called Wilson disease (Okoronkwo, 1998). Also, copper at high doses causes stomach and intestinal distress, liver and kidney damage as well as anaemia (Khair, 1994).

3.1.7 Iron

From the results of laboratory analysis, only five samples fell below the WHO maximum level of 0.3mg/l for Iron. However, iron has no any adverse health effect on human but it impacts bitter taste to water when it is in high concentration.

3.1.8 Magnesium

The results from all the samples showed low concentration of magnesium. The values ranged between 0.02mg/l – 22mg/l. These are far below the WHO acceptable limit of 50mg/l. Magnesium is useful to the nervous balance of the body but at high concentration it predisposes the body to the formation of kidney or bladder stone and irritation of the urinary passage (Mc Neekly et al., 1979).

3.1.8 Calcium

From the results of the laboratory analysis, three samples showed values above the maximum acceptable limit of 75mg/1 but fell below the maximum allowable limit of 200mg/1 (WHO, 1997). The values of the three samples are LG_1 = 96mg/l, JG_1 = 87mg/l and JG_2 = 151mg/l. The other samples range between 5.2mg/l – 48mg/l. Calcium is essential to human nutrition and is a major component in the formation of bone. It also helps to maintain the integrity of the muscles of the body.

3.1.9 Total Dissolved Solids (TDS)

The highest observed concentration of TDS was 102mg/l (LS_1) and the least was 15mg/l (LS_2). The maximum recommended is 500mg/l. This implies that TDS levels in the three districts of Toro Local Government Area fell within the WHO standards. TDS is the amount of inorganic salts and small amounts of organic matter contained in quantity of water.

3.1.10 Total hardness

Ten of the samples showed concentration higher than the desirable 100mg/l. These ranged between 120mg/l – 632mg/l. However, it was only 9 of the 18 samples that exceed the maximum allowable limit of 120mg/l (WHO, 1997). Hardness is not harmful to human health.

3.1.11 Manganese

In all the samples analyzed, the values of manganese were all below the acceptable limit of 0.05mg/l set by the WHO. The values in eleven of the samples ranged between 0mg/1 to 0.04mg/l. Manganese deficiency impairs glucose metabolism and reduced insulin production. Excess manganese interferes with the absorption of dietary iron. Manganese toxicity can cause kidney failure, hallucinations, disease of the central nervous system and neurological problems (Blaurock-Busc, 2002).

3.1.12 Lead

Results of the laboratory analysis revealed that lead was detected in only one sample (LS_3). However, the value was far below the maximum allowable limit of 0.5mg/l as set by the WHO. This indicates that the water in Toro Local Government Area is safe as far as lead is concerned. Lead is highly toxic to human; its accumulation causes brain damage, affects the red blood cell chemistry and delays mental and physical development in children (WHO, 1993).

3.1.13 Sulphate

Results of the analysis showed that two of the eighteen samples recorded values of 320mg/l (JG_1) and 321mg/l (JG_2) which are both above the WHO limit of 200mg/l. All other samples were below the maximum limit. At high concentration, it causes catharsis, dehydration and gastrointestinal irritation. Sulphate also impacts taste in water (Khair, 1994).

3.1.14 Chromium

The results of the laboratory analysis showed that all the eighteen samples recorded values less than the 0.05mg/l WHO limit. The values ranged between 0mg/1 to 0.01mg/l. Exposure to chromium fumes results in dermatitis and cancer of the lungs. However, chromium when present in desirable amounts (0.05mg/l-0.20mg/1) in the body is known to remedy impaired carbohydrate metabolism by increasing the effectiveness in insulin (Molly, 1972).

3.1.15 Barium

From the results of the analysis, five samples showed a value of more than the acceptable limit of 0.0mg/l in Toro district, two samples in Lame district and four samples in Jama'a district. Only eight of the eighteen samples showed values of less than the limit set by the WHO. Concentration of this element above the set limit causes hypertension.

3.1.16 Cyanide

From the results of the laboratory analysis of the eighteen samples, cyanide was not detected being a toxic metal, its concentration above the WHO limit of 0.2mg/l causes toxicity to kidney.

3.1.17 Arsenic

Arsenic was not detected in all the eighteen samples. Any concentration above the WHO maximum limit of 0.01mg/l can cause cancer.

3.1.18 Electrical conductivity

Electrical conductivity ranged between 30µs/cm - 639µs/cm for all the samples. The values are all below the 1000µs/cm maximum permitted level. Concentration of electrical conductivity is however having no any health effect.

3.1.19 Total alkalinity

The alkalinity of water helps as a buffer (to maintain constant pH). A buffer solution is a solution which acts by controlling acidity and alkalinity in a solution. The amount of alkalinity is expressed in terms of calcium carbonate ($CaCO_3$). From the results of the laboratory analysis, four samples indicated a concentration of alkalinity above the 100mg/l set by NSDWQ. They are; TG_3 (107mg/l), LG_1 (276mg/l), JG_1 (232mg/l) and JG_2 (421mg/l).

4. CONCLUSION AND RECOMMENDATION

The analysis of water quality in Toro showed that the water fell below the WHO standard in terms of several chemical parameters which include the pH, calcium, magnesium, copper, fluoride, zinc, nitrite, manganese, chromium, cyanide, arsenic, and electrical conductivity. Conversely, the water was found to be above the WHO standard in terms of the Total Dissolved Solids (TDS), total hardness, total alkalinity, iron, nitrate, lead, sulphate, chloride, and barium. It is therefore concluded that the water in the area is not potable but requires treatment before being used for drinking, cooking and other household activities that may have direct effect on human health.

REFERENCES

Aigbodion I.C. (1991*). Geology of the Area North of Zaranda Younger granite Ring Complex Bauchi State.* Department of Geology and Mining, University of Jos, Nigeria.

Beka, N.C. (2007). *The Spatial variation of ground water quality in parts of Jos metropolis*. Unpublished M.Sc. Dissertation. Department of Geo. & Plan. Uni. Jos pp 20-23, 81-89.

Blaurock-Busc (2002) in Titus, G.D (2009). *Ground water quality in Akira/Uba LGA Bornu State*. M.Sc. erp Thesis Uni. Jos Unpublished pp 55-59.

Chollom, T. (2006). *Groundwater Quality Assessment in the North Central Basement Complex of Nigeria*. Department of Geology and Mining, University of Jos, Nigeria.

Holdsworth, R. (1991). *New Health Consideration in Water Treatment*. Avebury Technical, England.

Isah M.A., Salau O.B.E., Harir AI, Chiroma MA, Umaru AA (2015). Parameters of Water Quality in Hand Dug Wells (HDW) from Hardo Ward, Bauchi Metropolis, Nigeria. *ARPN Journal of Engineering and Applied Sciences*, 10(16): 6804-6810.

Khair K. A. et al (1994). The environmental impact of human on groundwater in Lebanon. *Air and Soil pollution*, 78(1-2): 37-198.

McNeely, R.N. Neimania V.P and Dowyan L. (1979). *Water quality source book: A guide to water quality parameters, water quality branch*. Inland water directorate, environment. Canada, Ottawa pp 88.

Molly, M.B (1972). *Chemistry and Living Ogranisms*. 5th Edition John Wileyand sons Inc.co, New York. pp 92.

Okoronkwo M.O. (1988). Chemical Quality and Bacteriological Safety of Drinking Water Produced in Jos Metropolis. *West Africa Journal of Biological Sciences*, 119-128.

Okoronkwo, M.O. and Zoakah, A.I. (1998). Bacteriological Quality of water in a Drought Afflicted Community in Northern Nigeria. *Journal of Medical Laboratory Sciences*, 7: 67-72.

Oni, O.O. (1997). *Water Quality Testing and Control Course*. Outreach Department, National Water Resources Institute, Kaduna. pp 19, 20 and 42.

Population Report (2000). The Environmental Population Growth, Decade for Action Series in No. 10 pp18.

Shuval, H.I. (1980). *Water Quality Management under conditions of scarcity: Israel as a case study*. Academic Press Inc., New York, USA.

Underwood, E. J. (1971). *Trace Elements in Human and Animal Nutrition*. 3rd Edition, Academic Press, New York, United States. pp 1-4.

WHO (1993). *International Standards for Drinking Water*. Geneva pp 36-45.

WHO (1971). *Health Hazards of Human Environment*. WHO Geneva pp 36-64.

WHO (1983). *Guidelines for Drinking Water Quality*, *Vol. 1 Recommendations*. WHO, Geneva pp 1-2.

WHO (1985). *Guidelines for Drinking Water Quality, Vol. 2 Recommendations.* WHO, Geneva.

Table 1: Name of Sampling Locations and their Codes

S/N	District	Sample Code	Name of Location
1	Toro	TS_1	Upper Dilimi River
		TS_2	Ribina Stream
		TS_3	Balarabe River
		TG_1	S/Garin Narabi borehole
		TG_2	Jajuwa borehole
		TG_3	Toro District Pallace well
2	Lame	LS_1	Lower Dilimi River
		LS_2	Rishi River
		LS_3	Dokan Auwalu mining pond
		LG_1	Gumau Public well
		LG_2	Tulu Public well
		LG_3	S/Garin Tulu borehole
3	Jama'a	JS_1	S/Garin Nabordo Earth Dam
		JS_2	Nyela Bongo River
		JS_3	Dori Stream
		JG_1	Nabordo well
		JG_2	Tashan Durumi Well
		JG_3	Biciki borehole

Table 2: Values of Chemical Parameters in the Study Area

Samples	TS_1	TS_2	TS_3	TG_1	TG_2	TG_3	LS_1	LS_2	LS_3	LG_1	LG_2	LG_3	JS_1	JS_2	JS_3	JG_1	JG_2	JG_3
pH mg/1	7.3	7.4	7.5	7.0	7.2	7.2	7.2	7.2	7.3	7.1	7.2	7.0	7.2	7.2	7.2	7.0	7.2	7.0
El.Cond.(μs/cm)	130	26.5	123	238	178	272	205	30	54	573	295	239	96	90	49	401	639	172
TDS (mg/1)	65	133	62	119	86	138	1022	15	26	286	147	119	48	45	24	200	320	86
Hardness (mg/1)	60	192	72	140	124	200	120	25	40	476	150	124	40	40	42	320	632	100
Alkalinity (mg/1)	25	70	32	62	52	107	42	6.2	12	276	72	51	12	13	14	232	421	51
Ca^{2+} (mg/1)	14.4	23	17	32	31	48	30	5.2	9.6	96	36	31	9.5	9.5	9.7	87	151	24
Mg^{2+} (mg/1)	0.32	0.35	0.67	0.79	0.045	3.44	1.20	0.02	0.07	22	0.05	0.72	0.04	0.23	0.03	12	17.77	0.57
Fe^{2+} (mg/1)	4.12	0.60	0.72	0.78	1.42	0.04	2.34	0.43	0.86	0.14	0.78	0.01	5.48	2.38	5.61	0.02	0.04	3.04
Cu^{2+} (mg/1)	0.62	0.00	0.18	0.02	0.01	0.02	0.59	0.03	0.009	0.0	0.00	0.01	0.01	0.26	0.0	0.00	1.49	0.13
F^- (mg/1)	0.02	0.01	0.23	0.05	0.00	0.0	0.0	0.32	0.03	0.02	0.03	0.03	0.02	0.0	0.04	0.02	0.05	0.03
Zn^{2+} (mg/1)	0.24	0.53	0.65	0.07	0.73	0.76	0.87	0.43	0.87	0.34	0.54	0.45	0.23	0.65	0.34	0.09	0.62	0.43
NO^{3-} (mg/1)	46.2	0.07	7.8	8.8	0.045	21	54	65	14.3	46.2	0.23	23	18.7	16.8	8.8	46.2	19.8	60
NO^{2-} (mg/1)	152	0.008	0.14	0.13	0.009	0.049	0.57	0.105	0.01	0.062	0.04	0.046	0.22	0.011	0.119	0.044	0.056	0.196
MN^{2+} (mg/1)	0.01	0.00	0.0	0.02	0.004	0.0	0.0	0.4	0l.001	0.0	0.0	0.002	0.0	0.0	0.01	0.0	0.0	0.0
Pb^{2+} (mg/1)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SO^{4-} (mg/1)	5	4	20	56	4	70	87	6	12	200	140	50	4	24	1	320	321	18
Cl^- (mg/1)	21	40	28	43	30	51	38	29	40	200	58	39	99	72	32	87	205	30
Cr^{6+} (mg/1)	0.01	0.0	0.005	0.01	0.002	0.0	0.01	0.01	0.003	0.00	0.01	0.00	0.0	0.00	0.1	0.0	0.0	0.01
Ba^{2+} (mg/1)	0.001	0.12	4	2	1	4	2	0	2	0.01	0.0	0.0	0	0.56	1.4	0	2	0.18
CN^- (mg/1)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
As (mg/1)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

The Environmental and Health Effects of Quarrying Activities in Ban-Zazzau Area of Zaria City, Kaduna State, Nigeria

Inusa Musa[1]*, Zainab Dalhatu Muhammed[2], Zainab Mohammed Zakari[2], Maimunatu Aboki[2]

[1]*Department of Geography, Federal College of Education, Zaria*
[2]*Department of Urban and Regional Planning, Nuhu Bamalli Polytechnic, Zaria*
**inusaecole@gmail.com*

ABSTRACT

This study examined the environmental and health implications of quarrying activities in Ban-Zazzau area of Zaria City in Kaduna State. Questionnaire survey and interviews were conducted to obtain information from quarry workers, residents and stakeholders in the area. The respondents were selected using stratified and random sampling techniques. Findings revealed that in terms of the age structure, majority of the respondents are adults between the age of 26 and 45 years which is made up of 45.8% of the total respondents. These categories of people belong to the active proportion of the population who are likely to bear the burden of the quarry activities in the area. Findings also shows that majority of the respondents are quarry workers and traders each making up of 37.2% and 41.5% respectively. Also, majority of the respondents were found to be literate. In addition, findings revealed that among the activities carried out in the quarry site, the major ones are blasting, crashing and packing of products which amount to 54.3%. Deforestation and damage to farmland were found to be among the main environmental effects of quarry in the study area which made up 55.3%. The most noticeable health effects of quarrying activities were found to be cough, chest pains and throat infections. Suggestions made by the respondents to reduce effects on quarrying activities include control of blasting to reduce vibration and a reduction in dust produced according to 29.8% and 25.5% of the respondents respectively. There is also the need for government to formulate and enforce pollution control policy and also ensure compliance by quarry operators in the area.

Keywords: Quarrying; Environmental effect; Health effect; Ban-Zazzau area.

1. INTRODUCTION

Agriculture and mineral extraction play a critical role in rural livelihood improvement thereby helping to alleviate rural poverty. This is why over 500 million people in developing countries engage in occupations such as small-scale surface mining and quarrying for survival (Wang, Zhang and Liu, 2010).

Quarries are open cast excavations from which fairly massive and deep deposits of hard or soft rocks are extracted, usually for the production of aggregates (Coppin and Bradshaw, 2002). According to Ekwere and Ukpong (2012), quarrying is a form of landuse method concerned with the extraction of non-fuel and non-metal minerals from rock. Quarrying is usually done by open-cast method using rock drills, explosion of dynamite and use of other methods.

Quarrying has played a major role in providing the building materials required for construction to meet the increasing demand for housing and infrastructure development needs of the society in Nigeria. Murtala (2011a) asserted that quarrying of granite, marble, sandstone and gravels is helping in meeting the demand for infrastructural expansion in Nigeria. Quarrying is a huge supporter of local economic development; it enhances trade, it helps in creating jobs for people and generating revenue for the government. Most people in quarrying regions wholly depend on these quarrying for their livelihoods aside from other economic activities (Eshiwani, 2014). Quarrying as an extractive economy provides much of the raw materials used in building works and construction. Quarrying is a labour-intensive activity, and so creates employment opportunities and helps in the development of mining infrastructure (Murtala, 2011b).

However, the industrial activities of quarrying negatively affect the environment in a variety of ways from exploration and blasting, transport and disposal of waste rocks. Major environmental effects of quarrying are destruction of vegetation, disruption of animal habitats, diversion and blockage of natural drainage systems, soil erosion and river siltation, noise and vibration; and dust pollution (Lad and Samant, 2014). According to Stehouwer, Day and Macneal (2006), quarrying activities exert tremendous pressure on limited soil and water resources, thus increasing the rate of erosion processes and subsequent damage of existing arable lands. Quarrying operations can intensely modify preexisting ecosystems and disturb hydro-geological and hydrological regimes. Also dumping of waste rock in open areas disrupts drainage and cause diversion of rivers and streams into farming areas and results into flooding of crop fields (Stehouwer, Day and Macneal, 2006).

There is no doubt that quarrying activities have led to the development of infrastructure, created employment opportunities, growth of towns and have contributed to the establishment of various industries. Yet, quarrying activities have also led to many environmental damages (Siachoono, 2009). Oguntoke, Abaoba and Gbadebo (2009) examined the impact of granite quarrying on the health of workers and nearby residents in Abeokuta area of Ogun State, Nigeria. Findings of the study revealed that nearby residents suffer both psychological and health problems which include shock, nasal infection and asthma while the quarry workers suffered predominantly from cough, catarrh and sinusitis. Aribigbola, Fatusin and Fagbohunka (2012) assessed the health and environmental challenges of cement factory on Ewekoro community residents, Ogun State, Nigeria. The study confirmed extensive incidence of land, air, and noise pollution over and above recommended minimum limits. It also discovered lack of substantial compliance with the principle of environmental resource protection.

Essaghah, Ogbonna and Alabi (2013) worked on the economic impacts of Lead and Zinc ores mining in Shaiagu community of Ebonyi State, Nigeria. Findings revealed serious environmental pollution, widespread surface land despoliation and water resources degradation that threaten human living and farming activities in the area. The quarrying activities that are carried out by man affect our environment in one way or the other. The effect on the environment in most cases is usually negative. This study is aimed at examining the environmental and health implications of quarrying activities in Ban-Zazzau area of Zaria City in Kaduna State.

1.1 The Study Area

Zaria is located on a height of about 2200 feet above sea level in the centre of northern Nigeria. It lies between latitudes 11°13′N and 11°9′N and longitudes 7°39′E and 7°68′E as shown in Figure 1. Formerly known as Zazzau, it was one of the original seven Hausa city-states. The population of Zaria is approximately 975,153 (NPC, 2009; Oladimeji and Ojibo, 2012).

Zaria is characterized by gentle plains surrounded by rocky residuals. Other residual hills have developed and are found on deeply weathered materials and are called lateritic mesas and buttes, the slope is generally less than 4° with the exception of those of inserlbergs, lateritic mesas and river valleys and ruwares, which are distinctive shaped hills of more or less bare rocks. They generally belong to category of residual hills (Thorp, 1970). The plains on which Zaria is situated are part of the vast undulating plains scenery which are characteristics of Africa as a whole. The plains are surmounted by hill features of rock inselbergs and lateritic ironstone-capped mesas. The inselbergs vary considerably in dimension and shape, from prominent landmark of Kufena to inconspicuous whalebacks (Usman et al., 2015). The Galma River is the major river system and its tributaries, Kubanni, Shika and Saye are ephemeral carrying storm runoff during and immediately following rainfall events (Wright and Mc Curry, 1970).

Zaria possesses a tropical continental climate characterized by two distinct seasons; the dry and wet season (Usman et al., 2015). The daily maximum temperature rises from 15.3^{0}C in January and attains its highest of 36.3^{0}C in April. Rainfall in Zaria ranges from 180mm in May to 816mm in August (Abubakar, 2012). The natural region in which Zaria lies is the Northern Guinea Savannah zone. A designation which implies a woodland vegetation type characterized by the presence of *Isoberlinia doka, Isoberlinia tomentosa* and *Upaca togonensis*, with well developed grass layer of tufted and low ground cover of Andropogoneae (Jackson, 1970).

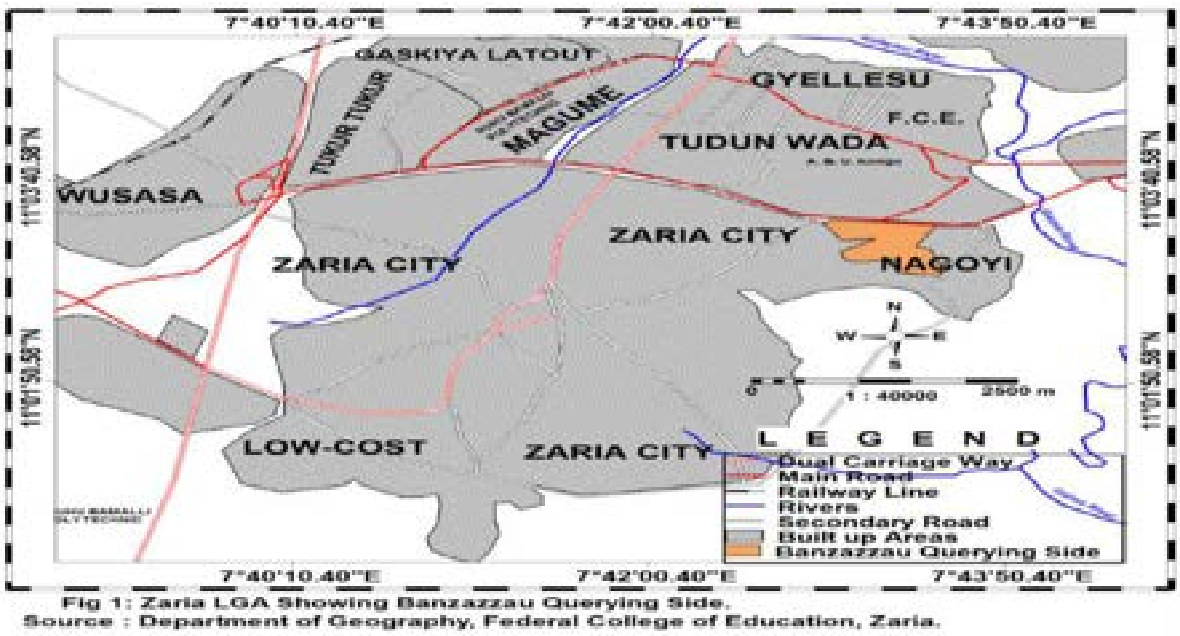


Figure 1: Zaria Showing Ban-Zazzau Area

2. MATERIALS AND METHODS

The instruments used for this study were questionnaire and interviews. The study adopted stratified and random sampling methods in selecting the respondents. In this type of sampling, there are clear cut groups within the given population. Two groups of strata were identified: quarry workers and residents of the area. According to Mugenda (2008), stratified random sampling helps to achieve the desired representation of various sub groups in the population. This method was used to ensure that sub-groups that constitute the majority in the population are also represented proportionately. The sample was chosen randomly where respondents were drawn from quarry workers and area residents. In total, the sample considered for this study was one hundred (100). The questionnaire used was validated by experts in the field of Geography. A draft copy of the questionnaire was produced, duplicated and given to experts in Federal College of Education, Zaria. This was done in order to draw criticism and inputs for the improvement of the items in the questionnaire. The instrument was evaluated and it was found to be well structured, free from all kind of discrimination so that it can measure the objective is achieved. Descriptive statistics was used in analyzing the data.

3. RESULTS AND DISCUSSION

3.1 Socio-economic Characteristics of the Respondents

This section describes the bio-data and the demographic characteristics of the respondents.

The age structure of the respondents showed that about 21% of the sampled population is between 15 - 25 years of age, 33% are between 26-35 years, and 29.8% are between 35-45 years while the remaining 16% are above 45 years of age (see Table 1). This age structure showed that majority of the respondents are adults between the age of 26 and 45 years. These categories of people are the active proportion of the population who are likely to bear the burden of the quarrying in the area. The underaged and the aged rely on these categories of people for their livelihood. Any adverse impact of quarry on this category of people will surely have backslash effects on the social and economic life of the general populace in the area.

Table 1: Age Structure of the Respondents

Age	Frequency	Percentage %
15 - 25 years	20	21.2
26- 35 years	31	33.0
35 - 45 years	28	29.8
Above 45 years	15	16.0
TOTAL	94	100

Table 2 shows the occupational status of the respondents. It was found that 6.4% of the respondents are civil servants, 41.5% are traders, 10.6% are artisans, 4.3% are involved in other occupations, while 37% of the respondents are quarry workers. It is observed that majority of the nearby residents of the quarry site are into trading which constitutes 41.5%. This is followed by quarry workers with 37.2% in the study area.

Table 2: Occupational Status of the Respondents

Occupation	Frequency	Percentage %
Civil service	6	6.4
Trading	39	41.5
Artisan	10	10.6
Quarry workers	35	37.2
Others	4	4.3

TOTAL	94	100

Figure 2 shows the educational status whereby majority of the respondents can read and write. The results show that 31.9% completed primary education, 47.9% had secondary education and 10.6% of the respondents have post secondary education. This implies that majority of the respondents have attained some level of literacy which might help them in understanding the issues of socio-economic and environmental impact of quarry in the study area.

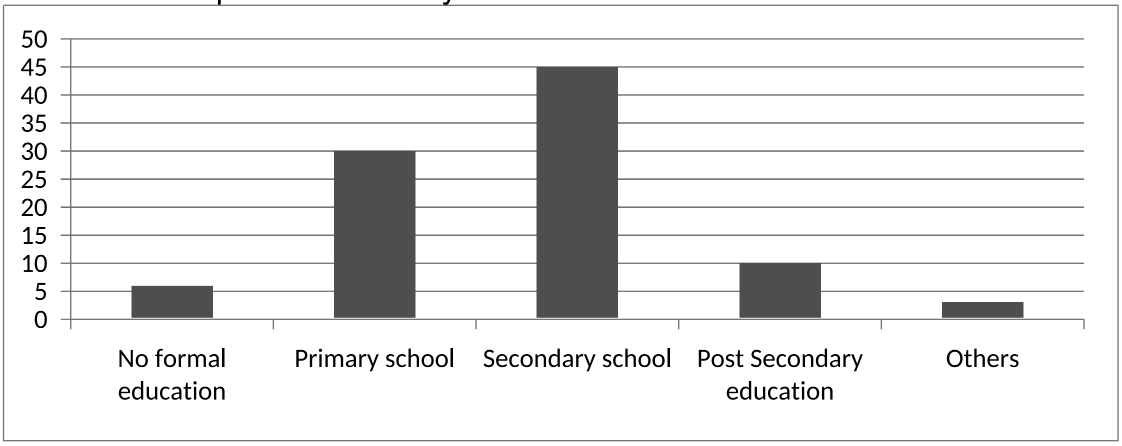


Figure 2: Educational Status of the Respondents

3.2 Quarry Operations in the Study Area

There are several activities that are carried out within a quarry depending on the method of quarrying used. Analysis of these activities at the Ban-Zazzau quarry showed that the main operation in the site is blasting according to 27.7% of the respondents, 26.6% agreed that crashing and packing of the finished product is a common activity, 25.5% were of the opinion that driving is also common while the remaining 20.2% agreed that construction is also an activity at the quarry site. This is shown in Table 3.

Table 3: Activities carried out within the quarry

Activities	Frequency	Percentage %
Blasting	26	27.7
Crashing and packing of products	25	26.6
Driving	24	25.5
Construction	19	20.2
TOTAL	94	100

3.3 Environmental Effects of Quarry in Ban-Zazzau Area

There several environmental effects of quarrying ranging from minor to major effects. Table 4 shows the impact of quarry industry on the environment. It can be seen from the table that 21.3% of the respondents said pollution from the quarry causes dust and visual disturbances, 23.4% of the respondents complained that the quarry activities cause vibration and noise, 28.7% of them claimed that the quarry activities lead to deforestation, while 26.6% of the respondents said the activities have effects on their plants and damage their farmlands. From the analysis, it is quite obvious that deforestation has reduced the rate of farming in the study area.

Table 4: Environmental effects of quarry on in the area

Effect	Frequency	Percentage %
Dust and visual disturbances	20	21.3
Vibration and Noise	22	23.4
Deforestation	27	28.7
Damage to farmland	25	26.6
TOTAL	94	100

Other effects of quarrying in the area are presented in Figure 3; it shows that about 19% of the respondents complained of land degradation which eventually resulted to erosion and landslide. About 43% and 32% of the respondents experienced either cracks or total collapsed on their buildings respectively, as a result of quarrying in the study area.

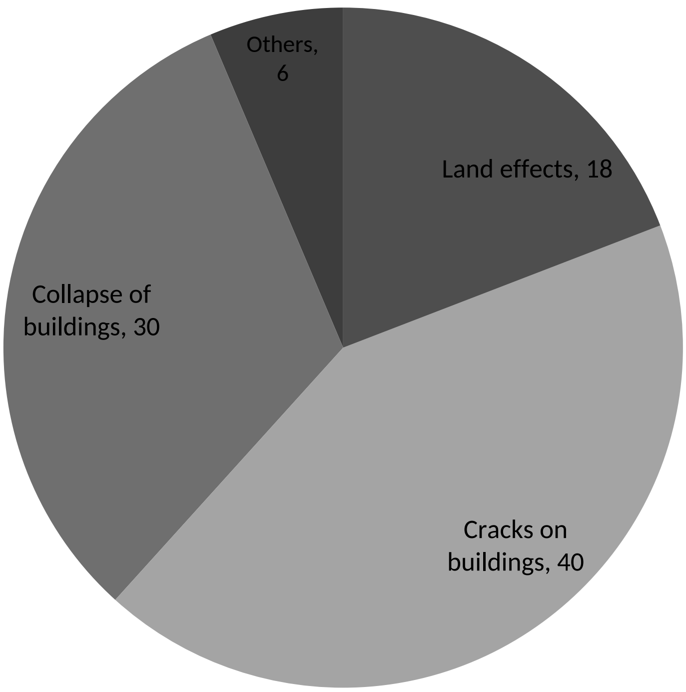


Figure 3: Physical effect of quarry activities in the study area

3.4 Socio-economic Effects of Quarrying in Ban-Zazzau Area

Apart from the negative effects, the quarry also has positive effects to the people that live nearby. Table 5 shows that 19% each of the respondents benefit from the quarry activities as they are involved in business and have got employment from the quarry either directly or indirectly; while 17.1% of the respondents is able to get materials that they use in building construction. However, 42% of the respondents did not see any benefit from the quarry.

Table 5: Socio-economic Benefits of Quarrying Activities to the Residents

Benefits	Frequency	Percentage %
Business activities	18	19.1
Employment	18	19.1
Building materials	16	17.1
None beneficial	42	44.7
TOTAL	94	100

3.5 Health Implications of Quarrying in the Area

Studies in different parts of Nigeria have reported health consequences of quarrying on nearby communities. Table 6 shows that 27.7% of the respondents complained of prevalence in throat infections in the area, 37.2% attributed the prevalence of cough and chest pains to quarrying in the area, while 14.9% complained of hearing problems probably as a result of blasting. However, 12.8% complained of eye infections while the remaining 7.4% reported the prevalence of skin infections. These health challenges to the nearby residents can largely be attributed to the pollutions coming from the quarrying activities and the high level of dust particulates generated at the drilling and crushing areas. Moreover, the general nonchalant attitude of most quarry workers to the use of protection gadgets predisposes them to several respiratory ailments.

Table 6: Health challenges of quarrying activities to nearby residents and quarry workers

Health Challenges	Frequency	Percentage %
Throat infections	26	27.7
Cough and Chest pains	35	37.2
Hearing Problem	14	14.9
Eye infections	12	12.8
Skin infections	7	7.4
TOTAL	94	100

3.6 Mitigations to Reduce the Effects of Quarrying in the Area

The nearby residents as well as the quarry workers offered different suggestions to reduce the effects from the quarry activities in the area. The suggestions are presented in Table 7. It can seen from the table that 25.5% of the respondents felt that there is need for the reduction of dust that is produced by the quarries, 29.8% recommended that the blasting should be reduced, 17% suggested the relocation of the quarries to another area; fencing of the quarry in order to reduce accidents such as people falling into the quarry pits and to reduce some other hazards were suggestions offered by 7.4% of the respondents. Also, 12.8% suggested compensation to nearby residents for the damages caused by the quarrying activities in the area.

Table 7: Mitigations to reduce the effects of quarrying in the study area

Mitigations	Frequency	Percentage %

Reduce the dust produced	24	25.5
Control their blasting to reduce vibration	28	29.8
Relocate to another area with less population	16	17.0
Fence the quarry	7	7.4
Compensation for the damages caused	12	12.8
None	5	5.3
TOTAL	94	100

4. CONCLUSION

Majority of the people that would bear the burden of the quarrying in the area are the active proportion of the population who are mostly quarry workers and traders. The fact that majority of them have some level of formal education makes it easy to create awareness on adaptation to quarrying activities in the area. The main environmental effects of quarrying were found to be deforestation and damage to farmlands in the area. Also, the residents of the area complained of cracks on buildings resulting from quarrying in the area. The most noticeable health challenges of quarrying activities were found to be cough, chest pains and throat infections which are very common among residents of the area. It was however suggested that there is need to reduce effects of quarrying activities by controlling of blasting to reduce vibration and a reduction in dust produced during operation.

4.1 Recommendations

Based on findings of the study, the researchers made the following recommendations:

A sensitization programme on how to mitigate the effect of quarrying activities should be targeted towards the active age group that are mostly engaged in the quarry activities in the area. There is also the need to organize and promote more environmental awareness, campaigns and technical training programs, which will guide the locals on how to adapt to the quarrying in the area. More job opportunities should be created by government to reduce attachment to the quarry related businesses in the area. Also, the government should formulate and enforce pollution control policy and also ensure compliance by quarry operators in the area. Further studies on the search for more advanced methods of reducing the effects of the quarrying activity on the environment should be carried out.

REFERENCES

Abubakar, M. (2012). *An Assessment of Men's Role and Attitude Towards Family Planning in Zaria L.G.A, Kaduna State Nigeria*. Unpublished M.Sc Thesis, Department of Geography; Ahmadu Bello University, Zaria, Kaduna State, Nigeria.

Aigbedion, I. and Iyayi, S. E. (2007). Environmental Effect of Mineral Exploitation in Nigeria. *International Journal of Physical Sciences,* 2(2): 033-038.

Coppin,N.J.andBradshaw,A.D.(2002). The establishment of vegetation in quarries and open-pit non-metal mines. London. *Journal of Applied Mining and Ecology*, 4(2): 112 – 113.

Ekwere, A. S. and Ukpong, A. J. (2012). Groundwater Chemistry and Quality of Nigeria: A Status Review. *African Journal of*

Environmental Science and Technology, 5(13): 1152 -1169.
Eshiwani, M. F. (2014). *Effects of Quarrying Activities on the Environment in Nairobi County: A Case Study of Embakasi District.* Unpublished M.Sc Thesis; Department of Geography and Environmental Studies, University of Nairobi, Kenya.
Essaghah, A., Ogbonna, C. and Alabi, M. O. (2013). Environmental and Socio Economic Impacts of Lead and Zinc Ores Mining in Shaiagu Community of Ebonyi State, Nigeria. *Journal of Geography and Earth Science,* 1(1): 30-38.
Jackson, G. (1970). *Vegetation around the city and nearby villages of Zaria.* In Mortimore, M. J. (1970). Zaria and its Region (ed), Occasional Paper No.4 Department of Geography. A.B.U, Zaria. Pp. 191.
Lad, R. J. and Samant, J. S. (2014). Environmental and Social Impacts of Stone Quarrying: A case study of Kolhapur District. *International Journal of Current Research,* 6(3): 5664-5669.
Mugenda, A. G. (2008). *Social Science Research: Theory and Principles*. Nairobi, Kenya: Acts Press. 4th edition, pp. 42 – 49.
Murtala, I. C. (2011a). *An Examination of the Socio-economic and Environmental Impact of Planned Oil sands Development in Nigeria.* An unpublished thesis submitted for the degree of Doctor of Philosophy at the University of Leicester.
Murtala, I. C. (2011b). An Extensive Analysis of Mining in Nigeria Using Geographical Information System (GIS). *Canadian Center of Science and Education*, 3 (1): 3-12.
National Population Commission (NPC) 2009. *Nigeria Census Provisional Results.* National Population Commission, Abuja.
Oguntoke, O., Aboaba A. and Gbadebo, T. A. (2009*).* Impact of Granite Quarrying on the Health of Workers and Nearby Residents in Abeokuta, Ogun State, Nigeria. *Ethiopian Journal of Environmental Studies and Management,* 2(1): 61-66.
Oladimeji, J. S. and Ojibo, S. D. (2012). *Governance Perceptions of Informal Enterprise Operators in Zaria, Nigeria*. *American International Journal of Contemporary Research*, 2(10): 150.
Siachoono,M.S. (2009). Land reclamation efforts in Haller Park, Mombasa. *International Journal of Biodiversity and Conservation*, 2(2): 23 – 26.
Stehouwer, R., Day, R. and Macneal, E. (2006). *Nutrient and trace element leaching following mine reclamation with biosolids. Journal of Environmental Quality*, 5(35): 1118–1126.
Thorp, M. B. (1970). *Land Forms*. In mortimore, M.J (Eds) Zaria and its region. Occasional paper No. 4 Department of Geography, Ahmadu Bello University, Zaria: Pp.13-32.
Usman,J.G., Adeyemi, M.B., Mu’azu, H., Mohammad, H. and Ibrahim, M. (2015). An Assessment of Road Traffic Accident in Zaria Urban Area, Kaduna State, Nigeria. *Developing Country Studies,* 5(12): 105-112.
Wang, L., Zhang, J. L and Liu, L.M. (2010). *Diversification of Rural Livelihood Strategies and its Effect on Local Landscape Restoration in the Semiarid Hilly Area of the Loess Plateau,*

China. Retrieved on 6th December 2016.

Wright, J. B. and Mc Curry, P. (970). *Geology*: *The Geological Map of the Zaria Area*. In: Zaria and its Region, Mortimore, M. J.(Ed.).Occasional paperNo.4; Ahmadu Bello University, Department of Geography, Zaria, pp: 5-12.