African Journal of Geographical Sciences
Vol. 5 No. 1 & 2, 2024 (ISSN: 2786-9741; EISSN: 3043-6656)

Assessment of Urban Flood in Kaduna Metropolis

[1]Jeremiah A. Salifu, [2]Augustine C. Eziashi and [2]Daniel D. Dabi

[1] Department of Environmental Science, Kaduna Polytechnic, Kaduna.
[2] Department of Geography, University of Jos, Nigeria.
Corresponding Author: ojonugwa4jesus@yahoo.com
Doi: https://doi.org/10.5281/zenodo.13769550

Abstract
Kaduna metropolis has witnessed flood events since the early 1980's. This has caused damage to life, property and infrastructure as well as loss of lives. Global climate change and rapid urbanization has increased flood events in the metropolis. Communities within the metropolis have encroached into the flood plains of Kaduna River thereby exposing them to flood hazards resulting to direct and indirect impacts on the community. An objective description of the present flood situation in Kaduna metropolis was undertaken to determine the prevailing flood situation and the cause(s) of floods in the metropolis. Data for this study were obtained from field observations and measurements, satellite imageries, interviews and focus group discussions. Secondary data of rainfall and temperature record of Kaduna metropolis obtained from National Bureau of Statistics and flood incidences in the metropolis from Kaduna State Environmental Protection Agency were reviewed. Purposive and stratified random sampling techniques were employed for this study. Data was analyzed using descriptive method of frequency distributions and map displays. Findings indicate that communities close to the Kaduna River are at a high risk of continuous devastating impact of floods as a result of continuous development in the flood plains of the Kaduna river. There is also an increase in rainfall volume from year 2004 (115mm) to year 2014 (169.5mm) indicating this as a major cause of fluvial floods. Anthropogenic activities of development into the flood plains, indiscriminate dumping of refuse in storm water channels, concreting of surfaces, laying of tarmacs, erosion of soil into the river channel, removal of vegetation for industrial, commercial, recreational and residential use enhanced flood incidences in the metropolis. It is recommended that government should focus more on measures such as restriction of development into the flood plains, sensitization and awareness of the dangers of encroachment into the flood plain and relocation of community members that are within the flood prone areas. These measures in addition to others will assist in tackling the menace of flood in the metropolis.

Keywords: Urban floods, Flood impacts, Flood plain, Kaduna River, Kaduna metropolis.

INTRODUCTION
Floods have become a global environmental problem and its occurrence is associated with increasing disasters of devastating impact (Abashiya, 2006). Early recorded flood events are the Johnston flood of May 31, 1889 in Johnston, Pennsylvania U.S.A that left about two thirds of Johnston town submerged under water and its rail and telegraph lines washed off (Emeribeole, 2015). Flood disasters have been recorded in Paris (1910), the United States Mississippi flood (1927), the Chinese Yellow river flood (1931), the Japanese North Kyushu flood (1953), the Italian Arno river flood (1966), the United States Rapid City, South Dakota flood (1972) and the United States Winter flood in the Pacific Northwest (1993). Severe floods have also been experienced in Norway, Ghana, Bangladesh, the Netherlands and South Florida (Christopherson, 1997). Syvitski and Brakenridge (2013) recorded that flood disasters in the 21st century have increased in occurrence, intensity and impact. In May 2008, torrential rain in China and the Mississippi in United States triggered floods that killed dozens of people and caused a lot of damages after it overflowed its banks, flooding cities, towns and farmlands. In Mozambique, floods from cyclones caused devastation of huge areas of low lying lands, roads, homes, bridges and destruction of crops with 950,000 persons were rendered homeless. 14 million persons were affected by the August 2007 flood in Sathya Sai Bata, India. Pakistan, India and China experienced floods in the

summer of 2010, Colombia from October to December 2010 and Australia during the austral summer of 2010 and 2011(Wright, 2011).

In China, a total loss of US$51 billion was reported due to 2010 river floods. In 2010, there were nearly 2000 immediate fatalities from monsoonal floods in Pakistan (Wright, 2011). In 2011, severe floods were reported in Africa, the Americas and Cambodia and in Asia, with fatalities in each flood exceeding 50 (over 1000 victims in the Philippines and Colombia alone) with high material damage, in particular in the developed countries (Kundzewicz et al, 2013). In 2012, "killer floods," inducing more than 50 fatalities each, occurred in Madagascar, Niger and Nigeria in Africa; Bangladesh, China, India, North and South Korea, the Philippines and Russia in Asia; and Argentina, the United States and Haiti in the Americas.

In Nigeria, floods have become a common environmental problem that has impacted on the people, their livelihood, infrastructure, physical environment and social engagements. NEST (1991) noted that floods develop mostly in the following geographical areas in Nigeria. These areas are the:

(i) Low lying areas in the southern parts of the nation where annual rainfall is heavy.

(ii) The Niger Delta zone.

(iii) The flood plains of the large rivers of Niger, Benue, Taraba, Sokoto, Hadeja, Cross River, Imo, Anambra, Ogun, Kaduna.

(iv) Flat low lying areas around and to the South of Lake Chad which may be flooded and lasting for a few weeks after the rain.

Floods in Nigeria according to Nyomo and Aggarwal (2008), is gradually becoming a serious ecological problem. Floods occur in three main forms: River floods, Urban floods and Coastal floods (Gwary, 2008; Adeoti, Olayide & Coster, 2010). The impacts of floods in urban centers are enormous and often difficult to quantify. Heavy downpour in Lagos and Ibadan triggered floods that resulted in at least 98 losing their lives in Ibadan. (Relief Web, 2011). Floods resulting from heavy rainfall, bad human activities in relation to the environment and lack of drainage infrastructure in most Nigerian cities has left hundreds distressed and homeless. Properties worth billions of naira are lost to flood. An estimated combined loss of more than $16.9b in damaged properties, oil production, agricultural with other losses due to flood events was recorded in 2012 (NEMA, 2012; Oladokun & Proverbs, 2016).

Flooding in Nigerian cities is a critical environmental problem which continuously affects effective functioning of urban environment, especially in the areas of sustained infrastructure and services which are germane to sustainable livelihood (Odufuwa et al, 2012). Water flowing from streams, rivers and storm water tunnels can leave their normal channels, exceeding the capacity of the channel and overflow into the space used by the population for various activities. Heavy precipitation can increase the volume of water beyond the holding capacity of the natural channel causing an overflow into areas close to the river (Tucci, 2007). Urban flood experiences are recorded in Onitsha in Anambra state with devastating impacts (Adinna, 2001), the Yellow Duke River Flood in Calabar that annually displaces families and officers of Calabar Polytechnic (Isong, 1999) and the annual flooding of streets in Lagos (Ojo, 1988). The consequences of these urban floods are immeasurable. Roads are affected, properties are damaged, there is economic loss and stress on the living, loss of lives, displacement from homes and degradation of farmlands. Water supply, electricity, roads and railway lines are also destroyed. Half of disasters worldwide and 85% of deaths in the world are caused by urban floods (UN-Water 2011). Urban flood impact is also enhanced through unplanned development in flood plains, ageing drainage infrastructures, increased paving and other impermeable surfaces and lack of flood risk reduction activities.

Floods have become a threatening environmental hazard in Kaduna metropolis causing destruction of lives and properties. Communities close to the Kaduna river have experienced loss of lives and damages to property, infrastructure and the physical environment. A history of floods in Kaduna metropolis is presented in Table 1.

Table 1. Flood in Kaduna Metropolis

S.N	Date	LGA/Town/Community	Occurrence	Remarks
1.	September, 1988	Kaduna city, Kaduna State	City streets in the metropolis flooded	Affected roads within the metropolis including Kaduna International Airport road.
2.	August, 2003	Tudunwada in Kaduna State	Tudunwada flooded	Several corpses found floating on the flood waters
3.	August, 2003	12 LGA including Kaduna metropolis, Malali, Barnawa, Agwan Rimi	Flooding in Kaduna State.	30,000 houses destroyed, 5,000 rendered homeless, 2 lives lost, 1,500 persons in Kaduna metropolis affected.
4.	September, 2008	Kaduna Metropolis	Flooding of River Kaduna and other streams.	3 lives lost, houses affected and property damaged.
5.	August, 2009	Southern Kaduna	Floods/ Erosion	Rail line affected, Kaduna Bridge affected, over 1,500 lives affected, loss of lives undetermined.
6.	September, 2012	Kaduna metropolis. Abubakar Kigo raod, Angwarimi, Kabala costain, Rafin guza, Doka, Malali, Nasarawa, Tudun wada.	Flooding of Kaduna metropolis.	Seven deaths recorded, Homes and farms flooded, property destroyed.
7.	September, 2013	Kaduna metropolis flooded Agwan Boro, Agwan Maigero, Agwan Romi, Gonin gora, Tudunwada, Abubakar Kigo road, Nasarawa, Kabala doki, Karatudu.	Heavy precipitation and Flooding of River Kaduna and other streams	Thousands rendered homeless, property and infrastructure damage.
8.	September, 2015	10 LGAs and Kaduna metropolis flooded. Kigo road, Agwan romi, Rafin guza, Barnawa, Kudenda, Kabala costain	Heavy precipitation, overland floods and overflow of Kaduna River.	Two deaths recorded, many displaced; homes, property and infrastructure destroyed.
9.	August, 2016	2 LGAs and Kaduna metropolis. Barnawa, Narayi, Agwan romi, Kigo road, Rafin guza.	Heavy precipitation, overflow of Kaduna river.	10,000 displaced; homes, property and infrastructure damaged.

Source: Adefolalu, 2000; Ologunorisa, 2006; Nyomo, 2008; Vanguard newspapers, 2012, 2013 & 2015; Premium Times, 2015; Channels TV, 2016.

Table 2. Flood data from KADSEMA

Date	LGA	Communities	Mortality	Impact
1st – 20th August, 2015	Kaduna South Kaduna North Chikun	Metropolis and environs	2 persons	Houses, farmlands, properties destroyed
20th – 21st September, 2015	Kaduna South	Tudunwada, Barnawa, Kabala west.	-	Houses and farmlands destroyed
20th – 21st September, 2015	Kaduna North	Rafin guza, Malali, Gamji gate, Kigo road, Kabala costain.	1 person	Houses and farmlands destroyed
20th – 21st September, 2015	Chikun	Nasarawa, A/ Romi, Goningora, Kudendan.	-	Houses and farmlands destroyed
1st July – 30th August, 2018	Kaduna North, Kaduna South, Chikun, Igabi	Metropolis and environs.	-	> 12,982 persons affected, > 12,454 houses affected, 528 farmlands affected, Over 4Billion naira estimated losses
23rd – 24th August, 2018	Kaduna metropolis	A/romi, Karatudu, A/rimi, Rafin guza, Goningora	2 persons	Properties and buildings destroyed, > 1000 people displaced

Source: KADSEMA 2018

Over the last 38 years, Kaduna metropolis has experienced a gradual increase in the occurrence of flood episodes. Communities in the metropolis such as Rafinguza, Malali, Agwan rimi, Rigasa, Tudunwada, Barnawa, Kigo road, Kudendan, Kabala doki, Nassarawa, Agwan romi and Gonin gora in close proximity to the Kaduna river, have experienced fluvial floods. This has impacted on the community through property and infrastructural damage, economic losses, loss of lives, disruption in agricultural, transportation and commercial activities. This has brought untold hardship on the metropolis with difficulties in the functioning of their normal daily activities as recorded in the flood of 2015 (Ibrahim & Abdullahi, 2016). Flood management measures were ineffective and relief materials provided were not adequate enough to meet the need of the flood victims. This paper focuses on the present situation of flood in these communities and determined the cause(s) of floods in the metropolis. Recommendations for more effective measures to address the flood problem in the metropolis have been suggested.

MATERIALS AND METHODS

Study Area

Kaduna metropolis is located between latitudes 10^0 28^1 and 10^0 37^1 North and longitudes 07^0 19^1 and 07^0 31^1 East occupying an area of about 26km^2. Kaduna metropolis consists of two main LGAs, the Kaduna North and Kaduna South, and has Igabi and Chikun as adjoining LGAs (Kaduna state Government, 2016). It started as a dispersed indigenous "Gbagi" settlement. (Abashiya, 2006). The old Kaduna metropolis was bounded to the east by the Kaduna river, the south by the railway to Kafanchan and Jos, the west by the Mashi river valley and to the North by the Mando road to Lagos. This boundary has since been exceeded with the northern and southern villages having expanded and completely merged.

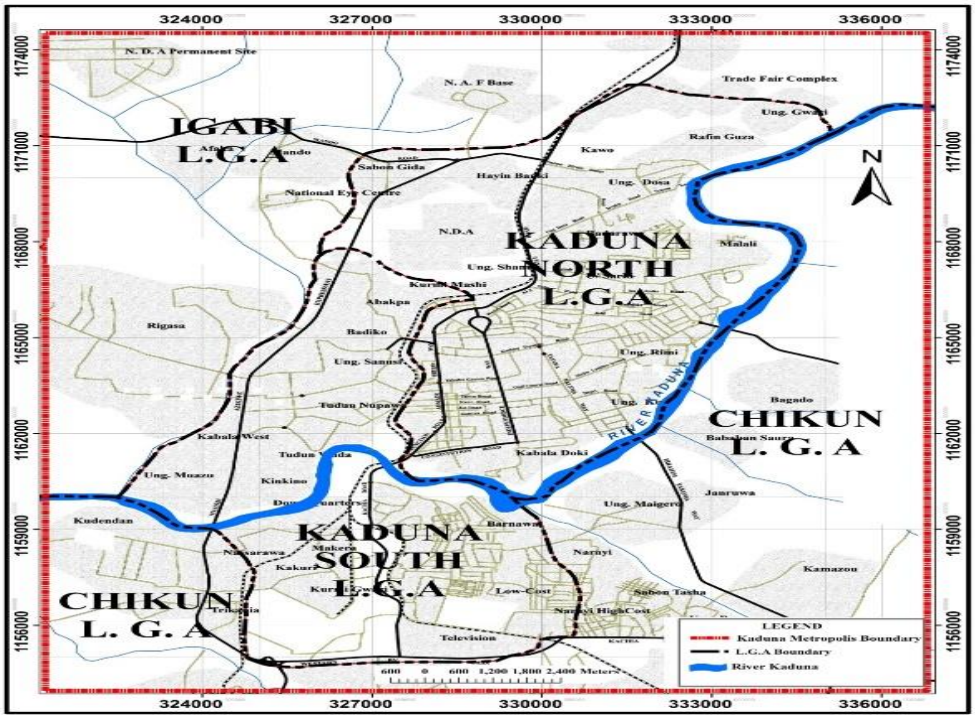

Figure 1: The Local Government areas that make up Kaduna metropolis.
Source: Department of Cartography, Kaduna Polytechnic (2018).

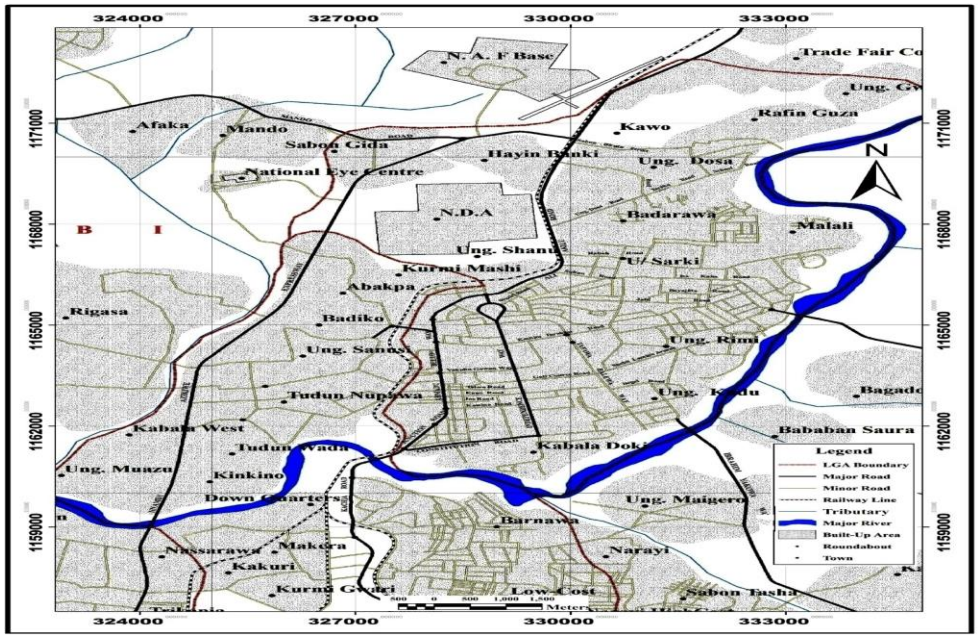

Figure 2: Kaduna Metropolis.
Source: Department of Cartography, Kaduna Polytechnic (2018).

Kaduna metropolis falls within the central high plains of Northern Nigeria. The metropolis consists of a peneplain developed on pre-cambrian rocks of variable composition, the older granite, schists and quartzites predominating in the area enclosed by lines joining the neighbouring towns of

Zaria and Birningwari. Smooth low ranges characterize the schists but the most conspicuous relief features which consist of isolated or massed inselbergs are associated with the older granite. The entire metropolis is drained by the Kaduna river which is a major tributary of the Niger (Udo, 1981). The bedrock geology is predominantly metamorphic rocks of the Nigerian basement complex consisting of biotite gneisses and older granites. In the south eastern corner, younger granites and bathyliths are evident (Bello, 1993).

The topography of the state is dominated by gentle undulating plains with slopes of 0-2% covering about 75% of the land area with steep slopes greater than 20% also present as well as rock outcrops with shallow patches of soil bedrock. The underlay of the state is mainly an undifferentiated basement complex of Igneous and Metamorphic rocks from which the soils are developed. Deep chemical weathering and fluvial erosion influenced by the bio-climatic nature of the environment have developed the characteristic high undulating plains with subdued interfluves.

The drainage of Kaduna metropolis falls within the drainage of the Central High plains of Northern Nigeria. The relief of the North central high plains has its highest parts in the north around Zaria (over 2,700 feet) and in the neighbourhood of the Jos Plateau (over 3,500 feet); the general slope of the land being in a westerly and south westerly direction. Although the Gurara and Mada rivers which are small rivers drain directly into the Niger and Benue rivers, the whole of the entire region is drained by the Kaduna river which is a major tributary of the Niger. The dominance of the Kaduna river system is so great that this region, which also contains the former Northern Nigeria capital of Kaduna territory can be properly designated the upper Kaduna basin (Bello, 1993).

Unlike most rivers in this part of the country, the Kaduna river is a perennial stream although it is subject to great seasonal fluctuations in level (Russ, 1957). The direction of the flow of the Kaduna river above Kaduna capital city and of the Galma tributary above Zaria indicate clearly that these headwaters formerly flowed into the Rima valley but have since been captured by streams flowing into the lower Kaduna valley. The smaller rivers which have little or no water in them during the dry season are flooded during the rainy season turning the country side into fresh water swamps. These seasonal flooded lands become valuable for agricultural purposes because of its high soil nutrient value (Udo, 1981).

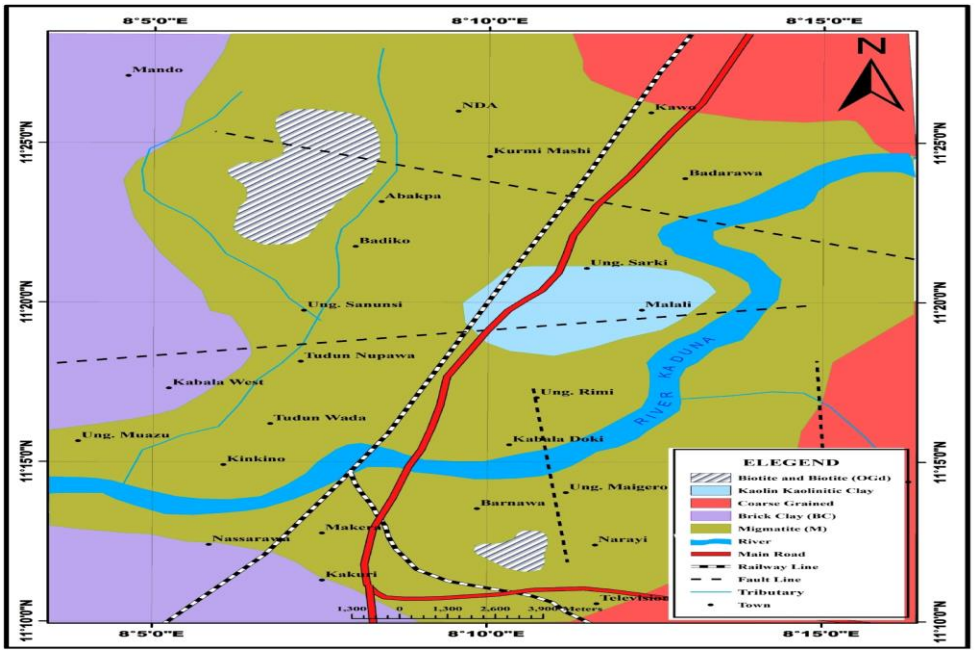

Figure 3. Geology of Kaduna Metropolis
Source: Department of Cartography, Kaduna Polytechnic (2018).

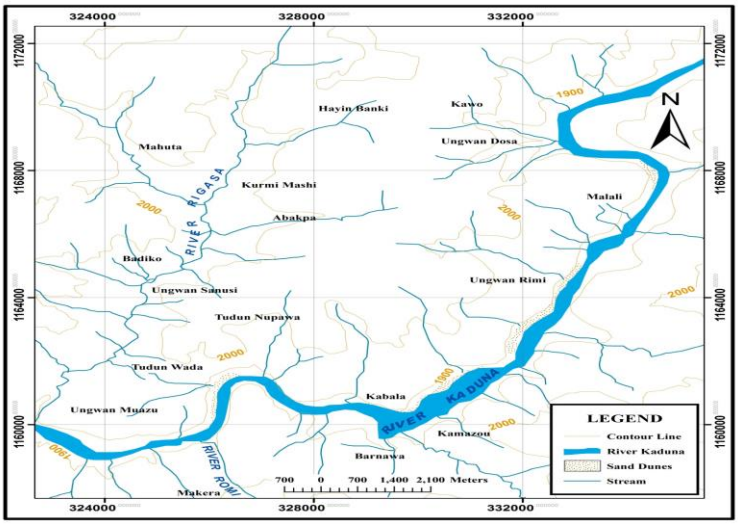

Figure 4. Relief and Drainage of Kaduna Metropolis
Source: Department of Cartography, Kaduna Polytechnic (2018).

Kaduna metropolis has a tropical continental climate. The rainfall pattern in Nigeria is generally governed by the movement of the inter tropical convergence zone (ITCZ) which shows a steady decrease from South to North. The study area, (Kaduna metropolis) therefore shares these characteristics and has distinct wet and dry seasons. The mean annual rainfall in the state ranges from 1000mm in the North to 1500mm in the South. The mean annual length of the rainy season (LRS) varies from about 150 days in the Northern part of the state to about 180 days in the Southern part. The rainy season starts between April and May, and extends to October (lasts for 6 – 7 months). The dry season starts around October/November and extends to March. During this season in the state, most especially around November to January, cold dry dusty winds prevail, blowing from the Sahara. The mean annual potential evapotranspiration ranges from 1500mm in the Northern part of the state to about 1200mm in the Southern part while that of actual evapotranspiration ranges from 1600mm in the Northern part of the state to 1100mm in the Southern part (Ayoade, 1976).

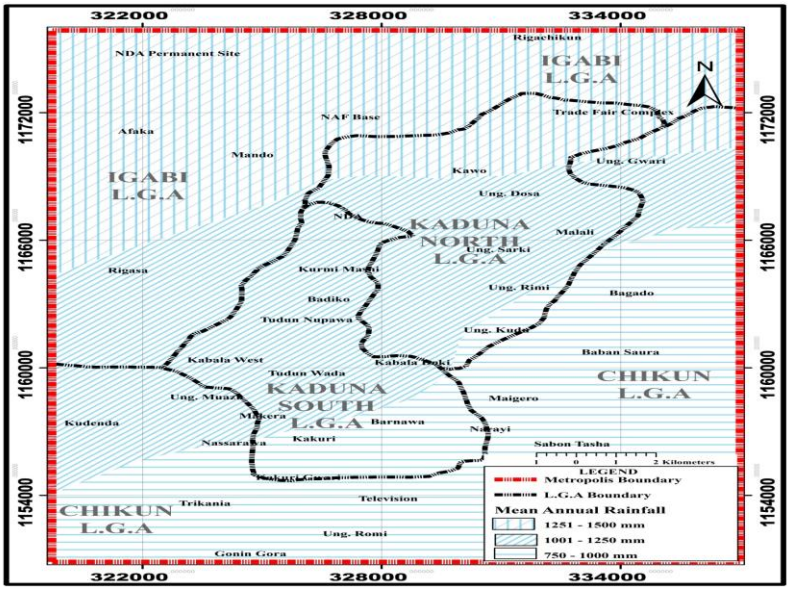

Figure 5. Isohytes map of Kaduna Metropolis
Source: Department of Cartography, Kaduna Polytechnic (2018).

The mean daily temperature of the metropolis ranges from 28^0C in the Northern part of the state to about 20^0C in the Southern part of the state. The mean annual range of temperature varies from 12^0C in the Southern part of the state to 16^0C in the Northern part of the state. The mean annual maximum temperature in the state varies from 35^0C in the North to about 28^0C in the South. There are spatial and seasonal variations in the relative humidity throughout the state. Months of May to October have relative humidity (monthly means) of over 80% while during January to April, mean values are close to 25% or 30% (Ayoade, 1976).

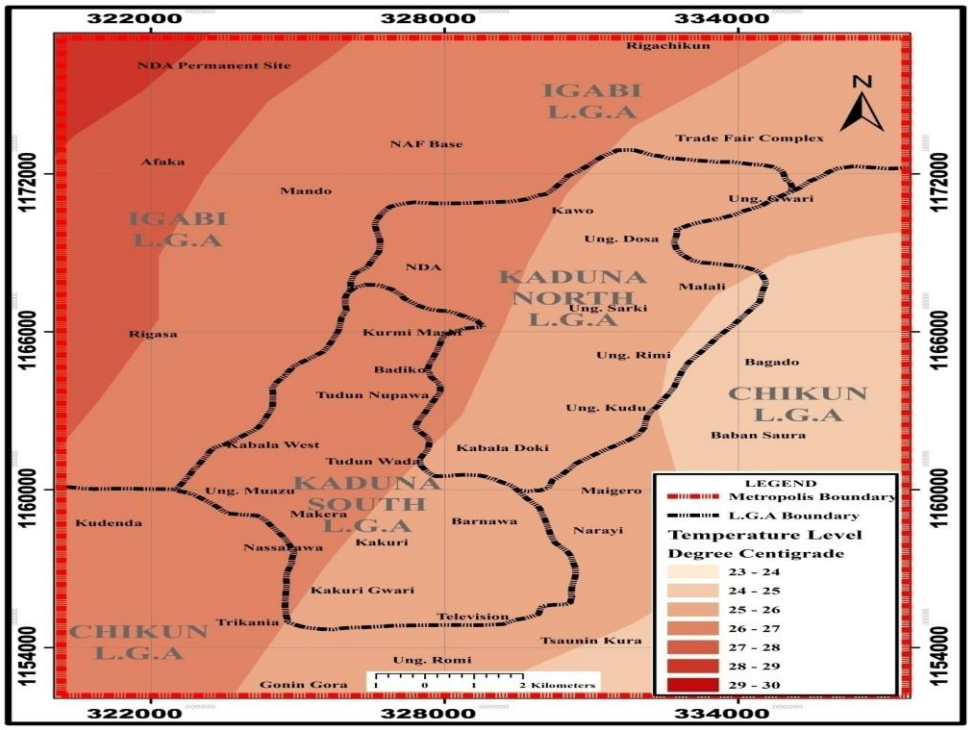

Figure 6. Isothermal map of Kaduna Metropolis
Source: Department of Cartography, Kaduna Polytechnic (2018).

Most parts of the state are under the ferruginous tropical soils which overlay a granite basement complex. These ferruginous soils are the most important group of soils in Nigeria because they support most of the important cash and food crops produced in the country (Areola, 1978). Apart from ferruginous soils, the other group of soils found in the state is hydromorphic and alluvial soils. These are seasonally or permanently water logged soils. The Fadama areas are richer in Kaolitic clay. There are two types of hydromorphic soils, organic and Inorganic mineral types. The mineral hydromorphic soils are usually the seasonally water logged where organic matter has a chance of being decomposed periodically when water levels subside. These types are found in Kaduna state around the valley and flood plains of Kaduna river and its tributaries. **A**bout two – thirds of Kaduna state fall within the Guinea Savanna Vegetation. The central part of the state down to the Southern part fall under the Guinea Savanna. This vegetation zone consists of tall grasses and clumps of trees. The trees are tall and mainly deciduous. Sudan Savanna vegetation zone is characterized by short grasses interspaced by short trees. This area is more important in groundnut production than other parts of the State. The trees in this vegetation always occur singly rather than in clumps. (Bello, 1993; Geoinformation, 2013).

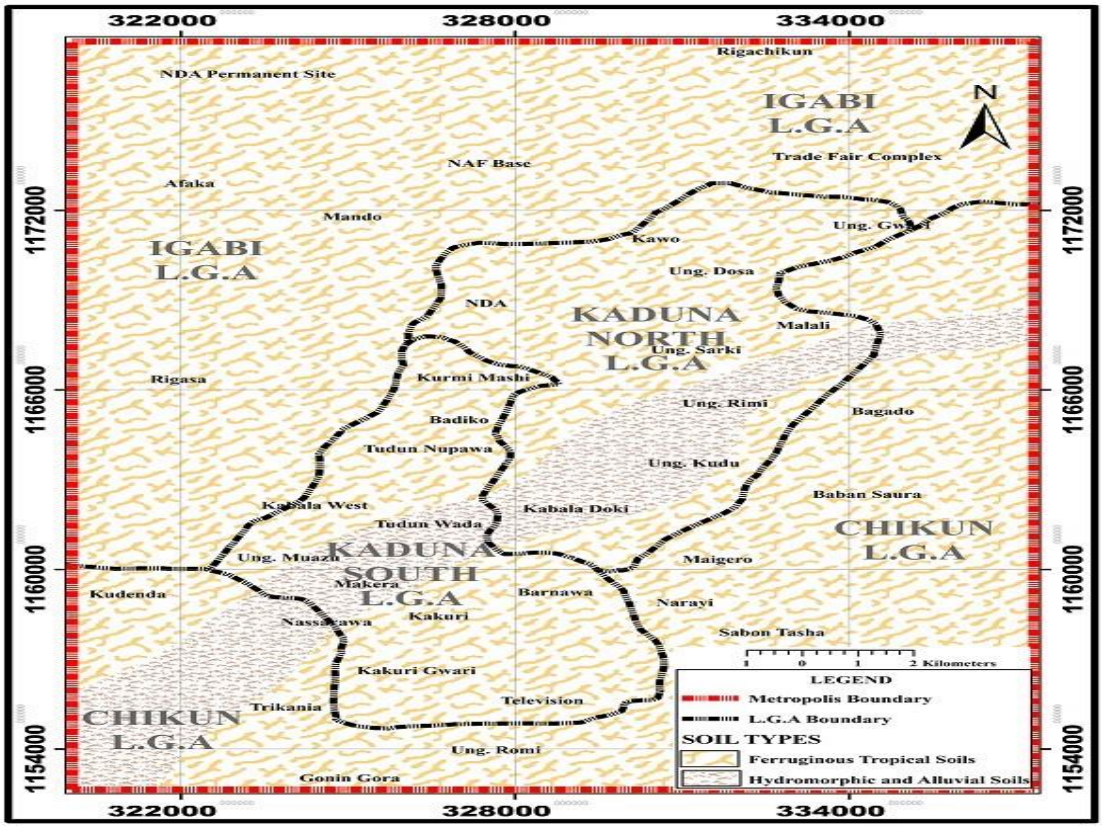

Figure 7. Soil map of Kaduna metropolis.
Source: Department of Cartography, Kaduna Polytechnic (2018).

Data and Methods

The methodology adopted for the study include visits to the communities to observe impact and effects of flood, interviews and focus group discussions with the affected community members. Satellite imagery of the metropolis indicating development into the flood plain was also obtained. Measurements of closest structures to the Kaduna River in each community to determine proximity was also undertaken. A purposive and random sampling technique was adopted using a sample size of 400 (Yamane, 1967) for the instrument of questionnaire administration. Questionnaire was administered to households in communities that have had previous experiences of floods. Secondary data for rainfall and temperature was also obtained from NBS (National Bureau of Statistics). The communities for these study are Agwan Rimi Low cost, Agwan Rimi Kudu, Gonin gora (Hayan Katafawa), Tudun wada, Kudenda, Nassarawa, Agwan Romi, Kabala Doki (Costain), Rafin Guza and Kigo road.

RESULTS AND DISCUSSION

A high flood risk of continuous devastating and destructive impact best describes the present flood situation in the metropolis. This can be observed as recorded in Table 1 with flood episodes and its impacts in Kaduna Metropolis over the years (From 1988 to 2016). This is attributed to the increased development into the flood plain of the Kaduna River as a result of population growth. A contrast of the population density of the local governments areas that make up Kaduna metropolis, looking at 2006 population (1,570,331 persons) and the projected 2018 population at 3% annual growth rate (2,238,913 persons) shows clearly this increase. Satellite imageries of the metropolis in the years 2010, 2015 and 2020 also indicate increased development into the flood plains.

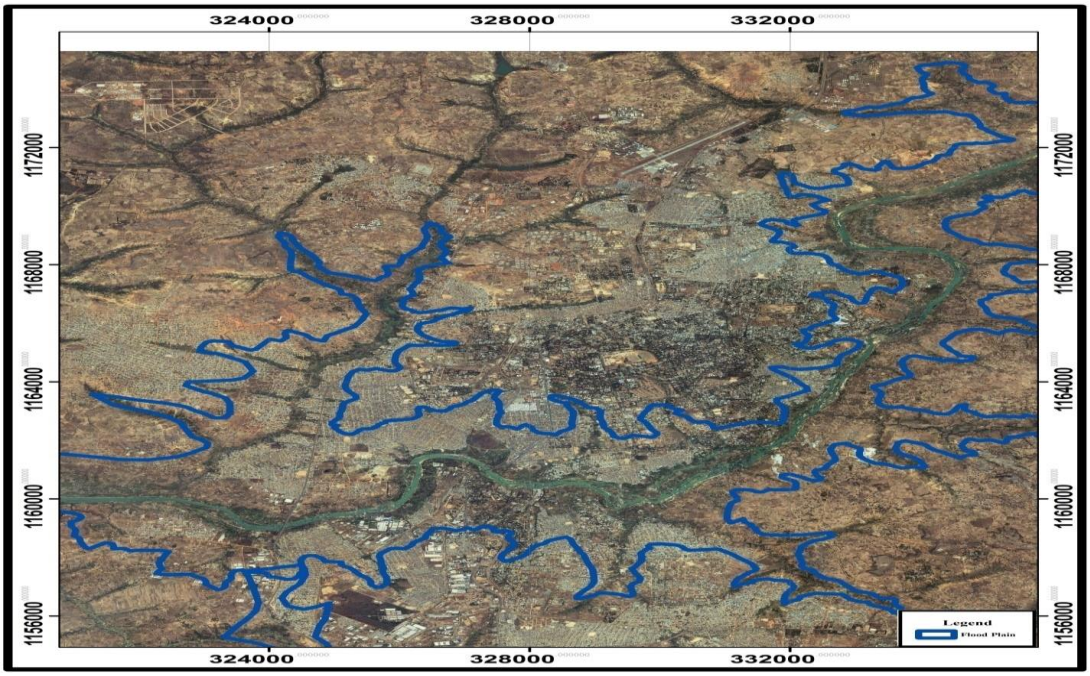

Figure 8. 2010 Satellite Imagery of Kaduna Metropolis
Source: Department of Cartography, Kaduna Polytechnic (2018).

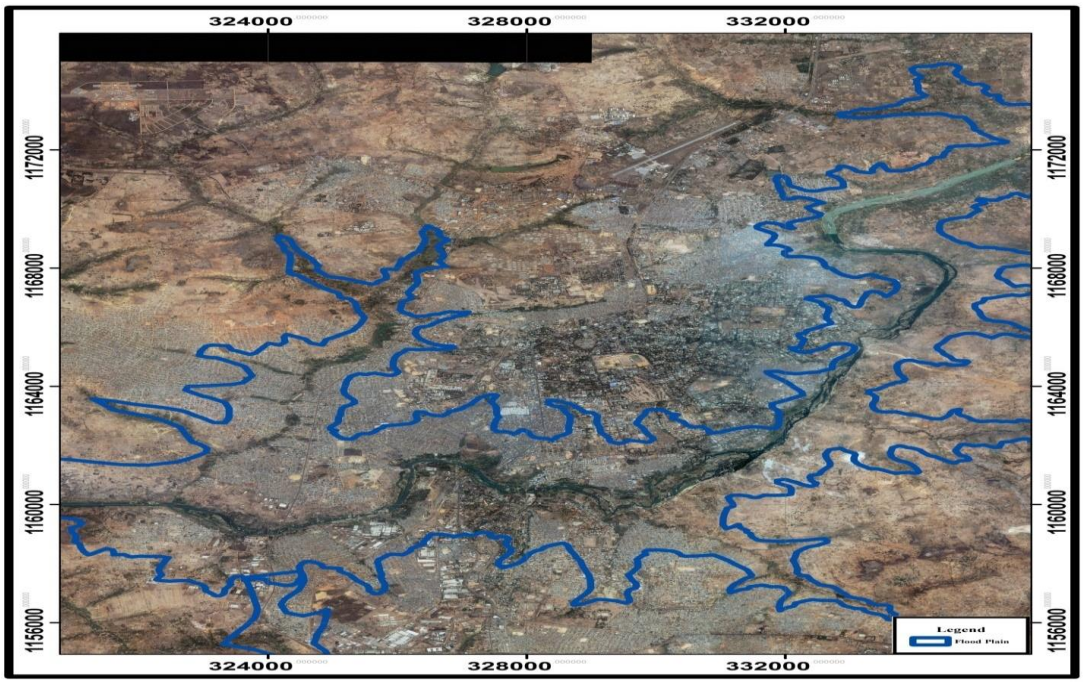

Figure 9. 2015 Satellite imagery of Kaduna Metropolis
Source: Department of Cartography, Kaduna Polytechnic (2018)

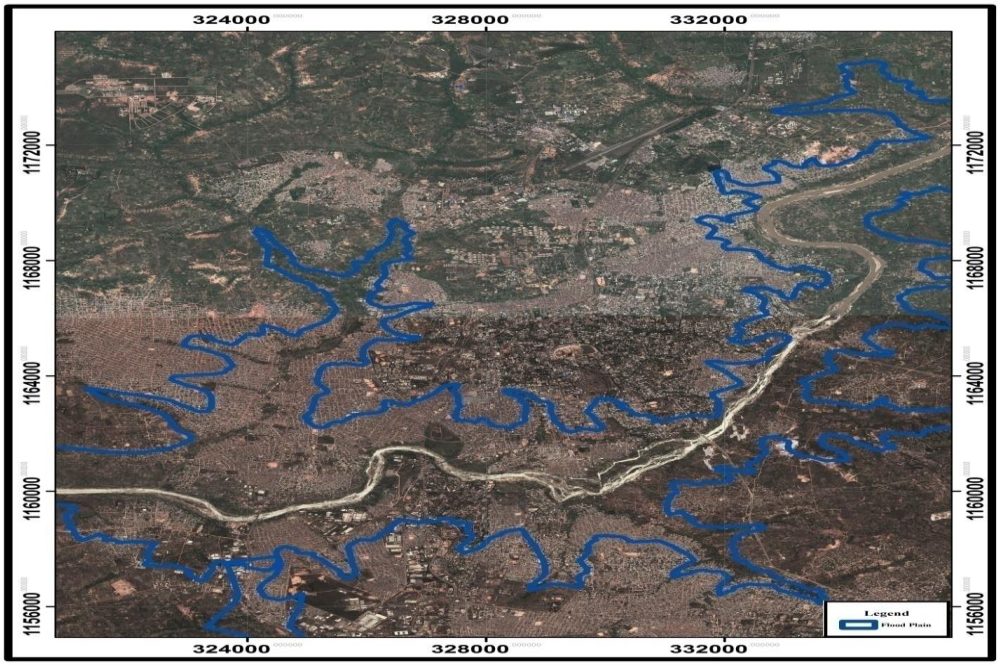

Figure 10. 2020 Satellite imagery of Kaduna Metropolis
Source: Department of Cartography, Kaduna Polytechnic (2018)

A closer observation of the satellite imagery of the metropolis in 2020 shows more concentration of development within the flood plains when compared to that of 2015. This is attributed to increased population and more of infrastructural development within the communities. Table 3 shows the distances of the three closest structures to the river bank in the various communities.

Table 3. Distance of the 3 closest structures to the river bank

Community	House 1	House 2	House 3
Gonin Gora (GG)	35m	33m	51m
Kudendan (KU)	16m	67m	103m
Agwan Romi (AR)	3m	9m	10m
Kigo Road (KR)	61m	27m	70m
Kabala Doki (KD)	19m	26m	24m
Tudun wada (TW)	40m	11m	26m
Agwan rimi Kudu (AGRK)	7m	9m	11m
Agwan rimi Low cost (AGRL)	14m	15m	19m
Rafin guza (RG)	140m	151m	192m

Source: Field work, 2018.

When reflected on the map of the Kaduna river flood plain, it indicates the proximity of the structures within these communities to the Kaduna River showing part of these communities in the flood plain of the Kaduna River. Results show that one of the causes of increasing flood incidences in Kaduna metropolis is the increase in annual rainfall. Increase in annual rainfall fills up the Kaduna river channel causing it to overflow its banks during high periods of precipitation, most especially in the months of August and September. Marginal increase in temperature increases atmospheric humidity leading to more cloud formation which results in more precipitation.

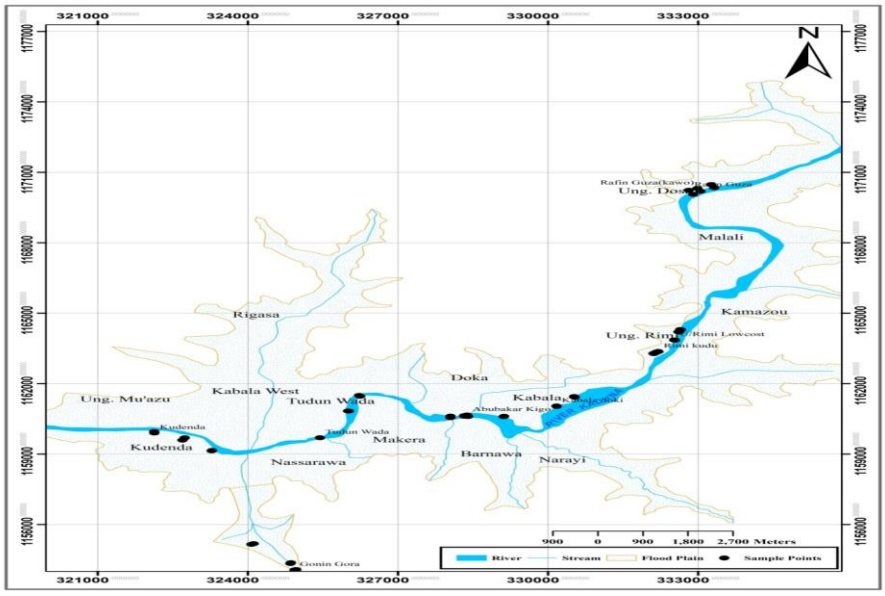

Figure 11: Location of Closest Structures in Community to the Kaduna River Bank.
Source: Department of Cartography, Kaduna Polytechnic (2018).

Data obtained from Annual Abstract of Statistics of the National Bureau of Statistics (NBS) of the Federal Republic of Nigeria show reasonable estimates of rainfall volume and temperature intensity and its effect on weather in relation to floods. Marginal increases in rainfall are observed in the flood years of 1988 (11.8mm), 2008 (20.8mm), 2009 (45.4mm), 2013 (51.5mm) and 2015 (18.7mm) with marginal temperature increase in flood years of 2009 (1.7°C), 2013 (2°C) and 2015 (1.7°C). Results in Table 4 show this variation in annual rainfall and temperature for the flood years.

Table 4. Variation in Rainfall and Temperature values for flood years

Rainfall (mm) (x)					Temperature (°C) (y)				
YB	(x)	FY	(x_i)	MD(x_i – x)	YB	y	FY	y_i	MD(y_i – y)
1987	150.1	1988	161.9	11.8*	1987	32.7	1988	31.6	- 1.1
2007	74.8	2008	95.6	20.8*	2007	34.5	2008	30.7	- 3.8
2008	95.6	2009	141	45.4*	2008	30.7	2009	32.4	1.7*
2011	123.6	2012	118.3	- 5.3	2011	32.6	2012	32.5	- 0.1
2012	118.3	2013	169.8	51.5*	2012	32.5	2013	34.5	2*
2014	139.8	2015	158.5	18.7*	2014	30.7	2015	32.4	1.7*

FY - Flood year, YB- Year Before flood year, MD – Marginal difference,
* - Increased Rainfall volume and Temperature values
Source: Field work, 2018.

Other causes of floods in Kaduna metropolis can be indirectly linked to anthropogenic activities of continuous siltation of the Kaduna River channel and the dumping of solid wastes into the Kaduna river. Anthropogenic activities of farming, construction and other infrastructural developments generates silts that are eroded into the Kaduna river channel. Run off from land erodes top soil into the river. Farming activities and reduced vegetation as a result of development in the communities increases the amount of soil particles that are eroded during the rainy season. This has led to gradual accumulation of silt in the river channel which reduces the capacity of the channel for containment. Silt deposits during heavy precipitation takes up the space meant for river water to flow through and also blocks free flow of water through the channel. Solid wastes are also dumped into the River channel. Observations within the communities indicate solid waste deposited in

storm water channels and drains. These flow with storm water during the rainy season and is discharged into Kaduna River. Communities like Kabala Doki, Kigo road, Rafinguza and other communities dispose their solid waste into channels and drainages. These solid waste materials on getting into channel settle to the floor of the river and take up space thereby enhancing flood incidences during high precipitation. This reduces the capacity of the channel to contain water resulting into an overflow of the Kaduna River during periods of high precipitation.

Plate 1. Siltation of Kaduna River
Source: Field work (2018).

Plate 2. Solid waste dumped into Kaduna River
Source: Field work (2018).

CONCLUSION

The study found out that the present situation of floods in Kaduna metropolis is that the communities are at a high risk due to their proximity to the Kaduna river. This is as a result of increased development of the communities into the flood plains. This large scale encroachment into the Kaduna river plains exposes the communities to high impact of flood waters. Inaction concerning flood plain encroachment will lead to increased damage and destruction of residential structures, infrastructure, social amenities and the physical environment. Increased rainfall is the major cause of flooding of the Kaduna river. Rainfall increases the volume of water in the river channel which overflows into the communities and impacts life and

property. Top soil is eroded during the rainy season due to farming practices, construction and top soil removal during precipitation as runoff. This leads to the deposition of silt in the river channel reducing the capacity of the channel to contain water. Molds of silt are visible along the stretch of the river channel. Indiscriminate dumping of solid wastes also constitutes a problem. Solid wastes dumped in drains find their way into the Kaduna river. These settle at the base of the river channel taking up space that is meant for water in the channel. To be able to tackle this menace, corrective steps must be adopted to reduce the increased impact and severity of the floods. The encroachment into the flood plain must be stopped by enforcement of laws. Regular de-siltation of the river channel should be embarked on. Proper solid waste disposal methods should be adopted by the communities with awareness created on the detrimental impact of indiscriminate solid waste disposal.

Based on the findings, there is the urgent need to protect the people, their livelihoods and the environment from future flood disasters. The following measures should be put in place to tackle the menace of flooding in the metropolis.

a. Sensitization and public awareness of the dangers of development in the flood plains.

b. Enforcement of provisions and policies by government to ensure strict compliance with existing regulations as to development in the flood plains.

c. Possible relocation of residents and structures that are in close proximity to the point of hazard, i.e the Kaduna river. This should be in line with international best practices for flood prone areas.

d. A partnership that will encourage synergy between the public and the private sector in waste management should be encouraged by the government.

e. Government should encourage re- vegetation as this will reduce run off during precipitation.

f. Construction of embankments along the river channel will reduce flooding to a large extent.

g. Dredging of the river channel can be embarked on to create more space for the channel to be able to contain water.

REFERENCES

Abashiya, M. (2006). Influence of Man - made Structures on Floods in Northern part of Kaduna Metropolis. [Unpublished M.SC thesis], Department of Geography, ABU, Zaria, Nigeria.

Adefolalu, D.O. (1999). Effects of Climate Change in Nigeria in 1999 – An Introduction to the Challenges of Climate Change and its Impact in Nigeria in the next Millennium. [Paper Presentation], Climate Change Center, Federal University of Technology, Minna.

Adeoti, A., Olayide, O., & Coster, A. (2010). Flooding and Welfare of Fisher's Household in Lagos state, Nigeria. *Journal of Human Ecology*, 32(3), 161-167.

Adinna, E.N. (2001). *Environment Hazards and Management*. Snaap Press Ltd.

Ayoade, J. O. (1976). Evaporation and evapotranspiration in Nigeria. *Journal of Tropical Geography*, 43, 9-19.

Bello, A.L. (1993). Nigeria: A People United, A Future Assured. Vol 2. Survey of States. In

Christopherson, R.W. (1997). *Geosystems: An Introduction to Physical Geography*. London: Prentice – Hall (Third Edition). .423.

Emeribeole A.C (2015). Managing Flood Disasters in Nigerian Cities: Issues and Strategies towards meeting the Challenges in the Modern World- A Case Study of Owerri Metropolis, Imo State, Nigeria. FIG working Week, Sofia, Bulgaria.

Geo-information. (2013). Vegetation types in Nigeria. The Ultimate Encyclopedia.

Gwary, D. (2008). Climate Change, Food Security and Nigeria Agriculture. [PaperPresentation], A Workshop on the "Challenges of Climate Change for Nigeria". NISER, 19th – 20th May, 2008.

Ibrahim A.H & Abdullahi S. Z. (2016). Flood Menace in Kaduna Metropolis: Impacts, Remedial and Management Strategies. *Science World Journal*. 11(2)

Isong, M. A. (1999). An Analysis of Flooding in Polycal and the Environs. *International Journal of Tropical Environment*. 1(1), 28 - 37.

Kaduna State Government. (2016). Demographics of Kaduna State. Kdsg.gov.ng.

Kundzewicz, Z.W., Pińskwar, I., & Brakenridge, G.R, (2013). Large floods in Europe, 1985–

2009. *Hydrological Sciences Journal*, 58 (1), 1–7

Mamman, A. B., Oyebanji, J. O. & Petters, S. W. Millenium edition, Gabumo press.

NEMA (2013). Nigeria lost N2.6 Trillion to Floods in 2012. Daily Trust newspapers, July 31, 2013.

NEST. (1991). *Nigeria's Threatened Environment: A National Profile*. Ibadan, Nigeria. Environmental Study Action Team.

Nyomo, D. & Aggarwal, A. N. (2008). Flood Inundation Hazard Modeling. *Journal of Applied Sciences Research*, 4(12), 1822-1833.

Odufuwa B, O; Adedeji O, H; Oladesu, J. O; & Bongwa A. (2012). Floods of Fury in Nigerian Cities. *Journal of Sustainable Development*, 5(7).

Ojo, O. (1988). Water and Urban Landscape in Nigeria: The Example of Lagos, Nigeria. *Urban Water, 88.*

Oladokun, V.O & Proverbs, D. (2016). Flood Risk Management in Nigeria: A Review of The Challenges and Opportunities. *International Journal of Safety and Security Eng*., 6(3), 485–497

Relief Web. (2011). Nigerian Flooding Claims 102 Lives: Red Cross. *Report by Agence France-Presse,* 31st August, 2011. reliefweb.int/report/nigeria/nigerian-flooding-claims 102 lives- red-cross.

Russ, W. (1957): The Geology of Parts of Niger, Zaria, and Sokoto Provinces. Geological Survey of Nigeria. 27, Lagos

Syvitski, J.P.M. & Brakenridge, G.R., (2013). Causation and avoidance of catastrophic flooding along the Indus River, Pakistan [online]. GSA Today, 23 (1). doi: 10.1130/GSATG165A.1. Available from: http://www.geosociety.org/gsatoday/archive/23/1/article/i1052-5173-23-1-4.htm

Tucci, C.E.M. (2007). Urban Flood Management. WMO Secretariat.

Udo, R.K. (1981). *Geographical Regions of Nigeria*. Ibadan. Heinemann Educational Books, Ltd.

United Nations Water. (2011). Cities Coping with Water Uncertainties. [Media Brief], UN-Water Decade Programme on Advocacy and Communication.

Wright, T. (2011). "Waterlogged: Pakistani Children Push a Motorbike through Flooded Er Streets after Rain in Lahore". The Wall Street Journal, London.

Yamane, T. (1967). *Statistics: An Introductory Analysis*, 2nd Edition, New York: Harper and Row.