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## ANALYSIS OF URBAN LAND USE ENCROACHMENT ON RIVER KADUNA FOODPLAIN, KADUNA METROPOLIS, KADUNA

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<sup>1</sup>Baba, Ezekiel Bahago; <sup>2</sup>Maiyaki, Dele Jibrin & <sup>3</sup>Musa, Isa

<sup>1</sup>Department of Urban and Regional Planning, Fed. Capital Development Authority, Area 11 Garki, Abuja

<sup>2</sup>Department of Urban and Regional Planning, Kaduna Polytechnic, Kaduna

Email: [easybahago@gmail.com](mailto:easybahago@gmail.com)

### ABSTRACT

Global trend of urbanization has changed considerably as the development on flood plain is evident in urban settlement. This is the case of Kaduna urban area. Kaduna urban area is divided into almost two equal halves by river Kaduna. The Master plan of the Kaduna designated floodplain along the river to avoid exposing the inhabitant of the area to flood vulnerability. Nevertheless, land use development has since taken over the designated area of the floodplain which is the thrust of the study. The study aims at analyzing the urban land uses components that had encroached into the flood plain with the view of making recommendation for improvement. The study uses GIS tool as a model to determine the spatial extent of encroachment into the floodplains of the River. The study divided the study area into catchment areas for easy assessment. At the end of the analysis, the study established that the rate and nature of urban land use encroachment into the floodplain is progressive in nature. The average encroachment rate into the designated area was established at 49.9Km<sup>2</sup> which represents 40.92% of the total land areas designated as flood plain in 1967. Among the land uses that has encroached into the flood plain, residential land use has the highest encroachment level with 85.8% of the area encroached by it while others like industrial, educational and institutional land uses encroached 5.8%, 2.8% and 1.4% into the floodplain respectively. The lowest encroached land use into the area is the commercial, infrastructure and recreational land uses with 0.1%, 0.2% and 1.2% respectively. Based on these established facts, the following recommendations were given; there should be relocation of the inhabitant of the land uses to avoid risk of flood vulnerability; there should be effective policy integration and implementation of all urban management agencies responsible for physical development in Kaduna metropolis to avoid further encroachment into the floodplain; there should be land acquisition of all encroached and un-encroached area of the flood plain by the state government so as to regulate the area; there should be the creation of floodplain Buffer Zone to outline detail profiling of the existing built up area and the existing land use encroachment in the floodplain of the area; and land in safe and accessible locations should be supply to meet the needs of all sectors of the society to avoid further encroachment into the floodplain;

**Keywords:** Master Plan Provision, Land Use Encroachment

## INTRODUCTION

### Background of the Study

The rate at which urban area is developing in the developing countries is alarming. This is evident in the development on vulnerability areas. Floodplain is one of the vulnerability areas in which land use development is deterred globally. In Kaduna Metropolis, the Master plan designated areas along river Kaduna as flood plain so as to deter development around the area. But in recent time, it has been observed that the designated area has been drastically encroached into by urban land use development which is the reason for this study. The study aims at analyzing the urban land use encroachment into the designated area of the floodplain with the view of making recommendations for improvement. Kaduna urban area is divided into almost two equal halves by the river known as river Kaduna. The study uses master plan of 1967 provision of the flood plain areas as the basis for the study and also uses GIS tool as a model to determine the spatial extent of the encroachment into the floodplains of the River. To effectively carry out the study, the study outlined the following objectives to be addresses; to examine the provision of the Master plan for the flood plain areas of the River Kaduna, to examine the extent of the encroachment into the river floodplain, and to analyze the extent of encroachment by each category of urban land use into the floodplain. Meanwhile, the study was designed to proffer answers to the following questions, what are the provisions of master plan of Kaduna Metropolis for the flood plain area of the River Kaduna; what is the extent of encroachment into the River floodplain and what is the level of encroachment by each category of land use in the area?. The study only focuses on land area coverage encroached into the flood plain by the urban land uses and the land area coverage is measured in kilometer square (km<sup>2</sup>)

### Description of the Study Area

River Kaduna is the only major river that passes through Kaduna metropolis which is the capital of Kaduna State in Nigeria. The Kaduna metropolis lies between latitude 10° 39 °N and 10° 24N and longitude 7° 33E and 7° 21E as shown in fig, 1.1. The metropolis engulfed two major local government areas of the state which is Kaduna North and Kaduna South and also share some parts of Igabi and Chikun local governments areas of the state. River Kaduna also have three major river tributaries which serves as natural



drainage that drains surface run-off and sludge the waters from the metropolis into the river Kaduna. These tributaries are river Romi, Barnawa and Thalma.

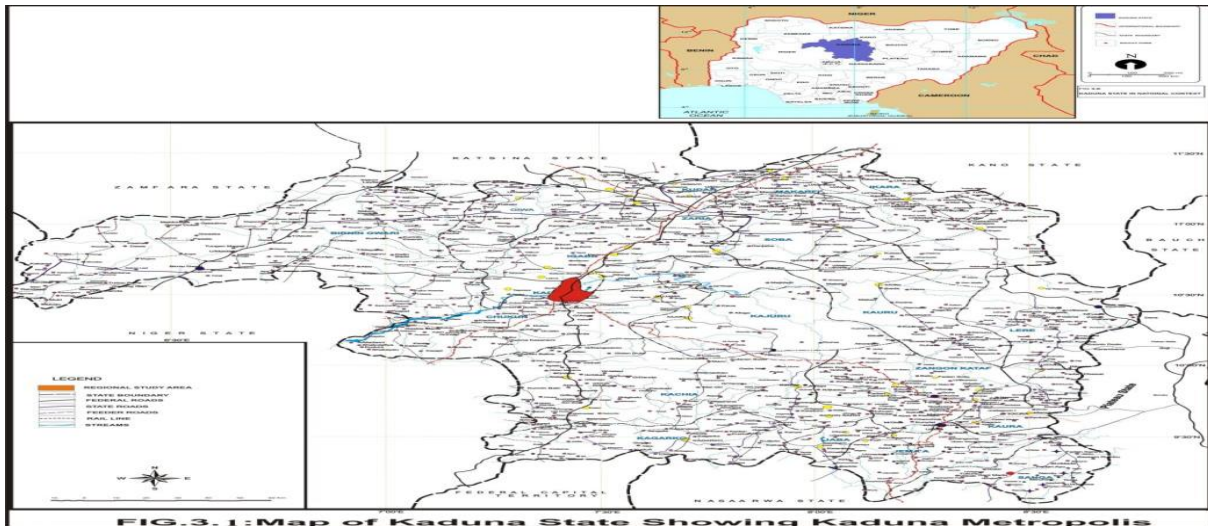


Figure 1.4: Kaduna Metropolis in the context of Kaduna State

Source: Field survey, 2019

## LITERATURE REVIEWS

### Concept of Flood Plain

The South-East Watershed Forum (SEWF, 2003) defined floodplains as low lying areas adjacent to bodies of water that are susceptible to flooding during seasonal or unexpected weather events. According to Associated Program on Floodplain Management (APFM, 2008) it consists of floodway and floodway fringes. Floodplains are “flood prone areas” they have been sought as sites for urban development because of the facilities they offer including access to source of water for a variety of uses Genoovese (2006). Floodplains have attracted people for living, industrial, commercial and recreational activities. Therefore, for this study urban Floodplain encroachment is any development or human activities on floodplains as a result of urbanization that can and do obstruct flood flow on the floodplain. Human development and activities have altered the landscape of urban floodplains thus affecting both the immediate floodplain and event downstream. Because of the attractiveness of floodplains for development during urbanization substantial urban population, facilities, utilities and services are subjected to flooding. According to Ogundele and Jegede (2011) the degree of urbanization of cities determines the spatial variation and intensity of river flooding in cities.

Abam (2006) defines flood as large volume of water which arrives at and occupy the stream channels and its floodplains in a time too short to prevent damage to economic activities including homes. The management of activities within the floodplain which are flood prone can significantly reduce flood damage to existing development and prevent the amount of damages from rising in the future. 2.

### **Floodplain Management**

Floodplain management according to the sustainable floodplain management policy (ASFPM) foundation in its Gilbert F. White (GFW) forum report 2050 (2007) the US unified national program for floodplain management defines floodplain management as “a decision making process that aims to achieve the wise use of floodplains by reducing human losses due to flood and protection of the natural resources and functions of floodplains”. Urban Floodplain encroachment management therefore is an opportunity for communities to make better land use decisions, zoning changes and building requirements on floodplains at the course of development.

### **Process of Urban Floodplain Encroachment**

The urban sprawl and infill development in urban centers located along major rivers is causing increasing encroachment of open spaces that are merely used as floodplain and subsequently spread of building activities in places not suitable for building. Encroachment of urban floodplains increases the vulnerability of the urban population and system to flooding APFM (2008). For effective management of floodplains there is the need to understand the relationship between flooding and the human habitation of the floodplain.

### **Pre-Development Phase**

This stage of encroachment is the initial land use change of the floodplain. The removal of the riparian vegetation is the major activity on the floodplain at this stage. The floodplains located in urban centers are initially encroached on for agricultural land use due to their fertile soil nature. In the developed countries it is also common to find industrial water intake or outlet development on the urban floodplains. These changes in land use increases the deposit of debris and silting on the river channel, thus increasing the frequency and time period of flooding on the floodplain. At the



advance stage of this phase development within the floodplain comes with altering channels or construction of bridges and culvert with small openings.

### **Development Phase**

This is the stage of transformation of the floodplain or water shed from the rural agricultural land use to urban land uses due to urbanization phenomenon. This is characterized by physical development on the floodplain and it fringes thereby reducing the water retention capacity of the floodplain Oyebande, (1990) and Adedeji et al (2012). The natural surface is replacing by more impermeable roads and concretes, which have very low infiltration capacity. When this occur the coefficient of runoff increase and this leads to increase volume of run off during rainfall Ogundele and Jegede (2011). According to Leo and Chang (2011) flood that once occurred infrequently during the pre-development periods becomes more frequent. The development along the river channel and floodplain alters the capacity of the channel to convey water and it also increases the height of the water surface on the floodplain (Odufuwa et al, 2012 and Konrad, 2003). At this stage of encroachment flood events on the urban floodplain results to the destruction of human life and properties. The vulnerability to flood disaster comes through exposure to locating on flood prone floodplains. According to Ivan (2001) the advance stage of floodplain encroachment due to urbanization results to floodplains that are not easy to recognize as neighboring land becomes more prone to flood.

## **RESEARCH METHODOLOGY**

### **Research Design**

The study adopted survey research design method for this study. This research design method allows quantitative data from satellite imagery, Review of published materials, Field survey and observation to be capture in the study for analysis and ArcGIS tool was used as a model for the collection of land information data relating to this study to be obtained for analysis.

### **Data Required and Sources**

As revealed in table 3.2, three categories of data were required for the study. Each of the data was reviewed based on the effect it exerts in the study. Designated flood plain areas were reviewed as a base-line policy document



for the flood plain while the current level of encroachment can only be ascertained through the flood plain Google map downloaded from satellite imageries while data on land area coverage can only be gotten through land cover map from satellite imageries and field survey

**Table 3.2 Data Required and Sources**

S/N	Data Type	Sources
1	Designated Floodplain area of the river Kaduna	Kaduna Master Plan (Max Lock 1967)
2	Extent of flood Plain encroachment	Floodplain Map, Satellite Images
3	Urban Land Use Data	Land Use Land Cover Map and Field Survey

Source: Field Survey, 2019

### Instrument for Data Acquisition

Three methods of data collection were used. Data from satellite imagery, Review of published materials, Field survey and observation to be capture in the study for analysis. Satellite imagery was used to obtain raster information from the Google earth; the information was then digitized and analyzed for the study. Review of published materials as a method was also used. This provided official document on the provision of flood plain in the study area. While field survey and observation were used to establish the relationship between ground conditions and satellite images, obtaining information on flood reach extent based on historical eye witness accounts, coordinates and altitude and the obtaining of information on physical characteristics of the floodplain of the area. To achieved the purpose of the recognizance survey and field observations. Hand held Global Position System (GPS) and Mobile GPS were used. The hand held GPS was used to take geographic coordinates and altitude while the mobile GPS was used to get instant image of the neighborhood. It also helped in the verification of names of neighborhoods that had encroached on floodplains.

### Data Processing (Maps and Satellite Imagery)

For data processing, the floodplain map of Kaduna metropolis was delineated from digital elevation map (DEM) and extracted digital topographic map



(DTM) using ArcGIS 9.3 tools (See figure 3.2). The Satellite images were then integrated with the extracted floodplain map for spatial analysis of built up encroachment into the floodplains. Due to inability to acquire satellite image of Kaduna metropolis for the period 1967 due to non-availability, the Kaduna physical development map of 1967 was digitized from the 1967 master plan. The digitized map was then geo reference using major features on the map. This was to enable easy and accurate overlay of the floodplain map on it for analysis.

### Grouping of Communities along the River Flood Plain

To achieve the success of the study, the Kaduna flood plain areas were divided into catchment areas, the catchment areas are reviewed in table 3.5.

Table 3.5: Grouping of Communities along the River Flood Plain

River Reach	Communities/Districts	Catchment Area
River Kaduna upper reach	Kawo, Malali, Ung. Rimi, kabala Doki, Kigo road.	Upper Right Reach Bank Community (URRBC)
	Barnawa and Narayi	Upper Left Reach Bank Community (ULRBC)
River Kaduna lower reach	Rigasa, Tudunwada, and Ung. Muazu	Lower Right Reach Bank Community (LRRBC)
Romi river reach	Kakuri, Nassarawa, Kudandan	Lower left Reach Bank Community (LLRBC)
	Sabo Tasha and UngwanRomi.	Romi. Romi Right Reach Bank Community (RRRBC)
	Gonin Gora, (Ung. Tanko, Karatudu,)	Romi Left Reach Bank Community (RLRBC)
<b>Total</b>		

Source: Field survey, 2016

### Analytical Tools and Presentation

The analytical tools for the study were mainly tables, graphs, charts and maps. ArcGIS 9.3, tables, graphs and Google Earth pro v6.2.2.6613. ArcGIS

9.3 was used as a mapping tool (arc map) which was used to map out floodplains area and the pattern of built up encroachment. Kilometer square (km<sup>2</sup>) was used as the measuring tool to quantify the floodplains and the extent of built encroachment on the study area. The quantification of the pattern of the flood plain area and extent of encroachment were expressed by the use of tables, graphs, charts and maps.

### Delineation of River Kaduna Flood Plain Areas

The delineation of River Kaduna flood plain areas was done through the provision of the master plan for the urban area. Though, Global Positioning System (GPS) was used to ascertain the coordinates of the provision of the master plan on the ground, and then ArcGIS 9.3 tool was used to establish the extent of the encroachment into the designated flood plain areas provided by the plan. The flood plain areas were divided into un-encroached and encroached floodplains and the quantification of the measurement area was done in (Km<sup>2</sup>) based on each catchment area. The result of the data analysis was presented using tables, graphs, charts and maps where necessary and inferences were drawn and presented.

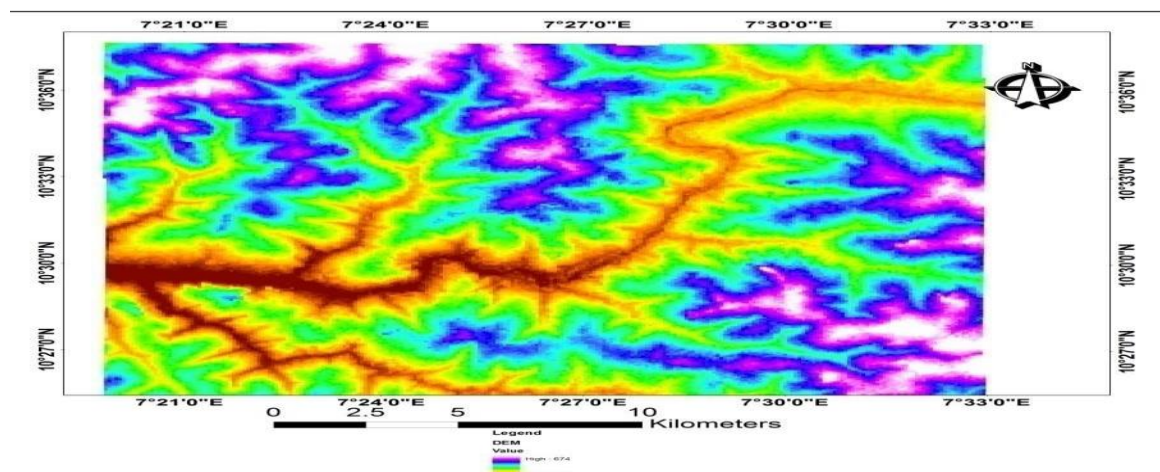


Figure 3.7a: Digital Elevation Model of the Designated Flood Plain Areas of River Kaduna

Source: Lansat, 2019



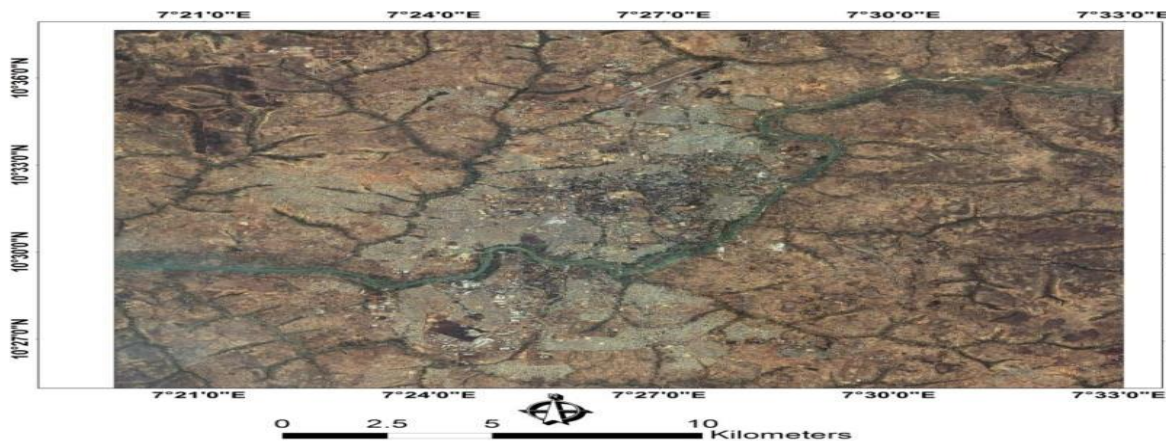


Figure 3.7b: Satellite Image of River Kaduna.

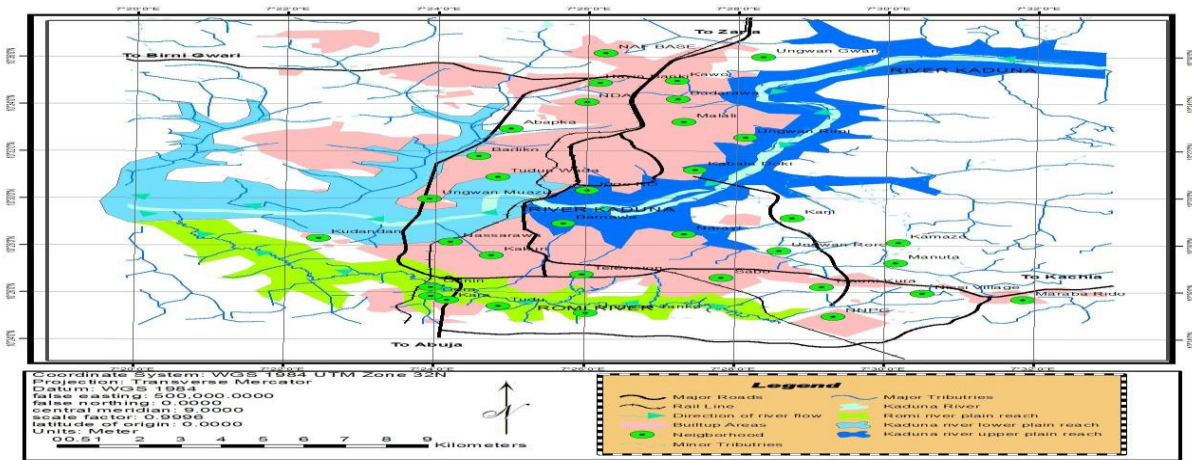
Source: Satellite Image, 2019

## PRESENTATION OF FINDINGS AND ANALYSIS

### Designated Flood Plain Areas of River Kaduna

From the provision of the master plan for the area, Kaduna metropolis has not been faced by physical limitation due to river Kaduna and its tributaries as well as gully site as a result of natural overflows of storm water across its banks until now when encroachment has altered the drainage pattern of the river. Table 4.1 shows that the total size of river floodplain designated by the Kaduna master plan as at 1967 was 112.99Km<sup>2</sup>. Even as it is till now, the river still serves as the major river that divides the metropolis into two equal halves, the Kaduna North and South. The plan as provided by the table also identified communities that were located along the riverbanks of Kaduna river that have the tendencies of encroaching on the floodplains due to the anticipated spatial growth of the metropolis. The analysis of the master plan provision for the river floodplain in 1967 indicates that URRBC has the highest extent at which the river could be encroached into by land use development. As such, the provision of the floodplain in the area as provided in table 3.1 was put at 1.9Km<sup>2</sup> which constitutes 8.0% of the designated floodplain areas in the metropolis while ULRBC had the lowest provision of 0.3Km<sup>2</sup> which represents 1.2% of the total floodplains designated area. Around Lower Left Reach Bank Catchment (LLRBC), Romi Right Reach Bank Catchment (RRRBC) and Romi Left Reach Bank Catchment Area, intense development was not expected in those areas that is why master plan provision was less considering the flood plain provision for other catchment areas revealed in table 4.1.

Analysis of Urban Land Use Encroachment on River Kaduna Foodplain, Kaduna Metropolis, Kaduna



Source: Maxlock, 1967

**Table 4.1: Analysis of the Designated Floodplain Areas of River Kaduna**

River Reach	Communities/ Districts	Catchment Area	Catchment size (Km <sup>2</sup> )	floodplain
River Kaduna upper reach	Kawo, Malali, Ung. Rimi, kabala, Doki, Kigo road.	Upper Right Reach Bank Community (URRBC)	23.7	
	Barnawa and Narayi	Upper Left Reach Bank Community (ULRBC)	26.0	
River Kaduna lower reach	Rigasa, Tudunwada, and Ung. Muazu	Lower Right Reach Bank Community (LRRBC)	25.2	
	Kakuri, Nassarawa, Kudandan	Lower left Reach Bank Community (LLRBC)	9.9	
Romi river reach	Sabo Tasha and Ungwan Romi.	Romi. Romi Right Reach Bank Community (RRRBC)	15.8	
	Gonin Gora, (Ung. Tanko, Karatudu,)	Romi Left Reach Bank Community (RLRBC)	12.3	
<b>Total</b>			<b>112.9</b>	

**Fig. 4.1: Designated Areas of River Kaduna Floodplain.**

Source: Maxlock, 1967



## The Extent of Land Use Encroachment on River Kaduna Floodplain

As it was revealed in table 4.2, the extent of encroachment into the flood plain is progressive in nature. As revealed in the table, the overall encroachment stood for 49.9km<sup>2</sup> which represents 44.2% of the total land area designated in the area. Within the catchment areas, there was also a significant record of encroachment into plain with LRRBC and URRBC recording the highest level of encroachment within with 14.9km<sup>2</sup> and 11.1km<sup>2</sup> respectively. They all constitute 29.9% and 22.2% of the total encroachment within the period. Around RRRBC and RLRBC also, there was some level of encroachment in those areas with RRRBC recording some level of encroachment of 7.1km<sup>2</sup> which represents 14.2% of the total encroachment in its designated area while RLRBC recorded 4.3km<sup>2</sup> which represents 8.6% of the total encroachment in its area designated.

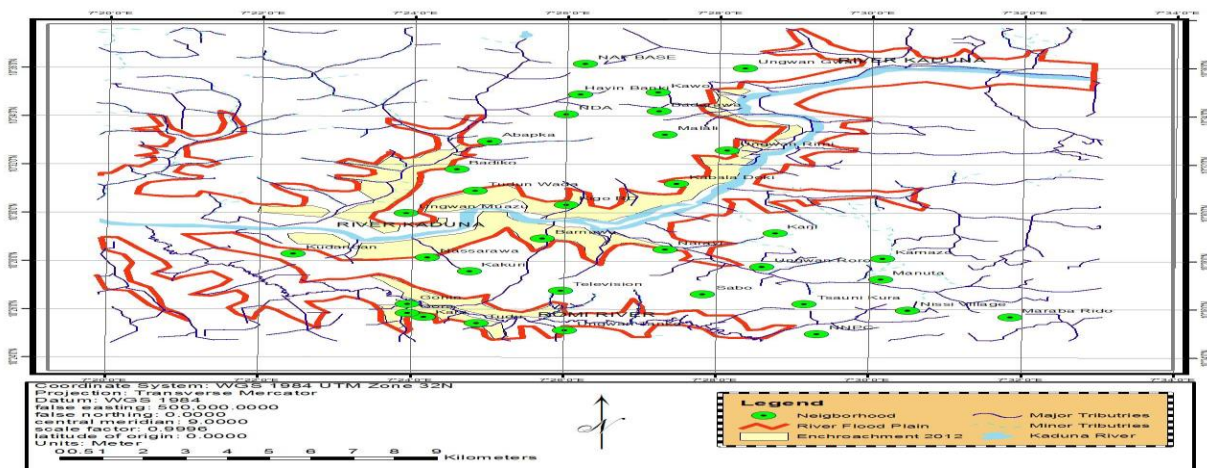


Figure 4.2: River Kaduna Floodplain Encroachment Pattern

Source: Field Survey, 2019

Table 4.2: Extent of Encroachment on River Kaduna Floodplain

Catchment Area	Total floodplain (Km <sup>2</sup> )	Extent of built up encroachment on floodplain (Km <sup>2</sup> )	un encroached floodplain (Km <sup>2</sup> )	Percentage of floodplain encroached (%)	Percentage of un encroach floodplain (%)	Percentage of total build up extent
URRBC	23.7	11.1	12.6	46.8	53.3	22.3
ULRBC	26.0	5.9	20.4	21.5	78.8	11.2
LRRBC	25.2	14.9	10.3	59.1	40.7	29.9
LLRBC	9.9	6.9	3.0	69.7	29.9	13.8
RRRBC	15.8	7.1	8.7	44.9	55.1	14.2
RLRBC	12.3	4.3	8.0	35.0	64.8	8.6
Total	112.9	49.9	63.0			100.00

Source: Field Survey, 2019

### Urban Land Use Distribution on River Kaduna Floodplain

Table 4.3 shows the violation on floodplain land use. The proposed green area (recreation, agricultural) land use on river floodplain in Kaduna by the 1967 master plan was estimated at 93.2%, however only 56.3 of floodplain are still green area land use in Kaduna metropolis. As indicated on table 4.3 only 1.5% of river floodplain was proposed for residential land use. However, at present residential land use makes up 37.8% of existing land use on floodplain which constitute 46.98% of land use violation. Only 1.4% of public/ institutional land use was proposed to encroach on floodplain in Kaduna metropolis, however the existing public/ institutional is estimated at 3.2% and this constitute 2.3% of land use violation on floodplain. The existing industrial land use is 2.7% instead of the proposed 3.7% and this constitutes 1.5% of land use violation on floodplain (See figure 4.4 for graphical illustration).

The high percentage (47.0%) of violation by residential land use on proposed land use on river floodplain is indicative of growing demand for land to provide accommodation. It also reflects the failure of urban planning and management authority to prepare and enforced land use zoning and planning schemes.

**Table 4.3: Urban Land Use Distribution on River Kaduna Floodplain**

Land use	Proposed		Existing		Violation	
	Area (Km <sup>2</sup> )	%	Area (Km <sup>2</sup> )	%	Area (Km <sup>2</sup> )	%
Residential	1.7	1.5	42.7	37.8	41.0	47.0
Public (Institutional, Infrastructure, Commercial)	1.6	1.4	3.6	3.2	2.0	2.3
Industrial	4.3	3.8	3.1	2.7	-1.3	1.5
Green area (recreational, Agricultural)	105.3	93.3	63.5	56.3	-42.9	49.2
<b>Total</b>	<b>112.9</b>		<b>112.9</b>		<b>87.2</b>	<b>100</b>

Source: Field Survey, 2019





## Existing Land Use Encroachment Based on Catchment Area on the Floodplain

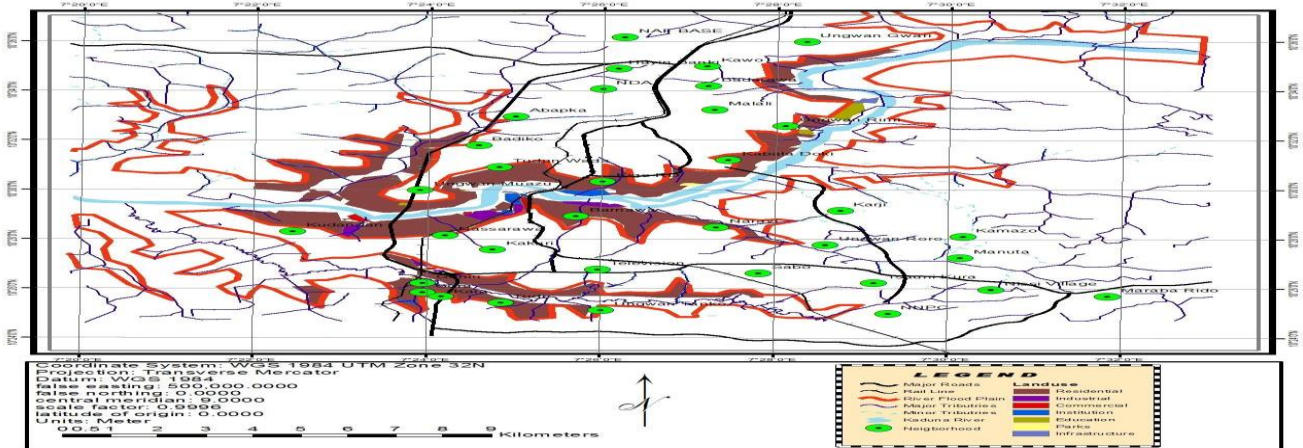
The analysis of existing urban built land use encroachment on floodplain as shown on table 4.4 indicates that residential land use constitutes 85.6% of built up encroachment on floodplain. Industrial land use makes up 6.1% while infrastructure and education urban land use type of activities are 1.9% and 2.9%, respectively. Recreational, parks and garden land use type occupy 1.0% of the floodplain. The recreational and parks activities areas are in the URRBC which is of close proximity to the central business district (CBD) See table 4.4 for more details on urban land use encroachment on floodplain. The high percentage of 85.6% residential use and low percentage of 1.0% recreation and parks land use indicates poor land use management. See figure 4.5 for illustration of urban land use encroachment distribution on floodplains in Kaduna metropolis. The high percentage (85.6%) of residential built encroachment on floodplains indicates exposure of the housing sector in Kaduna metropolis to annual and biannual flood disaster occurrences. The occurrences of these flood disasters incur cost on individual family and the government and this is not economical for development. The implication of which is the deviation of funds for infrastructural and human development to provision of relief material and reconstruction. The 1.0% recreation and parks activities on floodplain reflect unwise use of floodplain, as impact of flood disaster on recreation parks and gardens are less when compare to the housing sector. It can therefore be deduced that the spatial growth of Kaduna is failing to recognize Hazard on floodplain at the course of development.

**Table 4.4: Existing Land Use Encroachment Distribution on Catchment Areas on Floodplain**

Land use	URRBC		ULRBC		LRRBC		LLRBC		RRRBC		RLRBC		Total	
	Area (Km <sup>2</sup> )	%	Area (Km <sup>2</sup> )	%	Area (Km <sup>2</sup> )	%	Area (Km <sup>2</sup> )	%	Area (Km <sup>2</sup> )	%	Area (Km <sup>2</sup> )	%	Area (Km <sup>2</sup> )	%
Residential	8.8	79.5	4.8	84.7	14.8	99.3	4.3	62.3	6.0	83.8	4.1	95.1	42.8	85.8
Industrial	0.0	0.0	0.3	6.5	0.0	0.0	2.0	29.1	0.6	9.2	0.0	0.0	2.9	5.8
Commercial	0.0	0.0	0.1	1.7	0.0	0.0	0.4	6.2	0.0	0.0	0.0	0.0	0.5	0.1
Institution	0.0	0.0	0.4	7.1	0.0	0.0	0.1	1.7	0.0	0.0	0.2	4.1	0.7	1.4
Recreation and parks	0.6	4.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	1.2
Education	0.8	7.6	0.0	0.0	0.1	0.7	0.0	0.0	0.5	7.0	0.0	0.0	1.4	2.8
Infrastructure	0.9	8.3	0.0	0.0	0.0	0.0	0.1	0.7	0.0	0.0	0.0	0.0	1.0	0.2
<b>TOTAL</b>	<b>11.1</b>		<b>5.6</b>		<b>14.9</b>		<b>6.9</b>		<b>11.6</b>		<b>4.3</b>		<b>49.9</b>	<b>100</b>



Source: Field Survey, 2019



**Figure 4.4: Pattern of Urban Land Use Encroachment on Floodplains  
Density of Residential Development**

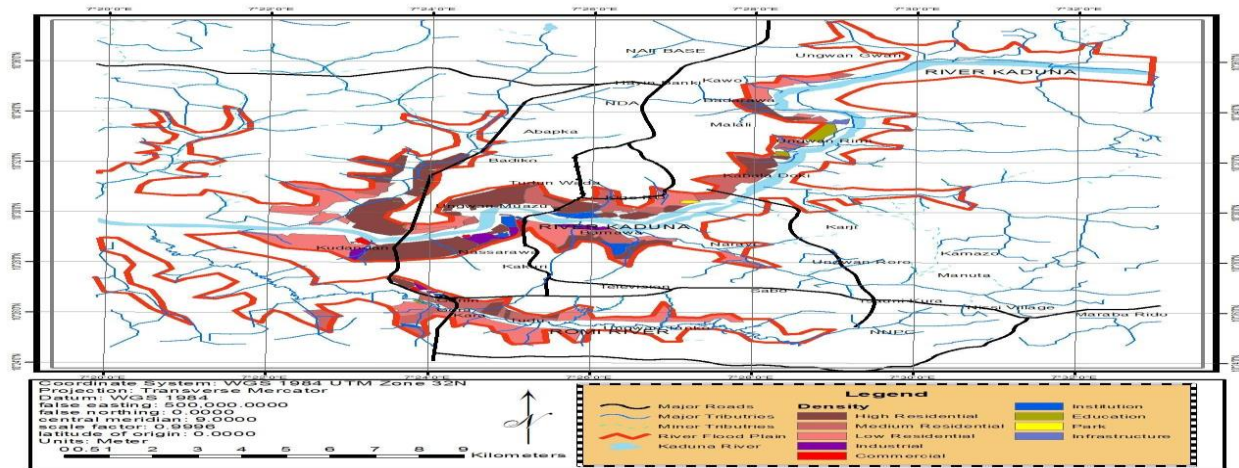
As shown on table 4.5 an estimated 50.6% of residential encroachment on floodplain along the LRRBC are of high residential density development which has the land mass of 7.5Km<sup>2</sup>. The URRBC that is of close proximity to the central business district have 46.1% high density built residential encroachment and 26.5% medium while 27.4% of the residential encroachments are of low-density development. In the analysis as shown on table 4.5 indicates that RRRBC and RLRBC have high low-density residential development of 52.4% and 79.0% respectively while the LLRBC has no low-density development. See table 4.5 for more details on density of residential development and figure 4.5 for the existing urban land use pattern of encroachment on floodplains in Kaduna metropolis. Figure 4.5 shows that low density residential developments are mostly at the periphery. High density and medium density residential land use types are dispersed across the floodplain. However, it can be seen that high-density residential land use are mostly within the upper reach and the lower reach bank of river Kaduna. It can therefore be deduced from the analysis above that the high percentage (40.4%) of low-density peripheral developments indicates disperse sprawling housing development on floodplain. The observed 24.5% medium density indicates continual infill development on floodplain for housing provision while the 35.1% of high-density development indicates successful compact infill development.



**Table 4.5: Density of Residential Development**

Density	URRBC		ULRBC		LRRBC		LLRBC		RRRBC		RLRBC		TOTAL	
	Area (Km <sup>2</sup> )	%	Area (Km <sup>2</sup> )	%	Area (Km <sup>2</sup> )	%	Area (Km <sup>2</sup> )	%	Area (Km <sup>2</sup> )	%	Area (Km <sup>2</sup> )	%	Area (Km <sup>2</sup> )	%
High	4.1	46.1	1.2	26.5	7.5	50.6	1.9	44.6	1.1	19.0	0	0	15.8	35.1
Medium	2.3	26.5	1.4	30.4	1.7	11.6	2.4	55.4	1.7	28.6	0.9	21.0	10.4	24.5
Low	2.4	27.4	2.1	43.1	5.6	37.8	0	0	3.1	52.4	3.1	79.0	16.6	40.4
<b>TOTAL</b>	<b>8.8</b>		<b>4.7</b>		<b>14.8</b>		<b>4.3</b>		<b>5.9</b>		<b>4.0</b>		<b>42.8</b>	<b>100</b>

Source: Field Survey, 2019



**Figure 4.5: Pattern of Residential Density Encroachment on Floodplain**

## SUMMARY OF FINDINGS

The analysis of the floodplain green area land use violation shows that residential land use constitutes 85.8% of total encroachment into floodplain while recreational land use on floodplain constitute only 0.6%. 35.1% of residential development on river floodplains is high density while medium density constitutes 24.5%. This indicates weak enforcement of land use zoning ordinances and development control by KASUPDA. The study also revealed that poor implementation of approve planning scheme have resulted to 48.9% of violation of green area land use to be within areas with approved planning scheme. The analysis also established that 51.1% of encroachments on floodplain are outside the approved planning scheme area. This can be attributed to failure of the ministry for land survey and country planning to regularly prepare plans and layout that will also be cheap and affordable as well as weak enforcement of land use zoning by KASUPDA. From the

analysis, the study identified three categories of communities that have been developed and settled within the floodplain area of the river and these communities are responsible for the land use encroachment into the flood plain. Meanwhile any recommendation given in this study is meant to address the vulnerability nature of these communities on the floodplain. Nevertheless, these communities include Community type A: these are Communities with extensive floodplain development and limited flood-free sites for further growth. This community type can be identified at the URRBC and The Lower LRRBC. The URRBC communities are Kawo, Ung. Dosa, Malali, Ungwan Rimi, kabala Doki and Kigo road while LRRBC consisting of Rigasa, Tudun wada, and Ung. Muazu communities. Community type B: Community with limited existing floodplain development and limited flood-free sites for community growth. This community type can be identified at the RRRBC and LLRBC catchment areas. The RRRBC communities consisting of Sabo Tasha, and Ungwan Romi communities while the LLRBC Communities comprise of Kakuri, Nassarawa and Kudandan. The type C community comprises of Communities with limited existing floodplain development and extensive flood free sites for community growth. This community type can be identified at along ULRBC and RLRBC areas. The ULRBC communities consist of Barnawa and Narayi while the RLRBC consist of Ungwan Tanko, Karatudu, and Gonin Gora. The analysis finally revealed that the designated floodplain of river Kaduna has been drastically encroached into by urban land use development. Some communities along the river have developed almost to the edge of the riverbank thereby subjecting the inhabitant to the vulnerability effect to flooding.

## CONCLUSION

The findings by the study have shown that the rate of urban land use encroachment of the metropolis into the river flood plain is alarming and is on the progression. This situation is creating huge flood vulnerability to the inhabitant of the urban area. As a result, the following recommendations were given for improvement in the urban area.

## RECOMMENDATION

Given the above conclusion on the subject matter, the below recommendations were given to mitigate and to improve in the management



of the area so as to reduce the risk of vulnerability of the inhabitant of the area to flooding.

- 1) there should be relocation of the inhabitant of the land uses to avoid risk of flood vulnerability;
- 2) there should be effective policy integration and implementation of all urban management agencies responsible for physical development in Kaduna metropolis to avoid further encroachment into the floodplain
- 3) there should be land acquisition of all encroached and un-encroached area of the flood plain by the state government so as to regulate the area
- 4) there should be the creation of floodplain Buffer Zone to outline detail profiling of the existing built up area and the existing land use encroachment in the floodplain of the area
- 5) and land in safe and accessible locations should be supply to meet the needs of all sectors of the society to avoid further encroachment into the floodplain;

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