ANALYSIS OF FLOODPLAIN ENCROACHMENT PATTERN AND MANAGEMENT IN KADUNA METROPOLIS

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DECLARATION

I hereby declared that the work of this dissertation entitled "**Analysis of Floodplain Encroachment Pattern and Management in Kaduna Metropolis"** has been carried out by me in the Department of Urban and Regional Planning under the Supervision of Mallam A. S. Usman and Prof. J.B. Kaltho. The information derived from the literature has been duly acknowledged in the text and the references provided. No part of this thesis was previously presented for another degree or diploma at any university.

Name	Signed	Date

CERTIFICATION

This dissertation titled "**ANALYSIS OF FLOODPLAIN ENCROACHMENT PATTERN AND MANAGEMENT IN KADUNA METROPOLIS"** by Sani Armageddon Sarki meets the regulation governing the award of the degree of M.Sc. of Ahmadu Bello University and is approved for its contribution of knowledge and literary presentation.

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DEDICATION

This research work is dedicated to God almighty, my parents Lt Col. (Revd) and Mrs Nache Sani Sarki (Rtd), my Brothers and sisters and the entire Nache family.

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Glory, honor and adoration to Almighty God the creator of all things visible and invisible that through his grace, guidance, protection and provision made it possible for me to complete this program. My appreciation goes to my supervisors Prof. J. B. Kaltho and Mal. A. S. Usman for all their contributions and support to make this academic achievement come true. My profound gratitude and appreciation goes to my parents Lt Col. (Revd.) and Mrs Nache Sani Sarki (Rtd.) for their spiritual, moral and financial support all through this program.

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ABSRACT

Rivers and their floodplains have always served as physical limitation to the spatial growth of urban centres located along river course. The rapid growth and expansion of these urban centres have always resulted to encroachment of urban activities on floodplains with increase in vulnerability to flood disaster. Therefore the monitoring of urban growth and changes along these river floodplains are of concern to the physical planner and urban managers who must understand the urban growth dynamics and manage resources while providing service to these rapid changing environments. This research therefore analysed the spatial growth of urban built encroachment and management on river floodplains in Kaduna metropolis. In conducting the research, river floodplains as identified by the 1967 Max lock master plan of Kaduna were delineated and mapped out from digital elevation model (DEM) using ArcGIS 9.3. Satellite images of 1990, 2000, and 2012 time epoch were then used to establish the encroachment extent and pattern using the monitoring land use change technique (MOLAND) within the ArcGIS 9.3 tools. The analysis of floodplain encroachment due to spatial growth between 1967 and 2012 revealed that 25.8% of physical developments are on river floodplain. The analysis further revealed that 44.2% of the river floodplains banks reserved as urban green and agricultural floodplains areas have been encroached by urban built activities. The average rate of encroachment between the year 2000 and 2012 is estimated at 0.32 Km^2 per year. Residential Land use constitutes 85.6% of urban built encroachment on floodplain. The pattern of residential encroachment revealed that 40.4% are low density, indicating sprawl while medium and high density constitute 24.5% and 35.1% respectively, reflecting continual infilling development on floodplains. These indicate high flood risk exposure and damage potential to the housing sector and infrastructural investment in the event of flood disaster. The study revealed that poor land management, ineffective zoning and development control have resulted to the continual urbanization of floodplains in Kaduna metropolis. Therefore effective institutional framework that will ensure integration of related policy, effective land use restructuring and development control were recommended.

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CHAPTER ONE

BACKGROUND OF STUDY

1.0 INTRODUCTION

Throughout history water supply sources have been a major decisive factor in the location and establishment of human settlement. Added to this advantage for settlement developments, is the fact that river floodplains provide fertile and flat land for agriculture, while navigational rivers are also known to provide accessible means of transportation. However with the urbanization of settlements located along river banks, coastal region and lake sides, has come the cost of increasing flood vulnerability risk (OECD 2009, Olorunfemi and Rahim 2007). This is attributed to the increasing human population and activities in these urban areas which are leading to their expansion in size and land mass. The accelerating urban or metropolitan spatial growth has often been viewed as a sign of the vitality of regional economies (UNDP 2010).

Metropolitan urban centres in Nigeria have over the years grown more expensive due to accelerated sprawling and sub urbanization. The accelerated urban growth and the resultant pattern of development in metropolitan centres located along river course are exposing the urban population and economic gains to the risk of flood disaster. This is due to encroachment of urban development on floodplains as well as effects of climate change. According to Sanusi (2011) cities in Nigeria are increasingly vulnerable to disaster due to poor management of urbanization with people living in sub divided land on vulnerable

location such as floodplains. Human lives, houses, infrastructure, buildings and machineries are destroyed by flooding of these urban floodplains thereby eroding the livelihood and assets base of residents. The urban poor are the most vulnerable to these disasters, (Lorena 2002, Henderson 2004, Allam et al 2008, UNDP 2010, Aletan et al 2011, and World Bank 2011). The occurrence of urban flood events have the potential to destroy decades of investment efforts and cause the diversion of resources intended for primary task such as education, health and infrastructure.

Recent Scientific documents on climate change have also shown that more intense hydrological events such as rain storms and floods are expected to occur (IPCC 2007, Hideaki 2010). These extreme flood events as a result of climate change and urban development encroachment on floodplains will pose as hazards to urban centres.

It has therefore been widely advocated that the identification of flood prone areas and understanding the pattern of urban development encroachment on river floodplains due to urban growth will provide the base for effective management of urban floodplains encroachment. This study therefore applied GIS tool in mapping and analyzing floodplain encroachment and management in Kaduna metropolis.

1.1 STATEMENT OF RESEARCH PROBLEM

The infill developments and sub urban conversion of peripheral urban land due to sprawl in Kaduna metropolis over the years to meet the increasing population and rising land demand have resulted to changes in land use and land cover. These have lead to physical planning

challenges, urban environmental and economic problems. The urban planning and management authorities are always struggling to cope with the rate of physical growth or expansion of the metropolis. This is evident in the manifestation of problems in the form of inadequate and poor provision of utilities and services, flood disaster and erosion among others. Attempts at solving these problems by government agencies are at best "crisis management" in approach.

Relevant studies have been carried out to address problems due to physical growth of Kaduna metropolis. Olaleye (2006) analyzed Kaduna north land use land cover changes to identify land cover temporal changing direction. Oladimeji et al 2010 analyzed the growth pattern of Kaduna metropolis which provides a robust quantitative measure of land use dynamics for Kaduna. Aliyu (2011) in his researched used the Shannon entropy to look at the pattern and urban management implications of sprawl in Kaduna metropolis which gave an insight of the financial cost implication of sprawl. However none of this research provides us with an insight and understanding of the flood risk threat to the urban built up system due to rapid growing land and housing projects development on river floodplains.

The activities of urban land speculators and private developers in Kaduna has resulted to rapid physical development of urban peripheral and satellite rural settlement land even before such areas are declared as planning area. The river floodplains are not spared. This has over the years encouraged physical development encroachment on river floodplains that were identified by the 1967 Max Lock Kaduna master plan. Urban built up encroachment

on these river floodplain banks in Kaduna metropolis due to sprawl and its associated land use change is rapidly altering natural drainage pattern. The resulting effect is exposure to flood risk vulnerability and increased frequency of flood disaster occurrence in the metropolis. The occurrences of these flood events over the years has impacted on the metropolitan system by affecting housing, health, roads, water and sanitation sectors with the associated risk of lost of human life and economic investment. The frequent occurrences of these flood events are believed to be the result of poor urban planning control of sprawl and continual land infilling development activities within floodplains.

Attempts at providing solution to the menace of urban floodplain encroachment due to urbanization and its associated risk are reactive and structural in approach (dams, and constructions of bridges, culverts and drainage channels). Although this approach solves the immediate problem of flooding, it creates a more insidious problem of its own by encouraging development within floodplains. The neglect of proactive urban planning and management techniques (floodplain mapping and zoning, land use management and development control) that are non structural in approach and cheaper and sustainable has over the years resulted to unregulated urban built up encroachment on river floodplains. This can be attributed to ineffective urban planning and management practices and lack of understanding of the current and future risked implications at the metropolitan scale.

It is against this backdrop that the study analyzed and established the extent and pattern of built up encroachment on river floodplains due to the ineffectiveness of planning control

frame work instrument to regulate the rapid growing development on floodplains. This research therefore seeks to answer the questions;

i. What is the extent and pattern of encroachment on river floodplains in Kaduna metropolis?
ii. How have the problems of floodplain encroachment been managed by urban planning and management agencies?

1.2 AIM

The aim of this research is to determine the spatial extent of encroachment into floodplains in Kaduna metropolis and effectiveness of management of encroachments.

1.3 OBJECTIVES

The aim of this research was achieved through the following objectives;

i. Review the concept and best practise principles for floodplain management
ii. Analyse river floodplains encroachment pattern in Kaduna metropolis.
iii. Examine the effectiveness of existing urban planning and management measures in management of floodplain encroachment in Kaduna metropolis.
iv. Make recommendations for effective management of floodplain encroachment in Kaduna metropolis.

1.4 SCOPE AND LIMITATIONS

The research made used of ArcGIS tools to map river floodplain and analyze the extent of floodplain encroachment in Kaduna metropolis. The research did not address the issue of vegetation and the protection of biodiversity, except as it relates to the human activities and

occupation of floodplains. The research did not look into the socio economic impact of flooding of floodplain in the study area and did not prepare flood management plan

Ideally spatial satellite image data at a regular interval are required for analysis to be done based on time series. The inability to acquire such images due to high cost has regulated the number of satellite images used as such the analysis was done using epoch time of available satellite images.

1.5 RELEVANCE OF STUDY

The study is important because it endeavours to establish the violation of urban floodplain green area thereby establishing failure to managing flood risk vulnerability of Kaduna metropolis as a result of urbanization. The study revealed the need to transit from urban flood control to the effective management of floodplain encroachment through effective enforcement of land use zoning, regulatory planning schemes, and development control in urban river floodplains areas. The study, through identifying of floodplains and the extent of encroachment, can help integrate floodplain encroachment management into urban land use management. This will help the physical planners and urban managers to direct and manage the growth and sustainable provision of infrastructure and services in the metropolis.

It is envisaged that the findings of the study will be the key inputs into understanding the possible social and economic impact of flooding in Kaduna. The study can also be used as

input into designing of sustainable mitigation measures to minimize the impact of flood events and its associated risk due to urbanization. These will therefore ensure that sustainable development will be attained by using the floodplain map to ensure appropriate land use planning that will provide maximum economic value to floodplains.

1.6 BACKGROUND OF STUDY AREA

1.6.1 Location and climate

Kaduna metropolis the capital of Kaduna state lies between 10^{o} 39' 0''N, 10^{o} 24'0''N and 7^{o}33'0''E, 7^{o}21'0''E on the high plains of northern Nigeria with undulating terrain. See fig. 1.1 Kaduna metropolis comprises of two urban local government area (Kaduna north and south) and parts of Igabi and Chikun local governments of Kaduna state.

The climate of Kaduna metropolis is tropical continental with hot wet season (March - October) and cool dry season (November - February) with an annual rainfall level of up to 120mm per hour.

1.6.2 Relief and drainage

The study area consisted of residuals mainly of crust origin, weathered bed rock mass capped with hardened iron stone and tropical ferruginous soil, Max lock (2010). Urban development over the years have modified the vegetation, relief and soil cover of Kaduna metropolis this is due to land cover change, excavation, physical urban construction and development. The undulating relief of the study area ranged between 457m and 645m above sea level (a.s.l). River Kaduna drains through the metropolis cutting it almost into

two equal parts. River Romi, Mashi and Barnawa rivers are the main tributaries serving as natural drainage that drains surface rain run-off and sludge water from the metropolis into river Kaduna. The wide and steep valleys of the rivers have broken urban built up and serve as physical challenge to urban spatial growth of the metropolis.

1.7 Kaduna metropolis development

Kaduna was formed as an administrative settlement from an indigenous settlement to serve as an administrative head quarters in 1912 by Lord Lugard, Max lock (1967). The city physical land mass built up extent has grown from an estimated 23.18Km^2 in 1967 to approximately 193.24Km^2 in size in 2012. The projected population population at present is estimated 1,731573 with a growth rate of 3.18%. The physical and economic growth of Kaduna metropolis over the years can be attributed to its roles as military cantonment, a major industrial zone of the north, and regional political and administrative head quarters over the years. The increasing demand for accommodations over the years as a result of influx of immigrant is continually leading to spatial expansion of Kaduna metropolis and its peripheral settlements. The growth and development of Kaduna metropolis is statutory guided by the Kaduna master plan of 1967, Max lock (1967).

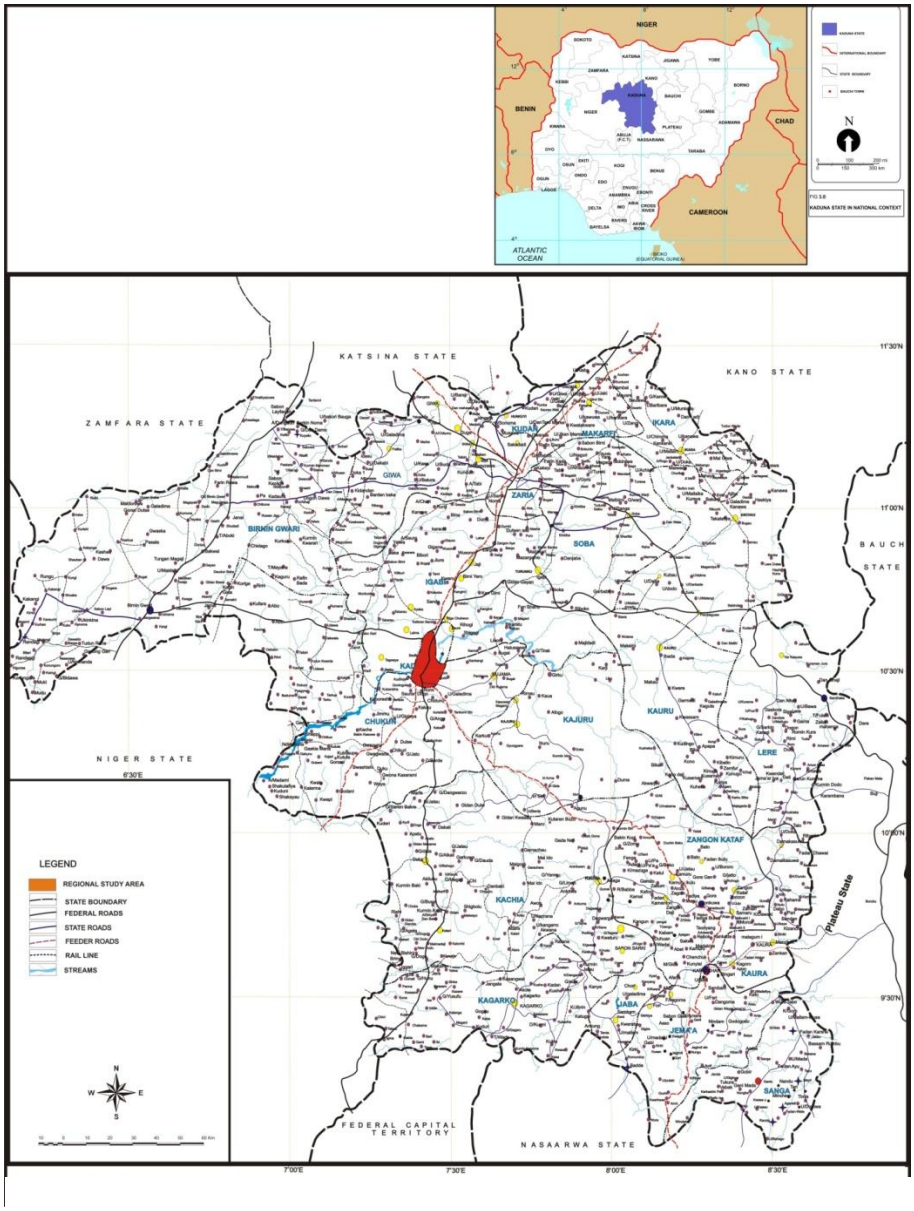


Fig. 1.1: Kaduna state in national context and Kaduna metropolis in context of Kaduna state

LITERATURE REVIEW

2.0 THE MANAGEMENT OF FLOODPLAIN ENCROACHMENT

2.1 Concept of urban floodplain encroachment and management

2.1.1 Floodplain encroachment

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 consist 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 reduced flood damage to existing development and prevent the amount of damages from raising in the future.

2.1.2 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.

2.2 PROCESS OF URBAN FLOODPLAIN ENCROACHMENT

The urban sprawl and infill development in urban centres 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.

2.2.1 Pre-development phase

This stage of encroachment is the initial land use change of the floodplain. The removal of the riparian vegetations is the major activity on the floodplain at this stage. The floodplains located in urban centres are initially encroached on for agricultural land use due to their fertile soil nature. In the developed countries it is also common to fined 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.

2.2.2 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 are replace 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 these 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 neighbouring land becomes more prone to flood.

2.3 URBAN SPATIAL GROWTH AND FLOODPLAIN ENCROACHMENT

Urban centres in developing countries are faced with litany of flood woes due to increasing pressure on the urban landscape as a result of rapid urbanization. As population becomes widely dispersed by sprawl and exurban development increasing number of people are exposed and vulnerable to encroached onto river and coastal floodplains and into areas prone to slope failure and flash floods. The consequences of increasing urban expansion and population growth on floodplain are rising cost of natural disasters and the increasing number of people at risk (Mileti ,1999 and FEMA, 1997). This according to Lawanson (2006) is impacting on the ability to achieve sustainable urbanization and development. Alam et al (2008) pointed out that with increasing urbanizing world, flood disasters in urban areas are impacting negatively on urban and human development. Cities in Nigerian like most cities found in the developing countries are vulnerable to flooding and erosion damage as a result of pressure on urban land leading to urban built area encroachment on

floodplains by both formal and informal development. Smit (2006) and Mabogunje (1999) linked the absence of an adequate response to the growth of informal settlement to a series of factors including poverty.

The combination of physical development on unsuitable lands such as wetlands, slopes, floodplains and other environmental sensitive areas and overcrowding exacerbate vulnerability to disaster in urban areas, (Raheem, 2011). Flooding events in urban centres are promoted by socio economic and cultural activities. These activities are characterized by stream or river floodplain and channel encroachment and abuse (Ogundele and Jegede 2011). According to Ogundele and Jegede (2011) man develops and occupiers floodplain at the risk of flooding, out of ignorance or for economic reasons. Once the floodplains are urbanized, the follows an almost inevitable demand from the community for flood protection, (Smit 2006).

The 2006 National population census data pointed to the fact that most urban centres in Nigeria have extremely limited capacity to take further population increase. This can be attributed to physical limits to spatial growth of these urban centres such as river floodplain and erosion. Thus according to Abhas et al (2012), and World Bank summary report (2011), rapid urbanization requires the integration of flood risk management into regular urban planning, management and governance. The psychological orientation of the people towards proper sustainable urban planning and management practices is central and important in the management of floodplain and its related risks. The urban planners and

managers have the responsibility in creating and sustaining urban growth that protects the present and the future generations (Daramola and Ibem 2010).

The World Bank report (2011) pointed out that as cities in the developing countries grow, the often expand into marginal areas such as floodplain, water catchment and steep hillsides. This is exacerbated by Poor urban management practice and policies. At the city scale there is the need for land use planning to consider floodplains and other hazards zones when determining where development should be permitted. The urban form is known to have a long time scales and its physical form cannot be change easily, thus decisions made in the provision of urban infrastructure and services will have impacts for decades to come. This is due to the long life span of infrastructures and buildings which can be as much as 100 years or more for high value buildings, bridges, or water systems which do go beyond their life span, World Bank (2010).

2.4 CONTRIBUTIONS OF FLOODLAIN MANAGEMENT TO URBAN DEVELOPMENT

According to the world Commission on environment and development Brundland Commission (WCED 1987) “sustainable development is meeting the needs of the present without compromising the ability of the future generation to meet their own need”. To plan and manage urban development in order to attain sustainable development, the urban population, spatial and economic growth most accommodate development where the environment is put into consideration. Failure to identify the fragile natural environment will increased the vulnerability of the urban system to disaster.

Cities and urban centres in developing countries are becoming more unsustainable in their pattern of physical growth due to sprawl. Unsustainable and un-control Sprawl do not only lead to land use change such as deforestation, reduction in agricultural land size and natural vegetation cover, it is also increasing the vulnerability of the urban population and investment to disasters such as landslide and flooding. Urban sprawl is destructively affecting and consuming a large portion of the urban environment and resulting to the need to extend infrastructure such as road, pipe water and electricity. Thus according to Aliyu (2011) urban sprawl has been shown to be highly inefficient in the provision of services and infrastructure from the economic point of view. Base on this therefore there is the need to minimize the conversion and encroachment of natural area such as river floodplains.

Urban floodplain management ensures appropriate land use on river floodplain that will ensure maximum environmental and economic uses of river floodplains. Urban floodplain management according to the WCED (1987) is aimed at ensuring sustainable urban growth and development which can only be achieved through appropriate land use planning. The application of land use planning in urban floodplain management is to ensure that three major urban societal attributes are sustained. These attributes are;

- Environmental resources (wetland, open space, parks and gardens)
- Public health and safety (avoidance of floodplains or wetlands and unstable soils)
- Infrastructure (Water treatment plant, roads, schools, jobs)

Table 2.1: Contribution of floodplain management to urban development

Land use	**Benefits/ contribution**	**Activities allowed without permit**	**Activities permitted under special conditions permit**	**Prohibited activities**
Urban agriculture and wetland	Ground water recharged point, Urban green belt, Fishery, jobs and perishable fruits and vegetable products.	Cropland and pasture Orchards and Forestry,	Farmhouses Barn silos and sheds Implement sales	
Recreation and natural protected wetland	Urban green belt and open space, Ground water recharge point, job, Safety, scenic beauty and tourism.	Natural areas	Swimming pools, Wells for drinking water, Temporary Shelters Parks, neighbourhood parks and playgrounds, Golf courses and tennis courts, Campgrounds.	
Residential	Housing and open space, Minimized impact of flooding.	Yards, gardens, and Patios	Garages and storage sheds Low density residential buildings, Manufactured homes, On-site sewage disposal Systems and wells.	High density and medium density development
Industrial and Commercial	Commercial	Parking lots and loading areas	Sand and gravel operations	Hazardous material processing or storage sites
Utilities, Public Facilities	Public services		Railroads Bridges and dams Utility lines and pipelines	Solid or hazardous waste processing or

				storage sites

Source: DNR (2005)

2.5 FLOODPLAIN MANAGEMENT FRAMEWORK IN NIGERIA URBAN AREAS

For sustainable development to be attained in the course of growth of any urban centre, urban planning framework and instrument or tools most be put to use in directing and regulating development. The use of the framework by urban planners and managers ensures that aesthetic and liveable environment is created. The following are the frame work in regulating development and encroachment on floodplains in Nigeria.

2.5.1 Institutional

Planning institutions are created by the government as enshrine in relevant laws. These planning institutions have the responsibilities to prepare and implement planning schemes that are to guide urban development. The planning institutions include the following.

A. Ministry of lands, survey and country planning

The ministry of lands, survey and country planning are established on the provisions of relevant laws such as the land use act of 1978 and the town and country planning laws of 1946. The ministry has a town planning department which prepares and implement layout plan base on land use zoning of Kaduna. All layout plans prepared must be the ministry are checked and approved by the state urban planning and development authority or board to ensure the conform with the zoning plan and regulations of the physical development plan.

Function

i. Land administration

ii. Survey

iii. Country planning

iv. Collections of rent and fees on land

B. State urban planning and development authorities or boards

State urban planning and development authorities or boards are established by the edicts of the state. The edicts mandate the board or authority to operate in all areas so declared as urban areas by the state governor.

Functions

i. Preparation and implementing layout plans

ii. Issuance of building permit

iii. Granting planning permits seeking for certificate of occupancy

iv. Enforcing planning regulation and standard (Development control)

C. Works department and health department of local authority

It's a common occurrence for the physical planning units of the local authority to have administrative conflicts with the state institutions that manage the growth of the metropolis.

Functions

i. Manage land under the jurisdiction of the local authority

ii. Prepare and implement layout plan

iii. Enforcing planning regulation and standard (development control)

2.5.2 Legal

A. Land use act of 1978

- The land use act (1978) in section 2 and 3 vested the control of land designated as urban land in the control of the state governor.
- Section 3 of the law provides the state governor the power to declare or designate urban planning areas within the territory of the state through and official published state gazette.
- Section 5 provides the governor the right by law to offer right of occupancy on urban land while the local government offers customary right of occupancy for any land other than urban area.
- Section 28 grants the state governor the law full right that he can use for overriding public interest to acquire land by revocation of all or any land title to such acquired land.

All this sections provides the basis in which the governor or any official so authorized by the governor can access any land for inspection in section 11. The acquisition of such a land by the governor provides the opportunities for the preparation of relevant planning schemes by the governor through the urban planning board or authority. The planning schemes are aimed at directing and controlling development through planning regulations.

B. Urban and regional planning law of 1992

The 1992 urban and regional planning law without doubt is the administrative instrument for ensuring effective and sustainable urban and regional growth. This document reaffirms the right by law granted to the governor by the 1978 land use act. The urban and regional

planning law of 1992 empowered the state planning board and the local planning authority to established development control department to implement and control physical development. The physical control department is to be multi-disciplinary professional shall perform the following responsibilities;

- Approval of any physical development on land by public or private individual, organization or establishments.
- Inspection all physical development and activities on site to ensure the conformed to approved plan and land use.
- Stop development that contravenes planning laws and standard codes and are nuisance to the well being of the general public or community.

The urban and regional planning law of 1992 assigns responsibilities to all level or tiers off governments. For the purposed of the study we shall review the responsibilities of the state planning authority and the local planning authority.

Responsibilities of the state planning boards

- Formulate state policy for urban planning
- Prepare and implement sub regional, urban and subject plan for the state
- Conduct research and make available the research results for adoption by user organizations.
- Provides technical assistance to local governments in preparing and implementing local and subject plans, development control on all state land.

Responsibilities of local planning authorities

- Prepare and implement rural, town, local and subjects plan

- The local authorities shall undertake development control within its area of jurisdiction

2.6 BEST PRACTICE PRINCIPLES IN URBAN FLOODPLAIN MANAGEMENT

Different countries and metropolitan cities may have developed their best practice and approaches to effectively manage floodplain encroachment due to urbanization. The pillars on which these best practice principle are built on are;

- Recognizing Hazards on urban floodplain as result of urban encroachment.
- Recognizing the need to avoid these hazards.
- Coping with the risk resulting from urban encroachment on floodplains.

The main aim of floodplain management in an urban area is to reduce the negative effect of flooding and flood liability on the urban infrastructure, services and properties that are located on flood prone areas along river banks. The effective management of floodplain ensures that maximum social and economic benefits are derived from floodplain while reducing flood risk to the barest minimum level. To ensure effective management of floodplain and its associated risk, best practice principles have been identified and put to use in the management of urban floodplains in Australia, USA and part of Europe and Asia. They are:

2.6.1 Flood maps

According to the Australia Emergency Management Agency (EMA) manual 19 Flood map is important in the management of floodplain. The flood map shows the extent of flood and

hazard on the floodplains and its adjoining areas. The flood map serves as a tool for the preparation of floodplain management plan and flood emergency plan. The flood map principle is applied in the identification of physical development limits to the spatial growth of settlement.

2.6.2 Identification of flood problems

The identification of flood problem is essential in the management of floodplain. According to the Emergency management Australia (EMA) manual 19 the modern floodplain management recognizes three types of "floodplain problems". These are:

- Existing: This has to do with the recognition of encroachment of human activities on floodplain resulting to change in land use within the floodplain. Therefore the existing physical development and activities are exposed to "existing" risk of flooding due to their location on floodplains.
- Future: This refers to proposed human activities on floodplain that will be exposed to "future" flood risk. Proposed development and human activities on floodplains needs to consider cumulative impact of all proposed and existing development on floodplains not just on individual bases.
- Residual: It refers to flood risk on floodplain that exceed the existing floodplain management measures employed in the management of risk associated with flooding on the identified flood plain in the future.

2.6.3 Proactive response

Urban floodplain management measures in most developing countries are reactive in approach. These have resulted to private and public losses resulting from flooding. The reactive measures apply structural engineering techniques which are limited in scope and effectiveness and gives way at maximum return flood period. Effective and sustainable floodplain management measures need to be proactive in response by recognizing, identifying floodplain and putting in place measure that will guide and control human use of floodplains. The principle of proactive response make use of urban management measures such as policy guide, land use and development control managements of human activities on floodplains.

2.6.4 Community expectation and awareness

According to Oludere et al (2012) the creation of awareness and coping measures to people living in flood prone areas is important to management of floodplain encroachment and imminent risk associated to it. The growing urban population expects that floodplains will be developed and used to meet their social and economic expectations. In developing countries in Africa, Latin America and Asia this has resulted to the sub division of floodplain in urban centres for housing development and squatter settlement. This is due to the fact that poverty risk is rated far higher than flood risk by floodplain occupants Peter (2006). Effective and sustainable floodplain management ensures that people are able to live and work on floodplain with no risk to life and unacceptable risk of damage to infrastructure because of flood disaster. For management of floodplain to be successful in an urban centre, the growing population must understand and appreciate the concept of flood risk and exposure to flood hazard as a result of floodplains encroachment.

2.6.5 Policy integration and implementation

According to the UNDP (2010) adequate governance is fundamental for the sustainability of urban risk management and risk reduction. The UNDP stress the need for institutional and legislative systems at the urban level to own the risk reduction process. Putting in place good policies that relates to urban planning are vital to development and management of urban water ways. There for development and implementations of integrated policy are essential for proper management of floodplains and flood disaster in urban centres that are located along coastal areas and river courses. Town plans, local environmental plan and other formal planning instruments should provide the basic foundation for floodplain management. These provides legal legislation to the urban managers that are essential for effective management of floodplain hence they should be well integrated. Floodplain management is multi objective land use planning that is best directed to the agency responsible for local planning.

2.6.6 Ensuring appropriate land use

According to ASFPM (2007) the principle of land use in floodplain management is arranging human occupancy or activities on the floodplain putting into consideration their vulnerability to flood hazard. When land use changes are to be permitted on floodplains they should be land uses that minimise flood risk and maximises the benefit of using the floodplains. Land use planning in regards to floodplain mapping are concrete decisions about land use that allows or forbid detailed uses without precautionary measures on urban use on floodplains (Peter, 2006). It is therefore imperative that land use planning be it in rural or urban area needs detailed information about floodplains and flood risks areas.

Enforcing ability of authorities concern has an impact on the choice of instruments to be applied. This depends on policy and legal legislation.

EMA grouped floodplain management measures into four principle categories. These are:

- Structural flood mitigation works: This has to do with physical construction on floodplains and river flood way of structures such as dams, levees and dykes, channel improvements. These are aimed at modifying the floodplains and flood behaviour by keeping flood water away from people that are encroaching on floodplains.
- Land use planning controls: this measure is aimed at keeping people away from the floodplains. It makes use of development plan to guide physical development and by extension human socio economic activities away from floodplains. These measures make use of zoning to ensure proper land use activities on floodplains. It determines the density of development on floodplains.
- Development and building control: This measure recognises the fact that flood will occur at some time base on existing or proposed encroachment on floodplains. These measures are aimed at reducing the risk of inundation and damages on flood prone areas within the city when flood disaster occurs. These measures among which are floor elevation, floor levels, and flood proofing of structures are also known as flood coping measure or strategies. Development and building control measures, codes and standard use in managing floodplain encroachment differs from one region to another and are determine by detailed analysis of the river floodplain.

2.6.7 Floodplain management plan

To realize the multiple objectives of floodplain management the best practice principle is for local urban planning and management authority to develop a more comprehensive floodplain management plan. The public perception that flooding will not occur should be discourage. According to the emergency management Australia (EMA) the floodplain management plan by local authority should consider flood risk rather than the flood recurrence interval. By using the flood risk as determinant for planning development and building controls the negative effects of "change" on flood level can be minimized. In putting in place an emergency flood plan the local agencies are to collaborate with stakeholders. Flood emergency plan should be able to address residual flood risks associated with flooding ALNAP, (2010) and ESDP, (1999).

2.7 CASE STUDY OF FLOODPLAIN MANAGEMENT IN CURITBA

Curitiba like any other city in the developing world is experiencing unchecked population growth and migration. This is resulting to high demand for land. The city centre was congested with the urban poor mainly encroaching and living on river floodplains areas the experienced flooding. The urban planners and managers in an attempt to solve this problem put in place floodplain management practices that are keeping development away from river floodplain. This turned the floodplains into potential for generation of new resources.

The government used legislation to set aside certain low laying areas and river floodplains as special protection and management areas. The government then acquired enncroached floodplains from the inhabitants. According to Carlos (2011) buffer zones were created using channel as the boundries that creates a limit to urban settlement pressure the main river Iguacu. Linear parks with infrastructure were then created along rivers and streams that act as buffers between flood-prone rivers and the city. Small dams and new lakes were created that act as holding basins when flooding occurs on this land. In effect, these green spaces acts as giant storm water facilities, with the lakes as central features. Whenever it rains heavily, the lake rises over the surrounding parks.

CHAPTER THREE

METHODOLOGY

3.0 INTRODUCTION

The method applied for carrying out this research put into considerations the need to identify river floodplain and understand the spatial growth of Kaduna metropolis and its physical limits to development as it relates to floodplain. Therefore the method for this research is divided into;

i. Identification of data required

ii. Data acquisition and collection

iii. Data processing

iv. Analysis and presentation

3.1 DATA REQUIREMENT AND ACQUISITION

The data required for this research and their sources are as shown on table 3.1 below

Table 3.1: data required

S/N	DATA TYPE	SOURCE
1	1967 Development plan of Kaduna metropolis	Kaduna master plan (Max Lock, 1967)
2	Floodplain map of Kaduna Metropolis extract from digital elevated model	Printed and electronic Published material, satellite image.
3	Land use land cover map of Kaduna metropolis	Published materials, documents and field survey
4	Landsat images of Kaduna metropolis 1990, 2000 and 2012 at 28m resolution.	Afrinet international consult ltd Abuja
5	Characteristics of floodplain	Floodplain map, Satellite images, Land use land cover map and field survey

Source: Author, 2013

Interviews

Interviews were conducted using formal and non formal methods with some management staff of KASUPDA, Kaduna state ministry of land survey and country planning, Chikun Local government, Kaduna South local government and Kaduna north local governments.

This identified the physical planning control program and instrument applied in the management of physical built up encroachment on river floodplains

Review of published materials and official documents

Review of literature provided information on concept and best practice in the management of floodplain encroachment due to urbanization and best practice principles. It also helped in identifying and naming of neighbourhoods on the base map that was use for field survey.

Field survey and observation

The field survey for this research served the following purposes;

i. Established the relationship between ground conditions and satellite images.
ii. Obtained information on flood reach extent based on historical eye witness accounts, coordinates and altitude.
iii. Obtained information on the physical characteristics of the floodplain.

This was achieved through recognizance survey and field observations. Hand held Global Position System (GPS) and Mobile GPS were used for the field survey. The hand held GPS was used to take geographic coordinates and altitude. The mobile GPS on the other hand was used to get instant image of the neighbourhood during the field survey. Field survey also helped in the verification of names of neighbourhoods that had encroached on floodplains. The field survey and observation method include a well-organized noting and recording.

3.2 DATA PROCESSING

Maps and satellite imagery

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 for floodplain delineation procedure). The Satellite images were then integrated with the extracted floodplain map for spatial analysis of built up encroachment into floodplains (see plates i, ii and iii). 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. Existing land use map was digitized and geo referenced from existing literature and satellite images using ArcGIS 9.3.

3.3 ANALYTICAL TOOLS

i. ArcGIS 9.3: The mapping tool (arc map) was used to map out floodplains and the pattern of built up encroachment. The measuring tool was used to quantify the floodplains and the extent of built encroachment as a result of spatial growth of Kaduna metropolis.

ii. Google Earth pro v6.2.2.6613: This was used in analysing the effectiveness of development control in managing floodplain encroachment.

3.4 DATA ANALYSIS AND PRESENTATION

For the purpose of this study the mapped river floodplain as generated from the DEM has been divided into three major reaches. The stadium round about bridge across Kaduna River was used as reference point to divide river Kaduna into two. The grouping of community and neighbourhoods into left and right reach bank of the river catchments is to

overcome the challenge of boundary delineation in the measurement of built up encroachment by communities. (See fig. 3.1). The three major reaches are;

Kaduna river Upper river reach: using the stadium round about all flood banks up river falls within the upper river floodplain. Communities along the river banks are then group into Upper Right Reach Bank Community (URRBC) and Upper Left Reach Bank Community (ULRBC).

Kaduna river Lower river catchment reach: This starts from the stadium round about bridge down the river using the river flow. The communities along this river banks are group into Lower Right Reach Bank Community (LRRBC) and Lower Left Reach Bank Community (LLRBC).

Romi river reach catcment: This is the whole stretch of Romi river to the point where it drained into Kaduna River. The communities along these major river tributary are grouped into Romi Right Reach Bank Community (RRRBC) and Romi Left Reach Bank Community (RLRBC).

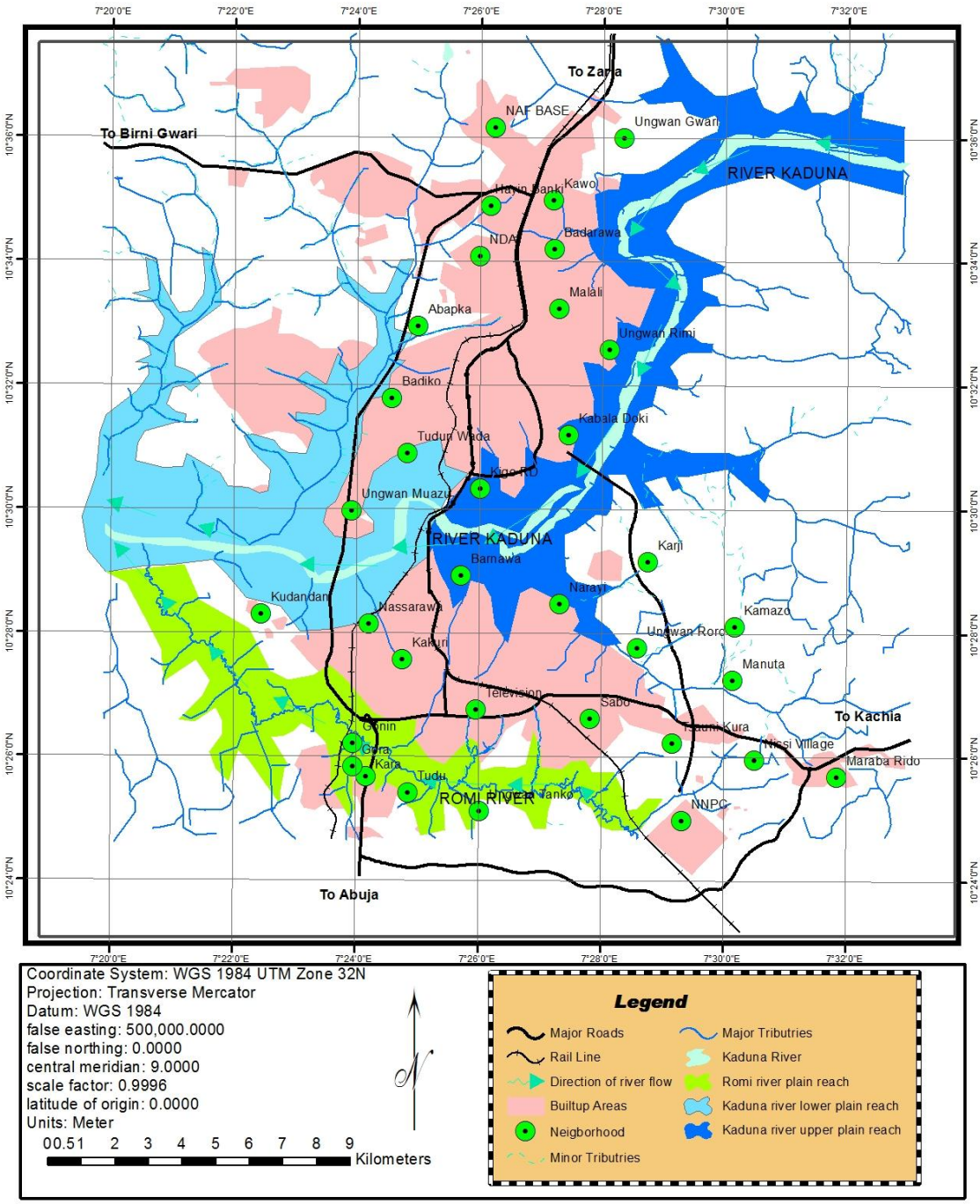


Fig. 3.1: Delineation of river floodplain.

The ArcGis 9.3 tools for measurement were used to measure the delineated floodplains and built up encroachment thus classifying it into un-encroached and encroached floodplains. The quantification of the measurement area (Km^2) was done based on each catchment and it identified the built up encroachment trend for four time epoch of 1967, 1990, 2000 and 2012. The use of satellite images for the various times epoch enabled the identification of pattern and extent of urban built up encroachments on floodplains at various time period in the spatial growth of Kaduna. The data on the ineffectiveness of planning control frame work in regulating physical development on floodplain was done using descriptive statistics through the use of tables and percentage.

The result of the data analysis were presented using tables, graphs, charts and maps where necessary and inferences were drawn and presented. Maps and graphs were used to show encroachment on flood plains.

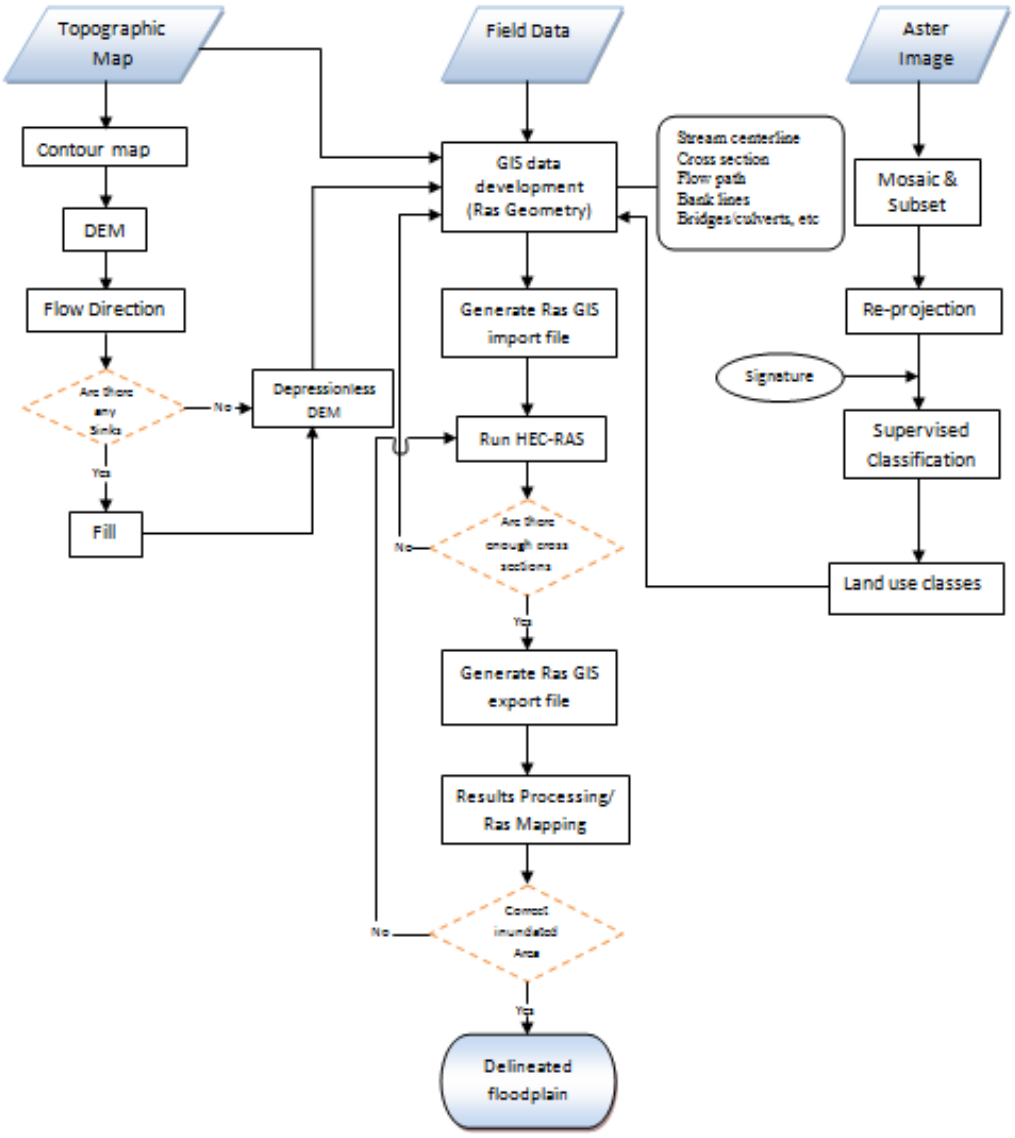


Figure 3.2: Process for delineating floodplain

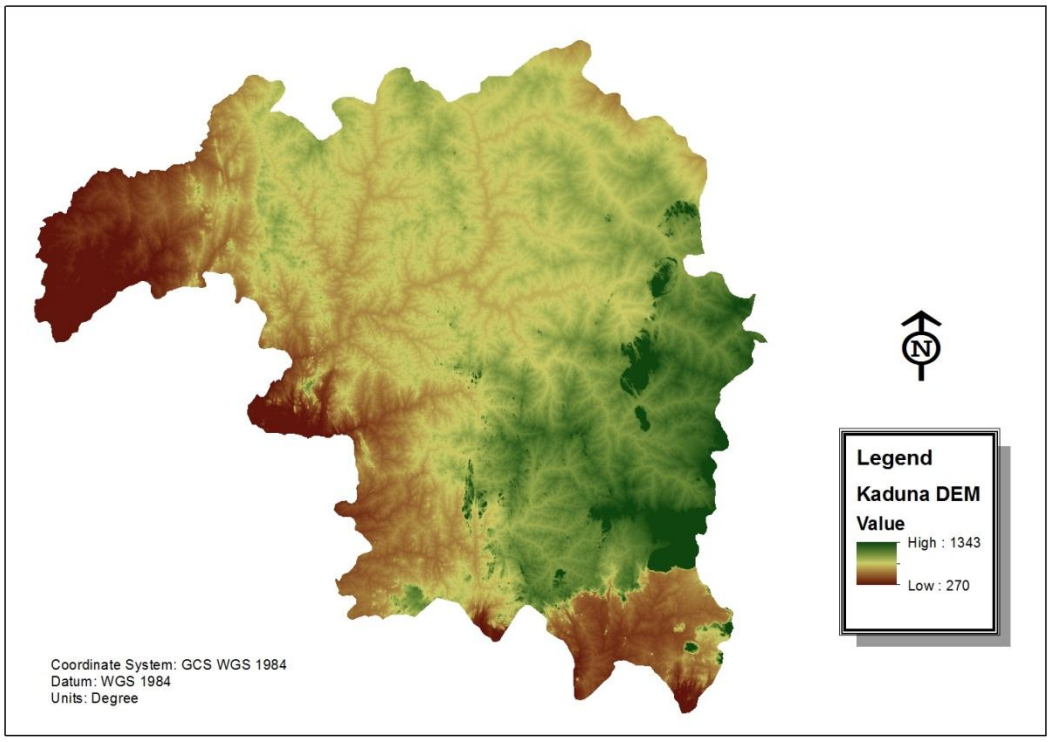


Figure 3.3: Digital elevation model of Kaduna

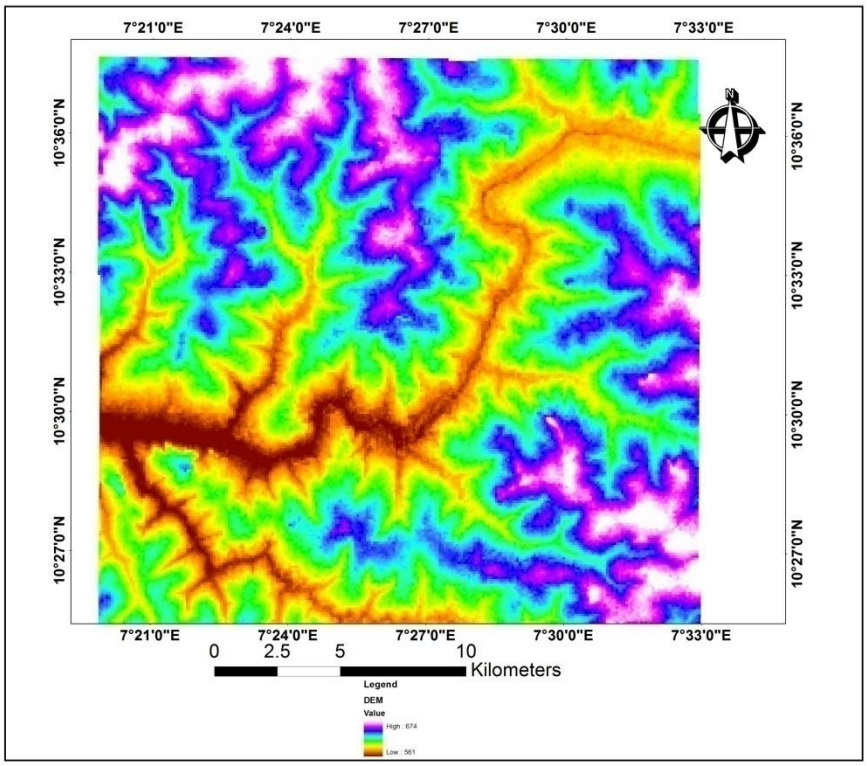


Figure 3.4: Extracted digital elevation model of Kaduna Metropolis

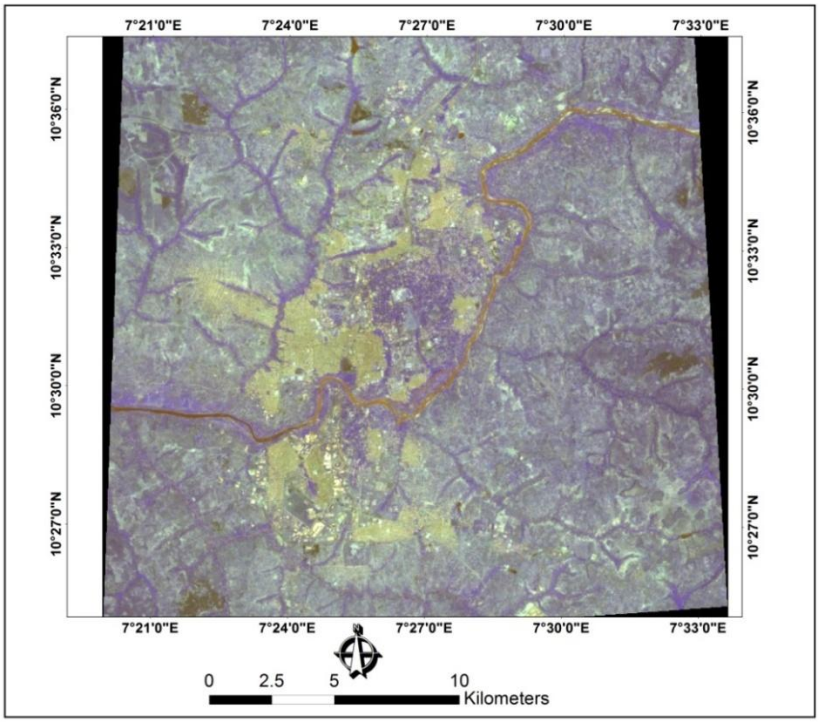


Plate I: Satellite image of Kaduna Metropolis 1990. **Source:** Lansat image

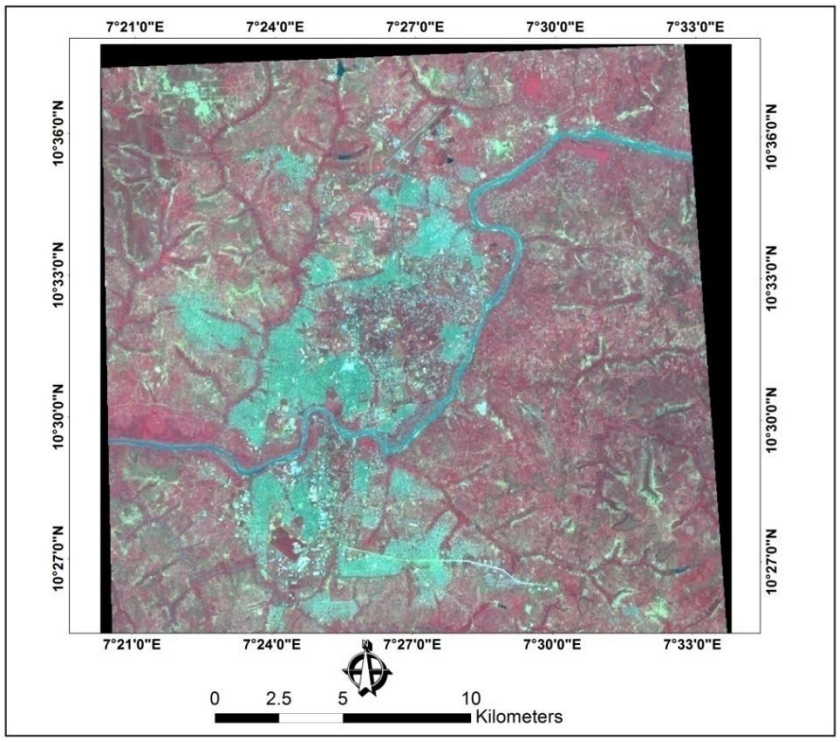


Plate II: Satellite image of Kaduna Metropolis 2000. **Source:** Landsat image

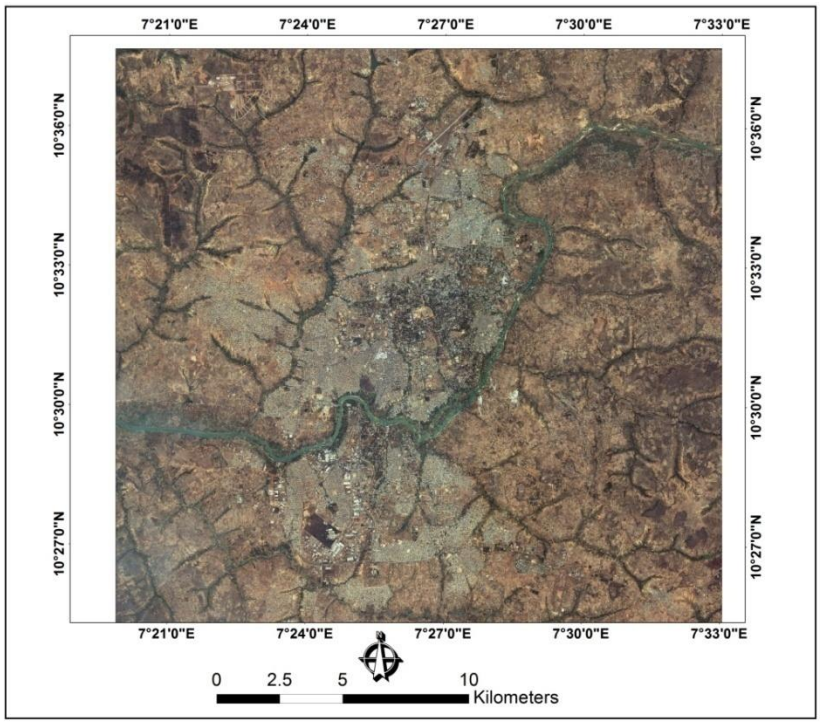


Plate III: Satellite image of Kaduna Metropolis 2012. **Source:** Lansat image

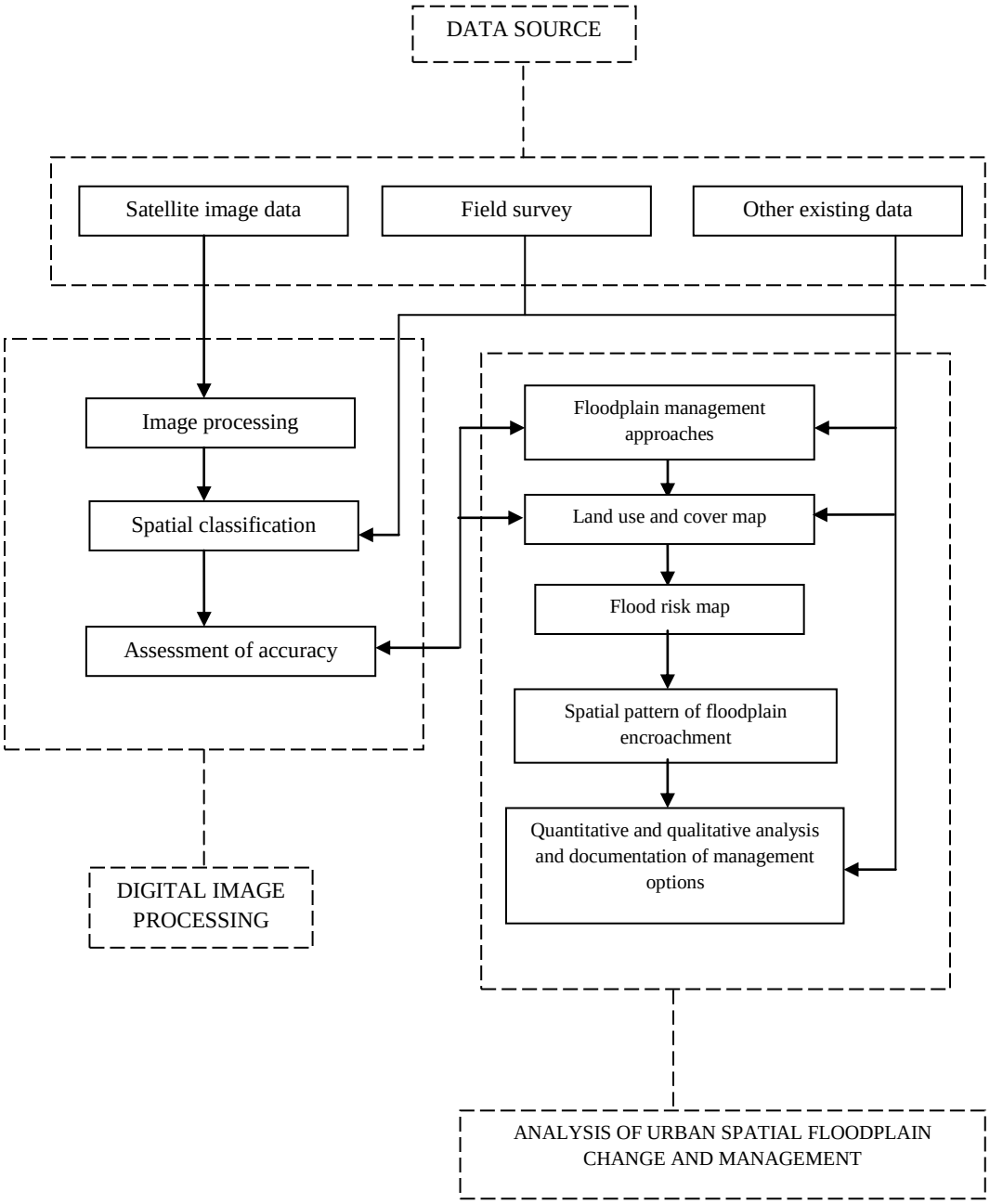


Fig. 3.5: Research methodology procedure.

CHAPTER FOUR

FLOODPLAIN ENCROACHMENT AND ITS MANAGEMENT IN KADUNA METROPOLIS

4.0 INTRODUCTION

This chapter dwells on identification and analysis of the pattern of river floodplains encroachment due to the physical growth of Kaduna metropolis. It also examines the physical planning control measures in the management of floodplain encroachment and the effectiveness.

4.1 ENCROACHMENT ON RIVER FLOODPLAIN IN KADUNA METROPOLIS

The spatial growth of Kaduna metropolis has been faced by physical limitation due to river Kaduna and its tributaries around the metropolis as well as gully site due to the natural drainage pattern. Table 4.1 shows that the total size of river floodplain in Kaduna metropolis is estimated at 112.99Km^2. Figure 4.1 show that river Kaduna almost divides the metropolis into two equal halves, which are the north and south. Table 4.1 and figure 4.1 below identified communities that are located along riverbanks of Kaduna metropolis that have encroached on river floodplains due to the spatial growth of metropolis.

Table 4.1: Communities areas that have encroached on river floodplains

River Reach	Communities/ Districts	Catchment	Catchment floodplain size (Km^2)
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, Tudun wada, 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.	Romi Left Reach Bank	12.3

	Tanko, Karatudu,)	Community (RLRBC)	
TOTAL			112.9

Source: Author, 2012

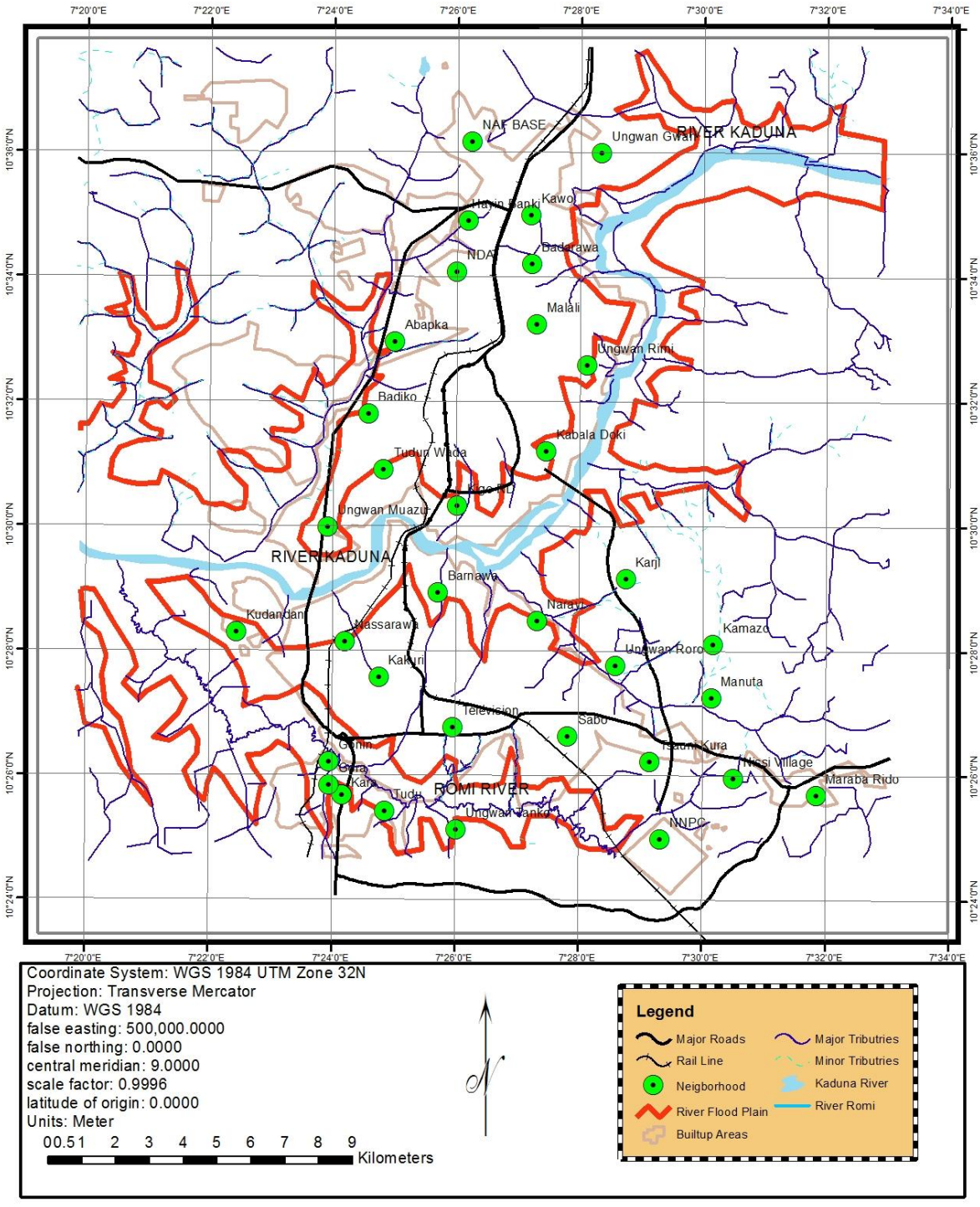


Figure 4.1: Communities along river floodplain

Source: Field work 2012

4.2 FLOODPLAIN ENCROACHMENT PATTERN AND EXTENT

4.2.1 Kaduna metropolis floodplain encroachment pattern and extent 1967

Table 4.2: Built up extent on river floodplain 1967

S/N	Catchment	Total floodplain (Km^2)	Extent of built encroachment on floodplain (Km^2)	Un encroached floodplain (Km^2)	Floodplain encroached (%)	Un encroach floodplain (%)	Total build up extent (%)
1	URRBC	23.7	1.9	21.8	8.0	92.0	52.8
2	ULRBC	26.0	0.3	25.7	1.2	98.8	8.3
3	LRRBC	25.2	1.4	23.8	5.6	94.4	38.9
4	LLRBC	9.9	0.0	9.9	0.0	100.0	0.0
5	RRRBC	15.8	0.0	15.8	0.0	100.0	0.0
6	RLRBC	12.3	0.0	12.3	0.0	100.0	0.0
TOTAL		112.9	3.6	109.3			100

Upper Right Reach Bank Catchment- URRBC, Upper Left Reach Bank Catchment- ULRBC, Lower Right Reach Bank Catchment- LRRBC, Lower Left Reach Bank Catchment- LLRBC, Romi Right Reach Bank Catchment- RRRBC, Romi Left Reach Bank Catchment- RLRBC

Source: Author, 2012

Analysis of physical encroachment on river floodplain in 1967 indicates that URRBC has the highest extent of built up encroachment of $1.9Km^2$ which is 8.0% of its floodplain (See table 4.2). The analysis shows that during the 1967 time epoch the upper left reach bank catchment (ULRBC) had the lowest encroachment extent of $0.3Km^2$ (1.2%). No built up development was recorded on the lower left reach bank catchment (LLRBC), Romi right reach bank catchment (RRRBC) and Romi left reach bank catchment (RLRBC) floodplains.

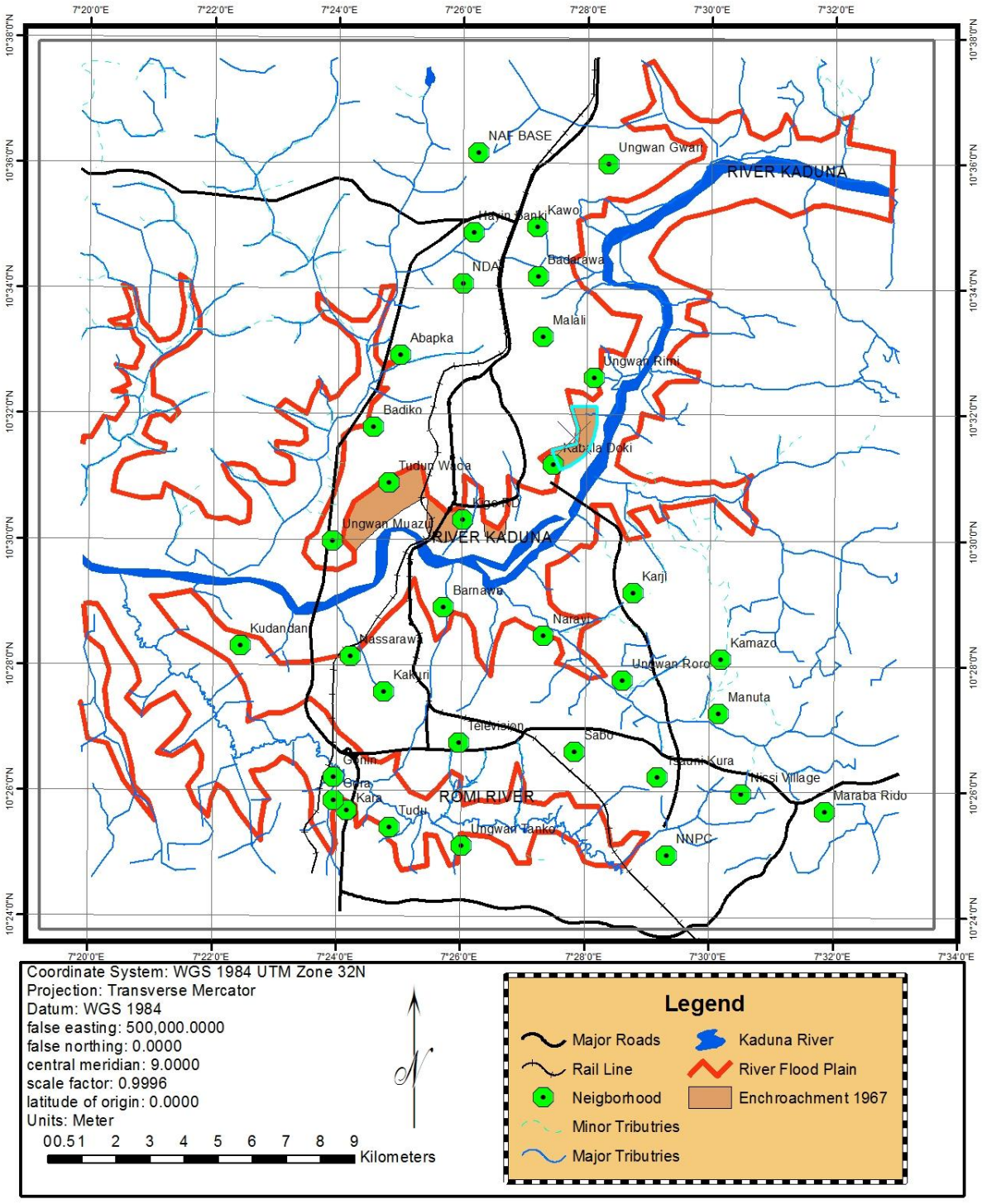


Figure 4.2: Kaduna metropolis floodplain encroachment pattern 1967

As it can be observed in figure 4.2 the pattern of floodplain encroachment as of 1967, indicates a scattered pattern of built up encroachment on river floodplain. The major encroachment fronts are; the upper right reach bank catchment (URRBC) at Kabala Doki and Ungwan Rimi communities, the lower right reach bank catchment (LRRBC) at Tudun Wada neighbourhood.

This can be attributed to the fact that Tudun Wada served as migrant settlement which provide labour to the colonial masters during the colonial era. Ugwan Rimi and Kabala Doki provided residential accommodations to the Colonial masters and native government workers.

4.2.2 Kaduna metropolis floodplain encroachment pattern and extent 1990

Table 4.3: Built up extent on river floodplain 1990

S/N	Catchment	Total floodplain (Km^2)	Extent of built up encroachment on floodplain (Km^2)	un encroached floodplain (Km^2)	Percentage of floodplain encroached (%)	Percentage of un encroach floodplain (%)	Percentage of total build up extent
1	URRBC	23.7	2.3	21.4	9.7	90.3	18.4
2	ULRBC	26.0	0.5	25.5	1.9	98.0	4.0
3	LRRBC	25.2	6.3	18.9	25.0	74.9	50.4
4	LLRBC	9.9	3.1	6.8	31.3	69.3	24.8
5	RRRBC	15.8	0.3	15.5	1.9	98.0	2.4
6	RLRBC	12.3	0.00	12.3	0.0	100.0	0.0
TOTAL		112.9	12.5	100.4			100

Upper Right Reach Bank Catchment- URRBC, Upper Left Reach Bank Catchment- ULRBC, Lower Right Reach Bank Catchment- LRRBC, Lower Left Reach Bank Catchment- LLRBC, Romi Right Reach Bank Catchment- RRRBC, Romi Left Reach Bank Catchment- RLRBC

Source: Author, 2012

Table 4.3 above shows that 25.0% of LRRBC have been encroached. The URRBC had 9.7% of its floodplain encroached while 2.0% of the ULRBC were encroached on for urban development. The LLRBC and the RRRB which are the new identified encroachment recorded 31.3% and 1.9% of built encroachment respectively within their floodplain. No Physical development was observed to have encroached into the RLRBC. As can be seen from table 4.3, 50.4% (6.3 Km^2) of physical development that encroached on river floodplain as of the year 1990 were within LRRBC. See table 4.3 for more details.

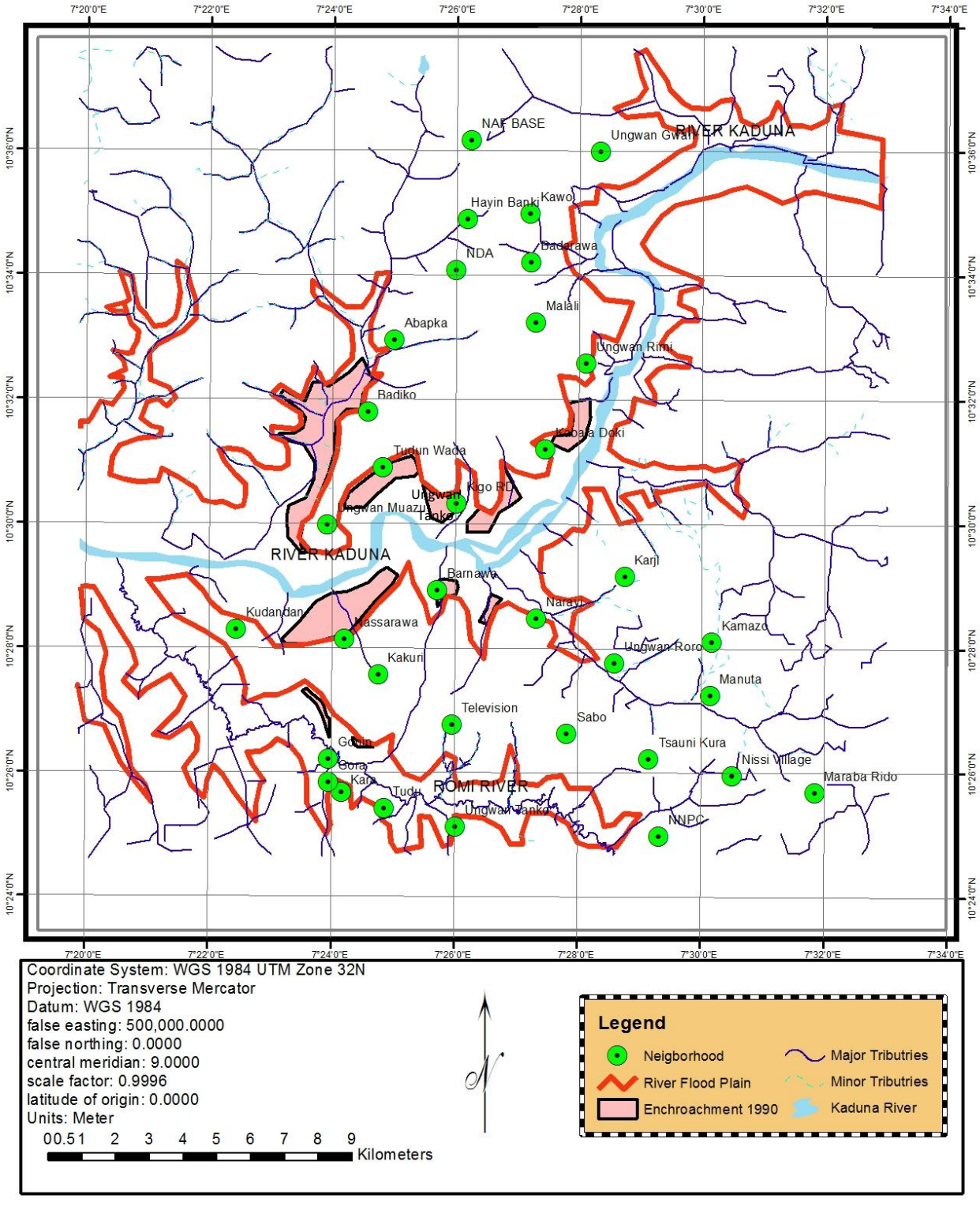

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NAF BASE
Ungwan Gwari
RIVER KADUNA
Hayin Banki
Kawo
NDA
Badarawa
Malali
Abapka
Ungwan Rimi
Badiko
Kabala Doki
Tudun Wada
Ungwan Kigo RD
Ungwan Muazu
Tanko
RIVER KADUNA
Karji
Barnawa
Kudandan
Nassarawa
Narayi
Kamazo
Ungwan Roro
Kakuri
Manuta
Television
Sabo
Gonin
Tsauni Kura
Gora
Nissi Village
Kara
Tudu
ROMI RIVER
Maraba Rido
Ungwan Yanko
NNPC
Coordinate System: WGS 1984 UTM Zone 32N
Projection: Transverse Mercator
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false northing: 0.0000
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scale factor: 0.9996
latitude of origin: 0.0000
Units: Meter
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Legend
Neigborhood
River Flood Plain
Enchroachment 1990
Major Tributries
Minor Tributries
Kaduna River

Figure 4.3: Kaduna metropolis floodplain encroachment pattern 1990

The encroachment pattern as illustrated on figure 4.3 is leap frog pattern of physical development encroachment on floodplains. The analysis shows that 1990 witness an increased floodplain encroachment with new encroachment observed at the lower left reach bank catchment (LLRBC) and Romi right reach bank catchment (RRRBC). Physical development encroachment on river banks was observed on the LRRBC and it extends from Tudun Wada to Rigasa communities. See figure 4.3.

The establishment of industrial layout at Kakuri and Mekira and the construction of the western bye pass road to redirect traffic away from the Central Business District (CBD) encouraged development at western axis of the metropolis. The road also serviced increased floodplain encroachment areas at the LRRBC and the LLRBC. The time epoch coincided with the industrial boom in Kaduna with Romi and Television settlements as well as Nasarawa, Tudun wada, Ungwan Muazu and Rigasa communities providing residential accommodation to migrant labourers. The time epoch of 1990 witnessed spatial growth and expansion to the south and south- west directions leading to new frontier of urban built up encroachment on LLRBC and RRRBC, while expanding at the LRRBC.

4.2.3 Kaduna metropolis floodplain encroachment pattern and extent 2000

Table 4.4: Extent of urban built up encroachment on river floodplain 2000

S/N	Catchment	Total floodplain (Km^2)	Extent of built up encroachment on floodplain (Km^2)	Extent of un encroached floodplain (Km^2)	Percentage of floodplain encroached (%)	Percentage of un encroach floodplain (%)	Percentage on total build up extent (%)
1	URRBC	23.7	6.8	16.9	28.7	71.5	25.2
2	ULRBC	26.0	4.1	21.9	15.8	84.2	15.2
3	LRRBC	25.2	8.3	16.9	32.9	66.9	30.7
4	LLRBC	9.9	4.0	5.9	40.4	59.4	14.8
5	RRRBC	15.8	2.8	13.0	17.7	81.8	10.4
6	RLRBC	12.3	1.0	11.3	8.1	92.0	3.7
Total		112.9	27.0	85.9			100

Upper Right Reach Bank Catchment- URRBC, Upper Left Reach Bank Catchment- ULRBC, Lower Right Reach Bank Catchment- LRRBC, Lower Left Reach Bank Catchment- LLRBC, Romi Right Reach Bank Catchment- RRRBC, Romi Left Reach Bank Catchment- RLRBC

Source: Author, 2012

The total extent of urban fabric built up that encroached on floodplain by the year 2000 is estimated at 27.0 Km^2 which is approximately 23.9% of the floodplains. The lower right reach bank catchment (LRRBC) which is at closed proximity to the industrial hub and Central Business District (CBD) of the metropolis had 32.9% (8.3 Km^2) of its floodplain encroached upon which is 30.7% of total built up encroachment on floodplains. The LLRBC and RRRBC have 40.4% and 17.7% of their floodplain encroached upon respectively. The analysis shows that 28.7% of URRBC have been encroached upon, while

15.8% of the ULRBC was encroached upon for physical development. As it can be seen on table 4.4 the Romi left reach bank catchment (RLRBC) which is a new front of encroachment has the smallest extent of built encroachment estimated at 1.0 Km^2 which is approximately 3.7% of the total encroachment on floodplain (See table 4.4).

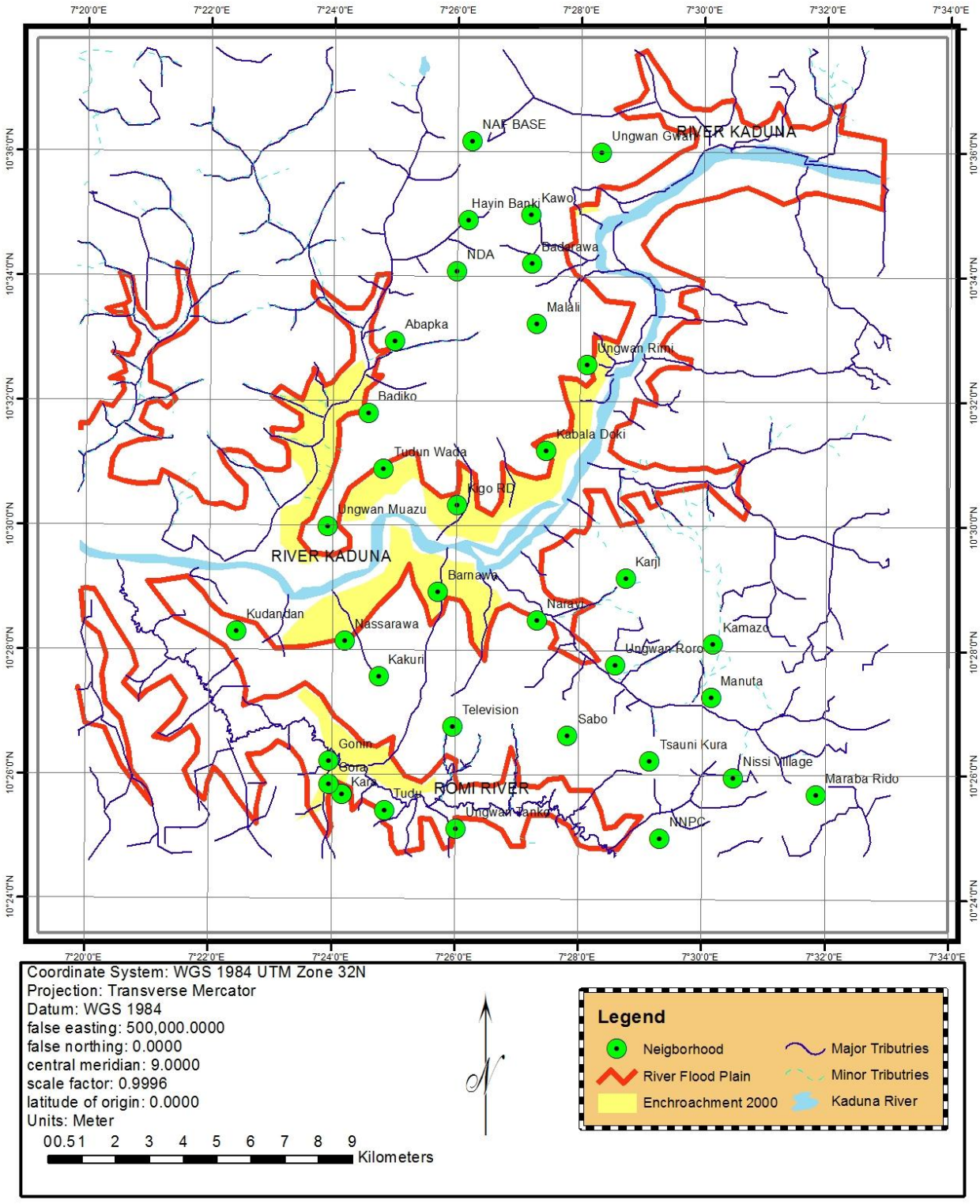


Figure 4.4: Kaduna metropolis floodplain Urban built up encroachment pattern 2000

Figure 4.4 shows that the pattern of built up encroachment on river floodplains as of 2000 epoch time was that of an extended urban built fabric within the river bank catchment areas. This can be attributed to infill and sprawl development which intensified encroachment thereby resulting to ribbon pattern of encroachment manifesting between 1990 and 2000.

The sprawl development resulted to communities like Malali and Badarawa on the URRBC, Nasarawa and Kudandan on the LLRBC built up areas encroaching on their various catchment floodplains. The dual carriage western bye pass road (Kano to Abuja road) carriage and the need to access basic service utilities can be said to contribute to the built up encroachment on the western side of the metropolis.

4.2.4 Urban built up floodplain Encroachment pattern and extent 2012

Table 4.5: Built up extent on river floodplains 2012

S/N	Catchment	Total floodplain (Km^2)	Extent of built up encroachment on floodplain (Km^2)	Un encroached floodplain (Km^2)	Encroached catchment (%)	Un encroached catchment (%)	Total build up extent on floodplain (%)
1	URRBC	23.7	11.1	12.6	46.8	53.3	22.3
2	ULRBC	26.0	5.6	20.4	21.5	78.8	11.2
3	LRRBC	25.2	14.9	10.3	59.1	40.7	29.9
4	LLRBC	9.9	6.9	3.0	69.7	29.9	13.8
5	RRRBC	15.8	7.1	8.7	44.9	55.1	14.2
6	RLRBC	12.3	4.3	8.0	35.0	64.8	8.6
Total		112.9	49.9	63.0			100

Upper Right Reach Bank Catchment- URRBC, Upper Left Reach Bank Catchment- ULRBC, Lower Right Reach Bank Catchment- LRRBC, Lower Left Reach Bank Catchment- LLRBC, Romi Right Reach Bank Catchment- RRRBC, Romi Left Reach Bank Catchment- RLRBC

Source: Author, 2012

The result in table 4.5 indicates that the total floodplain encroached as of 2012 is approximately 49.9 Km^2. The size of the urban built up fabric encroachment by communities located along the LRRBC is 14.9 Km^2 which is 29.9% of total built up extent which encroached on floodplain in Kaduna. While the LLRBC that has a floodplain landmass of 9.9 Km^2 has 69.7% (6.9 Km^2) encroached upon. Physical development on the URRBC and the ULRBC are estimated at 46.8% and 21.5% respectively. The RRRBC and the RLRBC which is at the periphery of the metropolis recorded 44.9% and 35% encroachment respectively by communities along Romi River (See table 4.5.). This indicates that 44.2% of river floodplains in Kaduna metropolis have been encroached upon.

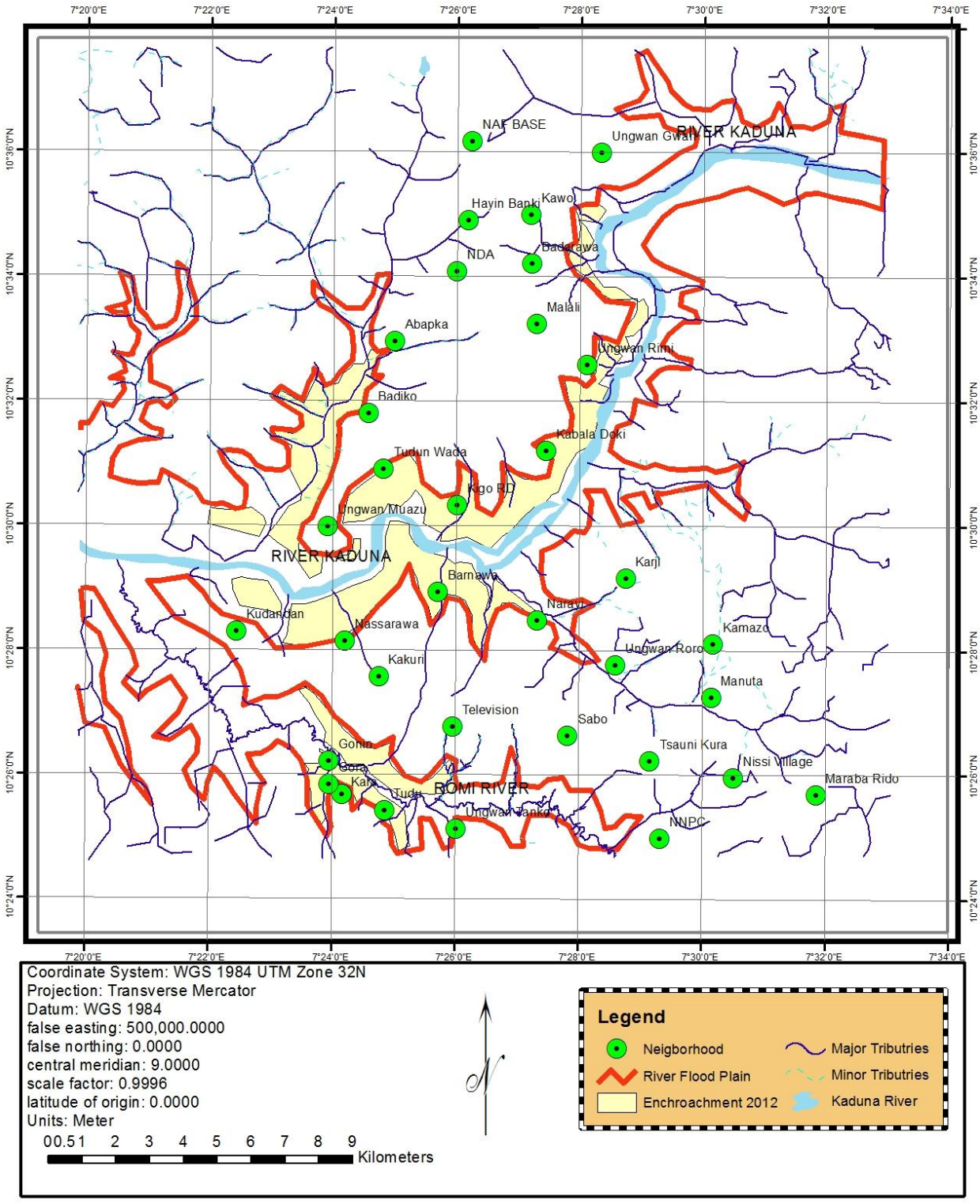


Figure 4.5: Floodplain encroachment pattern 2012

Figure 4.5 shows that the pattern of built up encroachment as of 2012 time epoch is that of spatial expansion of the urban built up fabric on floodplains. There was significant physical growth on all the floodplain catchment areas. Sprawling development of communities located along the upper right reach bank catchment (URRBC) led to floodplain encroachment at Malali, Badarawa, Ungwan Dosa and Kawo. While Juji and Gbagi villa of Sabo and Romi community respectively encroached on the Romi right reach bank catchment (RRRBC). Sprawling development led to encroachment on floodplain by Ungwan Tanko and Karatudu neighbourhoods of Goni Gora community located along the Romi left reach bank catchment (See figure 4.5).

The changes within river floodplain due to urban growth at the 2012 time epoch can be attributed to polarization of Kaduna metropolis based on ethno religious divides and the construction of major roads and bridges. These roads and bridges are the Patrick Yakowa way, Romi and millennium city roads and bridges as well as the dual carriage Nnamdi Azikiwe road linking Abuja road and Sabo Tasha.

4.3 PHYSICAL BUILT UP TRENDS AND RATE OF CHANGES ON FLOODPLAINS IN KADUNA METROPOLIS

4.3.1 Summary of floodplain encroachment and changes on river floodplains in Kaduna metropolis 1967-2012

The summary of analysis on Table 4.6 above shows that river floodplains encroachments have increased over the years. The extent of encroachment into the URRBC increased from

1.9Km^2 in 1967 to 11.1Km^2 in 2012 while the extent of encroachment on the ULRBC changed from 0.3Km^2 in 1967 to 5.6Km^2 in 2012. Built up extent on LRRBC increased to an alarming 14.9Km^2 in 2012 from its observed encroachment of 1.4Km^2 in 1967. The extent of encroachment on LLRBC increased in size from the observed extent of 3.1Km^2 in 1990 to 6.9Km^2 in 2012. The built extent on RRRBC was noticed in 1990 to be 0.3Km^2 and increased to 7.1Km^2 in 2012. The 1.0Km^2 encroachments noticed on the RLRBC in 2000 increased in size to 4.3Km^2 in 2012. The average encroachment rate is estimated at 0.32Km^2. See table 4.6 for rate of encroachment on river floodplains.

Table 4.6: Summary of changes on floodplains

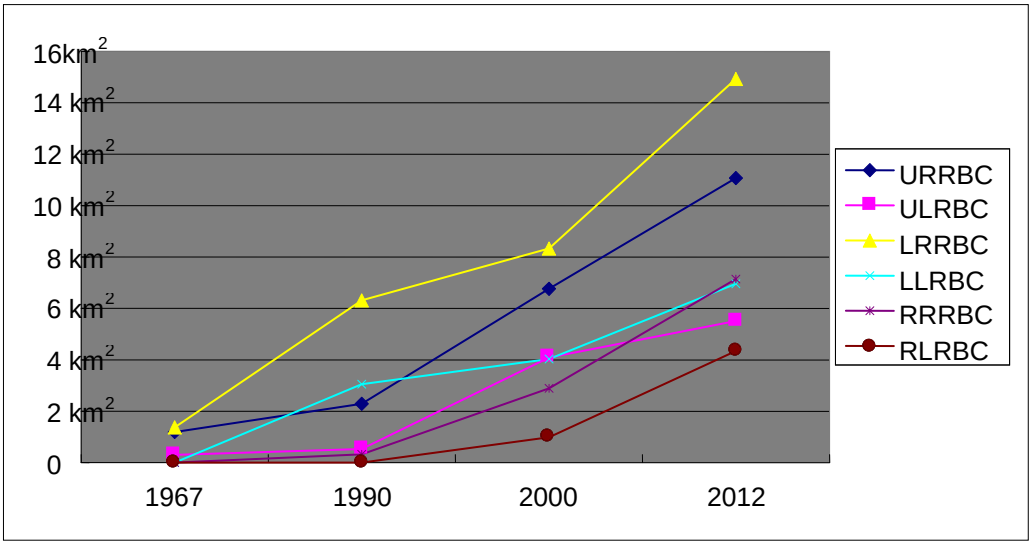
S/N	**Community**	**Flood plain (Km^2)**	**Extent of physical urban development encroachment on floodplain (Km^2)**				**Encroachment Change rate (Km^2 per year)**		
			1967	1990	2000	2012	1967 to 1990	1990 to 2000	2000 to 2012
1	URRBC	23.7	1.9	2.3	6.8	11.1	0.05	0.45	0.36
2	ULRBC	26.0	0.3	0.5	4.1	5.6	0.01	0.36	0.12
3	LRRBC	25.2	1.4	6.3	8.3	14.9	0.22	0.20	0.55
4	LLRBC	9.9	0.0	3.1	4.0	6.9	0.13	0.10	0.24
5	RRRBC	15.8	0.0	0.3	2.8	7.1	0.01	0.25	0.35
6	RLRBC	12.3	0.0	0.0	1.0	4.3	0.00	0.10	0.28
Total		112.9	3.6	12.5	27.0	49.9			

Upper Right Reach Bank Catchment- URRBC, Upper Left Reach Bank Catchment- ULRBC, Lower Right Reach Bank Catchment- LRRBC, Lower Left Reach Bank Catchment- LLRBC, Romi Right Reach Bank Catchment- RRRBC, Romi Left Reach Bank Catchment- RLRBC

Source: Author, 2012

It can therefore be inferred that an estimated size of 49.9Km^2 of floodplain have been covered by roofing sheets, concrete floors and asphalt. Physical development on the river floodplain over the years is gradually reducing floodplains sizes. The expanding roofing sheets, concretes floor, and asphalt due to physical development on this floodplain are also reducing the peculation and retention capacity of the floodplain thus shortening the time taken for increased in flood level and extent. The implication of the urban built activities encroaching on river floodplain is increasing vulnerability and occurrences of flooding in Kaduna metropolis.

4.3.2 Trend of built up changes on floodplain catchment areas



Upper Right Reach Bank Catchment- URRBC, Upper Left Reach Bank Catchment- ULRBC, Lower Right Reach Bank Catchment- LRRBC, Lower Left Reach Bank Catchment- LLRBC, Romi Right Reach Bank Catchment- RRRBC, Romi Left Reach Bank Catchment- RLRBC

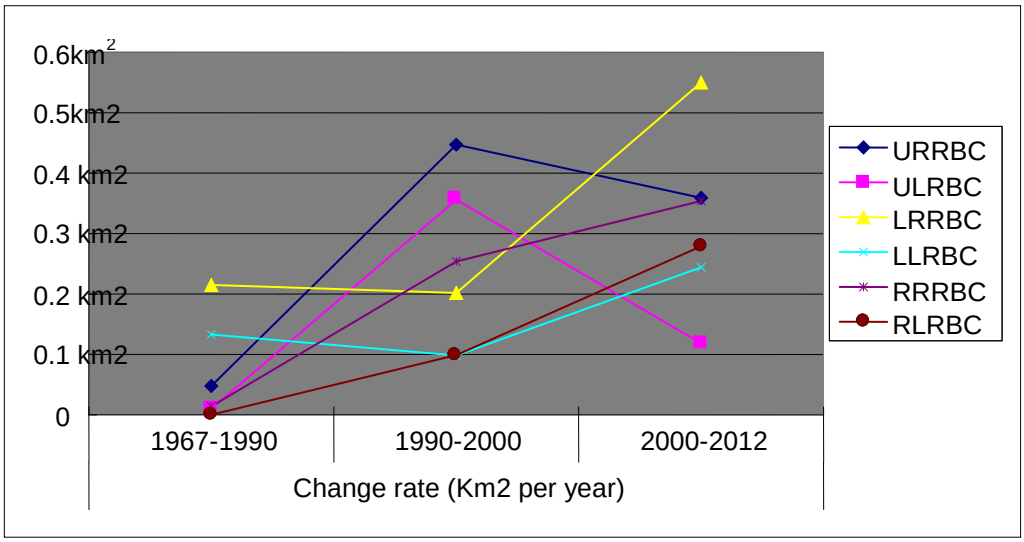
Figure 4.6: Trend of built up changes within floodplain catchment areas.

The regression analysis illustrated in figure 4.6 indicates that floodplain encroachment in Kaduna metropolis is increasing. It can therefore be inferred that the vulnerability to urban

flood disaster at the various river catchment is rising in Kaduna. The vulnerability and occurrences of flood hazards to some of the housing and infrastructure encroachment on floodplains might not be life threatening, but can impose cost on individual developers and the municipal governments.

4.3.3 Rate of urban built encroachment on floodplains catchments in Kaduna metropolis

The rate of encroachment on river floodplain varies from one floodplain to another and from one time period to another. Figure 4.7 shows that LRRBC has the highest rate of encroachment of 0.22Km^2 per year between the time period of 1967 to 1990 while the rate of encroachment on the URRBC and ULRBC are 0.05Km^2 and 0.01Km^2 respectively. The highest encroachment rate for the time period of 1990 to 2000 was recorded on the URRBC which is of close proximity to the Kaduna metropolis CBD. The rate of encroachment on the ULRBC dropped from 0.36 Km^2 between 1990 and 2000 periods to the rate 0.12 Km^2 during the time period of 2000-2012. See figure 4.7 and table 4.6 for further details.



Upper Right Reach Bank Catchment- URRBC, Upper Left Reach Bank Catchment- ULRBC, Lower Right Reach Bank Catchment- LRRBC, Lower Left Reach Bank Catchment- LLRBC, Romi Right Reach Bank Catchment- RRRBC, Romi Left Reach Bank Catchment- RLRBC

Figure 4.7: Rate of floodplain encroachment**.**

It can be inferred from the illustration of the linear regression analysis model as shown in table 4.7 the rate of urban built fabric encroaching on floodplain in URRBC and ULRBC are dropping after reaching their peak during the time period of 1990 to 2000. The LLRBC, LRRBC, RRRBC and RLRBC are witnessing a steady increase of encroachment change rates. The fall in encroachment change rates of the URRBC and the ULRBC can be attributed to reduction in sprawling development and the physical limit challenges to physical development by river Kaduna. Thus the observed encroachments for the time period of 2000-2012 are mostly as a result of infill development. The increasing encroachment rate being recorded at the LRRBC, LLRBC, RRRBC and RLRBC are as a result of urban sprawl

4.3.4 Spatial growth of Kaduna metropolis and changes on floodplain

Table 4.7: Spatial growth of Kaduna metropolis and changes on river floodplain

Year	Physical built up extent(Km^2)	Total floodplain area (Km^2)	Extent of built encroachment on floodplain (Km^2)	Un encroached floodplain(Km^2)	Physical built encroachment on floodplain %
1967	23.2	112.9	3.6	110.1	15.5
1990	128.4	112.9	12.5	100.5	9.7
2000	141.5	112.9	27.0	85.9	19.2
2012	193.2	112.9	49.9	63.0	25.8

Source: Author, 2012

Table 4.7 shows that 15.5% of the 23.2Km^2 physical built up extent of Kaduna metropolis in 1967 encroached on floodplain. By the year 1990 the spatial built up land mass increased to 128.36Km^2 and 9.7% of this built up are within floodplains. The analysis on Table 4.7 shows that by 2000 19.2% of the 141.5Km^2 of the urban built fabric encroached on floodplains while by the year 2012 the urban built fabric increased to a landmass area of 193.2Km^2 with 25.8% of it encroaching on floodplain. Figure 4.8 gives graphical representation of spatial growth of Kaduna as it relates to built encroachment on floodplain

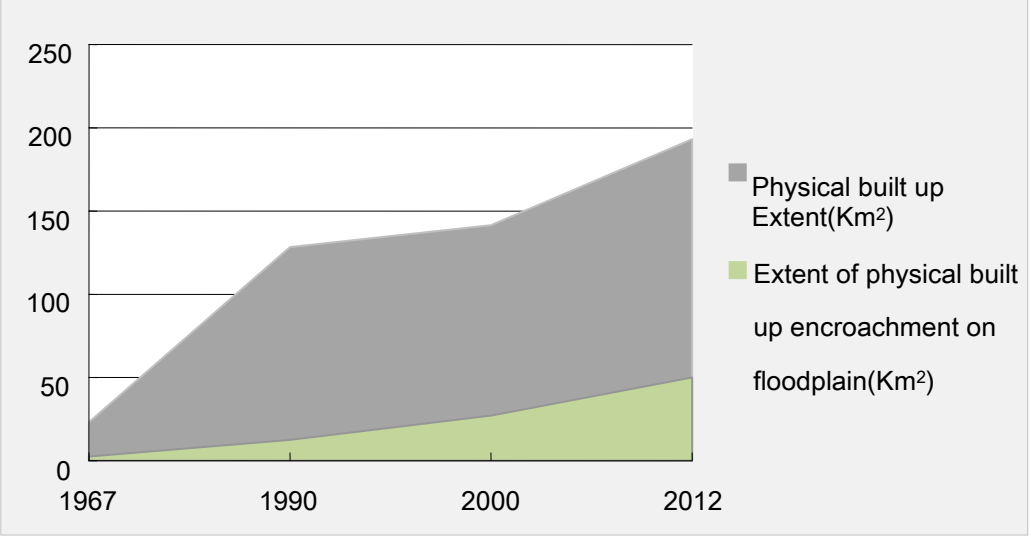


Fig.4.8: Extent of spatial growth and floodplain encroachment in Kaduna metropolis

As shown by the graphical illustration on Fig. 4.8 the physical spatial growth of Kaduna metropolis is accompanied by increase in floodplain encroachment. It can therefore be deduced that 49.9Km^2 (25.8%) of housing and infrastructural built up area of Kaduna metropolis are liable to flood disaster events at any flood returned period.

4.4 CHARACTERISTICS OF URBAN LAND USE ENCROACHMENT WITHIN FLOODPLAINS IN KADUNA METROPOLIS.

4.4.1 Land use distribution on river floodplain in Kaduna.

Table 4.8: Land use distribution on river floodplain

Land use	**Proposed**		**Existing**		**Violation**	
	Area (Km^2)	%	Area (Km^2)	%	Area (Km^2)	%
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
Total	112.9		112.9		87.2	100

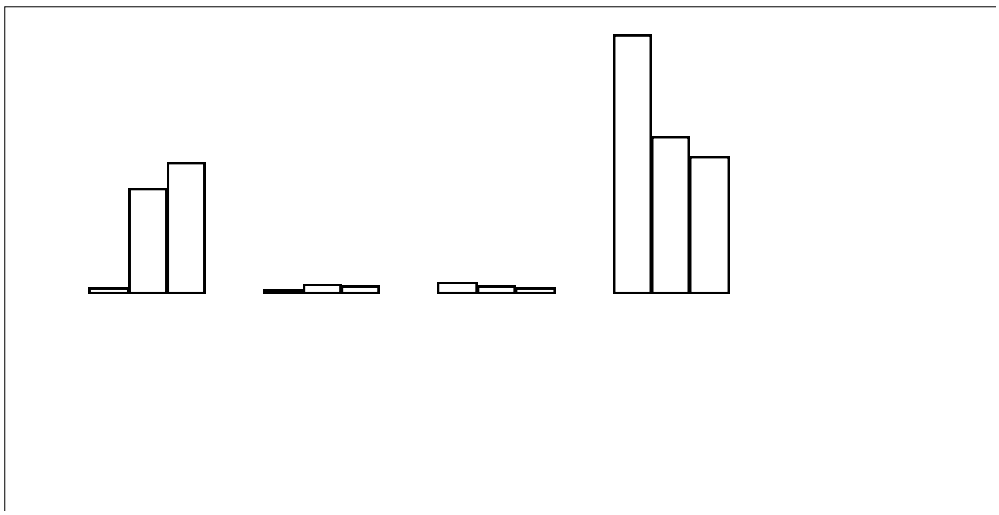


Figure 4.9: Proposed, existing and violated land use variation on floodplain.

Table 4.8 shows the violation on floodplain land use. The proposed green area (recreation, agricultural) land use on river floodplain in Kaduna by the 1963 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 4.8 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 4.9 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.

4.4.2 Existing urban land use encroachment on floodplains catchment in Kaduna metropolis

Table 4.9: Existing urban land use encroachment distribution on floodplain

Land use	**URRBC**		**ULRBC**		**LRRBC**		**LLRBC**		**RRRBC**		**RLRBC**		**Total**	
	Area (Km^2)	%	Area (Km^2)	%	Area (Km^2)	%	Area (Km^2)	%	Area (Km^2)	%	Area (Km^2)	%	Area (Km^2)	%
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
TOTAL	11.1		5.6		14.9		6.9		11.6		4.3		49.9	100

Upper Right Reach Bank Catchment- URRBC, Upper Left Reach Bank Catchment- ULRBC, Lower Right Reach Bank Catchment- LRRBC, Lower Left Reach Bank Catchment- LLRBC, Romi Right Reach Bank Catchment- RRRBC, Romi Left Reach Bank Catchment- RLRBC

Source: field survey, 2012

The analysis of existing urban built land use encroachment on floodplain as shown on table 4.9 indicates that residential land use constitute 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 occupies 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 4.9 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 4.10 for illustration of urban land use encroachment distribution on floodplains in Kaduna metropolis.

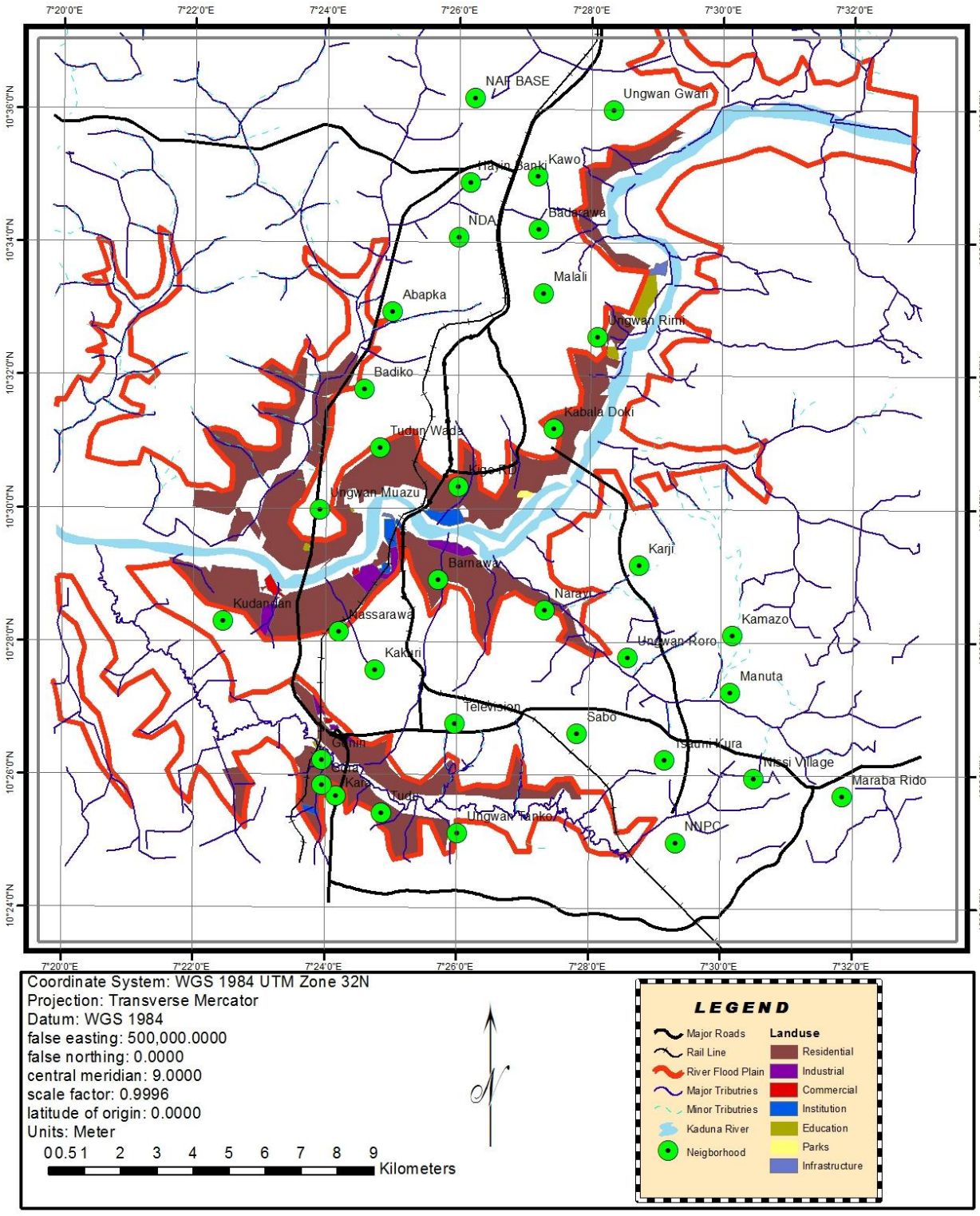


Figure 4.10: Pattern of urban land use encroachment on floodplains.

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.

4.4.3 Density of residential development

As shown on table 4.10 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^2. 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 4.10 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 4.10 for more details on density of residential development and figure 4.11 for the existing urban land use pattern of encroachment on floodplains in Kaduna metropolis.

Table 4.10: Density of residential development

Density	**URRBC**		**ULRBC**		**LRRBC**		**LLRBC**		**RRRBC**		**RLRBC**		**TOTAL**	
	Area (Km^2)	%	Area (Km^2)	%	Area (Km^2)	%	Area (Km^2)	%	Area (Km^2)	%	Area (Km^2)	%	Area (Km^2)	%
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
TOTAL	8.8		4.7		14.8		4.3		5.9		4.0		42.8	100

Upper Right Reach Bank Catchment- URRBC, Upper Left Reach Bank Catchment- ULRBC, Lower Right Reach Bank Catchment- LRRBC, Lower Left Reach Bank Catchment- LLRBC, Romi Right Reach Bank Catchment- RRRBC, Romi Left Reach Bank Catchment- RLRBC

Source: GIS Analysis, 2012

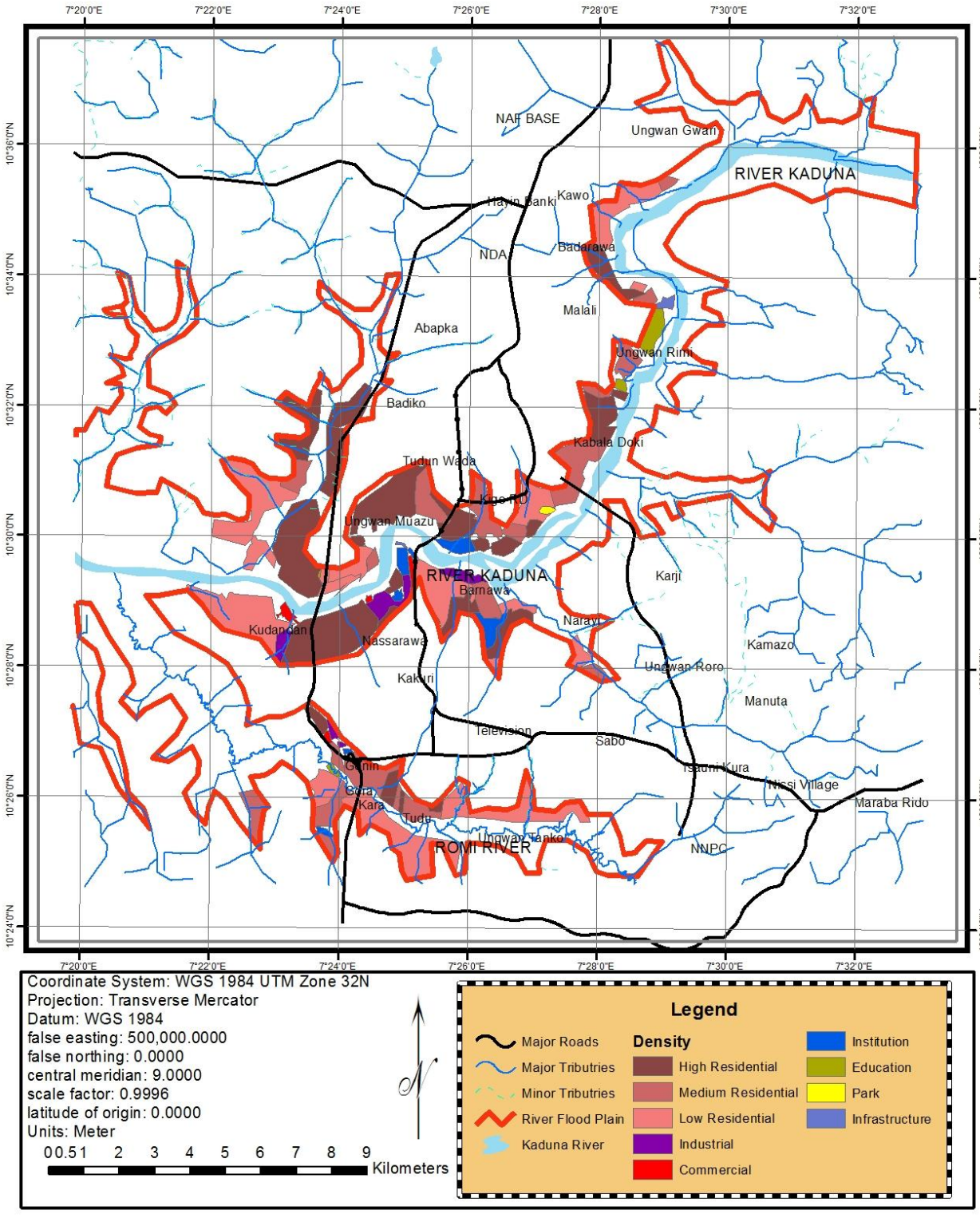


Figure 4.11: Pattern of residential density encroachment on floodplain

Figure 4.10 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.

4.5 PLANNING INSTITUTIONS AND MANAGEMENT CONTROL MEASURES FOR REGULATING FLOODPLAIN ENCROACHMENT

4.5.1 Urban Planning and management institutions in Kaduna

Planning institutions are created by the state government as enshrine in relevant laws such as the land use act of 1978, urban and regional planning law of 1992 among others. These planning institutions have the responsibilities to prepare and implement planning schemes that are to guide urban development. The planning institutions in Kaduna include the following.

a. Ministry of lands, survey and country planning

The ministry was established on the provisions of relevant laws such as the land use act of 1978 and the town and country planning laws of 1946. The ministry has a town planning department which prepares and implement layout plan base on land use zoning of Kaduna. All layout plans prepared must be checked and approved by KASUPDA to ensure the

conformed to the zoning plan and regulations of Kaduna. The ministry is responsible for land administration, survey, town and country planning, collections of rent and fees on land

b. Kaduna state urban and planning and development authority (KASUPDA)

KASUPDA was established by the Kaduna state edicts of 1985 and mandated to operate in all areas declared as urban areas by the state governor. KASUPDA is responsible for preparation and implementing layout plans, issuance of building permit and granting planning permits for seeking of certificate of occupancy, enforcing planning regulation and standard (Development control).

c. Works department of local authority

Kaduna metropolis is administratively divided into Kaduna north government and Kaduna south local government. Chikun local government at the peripheral south, south east and south west while part of Igabi local government at the north. It's a common occurrence for the physical planning units of the local authority to have administrative conflicts with the state institutions that manage the growth of the metropolis. The local authority managed land under the jurisdiction of the local authority, prepares and implement layout plan, enforces planning regulation and standards (development control)

Interviews and discussion held with selected officials of the planning institutions revealed that Kaduna metropolis does not have any specific floodplain management ordinance as well as development standards and codes. Therefore floodplains are managed using the general physical planning and development control frame work and instrument in Kaduna metropolis.

4.5.2 Management control measures for regulating floodplain encroachment

a. Plans and layout schemes

Table 4.11: Approved and un-approved Plans and layout schemes on river floodplains

Layout scheme/ plans	**Area encroachment on floodplain (Km^2)**	**(%)**
Approved	24.4	48.9
Un-approved	25.5	51.1
Total	49.9	100

S**ource:** Author 2012

From the analysis shown on table, 4.11 48.9% of physical development that encroach on floodplain are within approved planning schemes areas while 51.1% falls outside the planning area. See figure 4.12 for further illustration. 48.9% floodplain encroachment within approved schemes such as Ungwan Rimi, Malali, and Kigo road indicates failure by the ministry of land and country planning and KASUPDA to recognise the need to regulate physical development on floodplain. The 51.03% reflects the failure of KASUPDA to regulate the activity of land speculators and private developers that subdivide farmland into residential layout. It can therefore be inferred that the planning schemes of Kaduna has fail to use planning scheme as an instrument for regulating urbanization of floodplains. This can be attributed to their inability to regularly prepare affordable layout plans, site and services schemes to guide the growth of the metropolis.

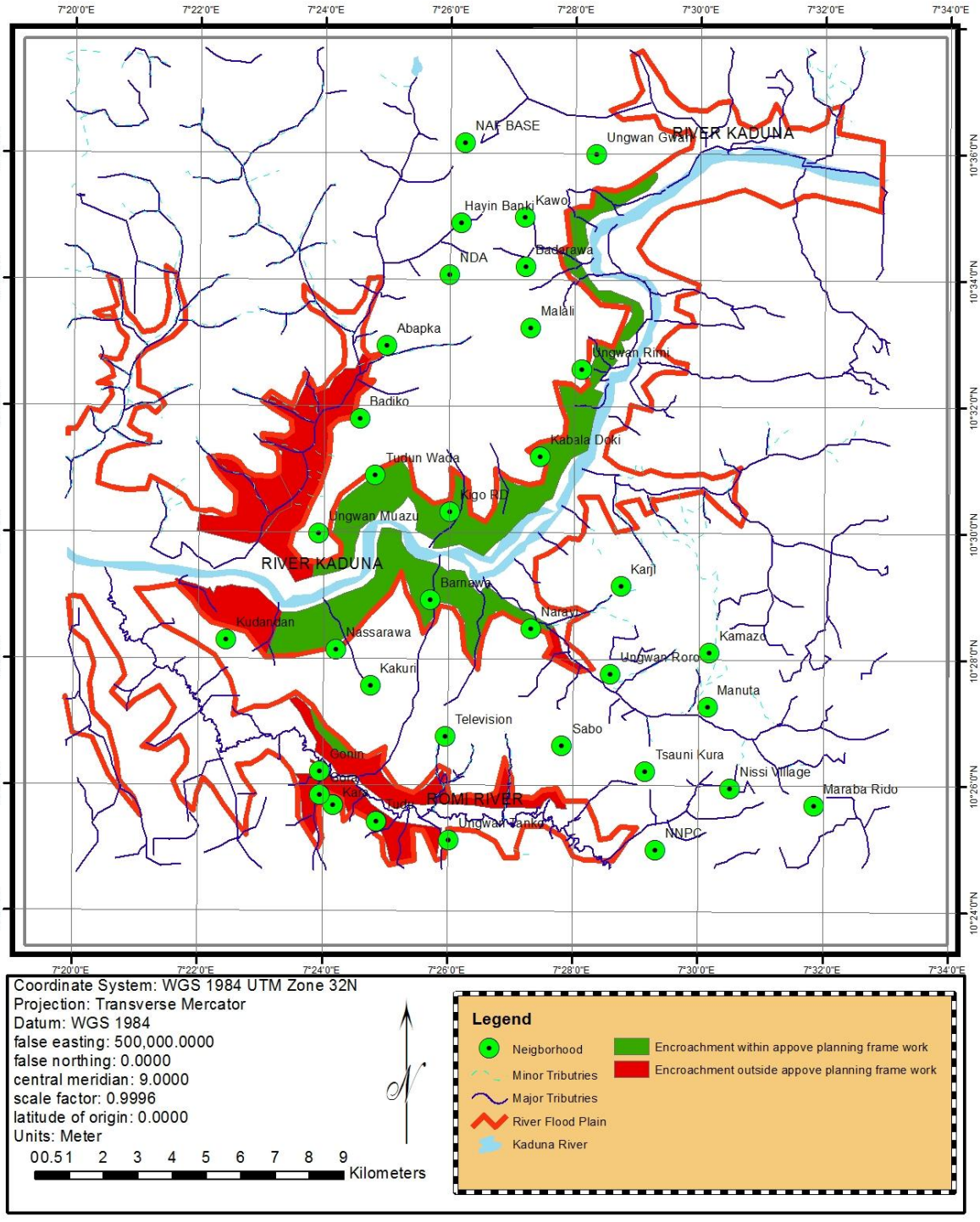

7°20'0"E
7°22'0"E
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7°26'0"E
7°28'0"E
7°30'0"E
7°32'0"E
7°34'0"E
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10°32'0"N
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10°28'0"N
10°26'0"N
10°24'0"N
NAF BASE
Ungwan Gwari
RIVER KADUNA
Hayin Banki
Kawo
NDA
Badarawa
Malali
Abapka
Ungwan Rimi
Badiko
Kabala Doki
Tudun Wada
Kigo RD
Ungwan Muazu
RIVER KADUNA
Barnawa
Karji
Nararawa
Kudandan
Nassarawa
Kamazo
Ungwan Roro
Kakuri
Manuta
Television
Sabo
Gonin
Tsauni Kura
Nissi Village
Maraba Rido
ROMI RIVER
Ungwan Tanko
NNPC
Coordinate System: WGS 1984 UTM Zone 32N
Projection: Transverse Mercator
Datum: WGS 1984
false easting: 500,000.0000
false northing: 0.0000
central meridian: 9.0000
scale factor: 0.9996
latitude of origin: 0.0000
Units: Meter
0 0.5 1 2 3 4 5 6 7 8 9
Kilometers
Legend
Neigborhood
Minor Tributries
Major Tributries
River Flood Plain
Kaduna River
Encroachment within appove planning frame work
Encroachment outside appove planning frame work

Figure 4.12: Encroachment within approved and un-approved planning schemes

As illustrated on figure 4.12 the URRBC and the ULRBC are areas that are within the approved planning scheme or framework of Kaduna metropolis as well as the industrial area around the Gonin Gora Bridge and Abuja junction. Noticeable among the communities on the URRBC are Ungwan Rimi, Malali and Kigo road communities which have government officials housing encroach on floodplain. Barnawa and Narayi communities are not left out on the ULRBC. Barnawa and Kigo road do experience flood disaster on the average of 2 years since 2003.

b. Land use zoning

Table 4.12: Summary of urban land use encroachment on floodplain in Kaduna metropolis

Land use type	**Extent ((Km^2)**	**(%)**
Residential	42.8	85.8
Industrial	2.9	5.8
Commercial	0.5	1.0
Institutional	0.7	1.4
Recreation	0.6	1.2
Infrastructure	1.0	2.0
Education	1.4	2.8
Total	49.9	100

Source: Author 2012

The zoning regulation according to KASUPDA officials is that river floodplains are always considered as green area or open space land use. Table 4.12 shows that residential, commercial, industrial, public institution, infrastructure and recreational land use encroached on river floodplain. Industrial land use makes up 5.8% of urban built activity area on river floodplain in Kaduna and they are located along the LLRBC and the RRRBC. Public institution and Infrastructure that are located along the URRBC constitute 1.4% and 2.0% of built activity area on river floodplain.

The analysis of urban land use encroachment activity on river floodplain shows that residential land use make up 85.8% of built up within river floodplains. The violation of the proposed industrial land use at Kakuri and Mekera along LLRBC by residential land use has resulted to violation of green area floodplain. The residential land use violation of green area land use at the periphery of Kaduna metropolis (Gonin Gora, Romi and Kudan) within and along floodplains can be noticed. It is therefore common to see development on river floodplains that have been stop to be approved for development as shown on Plate 4.1.

The physical limit to spatial growth posed by river Kaduna and the need to have access to common facilities and services at central business district can be attributed to the violation of green area land use. See figure 4.13. The illustration on figure 4.13 shows that violation close to the central area of the metropolis falls within planning framework.



Plate IV: Residential development on floodplain with planning approval.

Source: Field work 2012



Plate V: Satellite image of ongoing encroachment on Romi right and left reach catchments

Source: Google earth

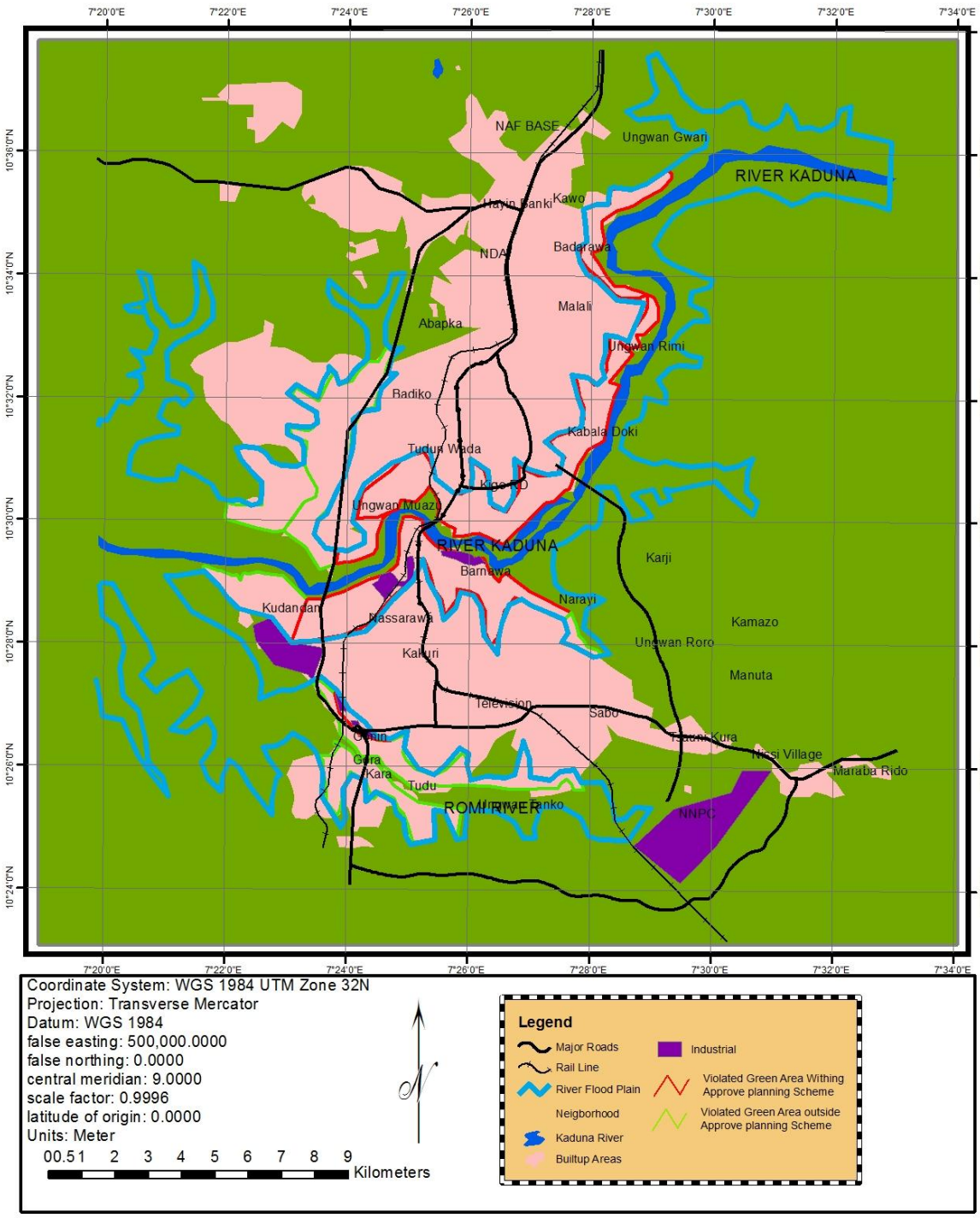


Figure 4.13: Violated green area within approved and non approved planning scheme

With an alarming 85.8% of encroachment on floodplain catchment residential land use it can therefore be inferred that KASUPDA lack the courage to enforce land use regulation and zoning ordinances according to the Kaduna master plan. Best practices in floodplain management ensures that permissible urban activities on urban floodplains are recreation, parks and garden as well as infrastructural development such as water intake plant. Only low density residential developments are permitted on a regulated basis on floodplains.

c. Physical development control

i. Density of development

Table 4.13: Density of housing development on floodplain

S/N	Catchment	Average no. of residential dwellings (4046.86m^2)	Average no. of persons (4046.86m^2)
1	URRBC	16	112
2	ULRBC	8	56
3	LRRBC	18	126
4	LLRBC	18	126
5	RRRBC	16	112
6	RLRBC	10	70

Upper Right Reach Bank Catchment- URRBC, Upper Left Reach Bank Catchment- ULRBC, Lower Right Reach Bank Catchment- LRRBC, Lower Left Reach Bank Catchment- LLRBC, Romi Right Reach Bank Catchment- RRRBC, Romi Left Reach Bank Catchment- RLRBC

Source: Author 2012

The development control standard for residential high density dwelling or houses in Kaduna like must urban canters in Nigeria is the average range of 6-8 dwellings per 4046.86m^2 and an average of 50-56 persons per 4046.86m^2. The analysis on table 4.13 indicates that the average range of number of dwelling per acre is 8-18 with an estimated average of 56-126 persons per acre. These findings are above the average development control regulation standard per (4046.86m^2). The average of dwelling per acre and 56 persons living within an acre falls within the permitted range. See table 4.13 for more details.

The deduction here is that KASUPDA is not enforcing development density standard in regulating the activities of land developers. These have resulted to high concentration of development on floodplain. The implication of non adherence to set standard for density of development and massive violation of floodplain green area land use by residential land use to urban management is high socio economic impact on households in the event of flood disaster occurrences.

ii. **Plot development coverage**

Table 4.14: Plot development coverage

Catchment	**No. of plots (15*30)m**	**No. of conformed plot dev.**	**% of conformed plot dev.**	**No. of Non conformed plot dev.**	**% of Non conformed plot dev.**
URRBC	78	12	15.4	66	84.6
ULRBC	39	19	48.1	20	51.9
LRRBC	105	27	25.9	78	74.1
LLRBC	46	5	10.9	41	89.1

RRRBC	50	8	15.6	42	84.4
RLRBC	31	17	54.6	14	45.4
Total	349	88	25.2	262	74.8

Upper Right Reach Bank Catchment- URRBC, Upper Left Reach Bank Catchment- ULRBC, Lower Right Reach Bank Catchment- LRRBC, Lower Left Reach Bank Catchment- LLRBC, Romi Right Reach Bank Catchment- RRRBC, Romi Left Reach Bank Catchment- RLRBC

Source: Author, 2012

The permitted development coverage by Kaduna State Urban Planning Development Authority (KASUPDA) for any high density residential developments in Kaduna is the maximum of 50% plot development coverage. The graphical illustration on figure 4.15 and analysis on table 4.14 indicates high rate of non conformity to permitted percentage of coverage. The LLRBC recorded 89.1% non conformity to the approve development coverage while having just only 10.9% development conformity to the set standard. 54.6 % of residential development that encroach into RLRBC conformed to development control standard. The analysis has shown that 74.8% residential high density development violated the maximum 50% permitted development coverage for high density residential development. Only 25.2% of plot development conformed to the maximum 50% developments coverage standard.

It can therefore be inferred that KASUPDA and the works department of local authority are failing in enforcing plot development coverage standard. These have resulted to high density of development and reduction of surface water peculation rate on the floodplain.

4.6 SUMMARY OF FINDINGS

The study has revealed that unregulated sprawl and infill development are continually resulting to unregulated urbanization of river floodplains in Kaduna metropolis. The analysis of floodplain encroachment due to spatial growth between 1967 and 2012 revealed that 25.8% of physical developments are on river floodplain. These are for the provision of housing, infrastructure and services. This constitutes 44.2% (49.9Km^2) of 112.9Km^2 of river floodplains in Kaduna metropolis. The result of the analysis shows that the average floodplain encroachment rate in Kaduna metropolis is estimated at 0.32Km^2 per year.

The trend in built up changes on floodplains in Kaduna shows an upward trend as was illustrated earlier on figure 4.6. The change rates based on floodplain catchments as at the year 2012 revealed that the LRRBC has the highest rate of change of 0.55Km^2 per year and it is followed by URRBC with a change rate of 0.36Km^2 per year. The RRRBC encroachment change rate is 0.35Km^2. The RLRBC and the LLRBC have encroachment change rates of 0.28Km^2 and 0.24Km^2 per year respectively while the ULRBC has the least encroachment change rate of 0.12Km^2 per year. The LRRBC, URRBC, and RRRBC have a change rate above the average change rate while RLRBC, LLRBC and ULRBC change rates are below the average change rate of Kaduna metropolis.

The analysis of the floodplain green area land use violation shows that residential land use constitute 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 of floodplain encroachment pattern and extent, three community types have been identified along river floodplains in Kaduna metropolis as illustrated in figure 4.14. These are;

i. **Community type A:** Community with extensive floodplain development and limited flood-free sites for community growth. This community type can be identified at the Upper Right Reach Bank catchment (URRBC) and The Lower Right Reach Bank Catchment (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.

ii. **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 Romi Right Reach Bank catchment (RRRBC) consisting of Sabo Tasha, and Ungwan Romi communities. The

Lower left Reach Bank catchment (LLRBC) Community which comprises of Kakuri, Nassarawa and Kudandan

iii. **Community type C:** Communities with limited existing floodplain development and extensive flood free sites for community growth. This community type can be identified at the Upper Left Reach Bank Community (ULRBC) which consists of Barnawa and Narayi. The The Romi Left Reach Bank Community (RLRBC) which consist of Ungwan Tanko, Karatudu, and Gonin Gora.

From the analysis it has been identified that Kaduna metropolis has existing, residual and future "floodplain problems".

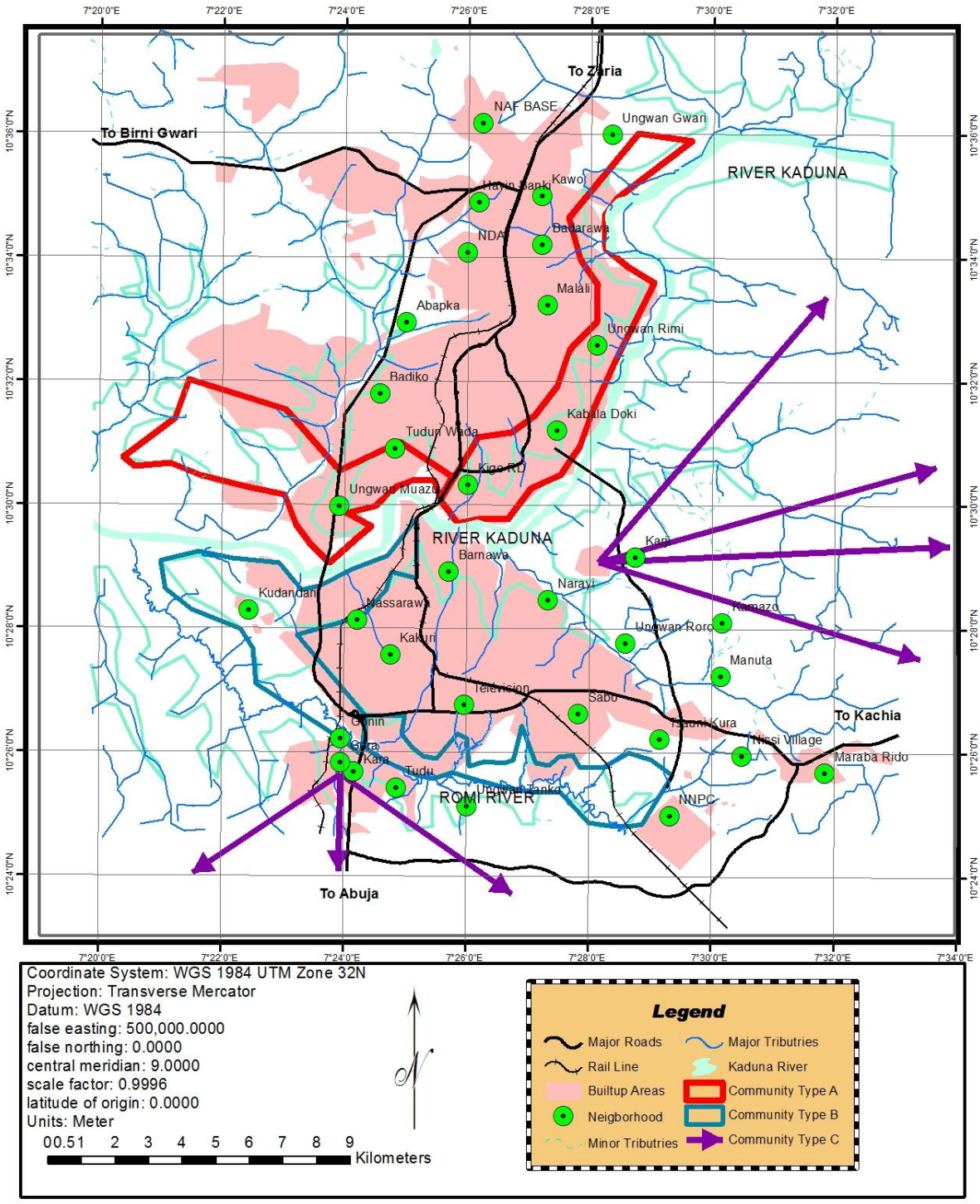


Figure 4.14: Community types

CHAPTER FIVE

RECOMMENDATION AND CONCLUSION

5.0 INTRODUCTION

This concluding chapter makes recommendations for the regulation and management of urbanization of river floodplain in Kaduna metropolis.

5.1 RECOMMENDATIONS

The findings of this research has shown that poor zoning and land use management coupled with poor development control of Kaduna metropolis have over the years resulted to unsustainable utilization of river floodplains. The spatiotemporal changes on these floodplains have lead to exposure of the urban population and infrastructure to flood disaster. It is based on these that the following recommendations were made:

5.1.1 Regulatory policy frame work (Policy integration and implementation)

The urban and physical planning authorities in Kaduna state (KASUPDA and ministry of lands, survey and country planning) must effectively make use of the following policy frame work to regulate floodplain encroachment in Kaduna metropolis.

i. The 1946 and 1966 town and country planning acts
ii. Land use act of 1978
iii. Urban and regional planning law of 1992

The use of these laws in the management of urban floodplain encroachment is to aim at;

- Acquire all floodplains

- Regulating floodplain encroachment and reducing flood losses and damages due to urbanization or river floodplain encroachment.
- Obtaining local government and general public participation in adoption of required minimal building regulations such as essentially elevation of all new construction above base flood elevation (BFE) at the fringes of floodplains and prohibition of new development within flood ways except as approved by the planning institutions.
- Preserving the urban environmental quality and natural value of floodplain land by emphasising on land use zoning and management than structural control (constructions of bridges, culverts and drainage channels) that induce floodplain development.

The use of the regulatory policy acts mention above will empower the government to acquire un-encroached urban floodplain and for a comprehensive floodplain management plan to be prepared for the metropolis. A special unit to regulate activities on floodplain is to be established under KASUPDA.

5.1.2 Land use restructuring and zoning of floodplains

Land use planning remains a major strategy for planners and urban managers to guide and manage the growth of cities. As such river floodplain must be seen and preserved as green areas. KASUPDA need to have a floodplain management approach that will incorporated floodplain management into the larger land use planning schemes. This will no doubt help in enhancing economic, social and environmental interests of floodplain usage. The use of

floodplain for urban green open space activities such as neighbourhood recreation parks and garden will ensure sustainable use of floodplains.

Mix approaches that comprises of spatial, technical and institutional measures must be used to ensure appropriate and effective uses that are compatible with river floodplains. The mix approaches must lay emphasis on appropriate use of land putting into consideration their possible adverse impacts on the objectives of development and general urban living condition. The land use restructuring and zoning using mix approaches must not just aim at regulating river floodplain encroachment. It must also aim at achieving secondary benefits such as ground water recharge, providing space for recreation and creating job opportunities. Land use restructuring and zoning of floodplain can be achieved by;

i. Acquisition of floodplain

The state government is to out rightly acquire all un-encroached river floodplain. This is with the sole aim of regulating the activities of illegal parcelling of floodplain into plots and subsequent sales to land speculators and private developers. Such acquired floodplains are to be held entrust for the people by the office of the governor and officially gazetted. The objective for acquisition of undeveloped floodplain land use must be for community economic development, provision of open space, storm water management and neighbourhood revitalization of parks and garden.

ii. Creation of floodplain Buffer Zone

The ministry of land survey and country planning are to carry out detailed survey of floodplains and ensure that proper delineation is done. The government through its urban management agency KASUPDA should carry out detail profiling of existing urban built up encroachment land use and individual plot. The community profiling will aim at identifying and providing accurate social, economic and environmental information on the existing built encroachment. This will help provide information on the flood management strategy to be applied to protect the buildings and infrastructures. Buffer zone should be created along all identified un-encroached river floodplains in Kaduna metropolis and any further encroachment prohibited unless as specified by a floodplain management plan. The buffer zone and the entire floodplain are to serve as urban green belt. Once the buffer zone to be known as green belt has been identified the planning authority then incorporate it into the physical planning scheme.

iii. Land use plan

Land use plan are use by urban planners and managers to organize and manage human activities over space. Therefore KASUPDA and the local planning authority are to ensure that floodplain management plans are use to direct activities that are compatible with floodplain. Thus floodplains are to be use for urban green space activities such as approved urban agriculture, wetland conservation, parks and gardens; community and neighbourhoods play ground for recreational activities. This can be used as a tool for achieving safety and better quality life for the urban dwellers as it will protect variety of economic and social services such as aesthetics quality, active and passive recreation, job

creation and shaping development patterns. Residential and industrial activities should be well regulated within the buffer zone. The use of the buffer zones as green area will also provide a ground water recharge point for the metropolis as urbanization is known to increased surface run-off while reducing peculation of surface water to the ground due to concretes floor, asphalt roads and roofs covers among others.

5.1.3 Restrictive Ordinance Measures and Development control

Effective monitoring and management of development is important to creating a sustainable urban environment. The urban planning authority has to establish a restrictive management ordinance measures to ensure minimum floodplain management requirement for development on floodplains. The restrictive measure must aim at setting and ensuring enforcement of standard such as, development density, setbacks and free board for any approve development on floodplains in Kaduna state. Government agencies such as Kaduna state urban and physical development authority (KASUPDA) which is saddle with the responsibility of regulating the physical growth of the metropolis must be seen enforcing floodplain management plan zoning regulation while regulating urban development of the metropolis. Remote Sensing and Geographic Information System Technology are to be integrated in the monitoring of urban growth and floodplain encroachment. Remote sensing and GIS are better planning and management tools that the planning authority will use for predicting land use dynamics. There is also the need to enhance the capacity of staff in this respect.

5.1.4 Access to land, Site and service schemes

Land in safe and accessible locations should be supply to meet the needs of all sectors of the society. Government through the ministry of lands, survey and country planning are to regularly prepare cheaper and affordable layout plans that will guide development away from river floodplains. The development layout must be provided with the basic needed infrastructures and land title. This will help to decentralize facilities, utilities and services in the metropolis.

5.1.5 Technical assistance and detailed survey of encroached floodplains

Detailed survey of all encroached river floodplain should be conducted so as to determine their characteristics and best management strategy that will be apply to reduce the impact of flooding on the urban system. The federal and state government should provide technical assistance to the local authority of the metropolis in the acquisition and relocation of development. The aim will be to reduce the density of development on floodplain. This can be achieved through urban renewal and redevelopment schemes. Floodplain and hazard management programmes that are design primarily to assist the private sector with measures to deal with floodplain encroachment and its associated flood risk should be developed and put in place.

5.1.6 Urban renewal

Urban renewal measure should be used as a means to decongest neighbourhoods with high and medium density of built up on floodplain. It should then be use to regulate development within low density built up encroachment on floodplain.

5.1.7 Special standards and building Codes for floodplains

Special building codes in times of plot size, plot development coverage, building elevation and building material types are to be specified and adhered to in regulating development on floodplains when so permitted. The standards and codes for development on floodplain will be determined by the detailed survey of river floodplains.

5.1.8 Specific management mechanism

i. All acquired floodplain are to be declared by the state government as floodplain "conservation area" through an act of law by legislation. The act is to among other things; Identified un-encroached floodplain, prohibit residency on all identified un-encroached floodplain, prohibit the use of floodplain to store toxic and hazardous materials, prohibit critical facilities such as schools, fire and police stations as well as hospitals and nursing homes on floodplain.

ii. Floodplain management and control unit is to be established in the urban development authority (KASUPDA) that will be responsible for regulating all activities on river floodplains.

iii. The government through its agency (KASUPDA) must seek collaboration and participation of residents, community base organizations (CBOs), and nongovernmental organizations (NGOs) in conservation of river floodplains. This can be achieved through their participation in recreational projects (neighbourhood parks and gardens) and other floodplain conservation programs. Their participation will ensure transparency and reduced possible challenges in enforcing regulatory frame work on floodplains.

iv. To ensure sustainable urban growth the urban development authority (KASUPDA) is to employ corrective and preventive approaches so as to tackle the existing, residual, and future "floodplain problem". The corrective strategy is aimed at reducing cost of correction or reclamation and regulatory enforcement in the future. Regulatory frame work should be made known to residents and developers as their participation will ensure transparency as well as reduce possible challenges in enforcing regulation. The corrective approach which will seek to reclaim some encroached floodplain through urban renewal after detailed survey of encroachment most send a clear signal that floodplain encroachment laws and regulations are being enforced.

5.2 CONCLUSION

The research has no doubt provided an insight into the pattern and extent of urban built up encroachment on river floodplains due to sprawl and infill development in Kaduna metropolis. The findings of the study have shown that urban built up encroachment on river floodplain is progressing at an unprecedented rate in Kaduna metropolis with little or no effort at curtailing the menace. The development is a potent danger to sustainable physical, social and economic development of the metropolis. This is worsening with the fact that floodplain with close proximity to the Central Business District (CBD) have the highest rate and density of built up encroachment. The development is attributed to poor land use zoning and management couple with an ineffective development control system that has over the years lead to poor monitoring and management of sprawl in Kaduna metropolis.

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