IMPACT OF URBAN FLOODING ON PARTS OF BWARI AREA COUNCIL, FEDERAL CAPITAL TERRITORY (FCT), ABUJA, NIGERIA

BY

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ABSTRACT

In recent years there has been a rise in the frequency and severity of natural disasters such as floods, While the causes for these events are many, there is little doubt that man's role in rapid urbanization is amplifying the impacts of such occurrences. The change in the land use pattern due to rapid urbanization adversely affects the hydrological processes leading to a deteriorating environment. This study examine the impact of urban flooding in some parts of Bwari Area Council, FCT, Nigeria. The specific objectives were to Identify the causes of urban flooding in the study area, Examine the impact of flood events on housing in the study area, generate flood risk vulnerability map of the study area, Assess the adaptation strategies put in place to reduce the impact of flooding in the study area. landsat imageries of 1990, 2000 and 2020 were used to analyze and monitor the LULC of the area and rainfall data was obtained from Era5 website and questionnaires were administered to illicit responses on the effect of flooding in the study domain. findings show that rainfall decrease from 1619.06mm in 1990 to 1318.95mm. Result from the analyzed Landsat images shows that built-up areas have been on increase from (13.37%) in 1990 to (30.90%) in 2020 which has resulted in encroachment into the flood plain, an increase of 17.53% and a decadal increase of 5.84%. The result of the questionnaire analysis indicates that 29.16% of the population blamed urban flooding on unplanned settlement built up, with 15.80% of the population agreeing to the fact that a large part of the study area is on low lying terrain and making it highly susceptible to flood. The major adaptation strategies put in place is to relocate to higher grounds and make way for proper drainage and avoiding waste dumping on water ways. Conclusively, the research reveal factors such as land use pattern, low relief, increased in built-up and human activities along drainage pathway will continue to exaggerate flooding in the area. It is therefore recommended that the master plan of the study area developed by the FCT must be strictly adhered to by land developers to prevent future flood problem.

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GLOSSARY OF ABBREVATIONS

LULC	Land Use Land Cover
FGN	Federal Government of Nigeria
GRA	Government Residential Area
GIS	Geographic Information System
GLOVIS	Global Visualization
RS	Remote Sensing
GPS	Global Positioning System
SRTM	Shuttle Radar Topography Mission
AOI	Area of Interest
DEM	Digital Elevation Model
OLI	Operational Land Imager
ETM+	Enhanced Thematic Mapper

TM	Thematic Mapper
TIN	Triangular Irregular Network

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to the Study

Urban areas are home to more than half of the global population, and this proportion is projected to be 60% by 2030 (United Nations, Department of Economic and Social Affairs, Population Division 2011). Numerous cities are growing in size at a phenomenal rate (Pathirana *et al.*, 2014). Urbanization-driven land use change influences local hydrometeorology by modifying surface and boundary layer atmospheric properties (Ren *et al.*, 2008; Zhong *et al.*, 2020), which changes the urban microclimate and significantly affects urban flood processes (Muis *et al.*, 2015). Land use and land cover (LULC) changes associated with urbanization also extensively affect hydrological processes by altering the partitioning of rainwater through the vegetation and soil into interception, infiltration, evaporation, surface runoff, and groundwater recharge (Warburton *et al.*, 2012).

Floods can be mentioned as one of the most recurring and devastating disasters affecting human lives and causing severe economic damage worldwide. It can be dated as far back in history to the time of Noah. Floods occur naturally; nevertheless, they pose a threat when they go beyond the capacities of affected communities, destroying lives and properties. Flood risks do not look likely to subside in the future, and with the recent incidence of climate change, flood intensity and frequency will pose as threats to many parts of the world (Ouma and Tateishi, 2014).

Urban Flood is described as a situation where urban centres are inundated as a result of intense rainfall, high total impervious cover (resulting in less infiltration and more surface runoff), flat topography, inadequate drainage networks, obstruction of drainage channels with solid objects, etc. Aba, Uyo, Port Harcourt, Warri, Benin, Abuja, Lagos, etc., are examples of cities that experience this type of flood in different magnitudes. Hazards associated with this type of flooding are loss of lives, destruction of household properties, public infrastructures such as rail lines, electricity/utility facilities, obstruction of traffic flow, loss of man hours, health problems (e.g., outbreak of typhoid, fever, cholera) (Teme and Gobo, 2015).

Globally, flooding has displaced more people than any other hazard or disaster. About 20% of the Nigerian population is at the risk of flooding as concluded by Etuonovbe, (2011) who also acknowledged flooding as a perennial problem in Nigeria which consistently causes death and displacement of communities. In 2010, lives were lost as about 1,555 people were killed and 258,000 more displaced while properties worth billions of naira were destroyed. Flooding is a recurring phenomenon in most cities of Nigeria. On the 26^{th} of August 2011, the flooding disaster which occurred in Ibadan metropolis caused monumental destructions in the city.

The continuous construction of structures on flood plains, indiscriminate dumping of refuse, excessive rainfall and deforestation were identified as the causative factors which helped render the town vulnerable (Khandlhela and May, 2016; Okoli and Chiaghana, 2020). The National Emergency Management Agency (2012) reported that the 2012 flood in Nigeria was declared a national disaster as it affected over 2.3 million people and killed over 363 people. Some Nigerian cities were swept off by the flood and affected 34 out of 36 states of the federation including Abuja which were ranked as the worst hit. According NEMA (2012), at least 68 people were killed in Plateau State in central Nigeria and also 25 bodies found in Benue River after the flood while properties were also lost. These occurrences show that flooding is ailing to the affected the national populace and economy; yet effective and efficient ways of addressing the problem sustainably are still poor as affirmed by NEMA (2017).

Rapid urbanization without due planning is also a major cause of flooding in our urban areas (Amangabara and Gobo, 2017). There has been increase in the number of people who move from the rural areas to urban areas all over the world. There were about 352 million people in all the countries bordering the Mediterranean Sea in 1985 and it was projected that by 2025 it would be 545 million people (Guerrieri, 2018). Seventy-five percent (75%) of this projected population is expected to live in urban areas. Alkali (2015) reported that 48.2% of Nigeria's population lives in urban centres and that this percentage is expected to increase to 60% of those that will live in urban centres by 2025.

1.2 Statement of the Research Problem

Several researchers have studied urban flooding both nationally and internationally and they include Alkali (2015); Amangabara and Gobo (2017); Etounovbe (2011); Khandlhela and May (2016); and Guerrieri (2018). Based on published theses and journals, no study has examined the impact of urban flooding on some parts of Bwari Area Council, FCT, Nigeria by integrating land use maps, digital elevation model and rainfall which has created a paucity of knowledge about the study area. This study intends to fill this gap created. The study area features an interesting terrain, which combines rounded hills and clusters of rock outcrops dissected by river valleys, as well as gentle rolling plains. It falls within the Abuja hills and dissected zone of the Jema'a Platform. Due to the affirmation nature of the terrain in the study area, urban flooding is frequent and it has destroyed several properties including loss of human lives. The flooding events dated back after Usuma dam was constructed in the study area and they started witnessing flood and it has gone from bad to worst in the study area. Therefore, this study examined the impact of urban flooding on some parts of Bwari Area Council, FCT, Abuja, Nigeria and evolve efficient and effective ways of controlling the situation.

1.3 Research Questions

The research questions for this study will include:

i. What are the causes of urban flooding in the study area?
ii. What are the impact of flood events on housing in the study area?
iii. What is the level of vulnerability of the study area to flooding?
iv. What are the adaptation strategies put in place to reduce the impact of flooding in the study area?

1.4 Aim and Objectives of the Study

The aim of this study is to examine the impact of urban flooding on some parts of Bwari Area Council, FCT, Nigeria. The objectives are to:

i. Identify the causes of urban flooding in the study area;
ii. Examine the impact of flood events on housing in the study area
iii. Generate flood risk vulnerability map of the study area
iv. Assess the adaptation strategies put in place to reduce the impact of flooding in the study area.

1.5 Justification of the Research

The successful implementation of this thesis will enable the determination of hot spot areas of flooding in the study areas, provide planners and disaster management institutions with a practical and cost-effective way to identify floodplains and other susceptible areas and to assess the extent of disaster impact. It will also Provide basic information for land use planning. Allow development plans for new urban areas. Enable adequate evaluation of cost of flood and flood reduction benefits. Show areas that are more vulnerable/ prone to flood as it is easier to ensure that emergency plans for evacuation or preparedness are developed well and easily, it will serve as the basis for insurance plans to affected areas and give a general guide for developer on where and how to build. Finally, it intended to serve as a basic reference to stakeholders of flood management policies as well.

1.6 Scope of the Study.

The study will be carried out in Bwari Area Council of FCT Abuja, it will cover three communities (Kubwa, Bwari town and Ushafa). This will be focused on various anthropogenic activities and natural processes that contribute to flooding in the study areas, investigate the mitigative measures towards the effect of anthropogenic activities on land use and cover change which enhanced flood disaster in the area. The research will make use of both theoretical, obervative and investigative method for collection of data such as land cover changes, rainfall, coping and adaptation mechanisms used by the people in such areas.

1.7 The Study Area

The study area is located within longitudes 7°23'29" and 7°29'3" East and latitudes 9°13'35" and 9°18'7" North as indicated in Figure 1.1 of the study.

1.7.1 Geographical Description

Bwari area council of the Federal Capital Territory (FCT). lies between 9° 08' 25" North and 7° 22' 25" East. Abuja has an area of 8,000km^2 and it lies wholly within the geo-political region referred to as the middle belt, and it forms part of the Guinea Savannah ecological zone (Chup, 2004). Abuja is bounded to the west and north by Niger State. It also shares boundary with Kaduna State in the North East, Nasarawa State in the West, and Kogi State in the South. A straight line drawn across Abuja from north to south covers a distance of about 87km, and from east to west is about 90km (Chup, 2004).

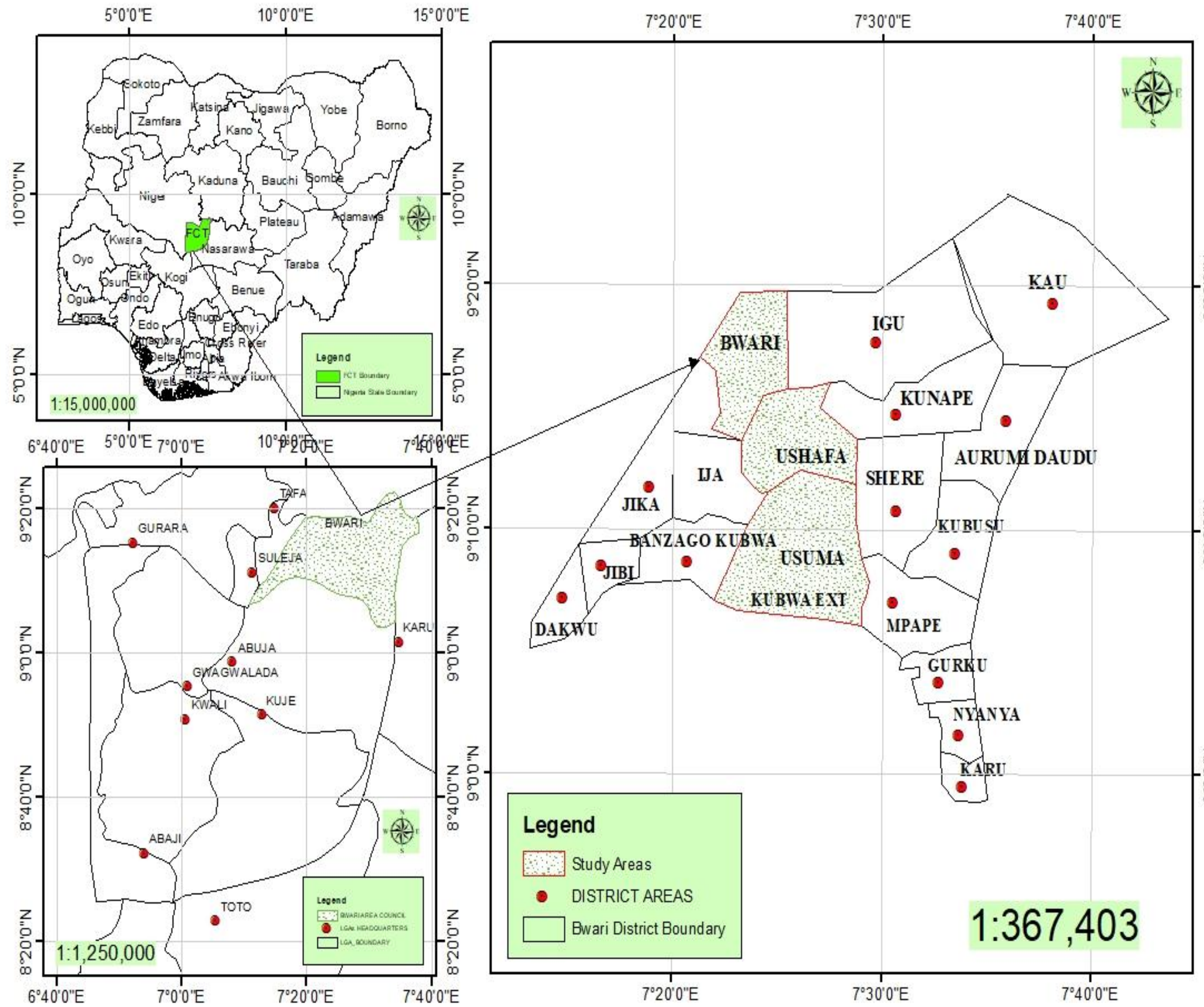

Figure 1.1: Location of Bwari Area Council, FCT, Nigeria

Source: Department of Geography, FUT Minna, 2021

1.7.2 Geology and Landforms of the study area

The basement complex rocks and the sedimentary rocks, cover a total land area of about 48% and 52% respectively (Adeniji, 2014), Bwari has base of complex rocks are occupied majorly by hills and terrain with rocks of schists, gneiss and older granites. The highest areas in FCT are located in these areas, with peak reaching 940 metres above sea level, towards the North

Eastern part. The undulating plains under the sedimentary rocks are deposits of erosional surfaces of the quarternary period (Adeniji, 2014). These plains are however dotted with isolated hills and inselbergs (Chup, 2004).

1.7.3 Soils of the study area

The soils of the FCT derive basically from two sources; the crystalline rocks of the basement complex rocks, which cover the northern two-thirds of the territory, and the Nupe sandstones, which covers the southern one-third of the territory. The soils are often described along the identified physiographic regions. The major soil types include the gleysols, fluvisols, luvisols, combisols, regosols and lithosols. Generally the alluvial complexes contain gleysols and fluvisols, with the exception of the alluvial pediment complex of the Zuba hills, which contain combisols and regosols. The interfluves are dominated by luvisols and combisols. The summit and upper slopes of most interfluves are dominated by combisols and lithosols, while the wooded hills of plains (especially Gwagwa, Iku and Kau) are dominated by the regosols (Chup, 2004).

1.7.4 Climate of the study area

The Bwari–Aso hill range, within which the study area is located experiences two weather conditions annually, these include a warm, humid rainy season and a dry season. The rainy season begins from about April and ends in October with an annual total rainfall in the range of 1100 mm to 1600 mm (Balogun, 2011). Daytime temperatures range from 28°C to 30°C while night time lows hover around 22°C to 23°C. Relative humidity is higher during the wet season with the average being above 70% (Balogun, 2011).

Highest temperatures in Abuja occur during the dry season months which are generally cloudless. Maximum temperatures in March and vary from 39°C in the south west to about 34°C in the north east. This period also records the highest diurnal temperature range of about 17°C. The rainy season months usually record lower diurnal temperature ranges of about 7°C. Maximum temperatures during this period vary from about 34°C in the south west to about 31°C in the north east. Average temperatures of about 24°C and 28°C are recorded in the rainy and dry seasons respectively in the north east and 27°C and 30°C, in the south west. Humidity varies in the dry season from as low as 20% in the afternoon, in areas of high elevation (North and North East), to about 30% in areas of lower elevation (South West). (Chup, 2004).

1.7.5 Vegetation of the Study Area

The vegetation cover of Bwari area is largely secondary in nature. Much of it has been degraded to savannah woodlands, shrub savannahs and parklands (FCDA, 2004). The population of the communities that comprise the study area is heterogeneous in nature. It comprises of Gbagyi and several other tribes such as Hausa, Gwandara, Nupe, Ibo, and Yoruba etc. Expectedly, this diverse population is engaged in different activities from primary through secondary to tertiary economic activities while agriculture is predominantly the preoccupation of the indigenes (FCDA, 2004). The population figure of Bwari is given as 227, 216 persons based on the 2006 census (Ajayi, 2007).The main land use types in the study area include built-up, residential, commercial, institutional, administrative, roads and industrial.

1.7.6 Population of the study area

The population of Abuja has been on the increase especially within the last two decades. At the 2006 census, Bwari Area Council has an area of 914 km^2 and a population of 227,216 as at 2006. The population of Abuja as at 1987 consisted mainly of eight ethnic groups which included Gbagyi 61.7%, Bassa 17.4%, Koro 6.1%, Gade 4.8%, Hausa 3.0%, Gwandara 2.7%, Ebira 1.3%, Tiv 0.8%. In addition, other ethnic groups constituted 2.2% of the population (Dakyes and Mundi, 2013). The indigenous population is presently mostly restricted to the rural areas, while the urban centers are heterogeneous. To illustrate this, the entire rural population of 1977, with no settlement having a population of up to 5,000 is believed to have had at least 27 settlements with populations of more than 5,000 by 1999 (Mundi, 2000).

1.7.7 Settlements of the study area

The capital city has more than 850 settlements out of which more than 80% are rural (Dawam 2000), apart from the Federal Capital City (FCC), Gwagwalada, Kwali, Kuje, Bwari, Yaba, Robochi, Karshi, Zuba, Kubwa, Gwagwa, Karimu, Idu, Lugbe, Nyanya and Karu, all other settlements are villages and hamlets which are of the isolated nucleated pattern (Dawam, 2000). As at 1977, all the settlements lacked basic infrastructure and the inhabitants were engaged in farming and other extractive activities. The urban areas today are provided with basic amenities and infrastructure, and have populations whose major occupation is in the secondary and tertiary sectors of the economy (Dawam, 2000)

CHAPTER TWO

LITERATURE REVIEW

2.1 Conceptual Framework

The effects of climate change are shown to have immensely affected the changing weather conditions in many parts of the world. There is a global concern about global warming. Global warming is leading to climate change as noted in the third assessment report of the Intergovernmental Panel on Climate Change (IPCC, 2011). Global warming has caused incidences of tsunamis, melting of iceberg, washing away of shorelines, flooding and drowning of islands (IPCC, 2011). Consequently, flooding has become of great interest to humanity (Oppong *et al.*, 2011). Floods claim approximately 20,000 lives annually, leaving people homeless in the process and have negative implications on at least 20 million people all over the world (Smith, 2011).

Flooding is crucial national issue as a great number of African countries Nigeria inclusive lack the resources, both financially and technologically, to fight the effects and impacts of flooding (Satterthwaite *et al.*, 2007). Between 1996 and 2005, floods have posed several devastating and terrifying effects on the continent of Africa (Satterthwaite *et al.*, 2007). Within that period, there were approximately 290 flood-disasters reported. Over 8,183 people lost their lives, approximately 23 million people were consequently affected in diverse ways. The results of the huge economic losses are numerous running into millions of dollars.

Among the various types of land use and land cover, urban areas have the greatest tendency of modifying the hydrological behaviour of an area. The construction industry (roads, buildings) accompanying urbanisation creates impermeable surfaces impeding infiltration of water and lead to overland flow leaving urban areas highly susceptible to floods (flash floods) especially when there are bad drainage network systems (Okyere *et al.,* 2013).

2.2 Floods

Floods occur due to the fast accumulation and release of run off waters from upstream to downstream, which is caused by very heavy rainfall. Discharges quickly reach a maximum and diminish almost rapidly (Ouma and Tateishi, 2014). Floods also occur as a result of flow of a stream becoming so great that it exceeds the capacity of its channel and therefore overflows its banks (Cunningham *et al.,* 2011).

Floods claim approximately 20,000 lives and in one way or the other have adverse effects on at least 20 million people worldwide, especially the homeless (Smith,2004). Flooding, after epidemics and transport accidents is considered one of the most common environmental disasters that occur all over the world. This is as a result of the geographical distribution of river floodplains and low-lying coasts and their longstanding attractions for human settlement (Smith, 2004).

2.2.1 Flooding in Global Perspective

According to the Belgium-based Centre for Research on Epidemiology of Disasters (CRED), the world's most disastrous floods to have occurred in terms of the number of people who lost their lives happened in the year 2004 in Haiti, a Caribbean island nation (CRED, 2011). The report also indicated that for fourteen (14) days, there were continuous and heavy rains which caused swelling of rivers and subsequently overflowing of river banks mostly in the southeastern parts along the areas that share borders with the Dominican Republic. The continuous rain generated floods that killed over 2,400 people, the Guardian Newspaper reported (CRED, 2011).

In Pakistan, the floods which destroyed at least 1,200 lives are already listed as the world's second worst flooding in the decade from 2001 to August 2010. "The number of people killed is very high for a natural event like a flood, which is among the easier disasters to predict and plan for," said CRED director Debarati Guha-Sapir. The monsoon rains generated the floods that occurred in India in 2005 (CRED, 2011). These floods caused approximately 1,000 deaths, placing this disaster in second place after the floods that hit Pakistan. The monsoon rains in the region normally carries on into September and the help/aid workers feared the number of lives lost to flood occurrence could increase annually. Notably, one-third of Pakistan (an area close to the size of England) is under water (CRED, 2011).

Reports indicate that 7 out of the 11 worst floods on CRED's list for the decade between 2000 and 2009 occurred in India (CRED, 2011). Guha-Sapir asserts that countries like India, Pakistan and Bangladesh appeared top of the list of numbers of lives affected by floods due to the high concentration of relatively poor rural people living along and within some distance from the river banks. During the years between 1996 and 2005, floods have had serious devastating effects on the continent of Africa (Satterthwaite *et al.,* 2007). During that seven-year period, approximately 290 flood-disasters have been recorded across the continent of Africa. Approximately 8,183 people were reported dead, 23 million people affected and there were reported economic losses worth approximately $1.9 billion (Satterthwaite *et al.,* 2007).

Several media and aid organizations have widely reported a lot of flooding incidences in Sub-Saharan Africa. These floods are mostly flash floods which resulted from several and continuous days of rainfall (Paeth *et al.,* 2010). Mozambique for instance, is consistently affected by flooding almost annually and in 2000 recorded losses amounting to millions of dollars (Maposa, 2016). Approximately 800 lives were lost and consequently there was the need for setting up a study area based early warning system. These study area-based early warning systems have dramatically reduced the number of casualties as well as fatalities in Mozambique‘s the yearly flood season (Maposa, 2016).

In 2012 and 2013, the Ghana News Agency (GNA) reported the flooding incidence in Central Nigeria ‘s Plateau State which resulted in the loss of at least 39 human lives. In similar reports, it was indicated that torrential rain has caused flooding paralyzing most parts of the Philippine Capital, Manila. Nigeria has recorded some of the highest death tolls in the West African region. In the northern parts of the country, entire villages and agricultural land have been destroyed by flooding (Augustine and Akinlolu, 2015).

2.2.2 Flooding in Nigeria

For the past decades in Nigeria, thousands of lives and properties worth millions of Naira have been lost directly or indirectly as a result of reoccurring flooding every year. It is a natural phenomenon occurring from time to time in all river and natural drainage systems. Flooding and rainstorm apart from causing destructions to lives and properties often causes significant damage to the livelihood (Emmanuel *et al.,* 2015). Re-occurring flood loses have handicapped the economic development of Nigeria and other developing and developed countries. The devastating flood occurrence and its multidimensional impact on the masses have been a great concern to Nigeria and the world as a whole.

For instance, Lokoja, Makurdi, Anambra, Lagos among other states were some of the worst affected towns in the 2012 flood disaster accounting for 24,476 damaged houses, 102,567 people displaced and about 96 people killed with an estimated loss of 1.2 billion naira (Umoren *et al.*, 2019). According to Aderoju *et al.* (2014), a large percentage of the land mass of was affected by the 2012 flood. Nwilo (2011) reported that 30% of the inhabitants of Lokoja live along the River Niger area and are worst hit during flooding due to lack of proactive preparation to avert the flood (Umoren *et al.*, 2019). Despite the havoc caused in 2012, little to nothing is seen in terms of a harmonized solution, strategic plan or concrete steps designed towards effectively mitigating and managing flood control in Nigeria and Kogi State in particular (Adedeji *et al.*, 2012 and Ahmadu *et al.*, 2019).

Growing attention however, has been given to the new paradigm of flood management based on effective establishment of both risk and mitigations (structural, technical flood defence measures such as Dams, dikes or polders) and adaptations (non-structural soft measure such as preparation of indigent people, flood insurances, information management, social networks) measures (Krysanova *et al.,* 2008, Kubal *et al.,* 2009).

It has been noted that heavy and continuous rainfalls are not solely the major cause of recent flooding in Nigeria. This plight has been heightened by human activities such as damming and opening of dam gates as well as dumping of filth to hinder flow in water courses (Karley, 2009).

Flooding incidences are becoming a more frequent occurrence in Nigeria. Between 2011 and 2012, there were a number of reported cases of flooding in several parts of the country. The major floods that overtook most parts of Kogi, Makurdi, Delta and Bayelsa states and Onitsha in 2012 is an example. Areas around the River Niger were totally submerged by floods and over 600,000 residents were rendered homeless, farmlands lost and many killed (Nkeki *et al.*, 2013). Like Okonkwo (2013), rightly said "In the year 2012, Nigeria witnessed the highest flood disaster in 100 years, where over ten states of the Federation came greatly under water".

According to experts, the floods were caused by excess rainfall which resulted in the over flooding of Rivers Niger and Benue and their tributaries, from Taraba to Adamawa all the way to the southern states of Nigeria (Nkeki *et al.*, 2013). This incident was predicted by The Nigerian Meteorological Agency. In Lagos, it has become a normal phenomenon for floods to accompany heavy and or prolonged rains. The July 10th flood of year 2011 is perhaps an incident that Lagosians would not forget in a hurry, as there were many devastating effects of the flood. This year also, there have been cases of severe flooding in Lagos after a heavy downpour of rain. On June 28th 2012, Lagos residents were enveloped by floods resulting from a heavy downpour of rain which started the night before and lasted for several hours. A number of houses and roads were submerged by the floods and some people lost their lives. Sections of Lagos-Abeokuta expressway were cut off on both sides by the flood and a portion of the Murtala Mohammed International airport road by Mobil Filing station was submerged. The worst hit areas were Okokomaiko, GRA Ikeja, Ipaja-Ayobo, Shogunle, Apapa, Shomolu, Magodo, Ejigbo and Surulere areas of Lagos state. Also between July and August 2021 most area in Lekki Lagos State were submerged with water disrupting movement as well as destroying a lot of properties.

2.3 Types of Floods

Floods are one of the most frequent occurring natural disasters that directly and indirectly have effects on human and the environment. A combination of both meteorological and hydrological extremes, such as extreme precipitation and flows brings about floods generally (Jha *et al.*, 2012). However, floods also occur as a result of human activities. Flooding occurs as result of unplanned growth and development of urban areas interfering with floodplains, or from the opening of dam gates or the overtopping of an embankment that neglects the protection of planned developments (Balabanova and Vassilev, 2010).

Descriptions and types of floods differ vastly. These categorizations are basically based on a combination of sources, causes and socio-economic impacts on the environment and study area as a whole. Considering these combinations, floods can be generally classified into riverine (or fluvial) floods, pluvial (or overland) floods, coastal floods, groundwater floods or the failure of artificial water systems. Also based on the speed of onset and force of flooding, floods can also be categorized and described as flash floods, urban floods, semi-permanent floods, and slow rise floods (Jha *et al.*, 2012).

2.3.1 Riverine (fluvial) Flooding

Coastal rivers with short, steep headwaters often have floods that rise and recede fairly quickly. Riverine floods (River floods) are due to high water levels overflowing the natural or man-made banks of a stream or river. The different nature of riverine flooding can be accessed in terms of the causes of the flood, the timing and the depth between different locations.

Road and building construction on a floodplain (where a river naturally overflows when its capacity is breached) may also increase the occurrence of a fluvial flood. This is as a result of the creation of impermeable ground on the flood plain which will definitely stand a greater risk of flooding due to the obstructions. A fast flowing water supply such as a river will gather speed if it is forced to squeeze through a tight gap creating a bottleneck effect (Spekkers, 2010).

2.3.2 Pluvial (overland) Flooding

Pluvial flooding occurs when an extremely heavy downpour of rain saturates the urban drainage system and the excess water cannot be absorbed. Furthermore, pluvial flooding occurs when soil absorption, surface runoff or drainage cannot adequately disperse intense rainfall, and is usually caused by slow-moving thunderstorms. These floods occur after short, intense downpours which cannot be evacuated quickly enough by the drainage system or seeped into the ground (Houston *et al.*, 2011).

Pluvial floods are generally classified as gradually occurring in a space of six hours or less. Pluvial flood occurs from continuous rainfall to the start of the flooding. This happens when rainfall overwhelms the urban (sub) surface drainage system and for some reasons unable to enter the system mostly due to human activities (Spekkers, 2010).

2.3.4 Groundwater Floods or the Failure of Artificial Water Systems

When dam failure happens, it involves much significantly downstream flooding from probably swift flowing water and considerable presence of debris. Dam failures rarely do occur, but when it does happen, the effects thereafter, are severe. Dam safety could be monitored and early warning systems put in place to warn residents living downstream of potential risks that can occur due to dam failure as in the case of Victoria Dam in Sri Lanka, Western Australia (Spekkers, 2010).

Levee failure typically occurs when floods go over their average capacity to handle, often with severe and tragic results. Poor and careless decisions made during dam design and construction or inadequate maintenance or operational mismanagement often causes dam failure. It may also result from natural hazards such as earthquakes, or from flow volumes that exceed capacity with or without some amount of pressure (Action aid, 2006).

2.3.5 Coastal Floods/Storm Surge

Storm surge occurs when the sea levels rises high above its normal tidal limit as a result of the action of intense low pressure systems over the open ocean. This therefore causes the sea level to rise as there is much less air pressing down on the sea. Combined with gale force onshore winds, this can lead to flooding of low-lying coastal land (Spekkers, 2010). Action aid (2006) based on a report on climate change, urban flooding and the Rights of the urban poor in Africa‘grouped flooding into four types based on the causes. These are the type of floods that generally hits Ghanaian towns and cities.

2.3.6 Localised Flooding

This normally occurs due to inadequate drainage system coupled with highly compacted ground with pathways and roads between buildings/shelters turning into streams after a heavy downpour of rain. This situation is worsened by the damping of filth (waste and debris) into the few drains and therefore blocking them in the process (Oppong, 2011).

2.3.7 Flooding caused by Small Streams in Urban Areas

Small streams found in urban areas easily overflow its extent due to increase in volume of water after heavy rainfall. In addition, relatively small and inadequate culverts are provided by city authorities for easy flow of water. These culverts may seem sizeable enough relative to the normal volume of water flow from such streams but gradual changes to development in the urban areas and duration and intensity of rainfall over a certain period of time usually lead to higher flows that exceed the capacity of the culverts. These drains are mostly filled with solid waste damped in by residents of the study area thereby choking them. This makes the passage way even much smaller and inhibits the flow of water through them (Oppong, 2011).

2.3.8 River Floods

Urban growth leads to vast use of land. Residents start to build along flood plains of rivers leading to major socioeconomic losses as well as loss of human life anytime these rivers overflow their banks and inundate the flood plains. In some developed countries, levees have been raised artificially. There is always the risk of the possibility that these levees may be breached causing massive urban flooding (Oppong, 2011).

2.4 Causes of Flooding in Urban Areas

Flooding is generally considered as an environmental hazard. It is quite a natural process and is simply the reaction of a natural or man –made system to the presence of too much water at a particular period of time. Natural causes of flooding refer to those causes that are not caused by human influence directly. An example of the natural causes of floods includes the rising global temperatures which in turn speeds the melting of glaciers and ice caps and cause early ice thaw on rivers and lakes. This further increases the volume of water and causes the river or lakes to overflow its banks and hence, cause flooding (Oppong, 2011). Human causes of flooding describe the flooding caused by the direct actions and inactions of humans. There is therefore a direct/indirect human influence of some sort (Oppong, 2011). There are several known and some unidentified causes of floods. Some are briefly described below.

2.4.1 Urbanisation

The number of people migrating from the rural to urban areas tends to be increasing greatly on daily basis. As urbanization increases, the need for construction of buildings and structures for shelter and other activities increases. There is an increase in risk of flooding specifically where there is an intertwining in inappropriate, or inadequately maintained infrastructure, low-quality shelters, and lower resilience of the urban poor (World Bank, 2008). The construction of buildings and structures has in some cases come into close proximity to streams and other primary drainage facilities. These drainage channels have subsequently been rendered incapable of coping with the high volume of runoff water during rainfall, which invariably carries large amounts of silt (Sam Jr, 2009).

The drainage systems in the study area have been impacted negatively due to the fast growing settlement rate in this area. Due to ignorance and sheer disregard of building regulations many people build haphazardly putting them at risk to the dangers of erosion and flooding. Paved roads and setting up of these buildings/shelters increases the imperviousness of the catchment areas. The catchment areas easily respond to rainfall and subsequently increase runoff (Adedeji *et al.*, 2012).

2.4.2 Building in Flood Plains causes

Several buildings and structures have been constructed in flood plains, some structures are ignorantly and dangerously built some few metres from the stream channel or even across natural watercourses. With the onset of an inundation these places are at high risk of flooding. Some residents have even constructed low walls across the entrance of their houses and ramps on pathways to avoid flooding (Adedeji *et al.*, 2012).

2.4.3 High Rainfall Intensities

The incidence of heavy rainfall is one of the cause of flooding in the study area. The river and drainage network system usually cannot carry all the water in its channels after a heavy downpour thereby causing flooding. It is worth mentioning that this situation is worsened by human induced activities. Also with the portions of land untarred, the ground becomes saturated after a heavy downpour and the soil is rendered incapable of storing water after saturation point has been attained leading to increased surface runoff. This is based on information retrieved through interactions with communities along the River during field surveys (Adedeji *et al.*, 2012).

2.4.4 Nature of Terrain

Flooding is rampant in low lying areas/lowlands. Since rivers flow more slowly in such areas, if the water volume increases abruptly or suddenly, floods occur (Oppong, 2011). There is a reduction in the amount of infiltration of water into the ground on steep slopes. This means water can easily flow down to rivers as overland flow. Steep slopes also make it easier for more through flow within the soil. These two situations can both raise river levels easily. Relatively gentle slopes or flat land also allows easy penetration of water into the soil and increase lag times (Jackson, 2012).

2.4.5 Absence and Inadequate Capacity of Drains and Culverts

A major contribution to the problem of flooding in the study area is the absence of drainage systems and the inadequate capacities of the already existing drainage facilities. Reconnaissance and field survey works carried out during this research showed that quite a number of drains and culverts in the area are of inadequate capacity.

2.4.6 Maintenance

There exists a schedule for maintenance of existing drains periodically in the Municipal Assembly but this schedule is rarely adhered to due to some limitations especially financial constraints. Most of the existing drains have not been maintained since construction and some are in bad state beyond repair. These drains therefore, barely serve its purpose of construction (MRSC, 2015).

2.4.7 Erosion, Sediment Delivery and Damping of Refuse in River, Streams and Drains

Untarred roads and paths easily allows for gullying and erosion on land surfaces and the soil between buildings. This leads to the undermining of portions of the roads and buildings, and obstructs flow of water entering drains. There is sediment delivery that accompanies this erosion problem. The sediment is carried along with the flood waters therefore choking drains and further reducing the capacity. The study area River and its banks as well as drains are mostly used for damping of refuse which includes faecal matter, and solid waste (Sam, 2009).

2.4.8 Obstructions

Water, telephone and power services crossing the drains at some point through pipes act as obstruction to the free flow of water through these drains. The sediments and refuse carried by the flowing water is easily trapped which further reduces the flow capacity of the drains (Sam, 2009). Some unauthorized buildings have also been sited right on watercourses which also further distort the drainage network system and obstruct free flow as well.

2.5 Effects/Impact of Floods

Effects of flood generally refer to the several types of harm and dangers that come along as a result of flooding incidence. It deliberates on a vast range of harmful effects on humans, their physical and emotional well-being, their day to day activities, their health and properties, on public infrastructure and amenities, the environment, ecological systems, industrial production and the competitive strength of the affected economy (Zhang *et al*, 2015).

Flooding is natural phenomenon that is almost impossible to totally eradicate but in most instances the damaging effects are mostly as a result of human activities directly and indirectly and changes to the environment. Occurrence of floods can be a catalyst for other unforeseen hazards both natural and human induced, or can be a major part of a long term chain of cascading events (Action Aid, 2006).

2.5.1 People and Health

Floods pose serious threats to the health, well-being and general human life. The impact of flooding on the residents of the study area varies and involves physical injuries, health related issues and disease and in extreme cases, death. Sprains and strains are amongst the most reported cases of flood related injuries. Residents in their bid to escape floods, either cling to objects being carried along the fast-flowing water. People get trapped when there are instances of buildings or structures collapsing (Du *et al.,* 2010). Some of the injuries that occur are before the floods set in when residents seek to find shelter. Some injuries also occur during the floods and some after the floods. It is not easy and simple to quantify the cases of ill health in totality as a result of flood events (Few *et al.,* 2004). This flood water can cause failure of electrical systems resulting in electrical shocks and other forms of secondary damage.

Cholera, diarrhea, typhoid fever and malaria are the common diseases that affect the residents of In the study area during and after flood events. Flood waters sometimes mix with raw sewage and in effect increases the risk of outbreak of water-borne diseases. Occurrence of deaths, witnessing injuries and destruction of homes and properties due to floods, can cause severe psychological problems in some individuals. The grief and loss of properties, as well as health issues, can lead to stress, depression and in some instances, anxiety (Ahern and Kovats, 2006). Children and the elderly according to studies and researches conducted are more vulnerable to death, particularly from drowning, than adults (Bartlett 2008).

2.5.2 Building and Infrastructure

Flooding has a great impact on the built environment considerably, as many buildings and structures are affected by the floods. In the study area, both completed and uncompleted buildings and structures are abandoned as a result of fear of what is now an annual occurrence. This indirectly affects daily activities of residents as well as major disruptions in the lives of people and businesses (Bartlett 2008).

2.5.3 Business/Trading and Education

Floods do not only directly affect people, buildings, infrastructure and the environment, but also have indirect impacts, such as losses from interruption in business activities. Damage to business premises and buildings, the increase in cost and travel time as well as the loss of income are indirect impacts of floods that are more often difficult to quantify. This represents a significant percentage of the overall cost of flood damage to communities (Ingirige *et al.*, 2011). Businesses sometimes close down temporarily during and after the floods and sometimes can take up to months to recover and return back to normal trading. This is sometimes due to inability to access roads and pathways, time to clean up and sometimes lack of access or failure of basic services, such as water supply and power cuts. Children are unable to commute from their residence to the schools during the floods. This is as a result of flooded roads and pathways as well as the school premises. The disruption to education, over a long term period can lead to children suffering academically.

2.5.4 Water and Sanitation

Cholera, diarrhea and typhoid fever ailment and sometimes, deaths are primarily caused by a lack of pure drinking water, improper storage and handling of drinking water, poor hygiene practices and the deterioration of sewage and sanitation facilities which lead to the contamination of drinking water in flood affected areas (Ahern *et al.,* 2005). There is an interruption in water supply and contamination leading to health issues. Waste collection and sanitation facilities can become overwhelmed leading to pollution and contamination of drinking water supplies (Ayeva, 2011). The waste water mixing with the flood water is a major cause of environmental pollution. Residents bear extra clean-up costs also due to wastewater mixing with flood water and entering and destroying their properties. The cost of recovery after floods both to households and the infrastructure runs into millions of Naira. The trend and the effects/impact of floods continue to escalate, hence the need to reduce the trend.

2.6 GIS and Flood Management

Geographic Information System (GIS) is defined as any system that integrates, captures, stores, analyzes shares, manages, and displays data that is linked to location or geographic data. GIS merges computer database technology with geo-referenced and cartographic information, resulting in digital maps and databases with fundamental applications in areas such as natural resource management, ecosystem conservation, environmental studies, utility management, infrastructures and transportation planning, town and regional planning, municipal government and also commercial applications. It is an ideal tool for integrating data from the land itself (e.g. data gathered from satellites) and socio-economic data (e.g. tax records). The power of a GIS lies in its ability to analyze relationships between features and their associated data. This analytical ability results in the generation of new information, as patterns and spatial relationships are revealed (Milla, 2005).

The main advantage of using GIS for flood management is that, not only does the system generate a visualization of flooding but also it also creates means to further analyse and estimate probable impacts of flooding incidence (Hausmann *et al.*, 1998).

2.6.1 Flood Risk Management

Disaster Risk Management deals with the organization of resources and responsibilities for dealing with aspects of emergencies including prevention of hazards, disasters and their mitigation. Risk is the probability of a loss depending on three elements; hazard, vulnerability and exposure. Flood risk management is considered as one of the most effective means to address flood control issues. It comprises of floodplain management, flood control maintenance activities, protection of flood prone areas, other flood hazard mitigation activities, and preparation for flood disasters where mitigation activities cannot totally curb flooding from its occurrence. Flood Risk management includes flood prevention/ mitigation, its control and floodplain management (MRSC, 2015). Flood Risk Management guidelines when implemented reduces future flood damages drastically in the event of its occurrence.

2.7 GIS and Flood Risk Mapping

Great attention has been given to the use of GIS and Remote Sensing to manage and control floods and in the production of flood risk maps. A lot of research has been done using diverse methodologies in the production of flood risk maps.

2.7.1 Flood Risk Mapping

Flood risk mapping is very important for land use and planning in flood prone areas. It creates easily read, rapidly accessible charts and maps which aids with the easier identification of flood risk areas and prioritize their mitigation effects (Forkuo, 2011). A flood risk map is a map that shows areas that would be flooded by stream discharges of a given magnitude for a given amount of rainfall. They are used to determine areas prone to flooding when discharge of streams exceeds the bank-full stage or runoffs or flows exceed the capacities of their channels (Forkuo, 2011).

The application of GIS, performing analysis and carrying out simulations can be a very useful tool in Flood Risk Mapping because it provides vital information in the case of planning and in the events of emergency. Flood Risk Mapping further aids in analysing the characteristics of the nature of the terrain of the study area and the drainage network system. These contribute immensely to accurate and timely intervention strategies and curbing the impacts thereafter (Fava *et al*, 2010).

Continuous updating and monitoring of risk maps is, therefore, most important for proper flood risk management: decision makers need up-to-date information in order to allocate resources appropriately (Jha *et al.,* 2012). Without a noticeable rise in cases of flood risk events, it is assumed the socio economic impacts of floods will continue to increase due to the upsurge in exposure of primary and secondary receptors (Sakyi, 2013).

Forkuo (2010) exhibits the integration of GIS and ASTER imagery in flood hazard mapping. The study further described classification of land use and Digital Elevation Modeling using elevations digitized from the topographic map of the study area. The highest point of elevation of each district in the study area, nearness of each district to the catchments area and portions of properties at risk were determined within the GIS environment. Flood hazard mapping was then addressed from perspective of different mapping scales in which administrative units were selected as the unit of investigation.

Sakyi (2013), used an SRTM DEM data of 90m resolution and further run hydrology analysis in the GIS Environment. A flood risk map was produced after determination of slope and creation of stream buffer areas. Classified land cover maps, Landsat 5 TM (1990) and 7 ETM+ Images (2006) were then overlaid and a land cover change detection map of the area was produced in addition.

Fosu *et al*. (2012) modelled the Susan River and carried on with hazard mapping using a Geographic Information System, spatial technology and the HEC-RAS hydraulic model as tools. A DEM was created from Contour Data. The geometric data needed for the modelling process were extracted from the DEM, topographic map and field measurements. A remotely sensed image was then classified into various land cover types which was used for estimating the roughness coefficient of the various cover types during the modelling process. The model results were displayed and analysed in ESRI ArcGIS environment. The flooded area was geometrically overlaid on the topographic map to delineate the affected buildings. The hazard map produced clearly showed the spatial distribution of the flooded area which was mainly located at areas with relatively low relief.

2.8 Gap in literature

Based on various literature reviewed on impact of urban flooding both nationally and locally among them are that of Alkali (2015); Amangabara and Gobo (2017); Etounovbe (2011); Khandlhela and May (2016) as well as Guerrieri (2018). Hence, this study will add to the latest literature on the impact of flooding by integrating land use, DEM and rainfall data which is lacking and the has filled the gap

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Research Design

This research is empirical in nature and has investigated the impacts of urban flooding in parts of Bwari area council of FCT. It was designed to collect information from all parameters that is needed to solve the research problems stated in chapter one.

The research made use of both theoretical and investigative method for collection of data such as land cover changes between 1990, 2010 and 2020. Also, data was collected from residents of these neighborhoods on land use practices that has increased runoff resulting to flooding in the area.

3.2 Types and Sources of Data

The types of data used comprise of both primary and secondary. The primary data was collected from the study area through the field work. It involved personal observation, structured questionnaire and the use of handheld GPS, while secondary data include satellite imagery (Landsat) for three (3) decade (1990-2010-2020) other data was obtained through library and internet search.

3.3 Techniques of Data Collection

The methods or techniques used in data collection include:

3.3.1 Reconnaissance survey: This served as an initiative for the preparation of questionnaire, interview and photographs. This was carried out with the aim that efficient data could be gathered which is essential to the achievement of the objectives of this research.

3.3.2 Questionnaires and interviews: Both questionnaires and interviews was used in obtaining information from the residents of the area selected. Questionnaires was structurally designed to capture the research objective that has to do with Questionnaire.

3.4 Sample and Sampling Techniques

A total number of 2,596 households were identified in the study area from which 10% which is approximately 260 was sampled. Out of the total 260 questionnaires distributed 144 copies were returned representing 55.38%.

Table 3.1: The Sample size and Number of Questionnaire Administered

Peri-Urban Area	Estimated Population in 2018	No. of Households	Sample Size (10%)
Kubwa	11367	1,421	142
Ushafa	3843	549	55
Bwari	4387	626	63
Total	26,506	2,596	260

Source: National Demography Survey, (2018)

3.5 Sampling Procedure

A Systematic random sampling techniques was employed. This is a method of choosing a random sample from among a large population. The process of systematic random sampling involves first selecting a fixed starting point in the large population and then obtain subsequent observations by using constant interval between samples taken. It uses the same statistical principles as simple random sampling, in which p values and confidence interval are calculated the same way. The sample interval was calculated by dividing the number of households in the population by the number of households needed to be sample.

3.6 Geospatial Techniques

The mapping depends on the use of computer-assisted interpretation of satellite imagery. Field survey was conducted; GPS coordinates was captured in the field to enable the GIS techniques to develop the geospatial map of degradation in the area. Change in Land use over time was detected by comparing the different and level of degradation in the area. urban land was delineated in order to determine the level of degraded which has enhanced flooding in the areas.

3.7. Materials used

The following materials, software and tools was selected to aid in the collection and analysis of information and data for the purpose of the study.

a) Digitized Topographic Map of the study area

b) Scanned layout of the study area

c) Garmin Hand Held GPS

d) ESRI‘s ArcGIS 10.8 was used for the data processing and analysis.

e) Statistical Package for the Social Sciences (SPSS) Version 23

3.8 Method of Data Analysis

The methods of data analysis for each of the stated objective is outline below

3.8.1 Identify the causes of urban flooding in the study area

For the purpose of this study, rainfall data was obtained Era 5 website and analyzed using descriptive statistical method to know if rainfall is the main causes of flooding on the study area.

Also, land use and land cover change analysis was carried out to compliment the rainfall data to ascertain the main causes of flooding in the area. Three (3) multi – date satellite images of Landsat, they include Landsat Thematic Mapper, Enhanced Thematic Mapper and Operational Land Imager with a resolution of 30m of 1990, 2000, and 2020 respectively was used for land use/ land cover classification. These datasets were imported to Idrisi Terrset. Digital image analysis was carried out. The major image processing steps include image layer stacking, resampling, and image enhancement of the datasets which are of utmost importance for LULC analysis. The types of land use land cover feature that was identified in this study includes; (built up area, agricultural land, grassland, water bodies). summary of satellite images used are indicated on table 3.1

The study area was extracted from the scene, and a supervised maximum likelihood classification method was carried out based on level 1 classification of Anderson *et al.* (1976) three basic operations namely image reconstruction to extract area of interest from the general satellite scene, image enhancement to improve visual interpretation by increasing apparent contrast among various features in the image and image classification to classify the various land use and cover types as indicated on table 3.2

Table 3.2 Details of Satellite Data Used

S/N	Sensor	Path / Row	Source	Year of Acquisition	Scale/resolution
1	TM	189/054	earth explorer	1990	30
2	ETM+	189/054	earth explorer	2010	30
3	OLI	189/054	earth explorer	2020	30

Source: Author's Analysis, 2021

Table 3.3 Land use land cover classes

S/N	Features	Description
1	Built-up area	Settlements which are places of human buildings with varying network of roads
2	Cultivated areas	Plantations, small farmlands.
3	Water bodies	Rivers and streams
4	Grassland	Forest areas, grasslands, shrubs and others

3.8.2 Examine the impact of flood events on housing in the study area

To achieve this objective, structured questionnaires, direct interview and field work was employed. Structured questionnaires were administered to the residents of the study area.

The questionnaires had questions on:

i. The areas in the Communities that experienced flooding
ii. The causes of floods in the study area
iii. The Occurrence of floods in the study area
iv. The Impact of flood on infrastructure and transport
v. The Impact of flood on education
vi. The impact of floods on trade and business activities

3.8.3 Generation of flood risk vulnerability map of the Study Areas

The flood vulnerable map was generated by carrying out the following operations

Digital Elevation Model of the Area

3.8.4 Digital Elevation Model of the Area

The digital elevation models are the data files that contain the elevation of the terrain over a specific area. The DEM of the study area was carried out in order to get the various spot heights on the ground or ground contour lines data of different locations in the study area. The DEM of the study area was extracted from the SRMT. This was done to in order to know the areas that are prone to flooding using the spatial analysis tool of ArcGIS software. The importance of using the DEM in the study is to assist in differentiating low and high spot areas that is available in the study area which help in identifying areas that are highly prone or less prone, potential prone to flooding in the area.

Procedure

i. File Geodatabase layers were created from the ArcCatalog,

ii. The boundary map is overlayed on the extracted DEM

iii. The editing tool was used to digitize the spot height and the contour lines and the values recorded in the attribute table accordingly.

iv. The symbols are then adjusted accurately

3.8.4 Generation of a Digital Elevation Model of the study area

In creating a DEM of the area, using the contour lines generated, the following steps were taken. (Note the DEM was created using the Triangular Irregular Network (TIN).

i. First, the arc toolbox was launched.

ii. The 3D analyst extension was activated by clicking on Customize → Extensions → 3D analyst tools.

iii. The TIN tool was then opened by clicking on ArcToolbox → 3D Analyst tools → TIN Management → Create TIN.

iv. After clicking on the Create TIN icon, the contour layer was then inputed and the DEM generated: Create TIN → Output TIN → Select output folder → Input spatial reference → Input feature class (the contour layer) → add the height field → ok. (The DEM is generated).

v. The colour ramp of the generated DEM is then changed by right clicking on the DEM layer → click on properties → elevation → change the colour ramp.

vi. The classification method was then edited by clicking on classification (still under properties) → classification method → equal interval → No of classes (the number of classes was changed to 4) → Apply → Ok.

vii. The DEM was then converted to raster using conversion tools by going to 3D analyst tools → conversion → From Tin → Tin to raster → Input Tin

3.8.5 Assessment of the adaptation strategies put in place to reduce the impact of flooding in the study area

To achieve objective IV, structured questionnaires, direct interview and field work was employed. Structured questionnaires were administered to the residents of the study areas with a section of questions asking on adaptation strategies used to reduce the impact of flooding in the area. The information and results generated from questionnaire was subjected to statistical treatment using descriptive statistics and presented in figures to demonstrate the effectiveness of the responses with analyzing comments.

Extensive personal observations (field work) was embarked upon so as to rightly and accurately identify and assess the adaptation strategies in the study areas. Field work was used to confirm the results from the classified land use and land cover, questionnaire administration in achieving objective IV.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Causes of Urban Flooding in the Study Area

4.1.1 Rainfall distribution Across the Study Area

The rainfall study was geostatistically analyzed using the spatial analysis of GIS to produce the spatial distribution of rainfall across the study locations. Findings from the map shows that the rainfall was generally high throughout the study periods. Bwari district has high density of rainfall when compared with other locations. As a result, this usually contribute to flooding in the study area since it flows pathway cut across Ushafa and Kubwa. In 1990, the highest rainfall recorded was 1619.06mm of rainfall while the lowest was 1609.54mm (figure 4.1). This is also the highest rainfall across the year's understudy.

Similarly, in 2010, the highest rainfall recorded was 1266.87mm while the lowest rainfall was 1263.86mm (figure 4.2), found majorly in Bwari stretching towards Ushafa and finally to Kubwa areas.

Additionally, in the year 2020, the highest rainfall recorded was 1318.95mm while the lowest rainfall was 1311.11mm (figure 4.3). found majorly in Bwari stretching towards Ushafa and finally to Kubwa areas. Ushafa area has more rainfall in 2020 than previous years when compared due to the intensity coming from Bwari area in the northern section of the area. This agrees with the work of (John-Nwagwu *et al.*, 2014) who carries out vulnerability analysis of flooding in Kubwa area of Abuja.

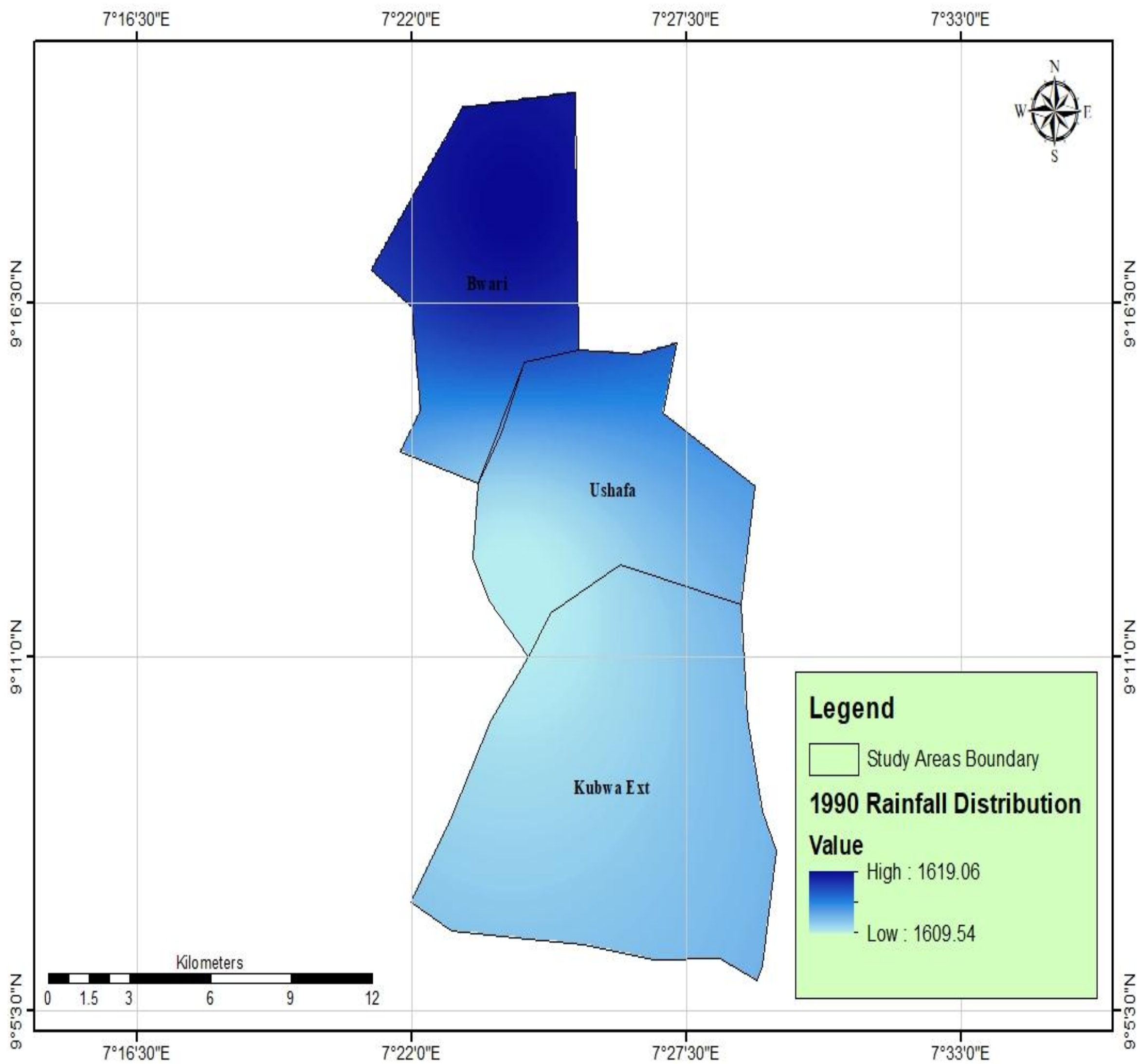

Figure 4.1: 1990 Rainfall Distribution Across the Study Locations

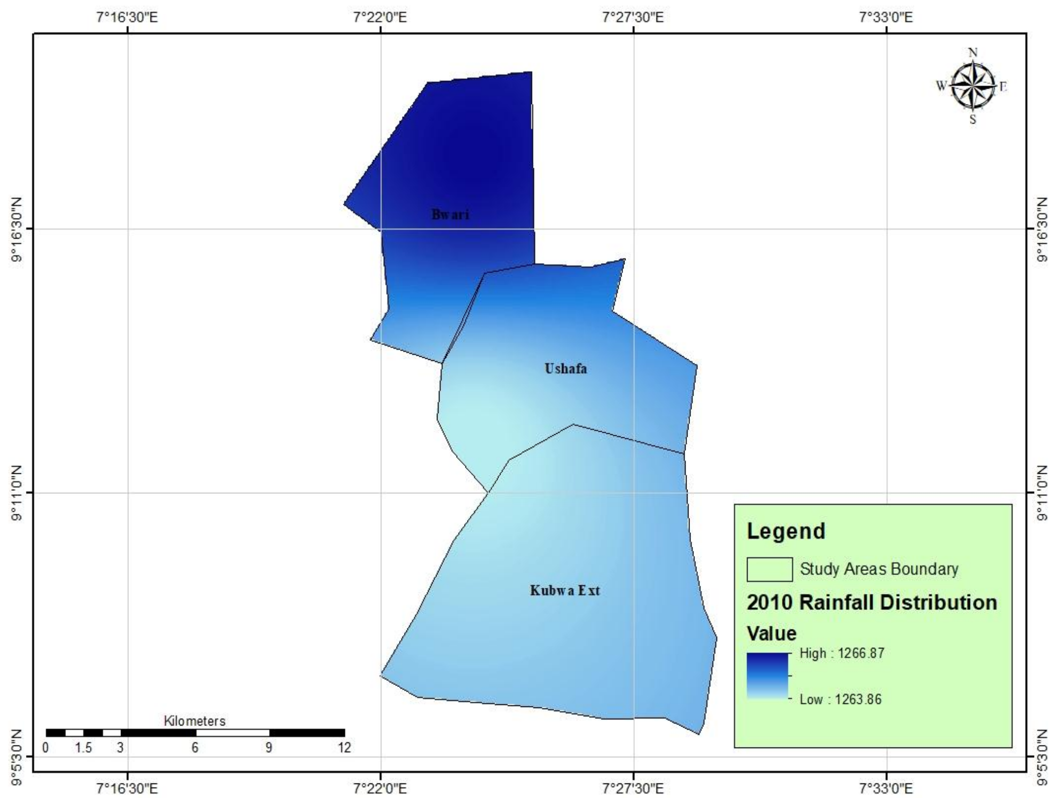

Figure 4.2: 2010 Rainfall Distribution Across the Study Locations

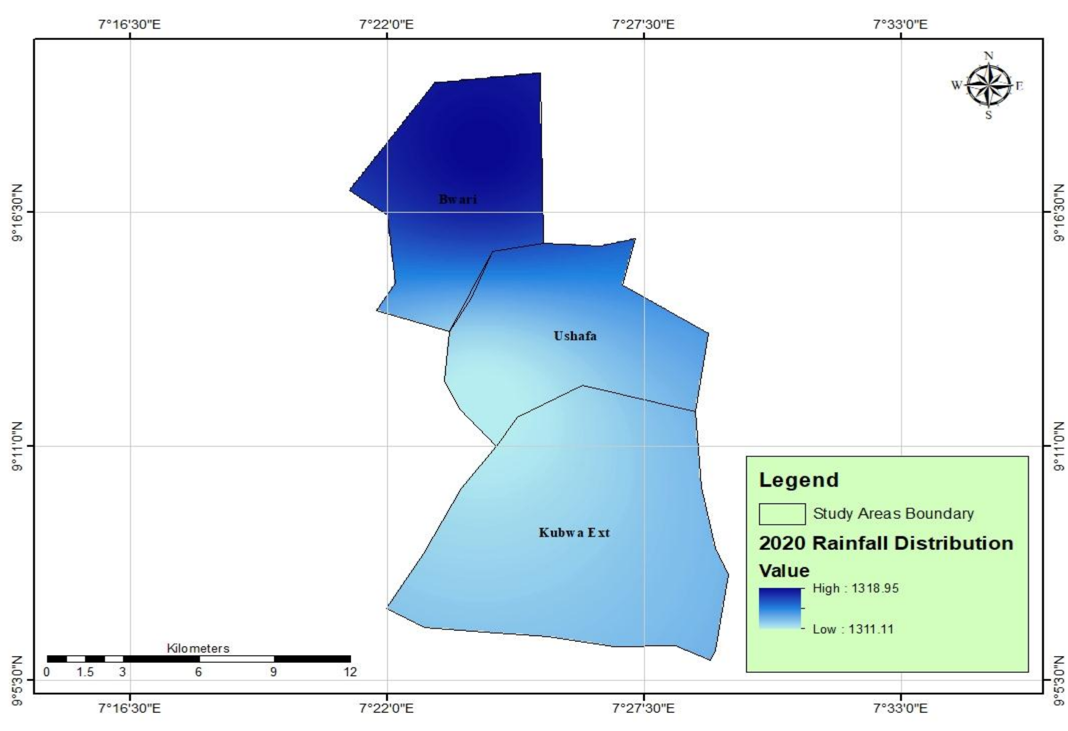

Figure 4.3: 2020 Rainfall Distribution Across the Study Locations

4.1.2 Analysis of Land use/Land cover classification for Bwari

(a) 1990 Satellite imagery LULC classification for Bwari

The land use/ land cover map gives an account of the spatial distribution and areal extent of various categories of land use/land cover over the study area. Figure 4.4 presents the classified land use/land cover map of the study area for the year 1990. The map portrays four (4) categories of land use/land covers; built-ups, grassland, agricultural land and water bodies.

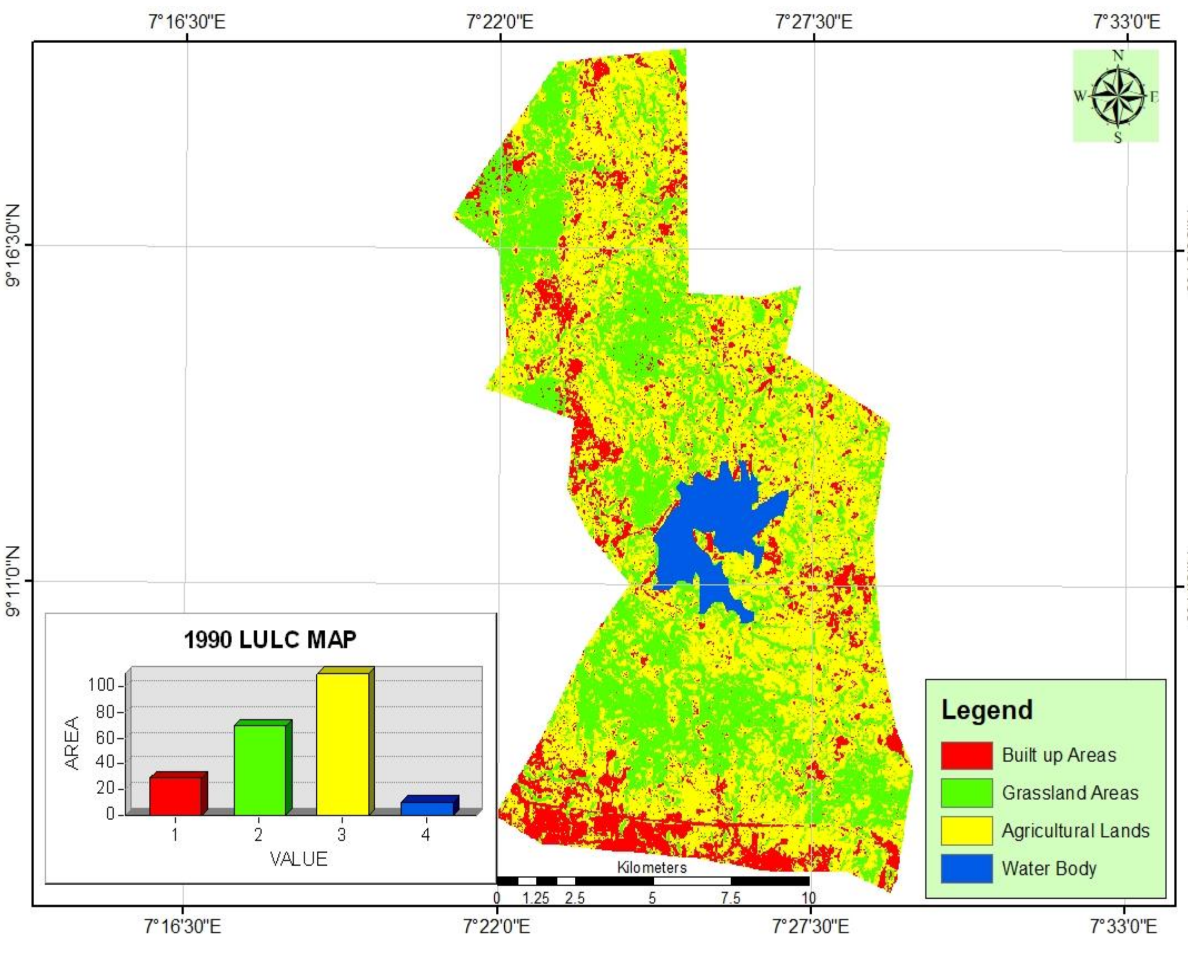

Figure 4.4 1990 Land use/Land cover distribution map generated from LandSat 4 TM

The areal extent of these classes reveal that the dominant class is Agricultural land which covers 110.10 km^2 (50.15%), this is followed by grassland with 70.00 km^2 (31.89%), built up areas covers 29.35 km^2 (13.37%). This is seen more at the Centre, and water bodies with 10.08 km^2 representing (4.59%) of the total area as the less dominant land use and land cover class.

(b) Analysis of Land use/land cover Classification of 2010 Satellite Imagery for Bwari

The land use and cover map of Bwari for 2010 (Figure 4.5), reveals that there was a drastic increase in built up areas. Result shows that built up area increase from 29.35 km^2 (13.37%) in 1990 to 42.17 km^2 (19.20%) in 2010. The built up expands towards the centre due to continuous influx of people. This sharp increase can be attributed to continuous influx of people as a result of the mark of a new era of democracy and the quest for people to get better job opportunities so as to improve their standard of living and improved socio-economic development in the area.

This is followed by agricultural land area; findings reveal that Agricultural land also increases from 110.10km^2 (50.15%) in 1990 to 112.21 km^2 (51.09%) in 2010. The large proportion of Agricultural land area indicates that most of the marginal dry and wetlands have been converted to agricultural land. However, there was a decrease in grassland area as findings indicate that grassland areas decreased from 70.00 km^2 (31.89%) in 1990 to 55.21 km (25.14%) in 2000. This may be attributed to conversion to build up areas, agricultural land and other land use and land cover categories. Furthermore, water body remains relatively stable with 10.04 km^2 (4.57%) respectively.

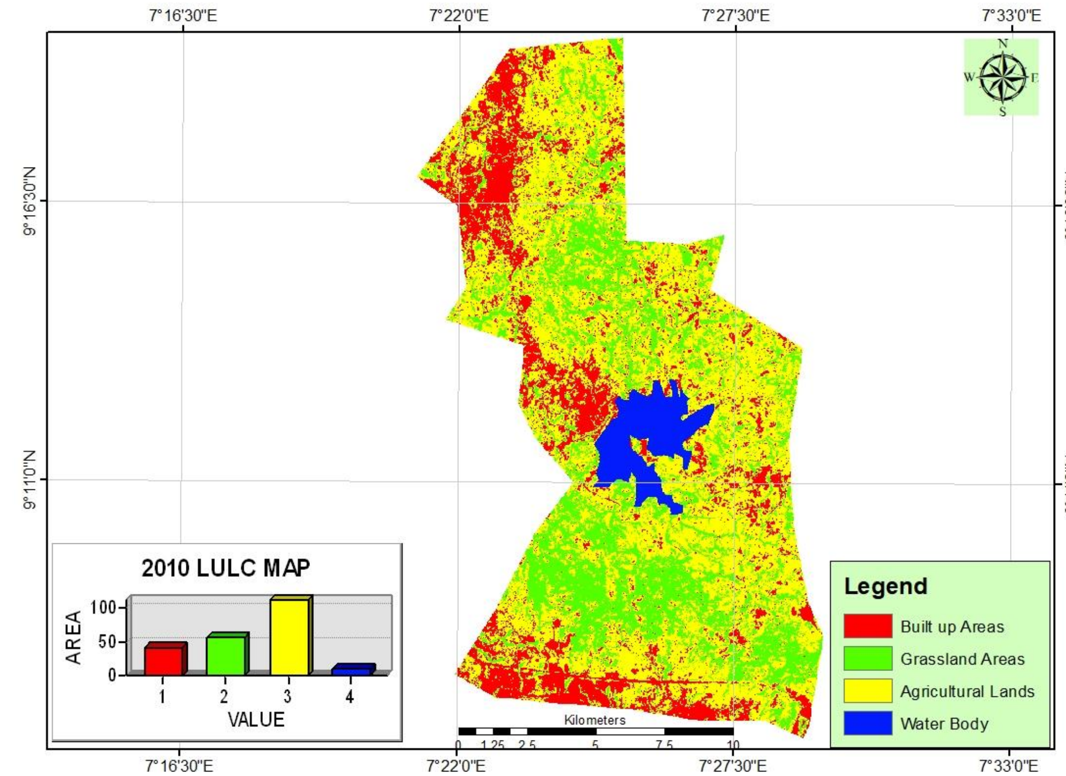

Figure 4.5 2010 LULC distribution map generated from LandSat 7 ETM+

(c) Analysis of Land use/Land cover Classification Satellite Imagery for 2020

Figure 4.6 shows the land use and cover map of Bwari for 2020, findings reveal that Agricultural land is the most dominant land use and cover type and continues to increase across the study area, an indication of increased urbanization. Result also shows that built up area increase from 42.17 km^2 (19.20%) in 2010 to 67.86 km^2 (30.90%) in 2020. The built up expands towards the city Centre, western, southern, north west and south western section of the study area as more people to influx the area.

This is followed by grassland areas as findings reveal that there was an increase in cultivated land but still occupies more land area than other land use category. Findings shows that grassland increased from 55.21 km^2 (25.14%) in 2000 to 58.93 km^2 (26.83%) in 2020.

Similarly, there was also a decrease in grassland area as findings indicate that grassland areas decreased from 974.76km (28.29%) in 2010 to 963.89 km^2 (39.07%) in 2020. In addition, water body witnesses a slight increase with 11.13km^2 (5.07%) respectively. This is in line with the works of (Peter *et al.*, 2018) who carry out similar work in Abuja.

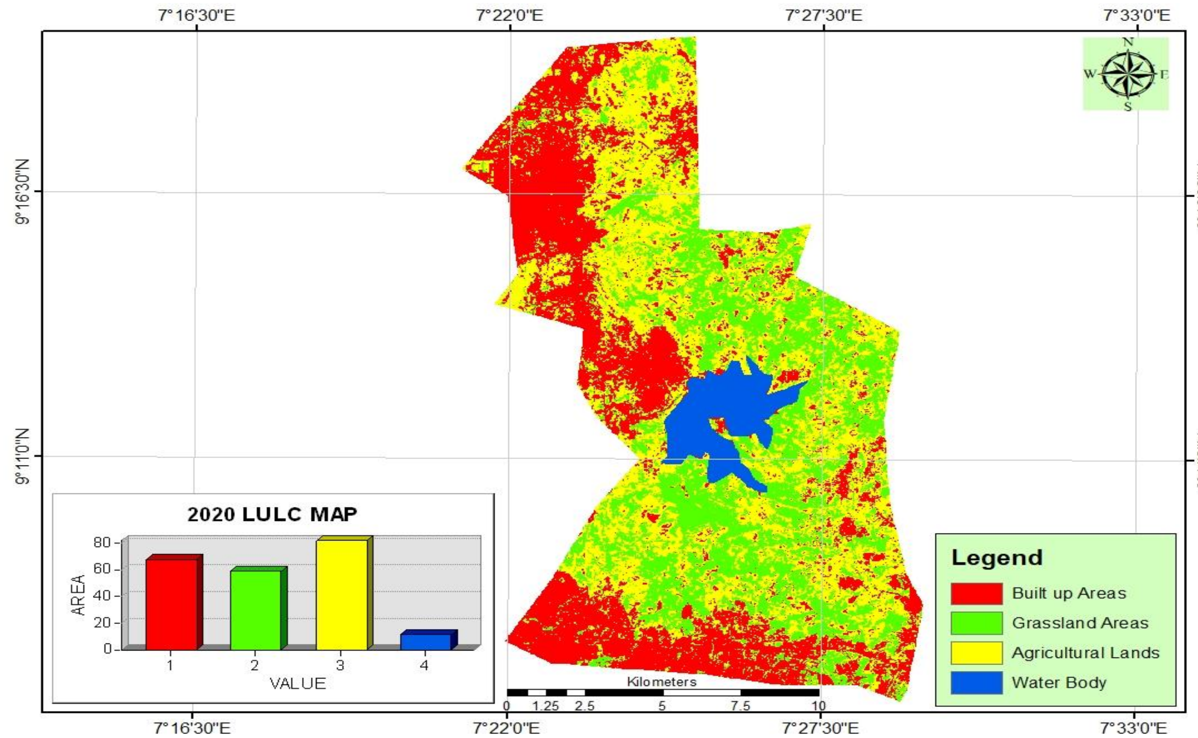

Figure 4.6: 2020 Land use/Land cover distribution map generated from LandSat 8 OLI

Additionally, table 4.1 shows the areal extent of each of the land use and land cover categories, from 1990 to 2020.

Table 4.1 land use and land cover Distribution of Bwari (1990, 2010 and 2020)

LULC	1990		2010		2020	
Land Cover Category	**Area (Sqkm)**	**Area covered (%)**	**Area (Sqkm)**	**Area covered (%)**	**Area (Sqkm)**	**Area covered (%)**
Build up	29.35	13.37	42.17	19.20	67.86	30.90
Grassland	70.00	31.89	55.21	25.14	58.93	26.83
Agricultural Lands	110.10	50.15	112.21	51.09	81.72	37.21
Water bodies	10.08	0.10	10.04	4.57	11.13	5.07
Total	**219.63**	**100**	**219.63**	**100**	**219.63**	**100**

Source: Author's Analysis, 2021

4.1.2.1 Magnitude and Percentage of Change in LULC between 1990 and 2010

The magnitude of change of forest area for 10 years between 1990 to 2000 shows that grassland decreased by -14.79Sq. km representing a change (-21.12%) of the total change for the period as shown on Table 4.1 Built up has one of the highest annual rates of change of 4.36% while water bodies has the least annual rate of change of -0.03%.

Table 4.2 Magnitude and Percentage of Change in Land Use/Landover between 1990 and 2000

LULC Class	1990 Extent (Sq. km)	2010 Extent (Sq. km)	Magnitude of Change (Sq. km)	Percentage of Change	Annual Rate of Change %
Built up	29.35	42.17	12.82	43.07	4.31
Grassland	70.00	55.21	-14.79	-21.12	2.11
Agricultural land	110.10	112.21	2.11	1.91	0.19
Water bodies	10.08	10.04	-0.04	-0.39	0.03
Total	**219.53**	**219.63**	**29.76**	**67.09**	**6.69**

4.1.2.2 Magnitude and Percentage of Change in Land Use/Landover between 2010 and 2020

The magnitude of change of forest area for 20 years between 2010 to 2020 shows that agricultural land decreased by -30.49Sq. km representing a change (-0.27%) of the total change for the period as shown on Table 4.2 built up had an annual rate of change of 3.04% while agricultural land had the least annual rate of change. The period witnessed further increase in Built up and farmland area. The built up land increased by 25.69Sq. km representing 60.92% of the total change.

Table 4.3 Magnitude and Percentage of Change in Land Use/Landover between 2000 and 2020

LULC Class	2000 Extent (Sq. km)	2020Extent (Sq. km)	Magnitude of Change (Sq. km)	Percentage of Change	Annual Rate of Change %
Built up	42.17	67.86	25.69	60.92	3.04
Grassland	55.21	58.93	3.72	6.73	0.33
Agricultural land	112.21	81.72	-30.49	-0.27	-0.01
Water bodies	10.04	11.13	1.12	11.15	0.55
Total	**219.63**	**219.65**	**61.02**	**79.07**	**3.93**

4.1.2.3 Magnitude and Percentage of Change in Land Use/Landover between 1990 and 2020

The magnitude of change of forest area for 30 years between 1990 to 2020 showed that grassland decreased further by -11.07Sq. km representing a change (-15.81%) of the total change for the period as shown on Table 4.2 Built up had an annual rate of change of 4.37% within the study years while Agricultural land had the least annual rate of change of -0.85%.

The period witnessed more increase in Built up and water bodies area. The built up land increased by 38.51Sq. km representing 131.20% of the total change, while water bodies increased by 1.05sq. km (10.41%) at an annual growth rate of 4.37% and 0.34% respectively as shown.

Table 4.4 Magnitude and Percentage of Change in Land Use/Landover between 1990 and 2020

LULC Class	1990 Extent (Sq. km)	2020 Extent (Sq. km)	Magnitude of Change (Sq. km)	Percentage of Change	Annual Rate of Change %
Built up	29.35	67.86	38.51	131.20	4.37
Grassland	70.00	58.93	-11.07	-15.81	-0.52
Agricultural land	110.10	81.72	-28.38	-25.77	-0.85
Water bodies	10.08	11.13	1.05	10.41	0.34
Total	**219.53**	**219.65**	**79.01**	**183.19**	**6.08**

In summary, findings reveal that it is not only precipitation or rainfall is not the only cause of flooding in the study area but human activities that have encroached the drainage path way has resulted to increased flooding in the study area. this is seen on the classified land use and land cover of the study; the rate of urban expansion has greatly increased across the three study locations. This agrees with the work of (Nnabuike *et al.*, 2020) who carries out similar work in Anambra state and found out changes in land use cover affect flooding. The implication of the statistic is the more the increase in population, the more the environment is being abused if not properly managed.

4.2 Examination of the Impact of Flood Events on Housing in the Study Area

This objective was achieved through the administration of questionnaire to the inhabitant of the different locations to examine the impact of flooding on their houses

Table 4.5: Demographic Characteristics of the Populations

Gender	Frequencies	Percentage (%)
Male	96	66.7
Female	48	23.3
Total respondents	144	100
Educational Level		
No formal education	1	0.69
Primary school	4	2.78
Secondary school	100	69.40
Tertiary	39	27.08
Total respondents	144	100
Occupation		
Student	21	14.58
Civil servant	40	27.78
Business/farming	63	43.73
Unemployed	20	13.89
Total respondents	144	100
Duration of Residence		
Less than 1-10 year	34	23.61
11 – 20 years	58	40.28
21 – 30	41	28.47
Above 30 Years	9	6.25
Total respondents	144	100
Age		
less than 18 years	15	15.36
20 – 39 Years	100	25.07
40 – 59Years	27	53.29
more than 40 Years	2	6.27
Total respondents	144	100

4.2.1 Demographic and socio-economic impact of urban flooding in parts of Bwari, Ushafa and Kubwa

The gender, age, educational level, occupation and duration of stay are all variables that influence how the population perceives the impact of urban flooding on the environment in the studied locations. It reveals that 66.7% of the respondents are males, while 23.3% are females.

Findings from the respondents based on their ages across the study locations shows that respondents between the age of 20-39 has 69.40%, 40-59 with 18.75% and 10.42% for less than 18 while 1.39% for 60 and above. It clearly shows that majority of the respondents in the areas of study are youths.

Based on the educational level of the respondents on the study areas, findings reveal that secondary education has 69.40%, this indicates that most of the respondents have secondary education while 27.08% of the respondents attained a tertiary education, primary education has 2.78% and 0.69% of the respondents had no education at all.

On the basis of occupation in the study areas, it shows that 43.75% of the respondents are farmers/business which shows that most of the respondents are into business and at the same time engage in farming activities to boast their means of livelihood, while 27.78% are civil servants who engage in government activities, finally, 14.58% of the respondents are students and 13.89% of the respondents are unemployed in the area.

On the hand, in response to the question of duration of stay of the respondents in the study locations, 40.28% of the respondent had stayed for 11-20 years in the locations, 28.47% of the respondents had stayed 21-30 years while 23.61% 1-10 years and 6.25% for 30 years and above across the study locations.

4.2.1.1 Causes of flooding

In response to the question, if the community had ever experienced flooding before in the study areas, 100% agreed with a yes and none with a contrary response to the question. Similarly, in response to the question, the last occurrence of flood, 100% of the respondents across the three study locations chose annually. It was agreed that flood in the area is annually which usually cause havoc in the area.

Table 4.6 Cause of Flood in the Study Area

Causes	Frequencies	Percentage
Building on/close to water courses	28	19.44
Bad refuse Disposal	20	13.88
Unplanned Settlements	42	29.16
Lack of/Inadequate Drains	17	11.80
Poor design of Drains	7	4.86
low lying nature of relief	30	20.83
Total	144	100

As regards the causes of flood across the study areas, 19.44% of the respondents agree that building on/close to water courses result to flooding the study the study locations, 13.88% are of the opinion that bad refuse disposal causes flooding, 29.16% of the respondents says unplanned settlements is responsible for flooding while 11.80% says lack of/inadequate drains causes flooding. On the other 20.83% agree that due to the low lying nature of relief of the area flooding is inevitable in the area.

4.2.1.2 Impact of flooding on the study locations

Based on the on the extent of flood the premises of the study areas, 51.39% of the respondents went with ground level, while 47.92% with came through doors, 0.69% for others and above windows had nothing to show for. On the other hand, in response to the question, if there is lost on any valuables across the study locations, 51.39% disagreed with a no, while 48.61%% of the respondents agreed with a yes answer meaning that whenever flood occur they usually lost valuable

Plate I: A car flooded away in Kubwa, Bwari Area Council, Abuja

Effects of floods in physical structures of the studied locations, 96.53% of the respondents went with cracking/collapsing of walls, while 2.08% with gradual soaking up of blocks and 1.39% for leaking roofs.

Plate II: Wash off Road in Ushafa Bwari Area Council, Abuja

Based on the question if the floods had affected health facilities in the community, 81.94% agreed with a yes this is because most of the health facilities are not properly protected, while 18.06% of the respondents disagreed with a no. As regards to any household members getting sick due to the flood across the studied locations 84.03% of the respondent affirmed yes, this is because most of the stagnant water serves as breeding place for mosquitoes which causes malaria while 15.97% went with a no answer meaning that flood do not affect their health facilities. Also, to the question if they were any damage to school infrastructure across the studied locations, 57.64% of the respondent affirmed yes, while 42.36% with the opposite.

Plate III: Houses flooded and submerged by flood water in Bwari Area Council, Abuja

Similarly, to the question if the flood had affected daily school activities, 98.61% of the respondents across the studied locations agreed with a yes, meaning that whenever there is flooding school activities will be affected as most roads are waterlogged, some of the school buildings are not well constructed exposing the windows open which can cause lemonier to some school pupils and students while 1.39% says flooding do not affect them.

In addition, the reason for the choice in question 7 is that about 61.81% of the respondents agree that road/pathway are usually affected by flood which hinders their movement, 27.78% of the respondents chose all of the above, 6.25% with school premises flooded, 4.17% for students absent.

Plate IV: A Demolished Building on water ways to prevent flood in Bwari Area Council, Abuja

To the question on if the floods affected business and trading activities, 98.61% agreed with a yes, while 1.39% of the respondents disagreed with a no.

On the ways as regards the response to question 9, 76.77% of the respondents went with reduction in the amount of time business/trade is conducted, while 13.19% with low patronage from customers, 11.81% for loss/damage to money, stock, equipment, fittings, 2.78% for all of the above and 0.69% for none of the above.

4.3 Generation of Flood Risk Vulnerability Map of the Study Area

4.3.1 Flood Risk Map in the study area

This occurs as a result of variations in degree of relief and drainage of the town; the map was based on susceptibility of settlement to flooding in the study area

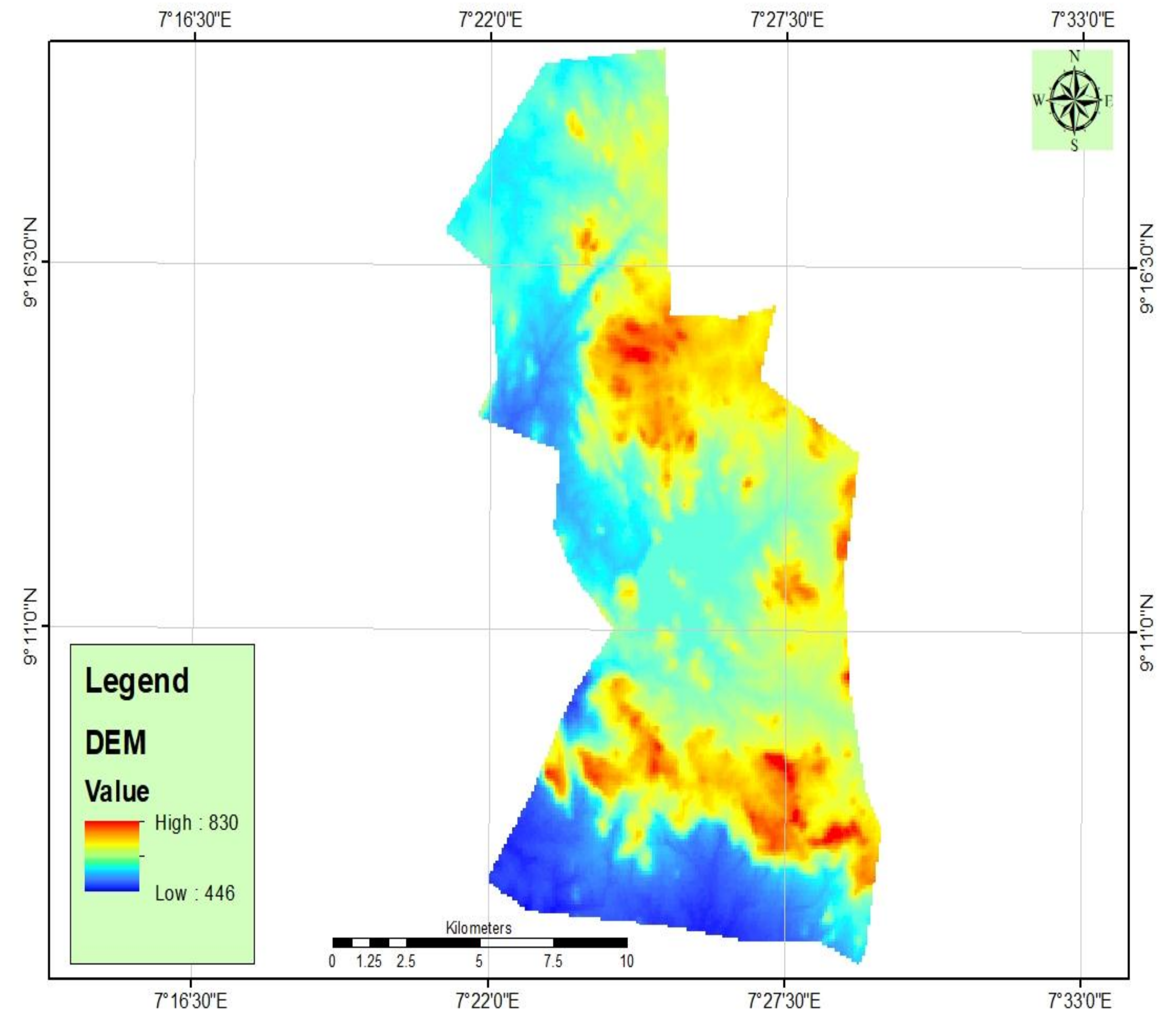

Figure 4.7. DEM of the study area

Source: Author's Analysis, 2022

4.3.3 Finding from the flood risk map

Figure 4.8 shows the flood risk zones of the study area; it has revealed that study areas is in fact potentially susceptible to flooding. This statement is drawn from the fact that several areas in study areas are in low elevation especially the Usman dam. These have been attributed to some degree of susceptibility. This was also confirmed through a ground truth exercise. It is therefore necessary to create awareness and steer away development from areas highly susceptible to floods to areas with lesser susceptibility in the area. The classification of flood risk zones in the area was mainly based on the interaction of relief and drainage. The DEM of the area revealed that the southern part of the area has high topography that is prone to erosion.

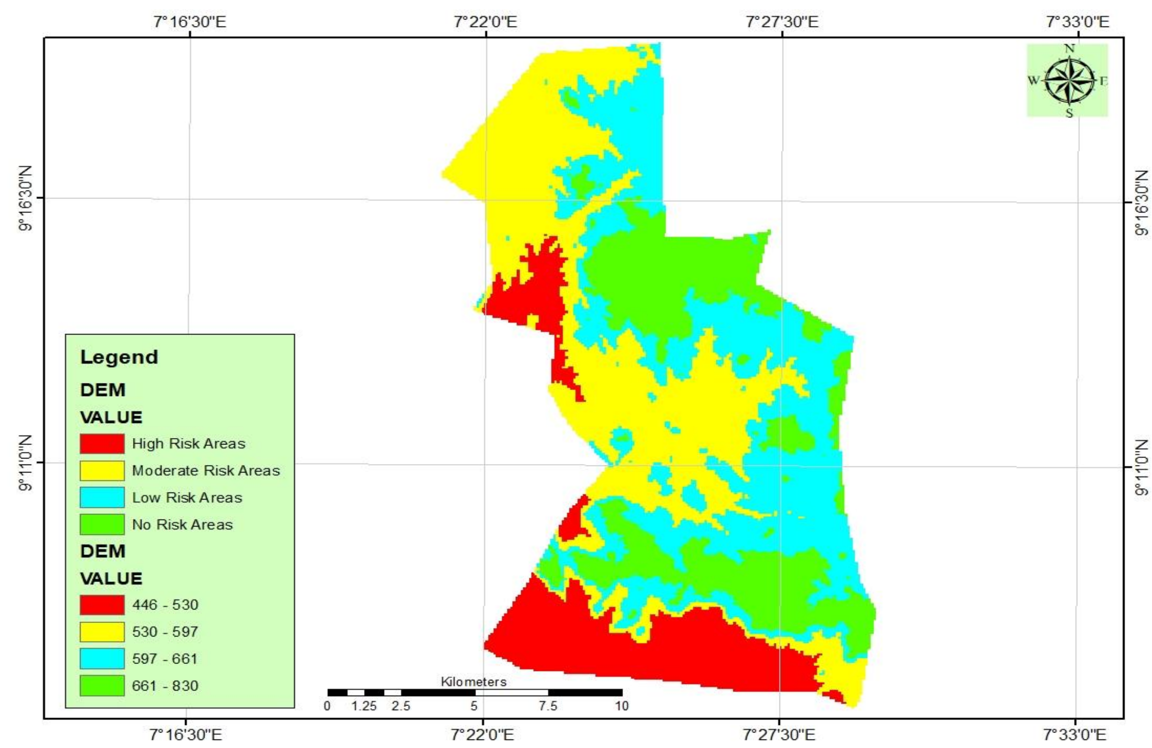

Figure 4.8. Map of flood Risk Vulnerability Zone of the study area.

Source: Author's Analysis, 2022.

The DEM further revealed that Study areas town is generally more susceptible to rain induced flash floods as well as river floods. At presented, there are variations in the degree of susceptibility to flooding in Study areas town these include high flood risk zone, Moderate, Low and No flood risk zones.

4.3.4 Flood Risk Vulnerability Zones

The areas marked as highly susceptible are mostly the areas closet to Usman dam. Flooding is experienced in most areas in this classification yearly. The areas are characterized by low relief and water logged soils. (Fig.4.8) is a classified DEM map of the study area which shows the slope in percentage and elevation of the study area, generated using zonal statistics in the spatial analysis tool of ArcGIS 10.3. The result from the classified DEM shows that about 33.50 square kilometer (15.80%) of the area is on lower elevation making the area on high risk area which is an evidence of recurrent flooding in the study area. then about 69.89 square kilometer (33.16%) are moderate risk areas and 62.96 square kilometer (29.87%) are low risk areas and finally 44.64 square kilometer (21.18%) is on high elevation. This are areas not affected by flood due to their elevation. Finding further reveals that not only rainfall is not the only factors responsible for flooding in the study area but the land use and land cover changes as well as the elevation of the study locations.

4.4 Assessment of the adaptation strategies put in place to reduce the impact of flooding in the study area

Based on the adaptation strategies of the respondents across the study locations, findings reveal that 92.36% of the respondents strongly agree that clearing water ways to remove dirt and enhance free flow of water is one of the adaptation strategy used. Also, 6.94% of the respondents agrees with while 0.70% are for indifferent, while the rest had none. On the hand, adaptation strategy on de-siltation, 53.33% of the respondents agree for de - siltation, 39.08% of the respondents went for indifferent, 31.07% strongly agree while 4.17% totally disagree with de-siltation.

Also, to the adaptation strategy for share contact information, 49.23% of the respondents strongly agree that sharing contact information is very important to seek for information and assistance for best adaptation strategies, 34.03% agree with the sharing contact of information, similarly 4.86% are indifferent and 4.17% disagree with the idea of sharing contact information which is best known to them. Similarly, based on the adaptation strategy produces through trained manpower across the study areas, 43.75% of the respondents went for strongly agree for training of manpower, 32.64% agree, 18.05% for disagree while 7.64% strongly disagree.

Based on the adaptation strategy for widened drainage channels, 86.11% of the respondents strongly agree that widened drainage channels will help to reduce the impact flooding as more flood water can flow, 7.64% agree to it, 4.86% are indifferent while 3.47% disagree. On the adaptation strategy for use of metal sheeting/sandbags, 56.94% of the respondents agree that the use of metal sheeting/sandbags are the adaptation strategy adopted across the study locations, also, 22.20% strongly agree, 14.58% disagree and 6.25% strongly disagree.

Also, based adaptation strategy to select safer location to stay when there is flooding, 40.97% of the respondents went for strongly agree, 36.11% for disagree., while 20.14% agree and 2.78% strongly agree On the other hand, to the adaptation strategy to temporary relocate to the nearest neighborhoods until after the flooding before they can return to their community, 42.36% of the respondents strongly agree, 40.97% for disagree, 10.42% are for indifferent and 6.25% agree for temporary relocate to the nearest neighborhoods until after the flooding.

In addition, the adaptation strategy of digging channels to draw water away from dwellings, 85.42% of the respondents strongly agree that digging channels to draw water away from dwellings helps them to adapt while 14.58% agree and the rest had no response.

4.5 Implication of Land Use change on Flooding

Figure 4.9 reveals the overlay map of land use and land cover and vulnerability map, findings reveals that most of the flood pathway has been encroached by developers which create more avenue for flooding to occur in the area. This is because earlier findings from both the classified land use and land cover and rainfall maps reveals that rainfall is not the prime cause of flooding in the area but land development across waterways.

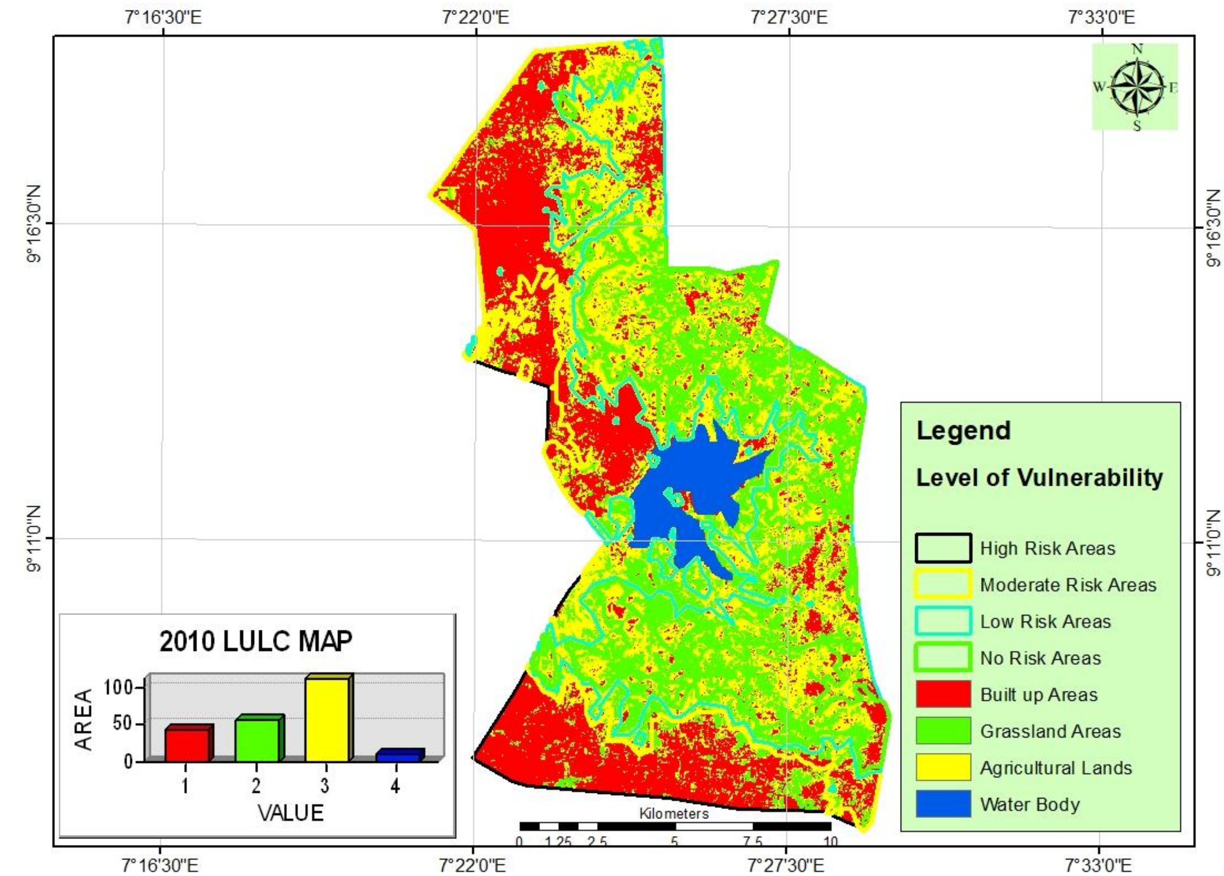

Figure 4.9: Overlay Map of Land use and land cover and Vulnerability

By comparing the overlay map of the land use and vulnerability map of the study area, it is pertinent to note that as development continues to surge towards flood plain areas or water ways without any embankments or drainage pathway. The impact of the flood will continue to increase and cause more havoc to the environment

4.6 Summary of Impact of Urban Flooding on the study Area

The researcher emphasize that the discussion exposed in this work could be useful to provide a better understanding of flooding as it relates to urban flooding. It is concluded that satellite derived data is much more effective and advantageous in mapping general land use and land cover, rainfall and elevation for informed decision. It can serve as a worthwhile alternative for quickly mapping urban land, level of flood vulnerability and extent. The study further reveals that rainfall is not the prime cause of flooding in the study area but due to human activities along flood pathway. This was confirmed during fieldwork as structures are built on drainage pathway. The vulnerability map shows different level risk across the study area while responses obtained from respondents shows that residents have developed different adaptation strategies to cope with impact flood event.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The spatio-temporal analysis of the land use and land cover classification across the study location shown that the degree at which Land use land cover changes have occurred has increased more than earlier times. This was further confirmed by the different Spatio-temporal LULC maps produce which reveals higher changes in LULC in recent times. It is important to note that human settlement is on the increase towards the floodplain. This certainly increases the vulnerability of built-up areas to flood events. The research reveal factors such as land use pattern, low relief, increased in built-up and human activities will continue to exaggerate flooding in the area.

The DEM analysis shows spatial variations at different scales. These variations are extremely important in determining the level of vulnerability in the study area. The flood risk map of the study area indicate that majority of the land mass are at risk especially at the southern part of the study area. Based on effects of floods in physical structures of the studied locations, 96.53% of the respondents went with cracking/collapsing of walls, while 2.08% with gradual soaking up of blocks and 1.39% for leaking roofs.

The result from the classified DEM shows that about 33.50 square kilometer (15.80%) of the area is on lower elevation making the area on high risk area which is an evidence of recurrent flooding in the study area. then about 69.89 square kilometer (33.16%) are moderate risk areas and 62.96 square kilometer (29.87%) are low risk areas and finally 44.64 square kilometer (21.18%) is on high elevation. This are areas not affected by flood due to their elevation. Finding further shows that it is not only rainfall that is responsible for flooding in the study area but the land use and land cover changes as well as the variation on elevation of the study locations.

In addition, based on the adaptation strategies of the respondents across the study locations, findings reveal that 92.36% of the respondents strongly agree that clearing water ways to remove dirt and enhance free flow of water is one of the adaptation strategy used. Also, 6.94% of the respondents agrees with while 0.70% are for indifferent.

The result of the questionnaire analysis indicates that 29.16% of the population blamed urban flooding on unplanned settlement built up, with 15.80% of the population agreeing to the fact that a large part of the study area is on low lying terrain and making it highly susceptible to flood. The major adaptation strategies put in place is to relocate to higher grounds and make way for proper drainage and avoiding waste dumping on water ways. Conclusively, the research reveal factors such as land use pattern, low relief, increased in built-up and human activities along drainage pathway will continue to exaggerate flooding in the area.

5.2 Recommendation

In order to reduce the impact of flood disaster as well as other environmental problems in the study area, the master plan of the study area developed by the FCT must be strictly adhered to by land developers. The implementation of laws on sold lands by the owners as well as governmental lands is necessary to reduce flood problem, development of the master plan should be based on the temporal changes. From the findings of this research, the following recommendations are made:

(a) Town planning and land use zonation should be encouraged in the study area. With the presence rapid influx of people from surrounding states and high rate of building construction, there is every need to make sure that these building do not block drainage channels or major runoff routes.

(b) Also, building close to the river banks and other vulnerable areas to floods should be discouraged as well as marshy areas should not be given out for development, they should be allowed to exits since their importance in containing excess water from rainfall has been stressed in the literature

(c) Drainage network of good depth and width should be constructed in areas vulnerable to flooding. The drainage network should be concentrated in the inland streets where they are absent and blocked. This is because damage drainages can lead to accumulation of runoff waters after rainfall, therefore, attention should also be given to it

(d) Awareness should be created to inform the resident of the appropriate and best adaptation to adopt in case of flood occurrence.

5.3 Contribution to knowledge

i. The study identified and exposed the knowledge gap on the existing research in the study area and also established linkage between rainfall, land use change impact on flood as well as Adaptable strategies by affected residents.

ii. The study reveals that if effect of flooding are left unchecked can easily cause enormous damages to the environment of the study area

iii. The study also indicates that increased in population has resulted in change in land use pattern across the study area.

iv. The study has shown that there is urgent need for increase awareness on access to education of residents on sustainable environmental impacts to enhance socio-economic activities well beings of the areas.

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APPENDIX 1:

DEPARTMENT OF GEOGRAPHY, FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, NIGERIA

THE IMPACT OF URBAN FLOODING ON SOME PART OF BWARI AREA COUNCIL, FCT, NIGERIA

Dear Respondent,

This research field work is part of requirement leading to the award of Masters of Technology Degree in geography. All information supplied will be used purely for this academic purpose and shall be treated with utmost confidentiality. You are therefore kindly requested to tick

(✓) from the options provided.**Thank you**

Name of your area____

BACKGROUND

1. (a) Name of Suburb (Area) ………………………………………………………………

2 Gender: Male [ ] Female [ ]

3 Age (i) 18 and below [ ] (ii) 20-39 [ ] (iii) 40-59 [ ] (iv) 60 and above

4 Educational level: (i) Primary [ ] (ii) Secondary [ ] (iii) Tertiary [ ] (iv) None [ ]

(e) Occupation: (i) Student [ ] (iii) Civil Servant [ ] ii) Farmer [ ] (iv) Unemployed [ ]

(f) Duration of stay in this community? (i) 1-10 [ ] (ii) 11-20 [ ] (iii) 21-30 [ ] (iv) 30+ [ ]

B Causes of flooding

1. (a) Has your community ever experienced flooding before? Yes [ ] No [ ]

2. (b) When was the last occurrence? …………….. (c) How long did it last? .... (d) How often do floods occur in your locality? (i) Biannually [ ] (ii) Annually [ ] (iii) Biennial [ ] (iv) Often, more than 3 times a year [ ] (v) Never [ ]

4. What, in your opinion is/are the causes of these floods?

(i) Building on/close to water courses [ ] (ii) Bad refuse Disposal [ ] (iii) Unplanned Settlements (iii) Lack of/Inadequate Drains [(iv) Poor design of Drains [ ] (v) Choked drains [ ] (vi) low lying nature of relief [ ]

C. IMPACT OF FLOOD ON THE STUDY AREA

1. What was the extent of flood on your premises? (i) Ground level [ ] (ii) Came into the rooms through windows/doors [ ] (iii) Above windows [ ] Specify…………………………………………………………………

2. Did the house lose any valuables/properties? Yes [ ] or No [ ] If Yes, specify…………………………………………………………………………………

3. What are the effects of floods on physical structures? (i) Cracking/collapsing of walls, floors, etc [ ] (ii) Leaking roofs [ ] (iii) Abandon house temporarily/permanently [ ] (iv) Gradual soaking up of blocks

4. Did the floods affect health facilities in the community? Yes [ ] No [ ] 15. Did the floods interfere with access to health services? Yes [ ] No [ ]

5. Did any of the household members get sick due to the floods? Yes [ ] No [ ]

Are there any education facilities in your community? Yes [ ] No [ ]

6. Was there any damage to school infrastructure (classroom blocks, etc.) due to the floods? Yes [ ] No [ ]

7. Did the floods affect daily school activities? Yes [ ] No [ ]

8. If yes to Question 7 above, what is/are the reason (s)?

(i) Road/ pathway affected by flood [ ] (ii) School premises flooded [ ] (iii) Students absent themselves purposely during/after floods for fear of the unknown [ ] (iv) School temporarily closes down [ ]

9. Do floods affect business and trading activities? Yes [ ] No [ ]

10. What are the effects of floods on trade/business? (i) Loss/Damage to money, stock, equipment, fittings, etc [ ] (ii) Reduction in the amount of time business/trade is conducted [ ] (iii) Low patronage from customers [ ]

SECTION D: Adaptation Strategies

S/N	Adaptation Strategies	SA	A	I	D	SD
1	Clear water ways to remove dirt					
2	De-siltation					
3	Share contact information					
4	Produce trained manpower					
5	Widened drainage channels					
6	Use of metal sheeting/ sandbags					
7	Select safer location to stay					
8	Temporary relocate to the nearest neighborhood until after the flooding					
9	Digging channels to draw water away from dwellings					