SPATIO-TEMPORAL ANALYSIS OF AREAS VULNERABLE TO FLOODING IN IBAJI LOCAL GOVERNMENT AREA KOGI STATE, NIGERIA

BY

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MARCH, 2017

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P14SCGS8172

A DISSERTATION SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES AHMADU BELLO UNIVERSITY, ZARIA IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF MASTER OF SCIENCE IN REMOTE SENSING AND GEOGRAPHIC INFORMATION SYSTEM

DEPARTMENT OF GEOGRAPHY,
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MARCH, 2017

DECLARATION

I declare that this dissertation titled "SPATIO-TEMPORAL ANALYSIS OF AREAS VULNERABLE TO FLOODING IN IBAJI LOCAL GOVERNMENT AREA, KOGI STATE, NIGERIA" was written by me and is a product of my research work in the Department of Geography under the supervision of Dr. A.K. Usman and Dr. B. Abdulkarim. This dissertation has not been presented for any degree or diploma at any university. All information derived from literature has been duly acknowledged in the text and by lists of references provided.

Abdulsamad MOHAMMED …… ……

(Signature) **(Date)**

CERTIFICATION

This dissertation titled, "SPATIO-TEMPORAL ANALYSIS OF AREAS VULNERABLE TO FLOODING IN IBAJI LOCAL GOVERNMENT AREA, KOGI STATE, NIGERIA" by Abdulsamad MOHAMMED meets the regulations that govern the award of the Degree in Masters of Science (Remote Sensing and GIS) of Ahmadu Bello University, Zaria, and is approved for its contribution to knowledge and literacy presentation.

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DEDICATION

This dissertation is dedicated to Almighty Allah for all His care, love and mercy. Indeed you are the greatest.

ACKNOWLEDGEMENTS

Thanks to my supervisors, Dr. A. K. Usman and Dr. B. Abdulkarim for their patience, support, comments, excellent guidance and time to ensure that this work became a successful one. And to other staff of the Department of Geography, Ahmadu Bello University Zaria, especially Dr. R.O. Yusuf, Dr. B. Akpu, Mallam Muktar and Mallam M. Isma'il I really appreciates your contributions and constructive criticism at different points during the development of this research.

My heartfelt gratitude goes to my mum and dad, Alhaji Muhammad Liguy and Hajia Mariam M. Liguy for their financial and moral support towards my academic pursuit. To my siblings: Mrs Halima, Mrs Zainab Abdulkadir, Miss Mariam, Abubakar, Mrs Rabi Abdul, Mrs Fatima Abdullahi, Hafsat, Zuerat, Munirat, Aishat, Ibrahim, Safiat, Rahmat and Aminat thanks for all your support. I am also grateful to Abdulmalik and Samuel, for believing in me. Indeed words are not enough to thank Fulela Ademu the most loving granddaughter in Liguy's family for her prayers. My appreciation also goes to my lovely wife Mallama Rahmat Abdulsamad whose measurable support has made this research a success.

To all my friends and colleagues of the Department of Geography, Ahmadu Bello University, Zaria and all the Muslim brothers in Akenzua hostel who gave me company and a lot of moral advice throughout this period, I say thank you. Furthermore, I wish to thank Mallam Musa for all his prayers. Finally the support and love of Abdurrahim, INJ and Sadola cannot be overlooked. I really appreciate you guys, thanks for all your supports.

ABSTRACT

The study focused on the Spatio-temporal analysis of areas vulnerable to flooding in Ibaji Local Government Area. Flood is an environmental hazard resulting largely from events such as heavy rainfall that lead to overflow of land area. Field survey, Satellite imageries, Global Positioning System (GPS), Shuttle Radar Topographic Mission (SRTM), Rainfall data and Questionnaires administration were the materials and methods used for the study. Medium resolution Landsat 8 imagery, elevation, slope, soil data, land use, drainage density and rainfall data were imputed into GIS as factor maps to determine which has more influence on the occurrence of flood. The results of the study revealed that rainfall has the greatest influence on flood occurrence in the study area. Other factors such as elevation, slope, drainage, land use and soil types represent significant factors of flooding. The results further revealed that, about 25% of the total land area is highly vulnerable to flooding, while moderate and low vulnerable areas constitute 21.875% and 53.125% respectively. The study also showed that the flood trend is increasing from the riverine areas to the hinter land and 96% of the respondents believe that the damage caused by flood in Ibaji is very serious, while only 4% are of the view that it is not serious. Also, 81.2% suggested government policies as flood control measure, 11.9% and 6.9% suggested public enlightenment and community effort respectively. In view of the risk which the people in the area are exposed to and the extent of environmental damage, there is great need for Settlements that are within or adjacent to the areas liable to flooding should be relocated where possible and future settlements should be discouraged.

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CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Flood is an environmental hazard resulting from events like heavy rainfall causing river and oceans to overflow their banks and can have far reaching effects on people and the environment. Flood is defined as the accumulation of excess water which rises to overflow land which is not normally submerged (Mukhopadhyay, 2010). According to Disaster Management Support Group (DMSG, 2001), flood is among the most devastating natural hazards in the world, leading to significant economic and social damages than any other natural phenomenon. Extensive damages on properties and loss of lives have been recorded globally due to flood events. In India for example, one hundred and twenty five people were killed and over twelve million people were displaced in the 2007 flood disaster that hit Bihar, Uttar Pradesh and Assam province (Isa *et al*., 2015). African countries have not been left out in this global flood event experience. In 2001, the Central Province of Mozambique was hit by flood disaster that affected five hundred and fifty four thousand and resulted in one hundred and thirteen deaths. (OCHA, 2003).

In Nigeria, devastating flood events was dated back to 1976 in Ibadan, when Ogunpa river over-flown resulted to loss of lives and properties (Adegbola and Jolayemi, 2012; Agbola, Ajayi, Taiwo and Wahab, 2012). Since then, 80% of Nigeria's landmass has been subjected to different magnitude of flood. Prominent among the areas affected by flooding include Kano, Niger, Jigawa, Kaduna, Adamawa, Benue, Kogi and southern parts of Nigeria (Adeoye, Ayanlade and Babatimehin, 2009). Between 2011 and 2012, Lagos

state recorded at least eight major floods with over thirty deaths recorded and many properties destroyed (Komolafe, Adegboyega, Anfowose, Akinluyi and Awoniran, 2014). On 23rd July, 2016, five hundred and eighty five houses and farm produce worth millions of naira were destroyed in seven communities in Wurno Local Government Areas of Sokoto state by flood that resulted as a result of blocked drainages (Dailytrust, 2016).

Vulnerability is the degree of damage to a given item at risk caused by flood with determined amount and is influenced by several factors such as human settlement conditions, infrastructure and authorities (United Nations, 1998). Vulnerability assessments have been recognized as being crucial to disaster management and are conducted to understand potential for loss, focusing on nature of the hazard and who and what are exposed (Enyinnaya and Ogbonna, 2015).

During the last two decades, remote sensing has played a key role in the field of flood management while GIS has been used extensively to model surface water and flood damage (Dewan, Kankam and Nishigaki, 2005). Remote Sensing is the science and art of acquiring information about an object, area, or phenomenon through an analysis of the data acquired by a device which is not in contact with the object, area or phenomenon under investigation (Anji, 2008). This technique has increasingly become important in providing reliable and timely information on environmental issues like flood monitoring. GIS is defined as computer systems capable of assembling, storing, manipulating, and displaying geographically referenced information (USGS, 1998). In the context of flood vulnerability analysis, GIS can be used to create interactive map overlays, which clearly and quickly illustrate which areas of a community are in danger of flooding (Awal, 2003).

Ibaji has witnessed serious river flood events in the past few years which could be attributed to climatic fluctuations. Annually, it displaced thousands of people in Ibaji and submerged several square kilometers of landed area in general and farmlands in particular. The floods usually occur during the peak of rainy season (June-October) and have attracted the attention of the State and Federal Government (KOSEMA, 2007).

1.2 Statement of the Research Problem

Flooding at whatever scale or magnitude is an annual phenomenon in Ibaji Local Government Area. It is an ecological disaster that results to destructions of houses, farm lands, lives and properties as well as biodiversity. In 2012, the most devastating flood event in Nigeria occurred as a result of heavy rain in addition to the release of water from Lagdo Dam in Cameroon Republic. According to KOSEMA (2012), this flood disaster ravaged most communities in Ibaji leading to displacement of a number of people and destroyed hectares of farm lands, and many lives and properties were lost.

River flooding occurs in Nigeria every year and the potential risk exists in the low lying flood plains of river Niger and human encroachment into areas liable to flood is growing rapidly due to the huge natural resources and agricultural potentials found in such areas. Thus floods have significant consequences for example, in August 2001; thousands of people were displaced in Kano and Jigawa States as a result of flood that was caused by the overflowing of Challawa dam. Twenty people were reported dead in Kano, while one hundred and eighty people were reported dead in Jigawa State. A record of the total number of people affected by the flood incidence was well above one hundred and forty three thousand (Jeb and Aggarwal, 2008).

The October 2007 flood disaster in Ibaji local government area displaced over thirteen thousand people and many properties and farm produce were destroyed. In 2012, Nigeria was worst hit with the flood disaster that affected many states in Nigeria. According to the National Emergency Management Agency (NEMA, 2012), about 363 people were reported dead, and over 2.1 million people were displaced. The flood was termed as the worst in 40 years and the estimated damages and losses estimated is 2.6 trillion (NEMA, 2012). In August 2015, NEMA also reported that about 302, 000 people in 10 local government areas of Adamawa state were affected by floods triggered by spillage of a nearby dam in Gombe State. The frequency and level of destruction of flooding globally has attracted a number of researches, for example, Surassawade, Anusorn and Chaowalit (2007) assessed the potential effects of flood vulnerability in Phra Nakhon Si Ayutthaya province, Thailand. The study used Remote sensing techniques in mapping areas affected by flooding. The results showed that an area of 257, 145 hectares were severely submerged, and 23,838 hectares were dry.

Kabir, Deo, Amarnath and Basanta (2013) also identified and mapped flood hazard zones and flood shelters zones in Sindh Province, Pakistan. The study used Remote Sensing and Geographic Information Systems techniques for flood hazard management in Sindh Province, Pakistan. The results of the study showed that, a total landed area of 6216Km² was vulnerable to flood hazard out of 46138Km². Jeb (2013) carried out a study on flood risk analysis in Kaduna metropolis, Kaduna state Nigeria. The study used geoinformation science to analyzed flood risk in Kaduna metropolis. The results of the research revealed that, Flood hazard is imminent along the River floodplain in Kaduna Metropolis and occurs every year and there will be an increase in the extent of flooding inundation from the 5-year

return period to the 100-year return period and almost all parts of the metropolis along the river will be affected. Areas with very low vulnerability to flood hazard, high vulnerability and very high vulnerability were also identified.

Emmanuel and Sadiat (2012) carried out a study on urban flood risk information on Aluko River in Ilorin Metropolis, Kwara State, Nigeria. The study used Geographic Information System to identify areas at risk to flooding along Aluko River in Ilorin. The results of the study showed that about 288 buildings were found to contravene the set-back rule and about 10, 820 people were estimated to be vulnerable to flood hazard. The study carried out by Eguaroje *et al* (2015) on flood vulnerability assessment of Ibadan city, Oyo state, Nigeria adopted Remote Sensing and GIS techniques in identifying the major factors contributing to flood and effect of flood in Ibadan. The results revealed that mean annual rainfall contributed to flooding than other factors considered in the model followed by slope, drainage and land-use. Aderoju *et al* (2014) carried out geospatial assessment of 2012 flood disaster in Kogi State, Nigeria. The study used Remote Sensing and Geographic Information System in mapping and analyzing the 2012 flood disaster in kogi state, Nigeria. The study revealed that 73 communities were directly affected and about 303,000 people were internally displaced. The study further revealed that agricultural land, residence and major infrastructures like schools, health centers and transportation routes were fully inundated and some were destroyed.

Several studies have been carried out on flooding in various parts of the country, but none of the previous researches has addressed vulnerability level of communities to flooding and adaptive measures used by residents in Ibaji Local Government Area despite the fact that the area has been witnessing annual flooding. It is therefore important to carry out

Spatio-temporal analysis of flood vulnerability in Ibaji Local Government Area in order to provide vital data and information that can be use in planning and managing future flood disaster in the study area. This study therefore intends to address the following research questions.

i. What are the underlying factors that influence flooding in the study area?
ii. Which areas are more vulnerable to flood risk in the study area?
iii. What was the trend of flooding in the study area (2002-2012)?
iv. What is the effect of flooding on the livelihoods of residents in the study area?
v. What are the coping strategies adopted by residents to flood risk in the study area?

1.3 AIM AND OBJECTIVES

The aim of the study is to analyze flood vulnerability in the study area. However, the specific objectives of the study are to:

i. identify the factors influencing floods in Ibaji Local Government Areas.
ii. locate and map out areas vulnerable to flooding in the study area.
iii. examine the trend of flood vulnerability level in the study area (2002-2012).
iv. examine the effects of flood vulnerability level on the livelihoods of residents in the study area.
v. examine the coping strategies to flood vulnerability by residents in the study area.

1.4 SCOPE OF THE STUDY

The spatial scope of the study is Ibaji Local Government Area which consists of ten wards: Akpanyo, Analo, Ayah, Ejule, Iyano, Odeke, Ojile, Onyedega, Ujeh and Unale. The content focused on Spatio-temporal analysis of flood vulnerabilty. The flood causative

factors considered were rainfall, landuse, soil, slope, elevation and drainage density. A vulnerability map was generated consisting of five levels of very low vulnerable areas, low vulnerable areas, moderate vulnerable areas, high vulnerable areas and very high vulnerable areas. The effects of flood vulnerability level and the coping strategies to flood vulnerability were also considered. The temporal scope of the study covered time frame of 2002 to 2012. This is due to the availability of data on flood events in the study area.

1.5 JUSTIFICATION OF THE STUDY

The devastating effects of flood hazard all over the world annually cannot be overemphasized in terms of the loss of lives, properties and valuable agricultural land. Ibaji is one of such areas that experience flood annually and this flood is a potential harm to residence of Ibaji because of its severity and magnitude of its impact. In 2007, 2008 and 2012 flood disaster ravaged most communities in Ibaji leading to loss of lives, displacement of people, destruction of farm lands and properties (KOSEMA, 2012). In the past, many studies have been carried out on flooding in various parts of the country but none of the previous studies have provided a solution to this devastating disaster in the study area. Although, the National Emergency Management Agency (NEMA), Kogi State Emergency Management Agency and Red Cross are trying their best in terms of providing camps, food items, health care services and money for the people affected each time this flood occurs. But knowing the factors that causes flooding and areas vulnerable to flooding will provide vital data and information to policy makers, scholars and is also required by local authorities in physical planning and in protecting citizens against future occurrence of this flood disaster.

CHAPTER TWO

CONCEPTUAL FRAMEWORK AND LITERATURE REVIEW

2.1 Introduction

This chapter reviews the concepts of flood, vulnerability and analytical hierarchical process. It also reviews related literature on flood history in Nigeria and flood occurrence in Ibaji local government area. Finally, previous studies on application of Remote Sensing and Geographic Information Systems (GIS) on flood vulnerability and application of analytic hierarchy process (AHP) are discussed.

2.2 Conceptual Framework

2.2.1 Flood Hazard

Flood hazard is the chance that a flood event of a certain magnitude will occur in a given area within a given period of time. Brooks, Nicolls and Hall (2006) defined Flood hazard as the probability of occurrence of a potentially damaging flood event of a certain magnitude within a given time period and area. However, Alkema and Westen (2005) defined flood hazard as the chance that a flood event of a certain magnitude will occur in a given area within a given period of time. Despite the differences in these definitions, it implies that, a flood hazard is the probability of any possible flood event of a given magnitude that can cause harm, danger, loss of life or property. And each hazard is characterized by its location, intensity, frequency and probability. De Moel and Asselman, Aerts (2012) stated that flood hazard can be described by these parameters flood extent, water depth, flow velocity, duration and the rate at which the water rises.

Flood hazard in Ibaji Local Government Area Kogi state exists and occurs yearly and is influenced by several factors such as frequency of rainfall, slope, elevation, soil, landuse/landcover and drainage density.

Several Scholars have categorized flooding into different types based on their occurrence, duration and location. Jeb (2013) looks at flooding based on their occurrences as follows:

(i) **Slow-onset floods:** Slow-onset floods usually occur as a result of water bodies over flooding their banks. They tend to develop slowly and usually last for a longer period; it may last for days, weeks and months. They usually spread over many kilometers and occur more in flood plains. The effect of this kind of flood on people is more likely to be disease and snakebites.

(ii) **Rapid-onset floods:** Rapid-onset floods usually last for a shorter period; they usually last for a day or two only. It is very destructive, but does not usually take people by surprise like flash flood.

(iii) **Flash floods:** Flash floods are associated with rivers in the inland areas where sudden heavy rains can change them into destructive torrents within a short period. They may occur within few hours (2-6 hours) after heavy rainfall, tropical storm, failure of dams (www.eschooltoday.com). Flash flood is characterized by an intense, high velocity torrent of water that is very dangerous and destructive not only because of the force of the water, but also the hurtling debris that is often swept up in the flow. There is usually no warning, no preparation and the impact can be very swift and devastating.

Flooding is also categorized based on their locations as follows:

(iv) **Coastal floods:** Coastal floods are regarded as among the most dangerous and harmful of natural disasters (Douben, 2006). A coastal flood as the name implies occurs in areas that lie on the coast of a sea, ocean, or other large body of open water. It is typically a function of storm surge, waves and heavy rainfall. In this type of flood, water overwhelms low-lying land, and often causes devastating loss of life and property. The severity of a coastal flood is determined by several factors, including the strength, size, speed, and direction of the storm. Although it is not that common in Nigeria, it does occur in coastal lowland cities like Lagos and Port Harcourt (Muoghalu and Okonkwo, 1998).

(v) **Urban floods:** Urban flooding results when development is concentrated within or along stream plains or channels. This normally occur in towns located on flat or low lying terrain especially where little or no provision has been made for surface drainage, or where existing drainage has been blocked with waste, refuse and eroded soil sediments. In Nigeria, urban flooding is a phenomenon of every rainy session in Lagos, Aba, Warri, Benin and Ibadan.

(vi) **River floods:** River flooding is a function of rainfall and run off volumes within the river valley. It usually occurs when surface water runoff introduced into streams and rivers exceeds the capacity of the natural or constructed channels to accommodate the flow of water, leading to overflowing of water and spilling out into low lying areas. The damage from a river flood can be widespread as the overflow affects smaller rivers downstream, often causing dams to break and flood nearby areas.

2.2.2 Causes of Flood

According to Olarenwaju and Fadaro (2003), flood disaster are anthropogenic activities and human interventions in the natural processes such as deforestation, climate change, population growth and economic assets in river plains has lead to alterations in the natural drainage and river basin patterns. Thus, most floods result from two major causes: Climatic and Non-climatic activities (Jeb, 2013).

(a) Climatic Causes: The following climatic phenomena are capable of causing flooding in a given area.

i. Heavy Rainfall; flooding occurs from heavy rainfall when natural water courses do not have the capacity to convey excess water. This is the dominant cause of flooding in Nigeria. Each time it rains and the volume is much for the drainage system to take, it can lead to flooding.

ii. Coastal Storm Surge; floods can also be caused by coastal storm surge, particularly in coastal areas where inundation can be caused by a storm surge associated with a tropical cyclone.

iii. Snowmelt; in many cold regions, heavy snow melts when the temperature rises can result in massive movement of water into places that are usually dry. This is worsening when the subsoil is still frozen and reduced the infiltration capacity.

iv. Climate Change; There is evidence that average sea temperatures have risen due to global warming and this rise has been blamed for the increasing frequency of storms. Climate change is expected to cause accelerated sea-level rise with elevated tidal inundation, increased flood frequency, accelerated erosion, increasing storm surges and increasing

frequency of cyclones (Fenster and Dolan 1996). Such storms bring heavy rainfall and storm surges along the coastline of countries lying in their path.

(b) Non-Climatic Causes: Flooding can also be caused by other non meteorological or climatic causes such as anthropogenic and natural causes as follows.

i. Earthquakes, Volcanic eruption and Landslide; Floods can also be caused by earthquake, volcanic eruption, and landslide which can disorganize river flow patterns and often makes them to flood the surrounding flood plains.

ii. Dam Collapse; Dams are man-made blocks mounted to hold water flowing down from a high land. Dam break can be triggered by earthquake, volcanic eruption and landslide, which can lead to flooding of the downstream area, even in dry weather condition.

iii. Blocked Drainages; Drainage consists of largely impermeable concrete which take water quickly and directly to the river channel. The drainage system is an important physical factor that greatly contributes to flood disaster. If the drainage systems are blocked it can cause flooding especially in urban areas.

iv. Relief; The relief of an area plays a very significant role in the occurrence of flood disaster in a particular area. Since water responds to slope, a hilly area will discharge its water to lower elevation areas. This terrain pattern justifies why a highly prone areas to flood are areas with relatively low elevation.

v. Deforestation; Trees and plants normally help in absorbing too much water. When forests are cut or burned down, water from rainfall flows down barren land and can lead to flooding.

2.2.3 Consequences of Flooding

Flooding is one of the major environmental disasters one has to contend with, it has both positive and negative consequences. These consequences vary greatly depending on their location, duration, depth and speed, as well as the vulnerability and value of the affected natural and constructed environments they affect (IBIS World, 2011).

(i) Positive Consequences of Flooding: The good thing about water overflowing its banks is that, as water flows into the surrounding, sand, silt and debris are deposited into the surrounding land (Abowei and Sikoki, 2005). Floods are not always destructive natural events; flood brought along nutrients and made the land around the rivers fertile. Flooding could be constructive and economical.

(ii) Negative Consequences of flooding: Floods can have devastating negative effects on the economy, environment and people. During floods (especially flash floods), roads, bridges, farms and houses are destroyed. Additionally, the government deploys police and other emergency apparatuses to help the affected people. All these come at a heavy cost to people and the government. It usually takes years for affected communities to be re-built and business to come back to normalcy (Bunn and Arthington, 2002). The environment also suffers when floods happen. Chemicals and other hazardous substances end up in the water and eventually contaminate the water bodies. Also, many people and animals have died in floods. Also, Water supply and electricity are disrupted and people struggle and suffer as a result. In addition to this, flooding brings a lot of diseases and infections and sometimes insects and snakes make their ways to the area and cause a lot of havoc.

2.2.4 Flood Vulnerability

Flood vulnerability is one of the significant components in risk management and flood damage assessment (Connor and Hiroki, 2005). Since vulnerability is found to be the main reason of disasters, it seems necessary to develop our perception of the vulnerability (Klein, 2004). Different definitions and description of vulnerability has been given; United Nations defined vulnerability as a degree of damage to a certain objects at flood risk with specified amount and present in a scale from 0 to 1 (no damage to full damage) (United nations, 1982). Alexander (2002) and UNDP (2004) defined Vulnerability as a condition which is influenced by physical, social, economic and environmental factors that raises the susceptibility of people to the hazard impact. Fuchs, Kuhlicke and Meyer (2011) considered vulnerability as the extent of harm, which can be expected under certain conditions of exposure, susceptibility, and resilience of each community in risk condition. UNESCO (2012) described vulnerability as a place on the earth surface to which flood is a function of the place exposure to the hazard due to anthropogenic activities carried out within the catchment area, which impedes the free flow of water.

From these definitions, they all pointed to the fact that human systems are vulnerable to floods due to three factors: exposure, susceptibility and resilience (Balica, Douben and Wright, 2009). The vulnerability of any system is reflective of the exposure and susceptibility of that system to hazardous conditions and the resilience of the system to adapt and recover from the effects of those conditions (Smit, 2006). These flood vulnerability factors are discussed in details as follows;

i. Exposure to Flood Hazard: Exposure can be understood as the values that are present at the location where floods can occur. These values can be goods, infrastructure, cultural heritage, agricultural fields and people (United Nations, 2003). Also, Fekete (2009) describes exposure as the measure of susceptible elements within a region threatened by a hazard. While in Penning-Rowsell, Floyd, Ramsbottom and Surendran (2005), exposure is defined as the likelihood that humans and physical items will be impacted by flooding. UNISDR (2009) refers exposure to people and their surroundings and every element present in flood prone area being exposed to the flood impacts as a subject to potential losses.

ii. Susceptibility to Flood Hazard: The concept of susceptibility has developed through the years. For example, Penning-Rowsell and Chattereron defined susceptibility in 1979 as the relative damageability of property and materials during floods. The IPCC (2001) argued susceptibility as the degree to which a system is affected, either adversely or beneficially, by climate-related stimuli. Cardona *et al*. (2012) on the other hand, simply refer it to people, environment and infrastructure tendency to be influence by a hazard because of fragility of community or ecosystem. Susceptibility relates to system characteristics, including the social context of flood damage, especially the awareness and preparedness of people regarding the risk they live with (before the flood), the institutions that are involved in mitigating and reducing the effects of the hazards and the existence of possible measures, like flood hazard maps to be used during the floods.

iii. Resilience to Flood Hazard: Holling, originally, defined resilience in 1973 as a measure of persistence of systems and their ability to absorb change and disturbance and still maintain the same relationships between populations and state variables. Pelling (2003)

defined Resilience as the capacity of any kind of system, community, society or environment, potentially exposed to hazards to adapt to any change, by resisting or modifying itself, in order to maintain or to achieve an acceptable level of functioning and structure. Pelling (2004) defined resilience, as the coping and adaptation ability of a system in addressing disaster stress. This study instances the vulnerability of Ibaji local government areas as reflection of the exposure and susceptibility of the city to flood risk and the resilience of that region to cope and recover from the flood effects as noted in (Smit, 2006).

2.2.5 Vulnerability Mapping

A vulnerability map gives the precise location of sites where people, the natural environment or property are at risk due to a potentially catastrophic event that could result in death, injury, pollution or other destruction. In flood hazard, a vulnerability map could delineate the commercial, tourist, and residential zones that would be damaged in case of flood occurrence. Nelson (2015) stated that, vulnerability mapping is used to determine the areas susceptible to flooding when discharge of a stream exceeds the bank-full stage. Though, vulnerability maps can be created manually using background maps such as topographic maps. Most often, Vulnerability maps are created with Geographic Information Systems (GIS) and Global Positioning System (GPS) (Janet, Martin and Barbro, 2007).

Vulnerability maps can be of use in all phases of flood management: Prevention, mitigation, and preparedness measures. In the prevention stage, vulnerability maps serve to identify areas that are prone to flooding. Knowing these areas will allow for better visual presentations and understanding of the risks so that decision makers can see where resources are needed for protection of these areas. Mitigation is used to prevent or reduce loss of life

and injury (i.e. Riverbanks and canals can be widened and strengthened or to know if objects are to be relocated). After flood disaster, vulnerability map could be used to show the extent of the damage, from which one assess how well flood was managed. Several tools are employed in vulnerability mapping as follows.

1. Remote Sensing Techniques: Nowadays, satellite imageries and information derived from them are used in models to predict runoff and river discharge, and subsequent likelihoods of floods, and area at risk to flood (Shrestha, 2008). With the improvements in the resolutions of imageries and possibility of stereo capability and digital image processing method, the use of satellite imageries has become increasingly important for hazard and risk assessment. The emerging trend of researches on natural hazards by applying modern remote sensing techniques is a testimony of this (Bikram, 2010). Remote sensing provides synoptic data of the area either in real-time or near real-time in different spatial or temporal resolutions for different magnitude of flood (Jeb, 2013).

For planning the flood control and related works, reliable and timely information about flooded areas, river behavior and configuration prior to floods, during the floods and after the floods are required, such information are very difficult to acquire through conventional ground surveys. Advent of satellite remote sensing technology has helped in solving the problems of mapping flood vulnerable areas, monitoring and management of floods.

2. GIS and Vulnerability Mapping: Geographic Information system (GIS) is defined as computer systems capable of assembling, storing, manipulating, and displaying geographically referenced information (USGS, 1998). In the context of flood vulnerability mapping, GIS can be used to create interactive map overlays, which clearly and quickly

illustrate which areas of a community are in danger of flooding. Such maps can then be used to coordinate mitigation efforts before flood event and recovery after flood event (Awal, 2003). On the other hand, GIS also provides the environment for the integration of remote sensing data and different spatial and attribute datasets to delineate the flood affected areas under different magnitudes of floods or flood scenarios such as breach in the embankment, overtopping and unprotected rivers (Sharma, 2004; Forku, 2011).

3. Analytic Hierarchy Process: Analytic Hierarchy Process (AHP) is a theory of measurement through pair-wise comparisons and relies on the judgments of experts to derive priority scales. The pair-wise comparisons were developed by Saaty in (1980) in the context of a decision making process known as the Analytic Hierarchy Process (AHP). Saaty (1987) also defined it as a general theory of measurement that can be used to derive ratio scales from both discrete and continuous paired comparisons. The comparisons are made using the scale of absolute judgments that represents how one element dominates another with respect to a given attribute.

Pair-wise comparison involves the comparison of the criteria and allows the comparison of only two criteria at once which often results in a ratio matrix (Saaty, 1980). This method can convert subjective assessments of relative importance into a linear set of weights (Heywood, Oliver and Tomlinson, 1993). It takes pair-wise comparison as inputs and produces relative weights as outputs. This technique has found its widest applications in multi criteria decision. According to Figuera, Greco and Ehrgott (2005) processes for which we evaluate different factors has become mathematical science. This decision making involves many criteria and sub-criteria used to rank the alternatives with respect to the criteria or sub-criteria in terms of which they need to be evaluated.

2.3 Literature Review

This section focused on relevant literatures that have link with the topic

2.3.1 Flood Disasters in Nigeria

Flooding has always been a part of human history. The fact that many settlements developed along waterways because of the economic benefits makes people and infrastructure vulnerable. In Nigeria, flood accounts for the highest occurring natural hazards, with great consequences on the life and property (Aderogba, 2012). This flood hazard is becoming a yearly event: it occurs in the form of river flood, flash floods, urban floods and coastal floods (Akinola, Suleiman and Francis, 2015).

River flooding occurs in the flood plains of the larger rivers when their side channels overflow causing extensive inundation (Asian Disaster Preparedness Center, 2005). Flash floods are associated with rivers in the inland areas where sudden heavy rains can change them into destructive torrents within a short period (www.eschooltoday.com). Urban flooding occur in towns located on flat or low lying terrain especially where little or no provision has been made for surface drainage, or where existing drainage has been blocked with municipal waste, refuse and eroded soil sediments (Jeb, 2013). Coastal flooding usually occurs in low land coastal areas and is usually triggered by winds from offshore storms and tsunamis (Etuonovbe, 2011). Coastal flooding is described by Ologunorisa (2006) as the most dangerous of all the flood types. Although it is not that common in Nigeria, it does occur in coastal lowland cities like Lagos and Port Harcourt (Muoghalu and Okonkwo, 1998).

Flooding is the most frequent natural hazard accounting for about one-third of all

disasters arising from geophysical hazards and adversely affecting more people than any other natural hazard (Adebayo and Oruonye, 2013). Flood disasters according to Obeta (2009) accounted for about 38% of all the federally declared natural disasters between 1995 and 2005 in Nigeria. According to Adeoye, Ayanlade, Babatimehin, (2009) several flood disasters have occurred in Nigeria and more than half of the 36 States in Nigeria have been hit by one form of flood or another. Some of the States that have been badly affected by floods in the country include Benue, Borno, Cross River, Ebonyi, Gombe, Kaduna, Kebbi, Kogi, Lagos, Ogun, Oyo, Plateau and Sokoto (Obeta, 2014). Despite the fact that several studies have been conducted on flooding across the country, flooding is still an annual event in many Nigerian communities.

Table 2.1: A Review of Some Recent Flood Disaster in Nigeria

Year	Location	Cause	Recorded Effects/Estimated Damage	Source
2012	22 states	Overflowig of River Niger	Over 431 deaths, millions of people displaced, properties worth billion of naira destroyed.	Adebayo and Oruonye (2013)
2015	Zamfara	Rainfall	10 deaths, 46,200 people displaced, 6,450 hectares of farmland destroyed.	Premium Times 20/09/2015
2016	Calabar	Rainfall	30 housing units submerged, 200 people displaced.	Premium Times 11/04/2016
2016	Ebonyi	Overflowig of Iyi-Udele River	About 5,000 people displaced, over 100 houses destroyed.	Floodlist 12/06/2016
2016	Sokoto	Blocked drainages	635 houses destroyed and over 5000 people displaced.	Daily Trust 23/07/2016
22016	Kano	Rainfall	18 deaths, properties worth 700 million naira destroyed	Today Newsletter 26/07/2016

Source: Literature Review (2016)

2.3.2 Flood Occurrence in Ibaji Local Government Area

Ibaji Local Government Area has recorded varying degrees of flooding and it is known in Kogi state as a hot spot for flood disaster. According to Kogi State Emergency Management, the entire population of Ibaji is under threat to flood disasters (KOSEMA, 2012). The problem is worsened due to the fact that most people living in Ibaji are poor. This poor flood disaster victims keep on increasing along the flood plain placing additional people and infrastructure at risk. Table 2.2 summarizes flood events in Ibaji Local Government, Kogi State.

Table 2.2: A Review of Some Flood Disaster in Ibaji L.G.A

Year	Cause	Recorded Effects/Estimate damage	Source
2000	Overflowing of river Niger	Over 20,000 people rendered homeless.	Obeta (2014)
2002	Heavy rainfall	17 communities submerged with properties worth millions of naira destroyed.	KOSEMA (2002)
2007	Overflowing of river Niger	About 43,000 people displaced and many properties and farm produce destroyed.	KOSEMA (2007)
2012	Overflowing of river Niger	8 deaths recorded, most communities submerged.	Aderoju et al (2014)

Source: Literature Review (2016)

2.3.3 Application of Remote Sensing and GIS in Flood Vulnerability Analysis

Remote Sensing and GIS have proven to be very effective in flood vulnerability studies. This technique has really helped in gathering and analyzing flood events problem. Due to the importance of Remote Sensing and GIS, it has been used in different parts of the world to carryout flood vulnerability studies. Samarasinghe, Nandalalb, Weliwitiyac, Fowzed and

Hazarikad (2010) carried out flood risk analysis of river Kalu-Ganga in Sri Lanka. The study combined satellite imageries, rainfall data, field survey and census data for hazard and vulnerability analysis of the river. The results revealed areas at high risk with respect to population and buildings and predicted 100 years return period of flood event. It showed that approximately 19% of population is highly vulnerable for 100 year return period flood event whilst the remaining 74% and 7% of them fall into moderate and low vulnerability classes respectively.

Enyinnaya and Ogbonna (2015) assessed flood vulnerability in Aba, Southeastern Nigeria. The study used Remote Sensing and Geographic Information System in investigating the relationship between topographic information and trends in rainfall in Aba. The results showed that virtually all parts of Aba were liable to flood except Ogbor hill axis and 71.65% of the study area was vulnerable to flood. The study carried out by Eguaroje *et al*. (2015) on flood vulnerability assessment of Ibadan city, Oyo state, Nigeria adopted Remote Sensing and GIS techniques in identifying the major factors contributing to flood and effect of flood in Ibadan. The results revealed that mean annual rainfall contributed to flooding than other factors considered in the model followed by slope, drainage and land-use.

Emmanuel, Ojinnaka, Baywood and Gift (2015) also carried out a study on flood hazard analysis and drainage assessment of 2012 flood in Anambra state. The study implored Geographic Information System techniques in identifying the extent of damages resulting from 2012 disaster in Anambra state and also mapped out areas vulnerable to flood hazard. The result revealed that a total landed area of 1078Sq.Kms was covered by flood and property worth over twenty three billion naira was damaged. The study further classified and identified areas of very

high, high, moderate, low and no hazard zones.

Muhammad and Iyortim (2013) carried out flood vulnerability mapping of river Kaduna. The study applied Remote Sensing techniques and GIS techniques to produce flood map of the Middle Course of river Kaduna. High resolution imagery was used to identify flood prone areas along the middle course of the river. A flow accumulation model was created using DEM and the DEM was reclassified into high risk, moderate risk and low risk. The result showed that Tudun Wada, UngwanRimi, Kudendan, sabo and Barnawa areas fall within the flood prone zone. Ishaya, Ifatimehin and Abaje (2009) carried out flood vulnerability mapping of developing urban centre of Nigeria. The study used integrated approach of remote sensing and geographic information system techniques in mapping areas vulnerable to flood hazard in Gwagwalada. The result showed that, areas lying along the banks of river usuma are most vulnerable to flood hazards. The old town is the most vulnerable to flood threat. Phase 1, 2 and 3 are free from flood threat except for the extreme northwestern part of phase 3.

In most of these studies, satellite imageries were used in generating landuse/landcover map and buffering or overlay methods were used in mapping vulnerable areas. There were no attempts to use analytic hierarchy process to identify the major factors influencing flood and the vulnerable areas determined from these flood causative factors.

2.3.4 Application of GIS-Based AHP in Flood Vulnerability Mapping

This section reviews studies that employed Analytical hierarchy process to analyze flood vulnerability. According to Hajara (2015) only few examples of application of Multi Criteria Evaluation in flood management exists. Siddayao, Valdez and Fernandez (2014) assessed flood risk in Enrile, Northern Philippines. The study used GIS-based analytic hierarchy process to

identify the level of contribution of each of the flood causative factors in the area. Distance from riverbank was discovered to contribute most to flood events in the area with a weight of 63.33% followed by elevation 26.05% and population density 10.62%. These factors weight from the analytic hierarchy process (AHP) were further incorporated to produce a vulnerability map of five levels (very low, low, moderate, high and very high vulnerable areas).

Hajara (2015) carried out flood vulnerability assessment in Jalingo town Taraba state, Nigeria. The study produced thematic layers of six flood causative factors (elevation, slope, soil, drainage density, rainfall and landuse/landcover) and employed AHP to determine the influence of the flood causative factors on flood vulnerability in Jalingo. The study revealed that elevation has the greatest influence on flood occurrence in Jalingo with 25 as its weight, followed by slope and soil with 20 weights each, landuse and drainage density 13 each, and rainfall is the least contributing factor with 8. These factors were further integrated using the weighted overlay tool of ArcGIS 10.1 to determine the elements and population at risk in Jalingo.

Lawal, Matori, Hasim, Yusof and Chandi (2012) also carried out a study on flood susceptible areas in Perlis, Malaysia. The study used GIS-based analytic hierarchy process in identifying the contribution of each of the flood causative factors. The flood causative factors considered were rainfall, capacity of existing drainage, size of watershed, landuse, soil and slope. The result of the study showed that rainfall and capacity of existing drainage are the major factors contributing to flood in Perlis.

CHAPTER THREE

THE STUDY AREA AND METHODOLOGY

3.1 Introduction

This chapter consists of two parts. The first gives account of Ibaji Local Government Area in terms of size and location, weather and climate, soils, vegetation and drainage, geology and land-use. The second section discusses the materials and methods that were used to carry out this research work.

3.2 The Study Area

The various aspects of the study area that have relevance to the topic are discussed as follows.

3.2.1 Location

The study area, Ibaji Local Government Area located between Latitude 06°52'00"N 06°87'00"N of the equator, and between Longitude 06°48'00"E 06°80'00"E of Greenwich meridian. It is located in eastern part of Kogi state as shown on Figure 3.1. It has a land mass of 1, 377km² and it shared boundary with Edo State to the west, Enugu to the east, Idah Local Government to the north and Delta State to the south.

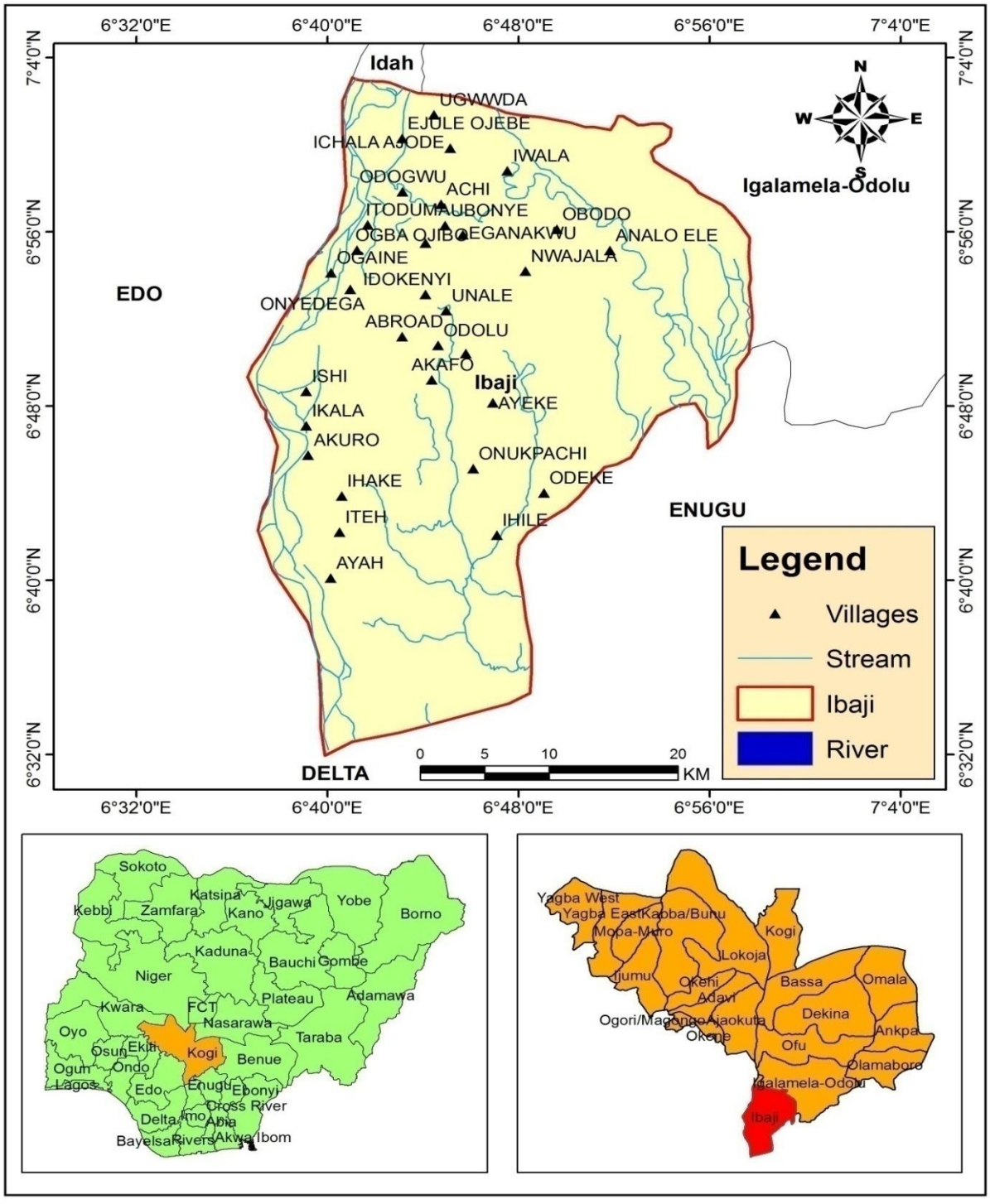

Figure 3.1: The Study Area

Source: Ministry of Lands and Survey Kogi State

3.2.2 Climate

The climate of the study area is largely controls by two major air masses, the tropical maritime air mass and tropical continental air mass, producing two seasons; the wet season and dry season. The wet season which last for a period of six (6) months usually begins around April and ends in October. About 70% of the rain in Ibaji local government falls between July and September, with mean annual rainfall between 1,523mm and 1,625mm (NIMET, 2015). The dry season is characterized by the prevalence of the Northeast trade wind popularly known as harmattan wind which begins from November and last till March. During the harmattan, there is cold, dry and laden wind which is prevalent during the peak of the dry season. Formation of morning dew is highly prevalent and Ibaji local government has an average maximum temperature of 31.3ºC and minimum temperature of 20ºC with the highest temperature experienced in the month of March.

3.2.3 Geology

The study area which falls under kogi state is dominantly underlain by the Precambrian complex and sandstones (Aderoju et al. 2014). However, part of the area is underlain by cretaceous sediments which unconformably overlie the basement complex and ridges of cretaceous sediments. Migmatite also covers large part of the study area outcropping at the southwest, west, northwest and central parts of the area. The South and Southeast parts of the area are underlain by undifferentiated older granite, mainly porphyroblastic granite, granite gneiss and fine grained biotite granite.

3.2.4 Soils

The soil of Ibaji Local Government Area consists of sandy, loamy and clay. Sandy lies in the

western part, while the loamy soil dominates the areas and clay soil lies in the eastern part. According to Federal Department of Agricultural Land Resource-FDALR of Nigeria (1990), the sandy soil is moderately poorly drained while the loamy soil on the other hand is well drained. The sandy soil favors the cultivation of groundnut, while the sandy loam is good for cultivating yam, rice, maize and guinea corn (Adagba, 2000).

3.2.5 Drainage System

Ibaji is drained by many streams and river Niger which is the principal river of West Africa with a length of 2,600miles, and it is the third longest river in Africa after the Nile and Congo rivers. This river had streamlined the settlement to a linear one. The Niger rivers rises in Guinea at 9°05'N and 10°47'N on the eastern side of the Fouta Djallon (Guinea) highlands, only 150miles from Atlantic Ocean (Akinlawon, ND). It flows due north over the first 100miles. In Nigeria, it has many tributaries, the major among them being Jebba, Kaduna River, Gongola River and river Benue which is an important tributary that contribute greatly to the river. The river flows from Lokoja downstream to the study area (Ibaji).

3.2.6 Land-use

The land-use type of Ibaji Local Government Area consists of built-up environment, farmland, bare land, vegetation and water body. The people live in bricks houses and mud houses, with tarred and un-tarred roads linking settlements. The built-up environment land use pattern is characterized by residential, agriculture, academic, commercial, health, religious, government facilities, open spaces among others.

3.3 METHODOLOGY

T he methodology adopted in this study is discussed as follows;

3.3.1 Reconnaissance

Reconnaissance survey was carried out in order to have a good knowledge of the study area. During the reconnaissance survey checklist method was used in observing the river plain and the proximity of each community to the river. The researcher found out that many settlements and farm lands were located along the river Niger bank.

3.3.2 Nature and Sources of Data

The primary materials used for the study include:

Table 3.1: Nature and Sources of Data

Data	Data Source	Data Source Type	Year
GPS Coordinates	Field work	Primary	2016
SRTM (90m)	GLCFI	Secondary	2005
Landsat ETM (30m)	USGS	Secondary	2015
Rainfall	NIMET	Secondary	1985-2015

Source: Field work

3.3.3 Methods of Data Collection

The materials were used as follows;

Satellite imagery (Landsat ETM imagery of 2015 with spatial resolution of 30m) obtained from United States Geological Survey was used to generate the landuse/landcover map of the study area. The information on landuse/landcover map is necessary in order to map out areas

vulnerable to flooding. A handheld Global Positioning System was used to obtain coordinates of settlements in the study area. The coordinates were used in determining the vulnerability level of settlements. Shuttle Radar Topographic Mission (SRTM) of 90m resolution obtained from Global Land Cover Facilities Index was used in generating the slope map, elevation map and drainage map of the study area. Rainfall data sourced from Nigeria Meteorological Agency (NIMET) Kogi State was used to generate rainfall distribution pattern in the study area. Soil map sourced from Ministry of Agriculture, Kogi State was also used in obtaining soil information in the study area. Questionnaires were administered to residents of the study area to collect data on the issues relating to the people's perception on the effects of flooding and coping strategies adopted by residents to flood risk in the study area.

High speed processing digital electronic hp Laptop was used to collect, store and analyze the data used in this study. And the following software were used

i. ArcGIS 10.2 was used to generate and integrate the thematic maps for the analysis.

ii. ERDAS IMAGINE 9.2 was used in the landuse/landcover classification.

3.3.4 Sampling Size and Sampling Technique

Ibaji LGA comprises of ten wards as shown on Table 3.1. All the wards were selected to represent the study area. Questionnaires were administered to the residents of the area from 18 years and above. In order to obtain the population of wards as at 2016, the 2006 population figures of Ibaji Local Government Area was projected to 2016 and the projection was done using growth rate of 3% (NPC, 2006).

$Pn = Pi(1+r/100)en$……..Equation 1

Where: Pi = population at the base year; r = growth rate (3%); n = interval years; e = exponential

Pn = Pi(1+r/100)en; Pn = 127572(1+3/100)e×10;

Pn = 171,447

Table 3.2: Population Distribution by Wards in Ibaji L.G.A

S/No.	Wards	Ward Pop. (2006)	Pop. Projection (2016)
1	Akpanya	16951	22781
2	Analo	10656	14321
3	Ayah	16009	21515
4	Ejule	12655	17007
5	Iyano	14863	19975
6	Odeke	11206	15060
7	Ojile	8552	11493
8	Onyedega	17757	23864
9	Ujeh	6854	9211
10	Unale	12069	16220
Total	10	127572	171447

Source: Computed from the 2006 Census Figures of Ibaji L.G.A.

In order to get the sample size of the population of Ibaji, Yamane (1967) formula was used to determine the sample size from the population. Yamane formula is used because it calculates sample size with 95% confidence level and 5% error assumption.

$n = N/1+N(e)^2$……Equation 2

Where n =sample size, N = population of the area, e = error margin (at 0.05).

n = 171447 / 1+171447(0.05)²; n = 171447 / 1+171447(0.0025); n = 171447 / 428.62

n = 399.99

Base on this calculation, 400 questionnaires were distributed for the study as shown on Appendix I. Data were collected on the issues relating to the people's perception on the effects of flooding and coping strategies adopted by residents in the study area using the questionnaires. The proportion of questionnaires administered in each ward is shown in Table 3.2.

Table 3.3: Proportion of Questionnaires Administered in the Wards

S/NO	Wards	Questionnaires to be administered
1	Akpanyo	53
2	Analo	33
3	Ayah	50
4	Ejule	40
5	Iyano	47
6	Odeke	35
7	Ojile	27
8	Onyedega	56
9	Ujeh	21
10	Unale	38
Total	10	400

Source: Computed from the 2006 census figures of Ibaji L.G.A

3.3.5 Data Processing

i. Image Processing: Satellite imagery of Ibaji Local Government Area was enhanced to improve visualization of features using ERDAS IMAGINE. Georeferencing was also carried out to translate the images real world coordinates to digital format, this is to define data sets in physical space and establish their location in the real world. The imagery was assigned

(Universal Traverse Mercator) coding using ArcGIS 10.2. The UTM System was adopted because of its high reliability since its measurements are cited in linear and decimal units rather than in angular and non-decimal units (Wilford, 1977).

ii. Generation of Landuse Map: The landsat 8 Imagery of Ibaji Local Government (30m) was geo-referenced using the Universal Traverse Mercator (UTM) Zone 32 North with datum WGS 1984. The area of interest was clipped out of the imagery. The Landsat imagery and shuttle radar topography mission were sub-mapped to Ibaji. Finally unsupervised classification was carried out into five classes (water body, vegetation, farmland, bare land and built-up area).

iii. Generation of Slope and Elevation Maps: The digital elevation model (DEM) Module creation of ArcGIS 10.2 was used to create digital elevation model (DEM) of Ibaji local government from Digital Elevation Dataset of Shuttle Radar Topography Mission (SRTM) version 2 (90). This was used to produce slope map and elevation map of the study area using spatial analysis tools on ArcGIS 10.2.

iv. Generation of Drainage Density: The drainage density of Ibaji Local government area was generated from shuttle radar topography mission data. The area of interest (Ibaji Local Government) was clipped out of Shuttle radar topography mission version 2 (90m) of SRTM Nigeria 2005. The spatial analysis tools on ArcGIS 10.2 software was used in computing the drainage density of Ibaji local government area.

v. Generation of Soil Map: The soil map of Nigeria was scanned and imported into ArcGIS 10.2 environment where it was geo-referenced using UTM Zone 32 North with datum WGS 1984. Ibaji Local Government Area was subset from the soil map of Nigeria and the soil types of Ibaji were digitized.

vi. Generation of Rainfall Map: The mean annual rainfall for 30 years was used to create rainfall map of Ibaji Local Government by interpolating from five (5) meteorological stations (Idah, Nsukka, Uromi, Ukehe and Itobe) that are close to Ibaji due to lack of rainfall data of the study area. The Kriging method on the spatial analysis tool of ArcGIS 10.2 was used for the Interpolation.

vii. Steps Used in Deriving Criterion Weight Using AHP

The relationship between the six causative thematic map and their attributes were derived using analytic hierarchy process (AHP). The methodology used for deriving their weights involved the following steps:

Step 1: Defining the problem clearly and decomposing it into various thematic layers containing the different features/classes of the individual themes so that they form a network of the model (Saaty, 1980).

Step 2. Generating Pair-wise comparison matrices: The relative important values are determined with Saaty's 1-9 scale (Table 3.4) where a score of 1 represents equal importance between the two attributes, and a score of 9 indicates the extreme importance of an attribute compared to the other one (Saaty, 1980).

Table 3.4: Fundamental Scale for Pair-wise Comparison

Intensity of Importance	Definition	Explanation
1	Equal importance	Two elements contribute equally to the objective
3	Moderate importance	Experience and Judgment slightly favor one Element over another
5	Strong importance	Experience and judgment strongly favor one Element over another
7	Very strong importance	One element is favored very strongly over another; its dominance is demonstrated in practice
9	Extreme importance	The evidence favoring one element over another is of the highest possible order of affirmation
	2,4,6 and 8 are intermediate values	

Source: Saaty (1980)

Based on the thematic layers used for delineating flood vulnerable areas, pair-wise comparison matrix was derived using Saaty's nine point importance scales. The AHP captures the idea of uncertainty in judgments through the consistency index (Saaty, 1980). The measure of consistency given by Saaty (1980) is as follows.

Consistency Ratio (CR) is a measure of consistency of judgment amongst the criteria.

i. The rule of thumb states that the consistency ratio (CR) should be less than or equal to 0.1. Thus a value of 0-0.1 is accepted in practice.

ii. Higher values indicate that the judgment needs to be re-visited.

iii. Consistency ratio is evaluated as follows: CR=CI/RI

Where CI= Consistency Index which reflects the consistency of one's judgment.

And CI= λmax-n/1-n. λ is calculated by averaging the value of the consistency vector (calculated factor weight).

Table 3.5: RI= Random Inconsistency Index that is Dependent on the Sample Size

n	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.58	0.89	1.12	1.24	1.32	1.41	1.45	1.49

Source: Saaty (1980)

In identifying the factors influencing flooding in Ibaji Local Government Area, the six flood causative thematic maps produced (Landuse/landcover, slope, elevation, drainage, soil and rainfall) were weighted according to the estimated significance towards causing flooding using the three steps involved in pair-wise comparison (Saaty, 1980). The steps are:

1. Development of pair-wise comparison which uses the Saaty's scale of preference with values ranging from 1 to 9.

2. Computation of the weights

3. Estimating the consistency Ratio (CR) to determine if the comparisons are consistent or not. The formula for calculating CR is: CR=CI/RI

Where CI = Converting Index and RI = Random Index

If CR is less than 0.1, the ratio indicates a consistency in the PC and the result is accepted. However, if CR is more than 0.1, it is said to be inconsistent and has to be revisited. (Saaty, 1980).

3.3.6 DATA ANALYSIS

The major factors influencing floods in the study area were identified as follows; Landuse/landcover, slope, elevation, drainage, soil and rainfall. The factors were weighted according to the estimated significance towards influencing flooding using Analytical Hierarchy Process (AHP). The thematic maps of these factors Landuse/landcover, slope, elevation, drainage, soil and rainfall were subsequently reclassified into appropriate classes depending on the factor perceived contribution to flood occurrence using Reclass > Spatial Analysis tools > Arctoolbox on ArcGIS 10.2.

The weights generated from the flood causative analysis using Analytical Hierarchy Process were overlaid using the weighted sum in ArcGIS 10.2 spatial analysis tools to produce the flood vulnerability map. This revealed the spatial distribution of flood risk areas into five classes of very high vulnerable, high vulnerable, moderate vulnerable, low vulnerable and very low vulnerable areas.

The available flood record of 2002, 2007 and 2012 of Ibaji Local Government Area was obtained from the Kogi State Emergency Management Agency. The flood information was imported into excel and save in CVS format to be read/recognized by ArcGIS. In the ArcGIS Environment, the spatial analysis tool was used to generate the trend map. Also, Respondent's perceptions to questionnaires were analyzed using descriptive statistics such as tables, pie charts and graphs.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter presents and discusses the results of this study. The first part is on the production of thematic maps of the considered factors influencing flood. Priority scale was assigned to the factor attributes, the factors and consequently generating weights. The second part is on generating the flood vulnerability map. The third part examines the trend of the flood vulnerability. The fourth part examines the effects of flood vulnerability Level on Livelihoods of Residents while the fifth part examines the Coping Strategies to Flood Vulnerability by Communities. The results are presented in the form of maps, tables, graph and pie charts.

4.2 Factors Influencing Floods in Ibaji Local Government Area

This sub section analyzes factors that are influencing flood in the study area. The factors considered are rainfall, elevation, slope, soil, drainage density and land cover. The classes of the factors are further weighed using pair-wise comparison in Analytical Hierarchy Process and reclassified using reclass tool on ArcGIS 10.2.

i. Rainfall: The rainfall pattern of the study area was generated from the interpolation of average annual rainfall from five meteorological stations: Idah, Nsukka, Uromi, Ukehe and Itobe as shown on Appendix II which lie around Ibaji Local Government Area due to lack of rainfall data for Ibaji L.G.A. Rainfall data for a period of thirty years (1985-2015) was collected and interpolated using the spatial analysis tool of ArcGIS 10.2. The analysis revealed that rainfall amount in the study area ranges from 1523mm to 1625mm per annum as shown on Figure 4.1.

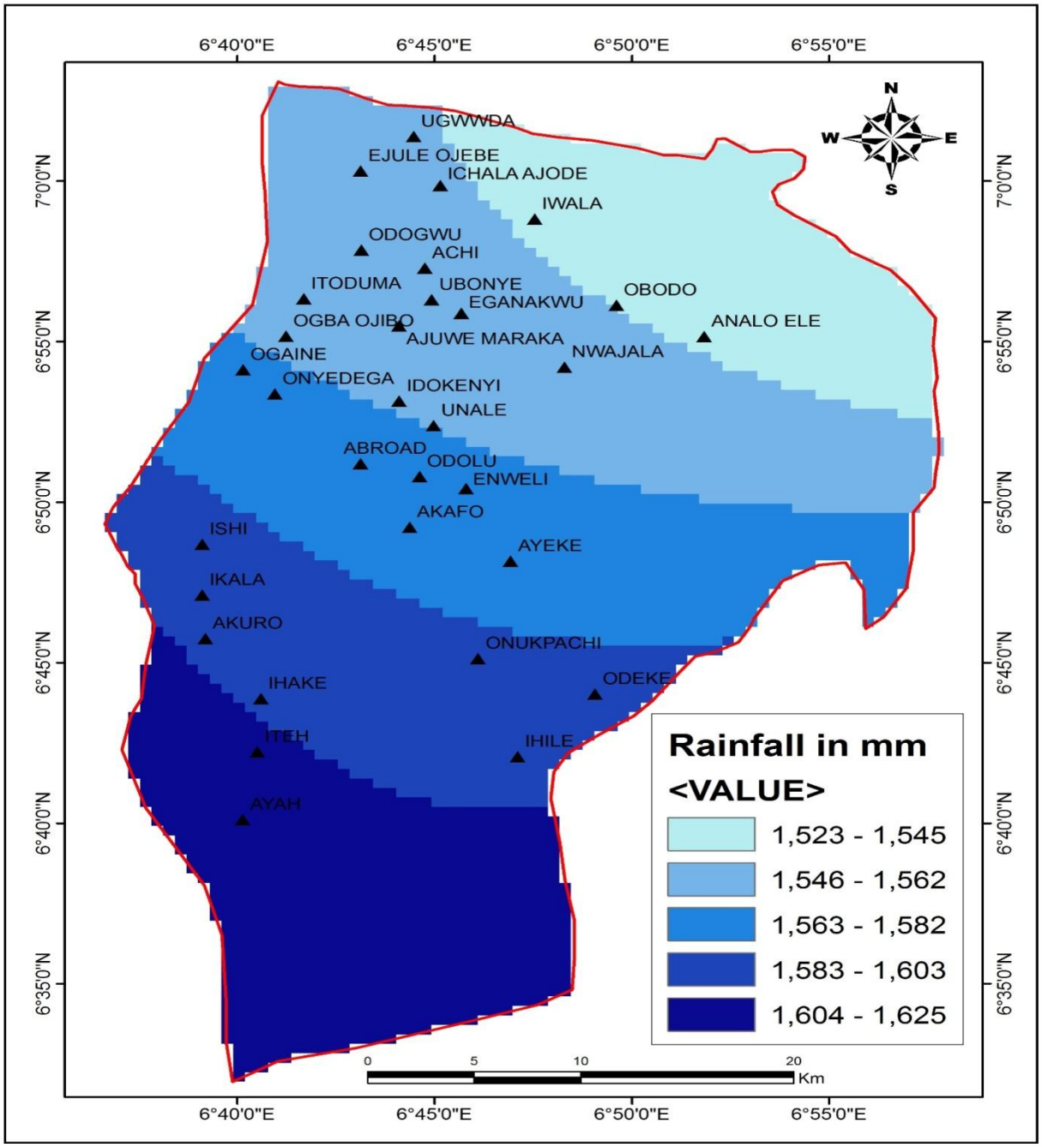

Figure 4.1: Mean Annual Rainfall Map of the Study Area

Source: Field work analysis (2016).

The result on Figure 4.1 showed the distribution of rainfall in Ibaji Local Government Area in five classes (very low, low, Moderate, High and Very High). The classification was

based on Hajara (2015) study and it showed that the rainfall increases southwards. To understand the contribution of rainfall pattern as a factor influencing flood in the study area, the five classes were further reclassified. The reclassification was done based on the rainfall pattern observed in the study area, areas with rainfall amounts between 1523mm to 1545mm per annum were considered very low, 1546mm to 1562 were considered low, 1563mm to 1582mm were considered moderate, those with rainfall amounts ranging between 1583mm to 1603mm were considered high and areas with rainfall amounts ranging between 1604mm to 1625mm per annum were considered very high. The pair-wise comparison was based on the fact that higher rainfall amounts will result in greater flood risk and vice versa. The result of the weights derived from the pair-wise comparison for the five classes very low, low, moderate, high and very high was found to be 4 for very low, 8 for low, 14 for moderate, 27 for high and 47 for very high as shown on Table 4.1.

Table 4.1: Weights for Rainfall

	1523 - 1545	**1546 - 1562**	**1563 - 1582**	**1583 - 1603**	**1604 - 1625**	**Weight *100**	**Vulnerability**
1523 - 1545	1	2	4	6	8	4	Very Low
1546 - 1562	1/2	1	2	4	6	8	Low
1563 - 1582	1/4	1/2	1	2	4	14	Moderate
1583 - 1603	1/6	1/4	1/2	1	2	27	High
1604 - 1625	1/8	1/6	1/4	1/2	1	47	Very High

Consistency Ratio= 0.01

Source: Field work analysis (2016).

With a consistency ratio (CR) of 0.01, the judgment was seen to be consistent.

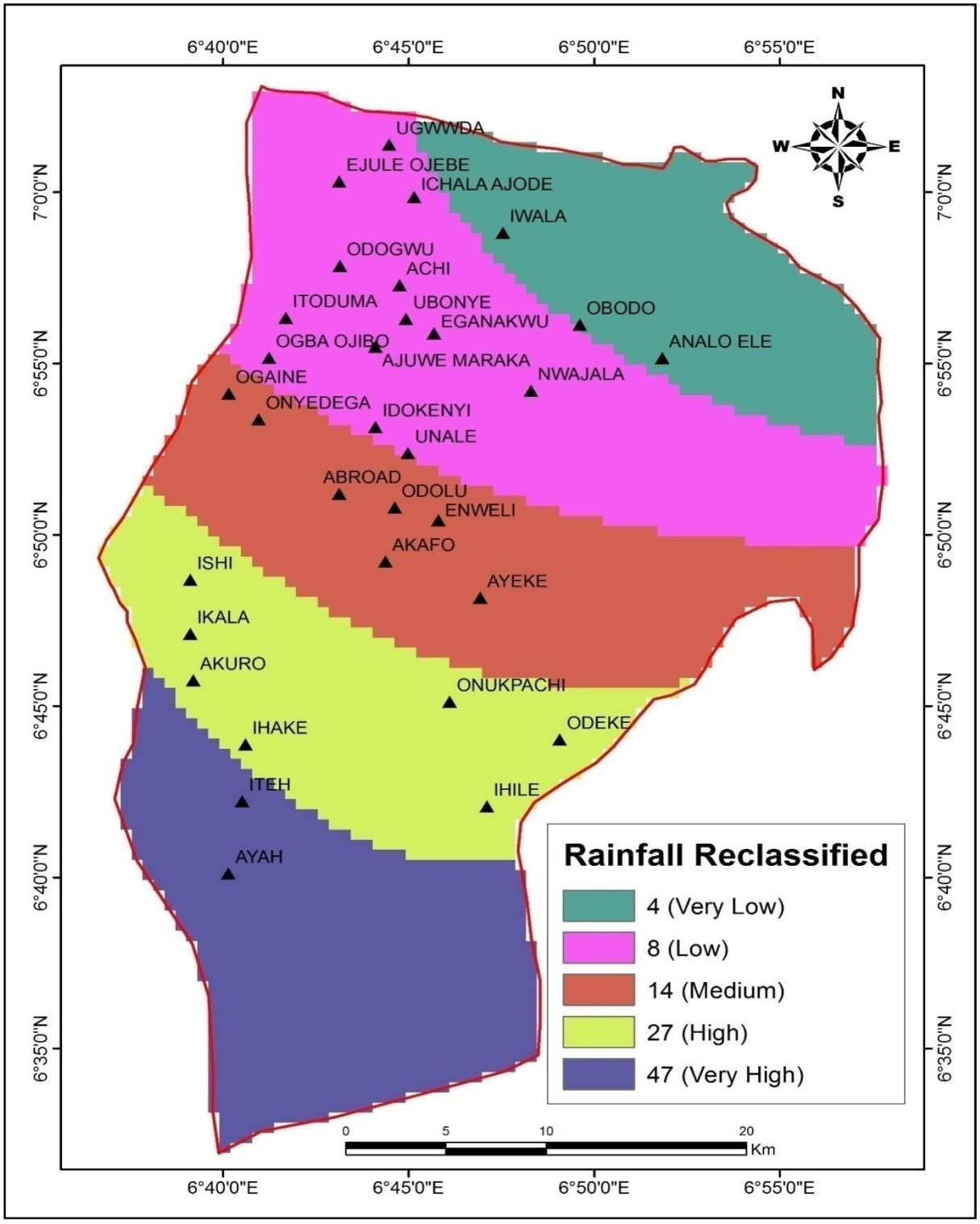

Figure 4.2: Reclassified Rainfall Pattern of the Study Area

Source: Field work analysis (2016)

The results on Figure 4.2 showed the reclassified rainfall pattern using Reclass tool on Spatial analysis tools of ArcGIS 10.2. As a result of the reclassification, five classes were obtained which are very low, low, moderate, high and very high. Looking at the classes of rainfall pattern of the study area, it clearly showed some communities (Akuro, Ayah, Ihake, Ihile, Ikala, Ishi, Iteh, Odeke and Onukpachi) receive higher rainfall than others which means that there is high tendency for those communities that experience high rainfall to be more liable to flooding than those that receive less rainfall. This result reflects the result obtained by Hajara in 2015 who work on Flood Vulnerability Assessment in Jalingo Town Taraba state, Nigeria. The result showed that communities that receive higher rainfall are more liable to flooding than those that receive less rainfall.

ii. Slope: Slope is a surface of which one end or side is at a higher level than another. The gentle the topography (low slope angle), the greater the chances for water to accumulate on the surface of the area. In other words gentle slopes will result in greater flood risk and vice versa. This is because previous study by Lindsay-Walters (2015) revealed that; the steeper the basin, the more quickly it drains and the gentle the basin, the greater the chances for water to accumulate on the surface.The slope was generated from the Shuttle Radar Topographic Mission (SRTM-90m) of the study area. The amount derived shows that the slope of the study area ranges between 0 to 51% as shown on Figure 4.3.

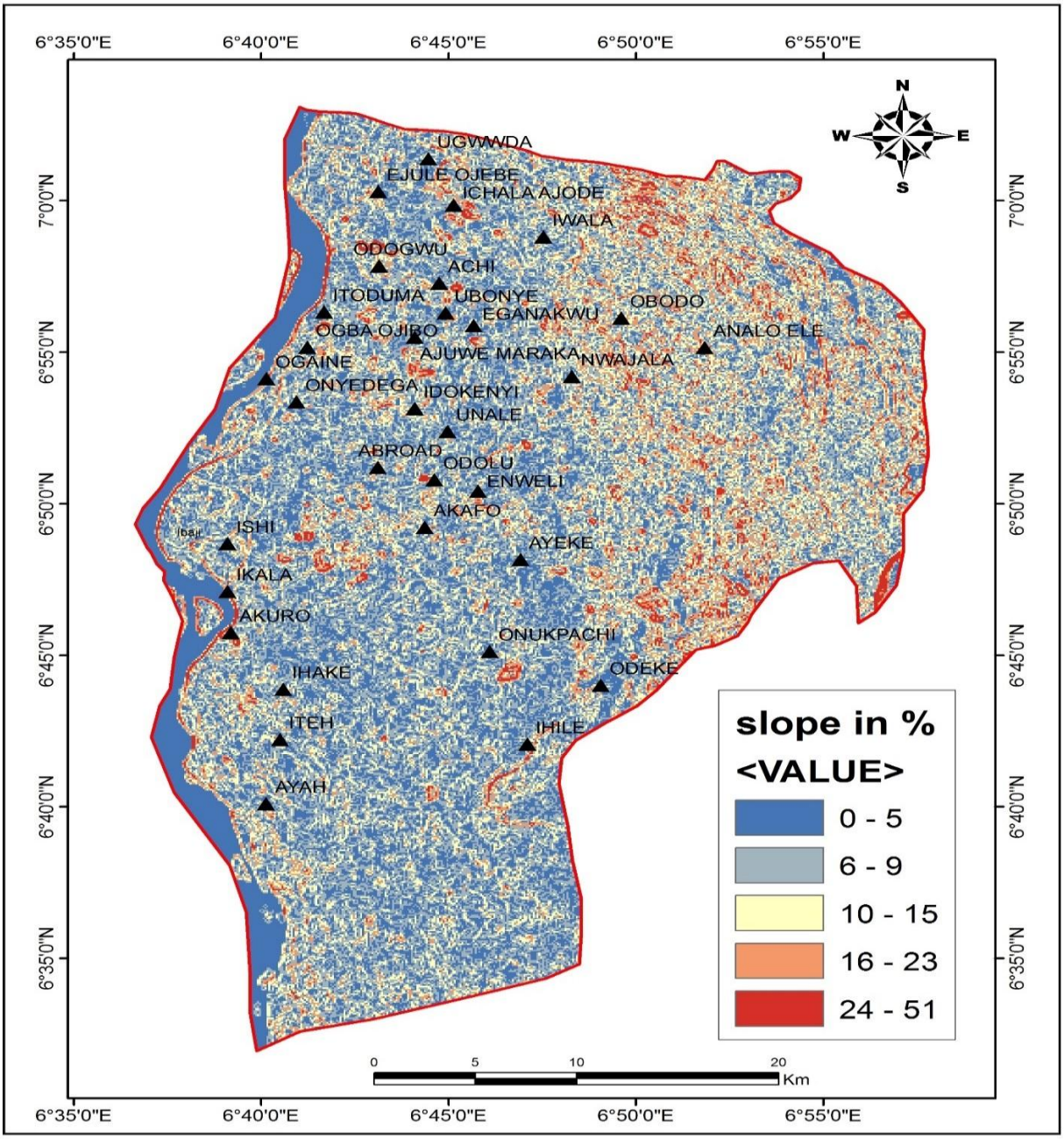

Figure 4.3: Slope Map of the Study Area

Source: Field work analysis (2016).

The data on Figure 4.3 showed the slope characteristics of the study area which ranges from 0-51 and was classified based on the nature of the slopes. In relation to the study, gentle areas where the slope amount is low are more vulnerable to flooding since they facilitate

accumulation of water on the surface. However, areas with steep slopes where the slope amounts are high encourage high run-off and low accumulation of water on the surface.

To ascertain the role of slope as a factor influencing flood in the study area, five classes of slope pattern (very low, low, moderate, high and very high) were further reclassified. The reclassification was done based on the slope pattern in the study area, areas with 0-5 were designated very high, 6-9 were designated high, 10-15 were designated moderate, 16-23 were designated low and areas with 24-51 were designated very low. The pair-wise comparison was based on the fact that the gentle the topography (low slope angle), the greater the chances for water to accumulate on the surface and vice versa. In other words gentle slopes will result in greater flood risk and vice versa. This is because previous study by Lindsay-Walters (2015) revealed that; topography of the drainage basin can affect the speed with which the precipitation flows: the steeper the basin, the more quickly it drains and the gentle the basin, the greater the chances for water to accumulate. The result of the weights derived from the pair-wise comparison for the five classes very high, high, moderate, low and very low was found to be 36, 28, 20, 12 and 4 respectively shown on Table 4.2.

Table 4.2: Weights for Slope

Slope %	**0-5**	**6-9**	**10-15**	**16-23**	**24-51**	**Weight**	**Weight*100**	**Vulnerability**
0-5	1	9/7	9/5	3	9	0.362	36	Very High
6-9	7/9	1	7/5	7/3	7	0.284	28	High
10-15	5/9	5/7	1	5/3	5	0.202	20	Moderate
16-23	1/3	3/7	3/5	1	3	0.116	12	Low
24-51	1/9	1/7	1/5	1/3	1	0.038	4	Very Low

Consistency Ratio=0.06
Source: Field work analysis (2016)

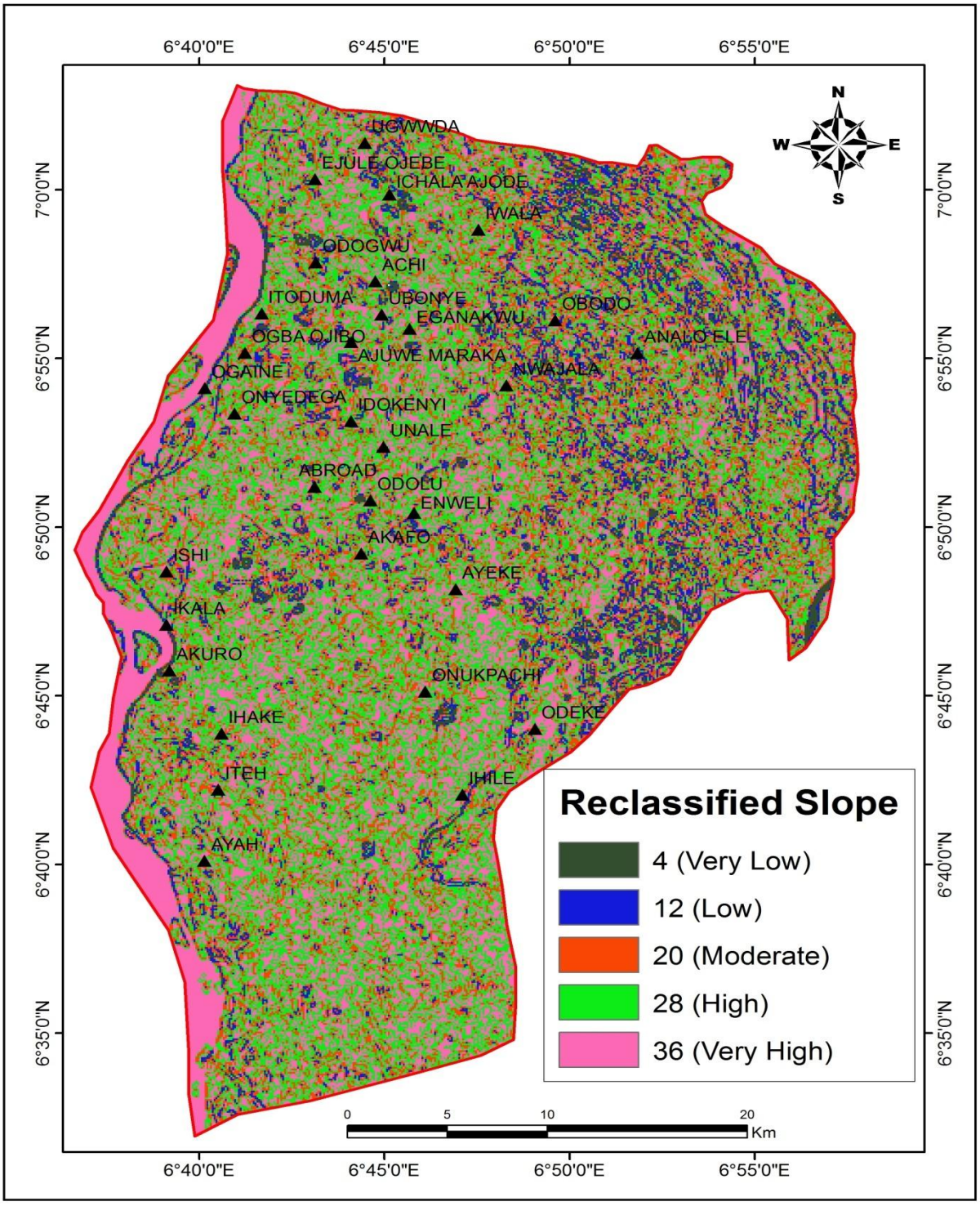

Figure 4.4: Reclassified Slope Map of the Study Area

Source: Field work analysis (2016)

The results displayed on Figure 4.4 showed the reclassified slope pattern using Reclass tool on Spatial analysis tools of ArcGIS 10.2. As a result of the reclassification, five classes were obtained which are very low, low, moderate, high and very high. Looking at the classes of the slope pattern of the study area, it showed that the study area is dominantly a low land area which means that there is high tendency for water to accumulate in the area and communities in such areas are more liable to flooding than those in areas with steep slopes. This is justified by the fact that a hilly area will discharge its water to a lower area.

iii. Elevation: Elevation is used to assess the spatial distribution of potentially endangered flood areas. According to Siddayao, Valdez and Fernandez (2015), areas on low elevations, lying adjacent to the rivers are prone to flood while those on high elevations are less prone to flood. This terrain pattern justifies why a highly prone areas to flood are areas with relatively low elevation. The elevation of the study area was obtained from the Digital Elevation Model (DEM) of the study area which was generated from the Shuttle Radar Topographic Mission with a 90m resolution**.** The DEM reveals that the elevation of the study area ranges from 6m to 56m above sea level as shown on Figure 4.5.

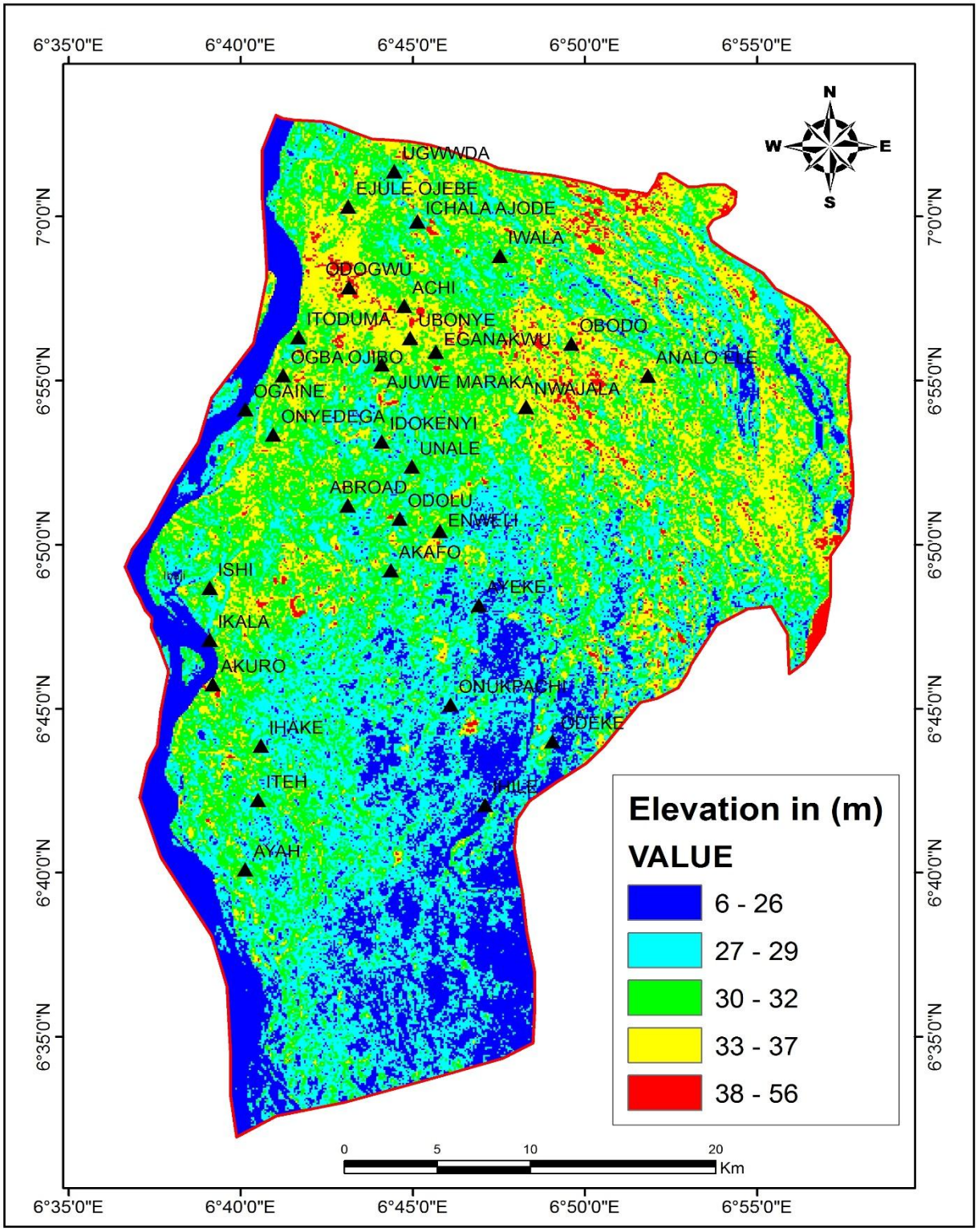

Figure 4.5: Elevation Map of the Study Area

Source: Field work analysis (2016)

The data on Figure 4.5 revealed that high elevations are found in patches to the north and eastward while lower elevations exist in the westward and around the southern areas. To ascertain the contribution of elevation as a factor influencing flood in the study area, the five classes (very high, high, moderate, low and very low) were further reclassified. The reclassification was done based on the elevation pattern in the study area, areas with elevation ranging from 6-26 were considered very high, 27-29 were considered high, 30-32 were considered moderate, 33-37 were considered low and areas with 38-56 were considered very low. The pair-wise comparison for elevation as shown on Table 4.3 was done based on the fact that areas on low elevations, lying adjacent to the rivers are prone to flood while areas on high elevations are less prone to flood. The results of the weights derived from the pair-wise comparison for the five classes very high, high, moderate, low and very low was found to be 36, 28, 20, 12 and 4 respectively. It can be seen from the Table 4.3 that areas with low elevations weight is 36 which implies very high flood vulnerability and vice versa.

Table 4.3: Weights for Elevation

Elevation (m)	**6-26**	**27-29**	**30-32**	**33-37**	**38-40**	**Weight**	**Weight*100**	**Vulnerab**
6-26	1	9/7	9/5	3	9	0.362	36	Very high
27-29	7/9	1	7/5	7/3	7	0.284	28	High
30-32	5/9	5/7	1	5/3	5	0.202	20	Moderate
33-37	1/3	3/7	3/5	1	3	0.116	12	Low
38-56	1/9	1/7	1/5	1/3	1	0.038	4	Very low

Consistency Ratio=0.06.

Source: Field work analysis (2016)

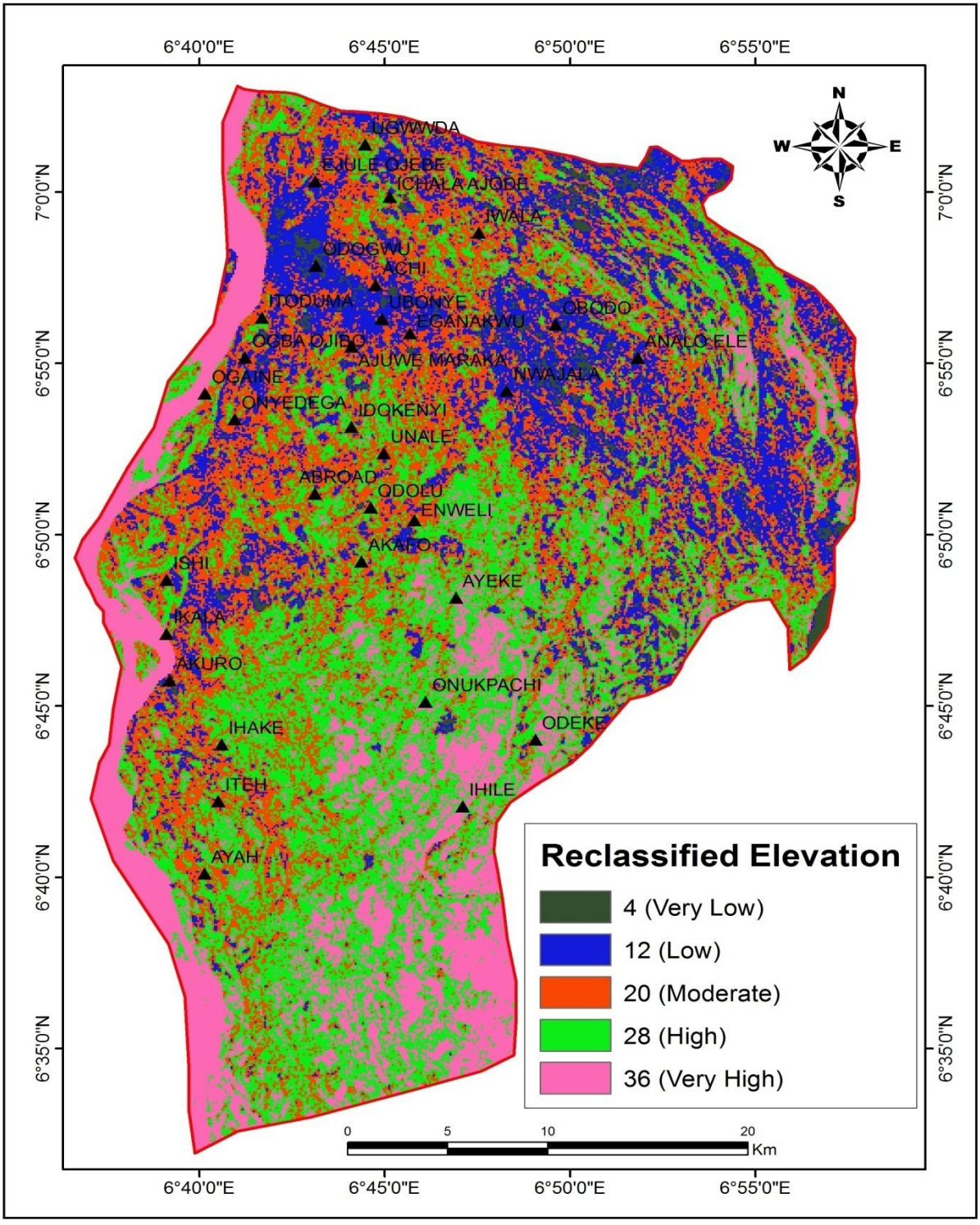

Figure 4.6: Reclassified Elevation Map of the Study Area

Source: Field work analysis (2016)

The results displayed on Figure 4.6 showed the reclassified elevation pattern using Reclass tool on Spatial analysis tools of ArcGIS 10.2. As a result of the reclassification, it revealed that some communities are within the low elevation areas which means that there is high tendency for those communities to be more vulnerable to flooding than those that are within the high elevation areas.

iv. Drainage Density: Drainage density has been recognized by author's such as Gardner and Gregory (1982); Pallard, Castellarin and Montanari (2009) to be significantly effective on the formation of floods. The drainage density of any given area shows how well or poorly a particular geographical area is drained by stream channels. Drainage density is simply the total length of all the streams and rivers in a drainage basin divided by the total area of the drainage basin. According to Gardner and Gregory (1982), high densities can indicate a poorly drained since it increases flood risk, while a decreasing density implies well drained since it decreases flood volumes. The drainage density of the study area in Figure 4.4 was generated from SRTM data. The major river in the study area is River Niger which is fed by many streams in the area that drain directly into the river channel. Five classes of drainage density have been identified in the study area ranging from 0 to 299km^2 as shown on Figure 4.7.

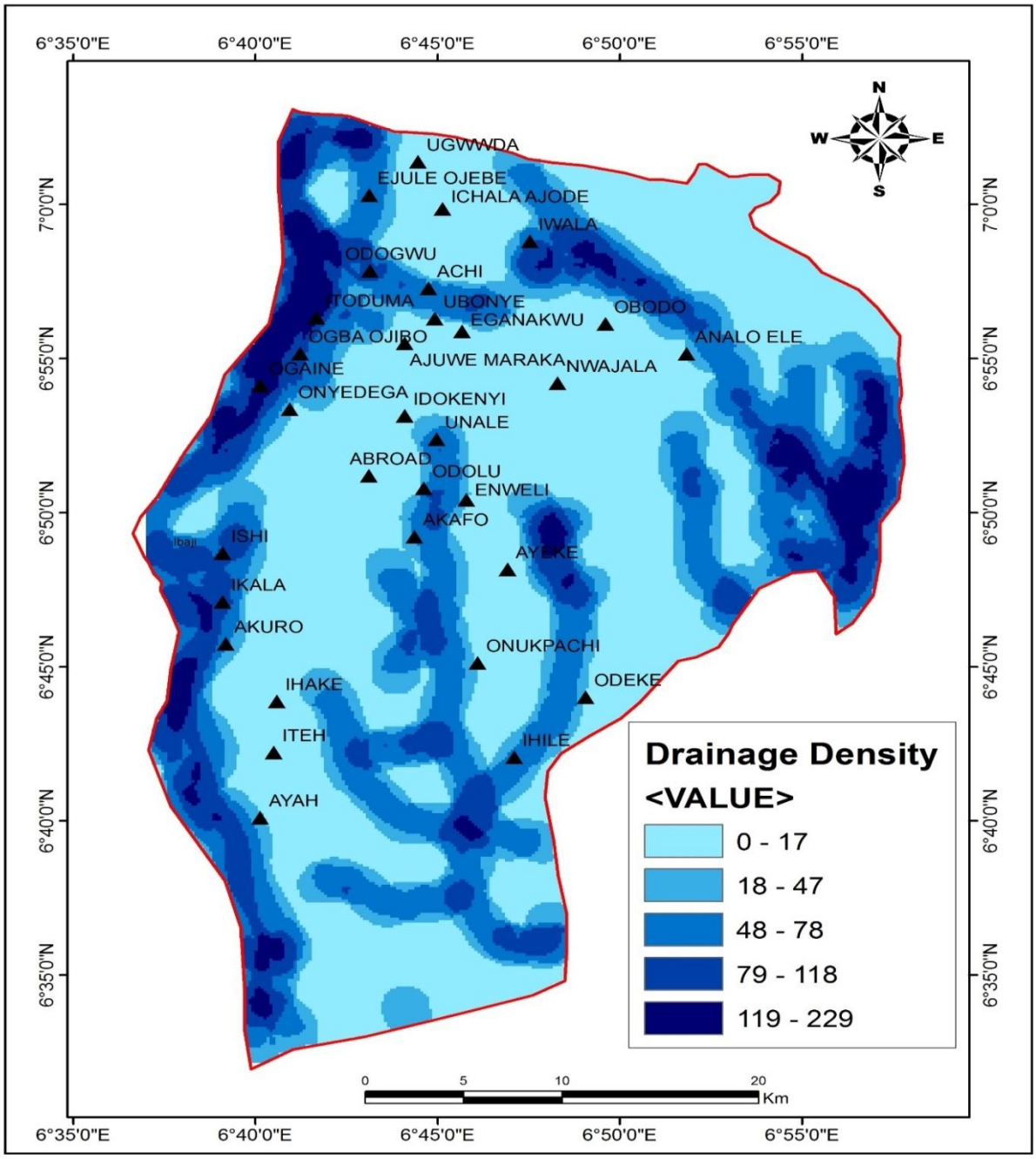

Figure 4.7: Drainage Density Map of the Study Area

Source: Field work analysis (2016)

From figure 4.7 it can be seen that High drainage density (119-229km^2) occurs more in the west and eastern parts of the study area and low drainage density (0-17km^2) is found more

around the central areas. To understand the contribution of drainage density as a factor influencing flood in the study area, the five classes (very low, low, moderate, high and very high) were further reclassified. According to Pallard, Castellarin and Montanari (2009), high drainage densities can indicate a greater flood risk, while a decreasing drainage density generally implies decreasing flood volumes. Thus, the five classes of drainage density generated (figure 4.4) were compared against each other as shown on Table 4.4. The results of the pair-wise comparison done for areas with very high drainage densities against those with high densities has the ratio 9/7 on the second column/last row, indicating that areas with very high drainage densities rated 9 is poorly drained and have great influence on flooding over high which has been rated 7. The ratio 9/5 on the third column/last row indicate that very high drainage densities 9 is still poorly drained and have great influence on flooding over areas with moderate rated 5. The 3 digit on the fourth column/last row is the result of the ratio 9/3 of the comparison between very high drainage rated 9 and low drainage rated 3. This procedure is repeated for all the classes against each other and weight generated automatically by the analytic hierarchy process software. The results of the weights derived from the pair-wise comparison for the five classes very low, low, moderate, high and very high was found to be 4, 12, 20, 28 and 36 respectively as shown on Table 4.4.

Table 4.4: Weights for Drainage Density

Drainage Density (km^2)	**0-17**	**18-47**	**48-78**	**79-118**	**119-229**	**Weight**	**Weight*100**	**Vulnerability**
0-17	1	1/7	15	1/3	1	0.038	4	Very Low
18-47	1/9	1	3/5	5/3	3	0.116	12	Low
48-78	1/3	3/7	1	7/3	5	0.20	20	Moderate
79-118	5/9	5/7	75	1	7	0.28	28	High
119-229	7/9	9/7	9/5	3	9	0.36	36	Very High

Consistency Ratio=0.06

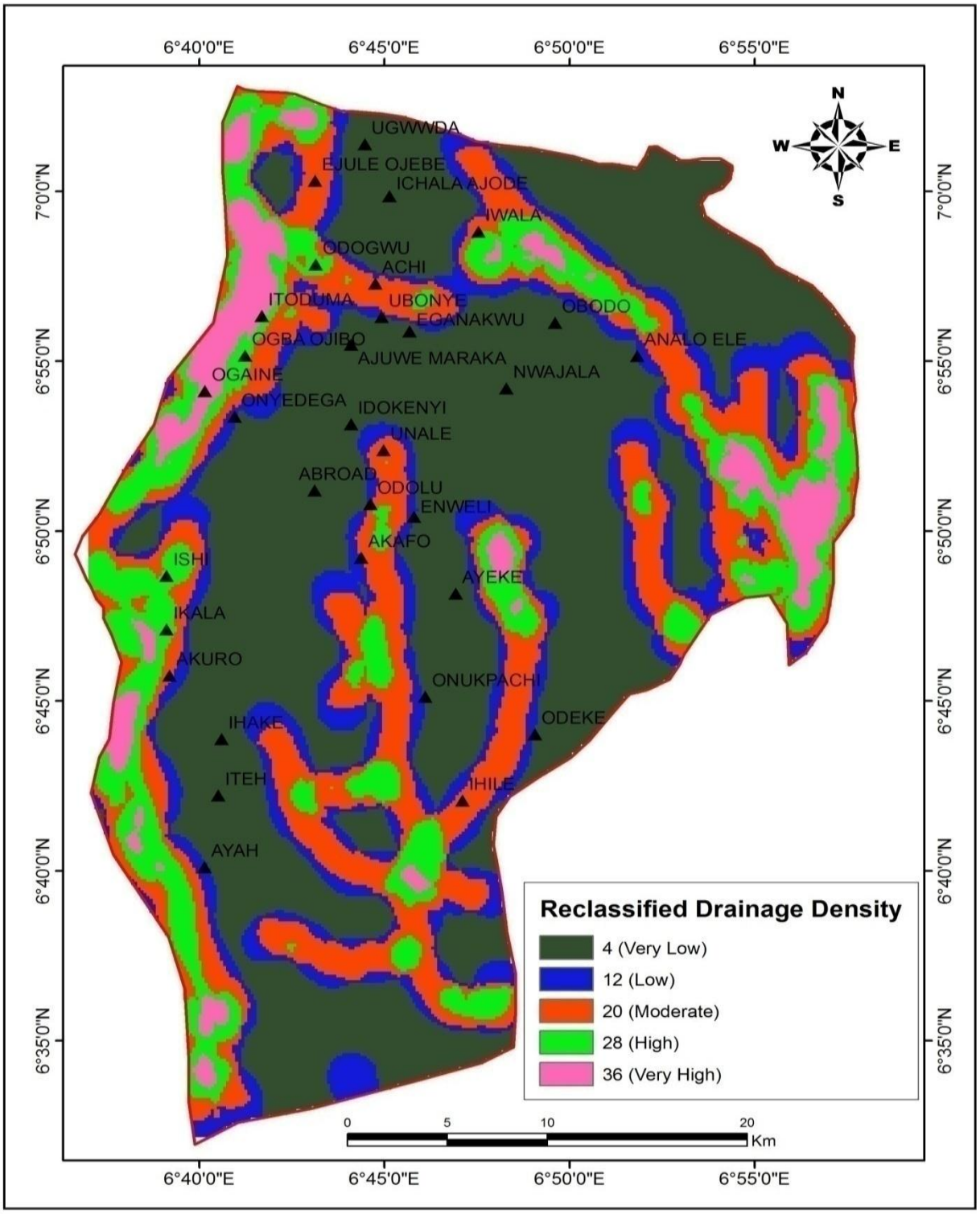

Figure 4.8: Reclassified Drainage Density Map of the Study Area

Source: Field work analysis (2016)

The results on Figure 4.8 showed the reclassified drainage density pattern using Reclass tool on Spatial analysis tools of ArcGIS 10.2. As a result of the reclassification, it revealed that only two communities (Ogaine and Itoduma) lie within high drainage density which means that there is high tendency for those communities to be more liable to flooding than those that falls within low drainage density. This result reflects the result obtained by Gardner and Gregory in 1982 who work on Drainage density in rainfall-runoff modeling: rainfall-runoff relationships. The result of the study showed that, high densities indicate a greater flood risk, while a decreasing density generally implies decreasing flood volumes.

v. Soil: According to Federal department of agricultural land resources (FDALR, 1990) areas with sandy soils are more prone to flood than areas covered by loamy soils since its infiltration rate is poor. The soil map was generated by digitizing the existing map of the study area. Three categories of soil were identified sandy, loamy and the clay soil as shown on Figure 4.5.

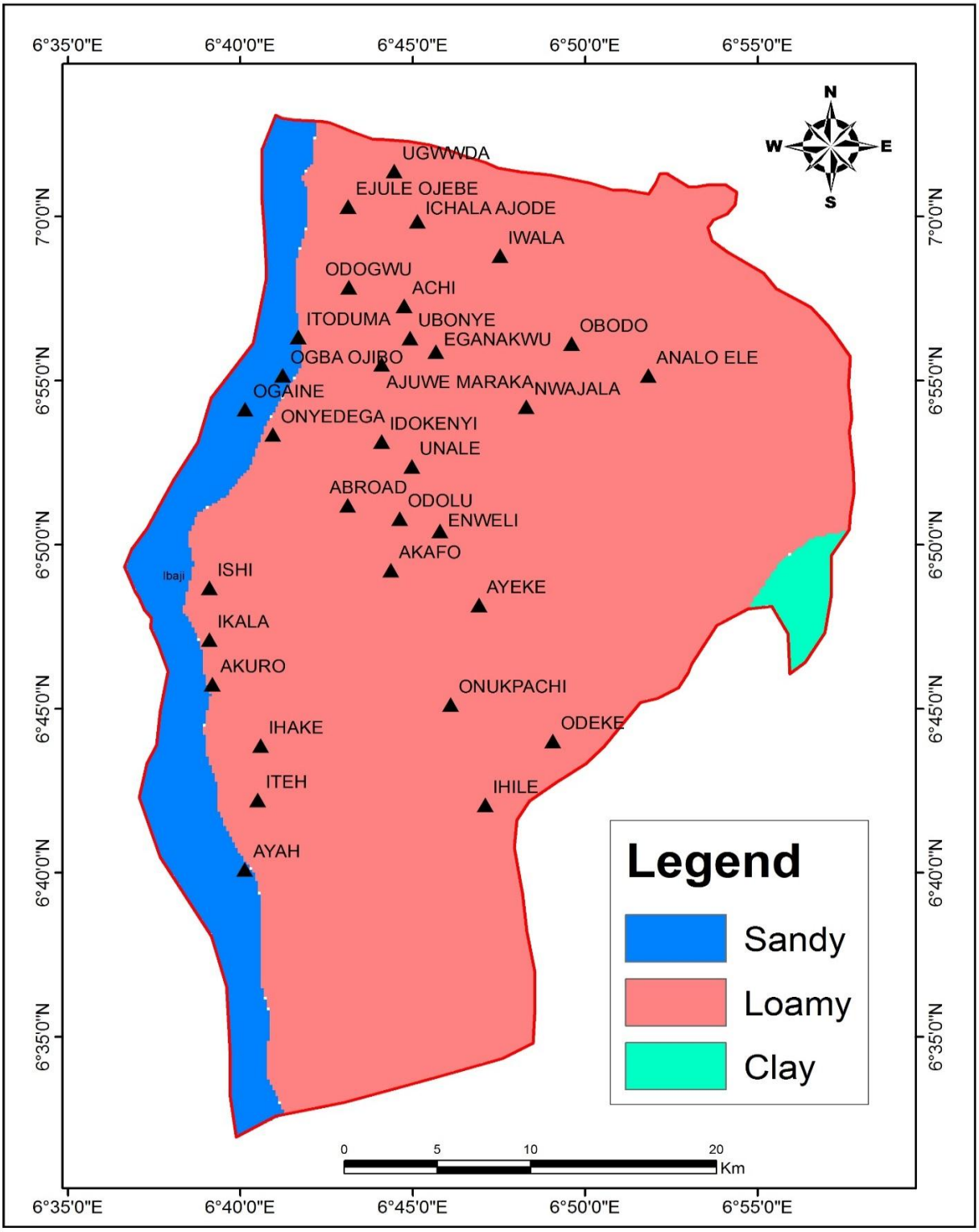

Figure 4.9: Soil Map of the Study Area

Source: Field work analysis (2016).

From Figure 4.9 it can be seen that Sandy clay lies to the western axis while the loamy soil dominates the areas and the clay lies within the eastern part. To understand the influence of soil as a causative flood factor in the study area, the three classes (Sandy, Loamy and Clay) were further reclassified. The Classification of soil types was done based on their ability to allow water to infiltrate into the ground and to hold water in the ground thereby reducing run-off or vice versa as recognized by FDALR, (1990). According to Federal department of agricultural land resources (FDALR, 1990) areas with sandy soils are more prone to flood than areas covered by loamy soils since its infiltration rate is poor. To facilitate the comparison, sandy has been designated as poorly drained, loamy moderately drained while clay has been designated as well drained. The pair-wise comparison done was carried out for the three categories of soil as shown on Table 4.5.

Table 4.5: Weights for Soil

Soil	**Sandy**	**Loamy**	**Clay**	**Weight**	**Weight*100**	**Vulnerability**
Sandy	1	3	9	0.66	66	High
Loamy	1/3	1	7	0.29	29	Moderate
Clay	1/9	1/7	1	0.05	5	Low

Consistency Ratio: 0.08

Source: Field work analysis (2016)

With a consistency ratio (CR) of 0.08, the judgment is consistent.

Table 4.5 showed the weights generated after pair-wise comparison. Sandy soil has the highest weight of 66 while loamy soil has 29 and clay soil with the lowest 5.

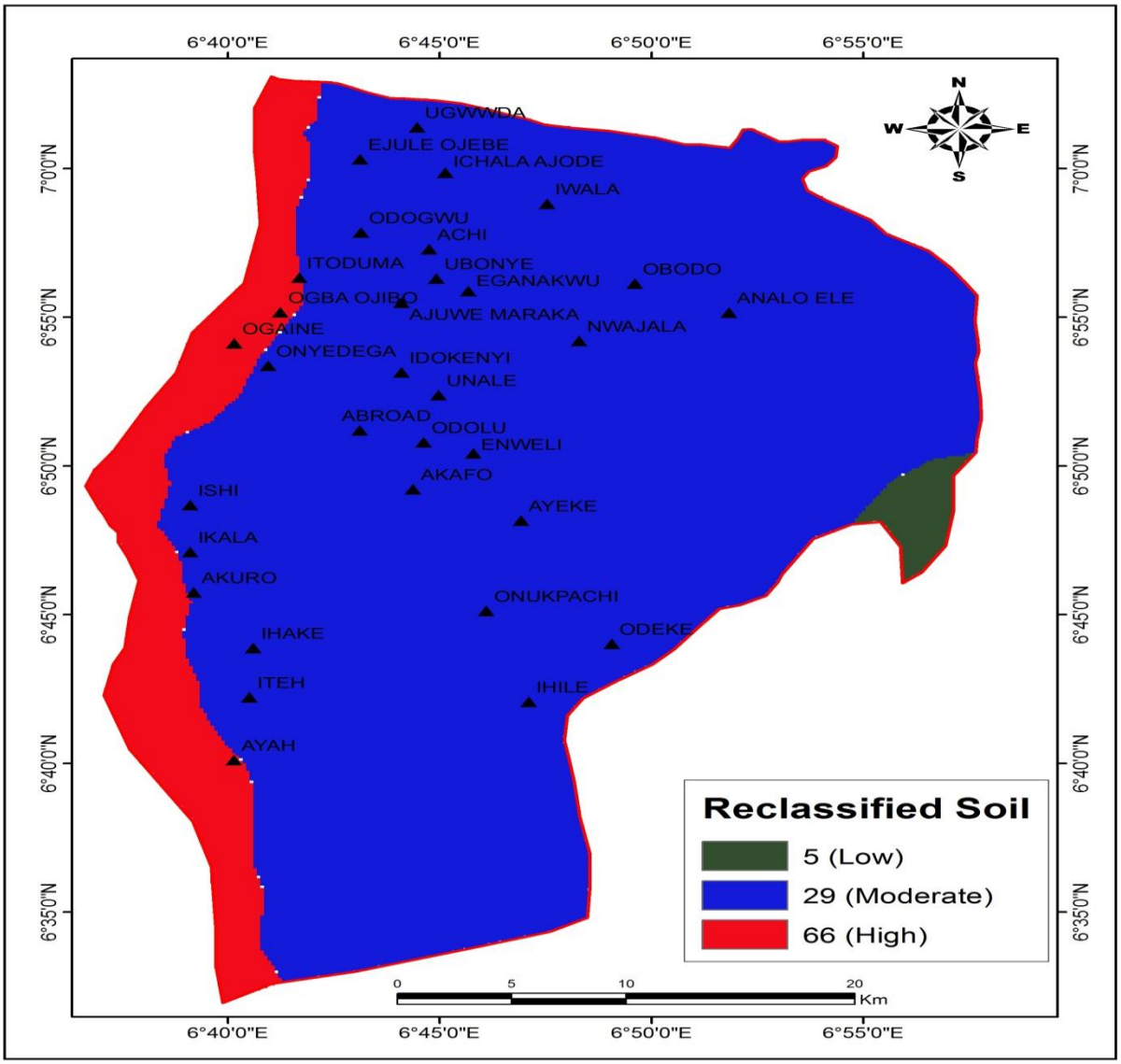

Figure 4.10: Reclassified Soil Map of the Study Area

Source: Field work analysis (2016)

The results on Figure 4.10 showed the reclassified soil pattern using Reclass tool on Spatial analysis tools of ArcGIS 10.2. As a result of the reclassification, three classes were obtained which are low, moderate and high. Looking at the classes of soil pattern of the study area, it clearly showed some communities (Ayah, Itoduma, Ogba ojibo and Onyedega) lie within the sandy soil which means that there is high tendency for those communities to be more liable to

flooding than other communities with different soil type in the study area.

vi. Land use and Land cover (LULC): The land cover class of the area was obtained from the Landsat 8 imagery via supervised classification using ERDAS IMAGINE 9.2. The classes are built-up, farmland, bare land, vegetation and water-body Figure 4.6 represents the Land cover map and Table 4.6 represents the area coverage of the land cover in Percentage.

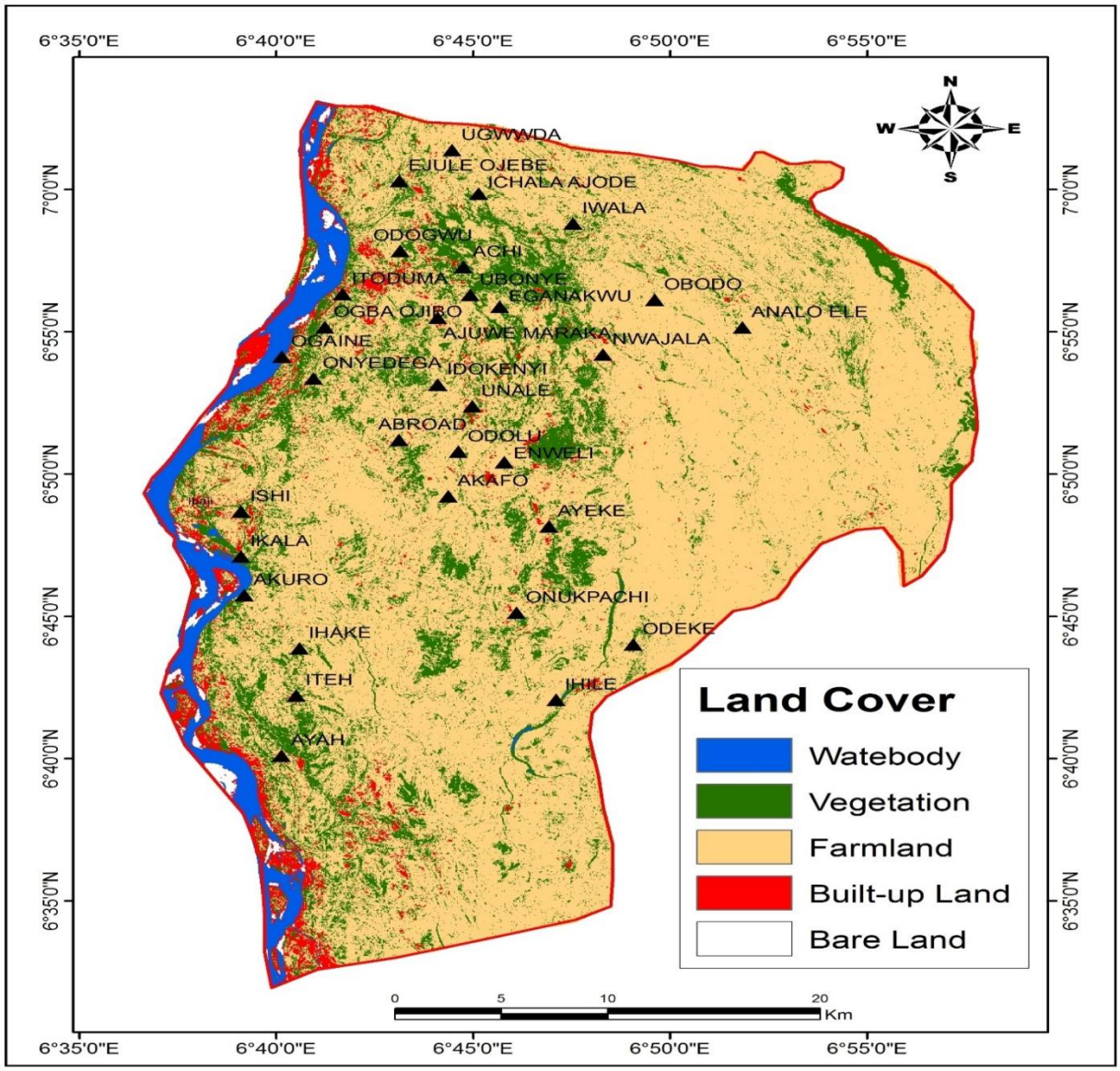

Figure 4.11: Land Cover Map of the Study Area

Source: Field work analysis (2016)

Table 4.6: Area Coverage of Landcover

Landcover	**Area in Sq. Km**	**%**
Waterbody	49.51	3.61
Vegetation	226.27	16.48
Farmland	1041.55	75.86
Built-up Land	49.51	3.61
Bare Land	6.2	0.47
Total	**1373.04**	**100**

Source: Field work analysis (2016)

The total extent is 1373.04Sq out of which farmland accounts for 75.9% of the total land coverage, while vegetation, water body, built-up and bare land accounted for 16.5%, 3.6%, 3.6%, and 0.5% respectively.

To understand the influence of land cover as a flood causative factor in the study area, the five classes (Water body, Vegetation, Farm land, Built-up land and Bare land) were further reclassified. The pair-wise comparison carried out and weights calculated for land-cover (Table 4.6) was based on the fact that built-up areas and cemented surfaces generate more surface runoff since they do not allow infiltration, while others like vegetation comprising of forests and farmlands on the other hand permit interception of precipitation which can either evaporate and return to the hydrological cycle or flow down the stem of the plants and trees (stem flow) and then flow along the ground or infiltrate and percolate into the ground, thereby reducing the surface runoff and consequently the flood magnitude (Lindsay-Walters, 2015). To facilitate the comparison, built-up areas has been designated as very high, farmland high, bare land moderate, vegetation low while water body has been designated as well very low. The pair-wise comparison was carried out for the five categories as shown on Table 4.6.

Table 4.7: Weights for Land Cover

Landcover	Built-up	Farm land	Bare Land	Vegetation	Water Body	Weight*100	Vulnerability
Built-up	1	9/7	9/5	3	9	36	Very High
Farmland	7/9	1	7/5	7/3	7	28	High
Bare Land	5/9	5/7	1	5/3	5	20	Moderate
Vegetation	1/3	3/7	3/5	1	3	12	Low
Water Body	1/9	1/7	1/5	1/3	1	4	Very Low

Consistency Ratio:0.035

Source: Field work analysis (2016)

With a consistency ratio (CR) of 0.06, the judgment is consistent and result accepted.

The pair-wise comparison carried out and weights calculated for land use and land-cover shown on (Table 4.7) was based on the fact that built-up areas and cemented surfaces generate more surface runoff since they do not allow infiltration, while others like vegetation comprising of forests and farmlands on the other hand permit interception of precipitation which can either evaporate and return to the hydrological cycle or flow down the stem of the plants and trees (stem flow) and then flow along the ground or infiltrate and percolate into the ground, thereby reducing the surface runoff and consequently the flood magnitude (Lindsay-Walters, 2015).

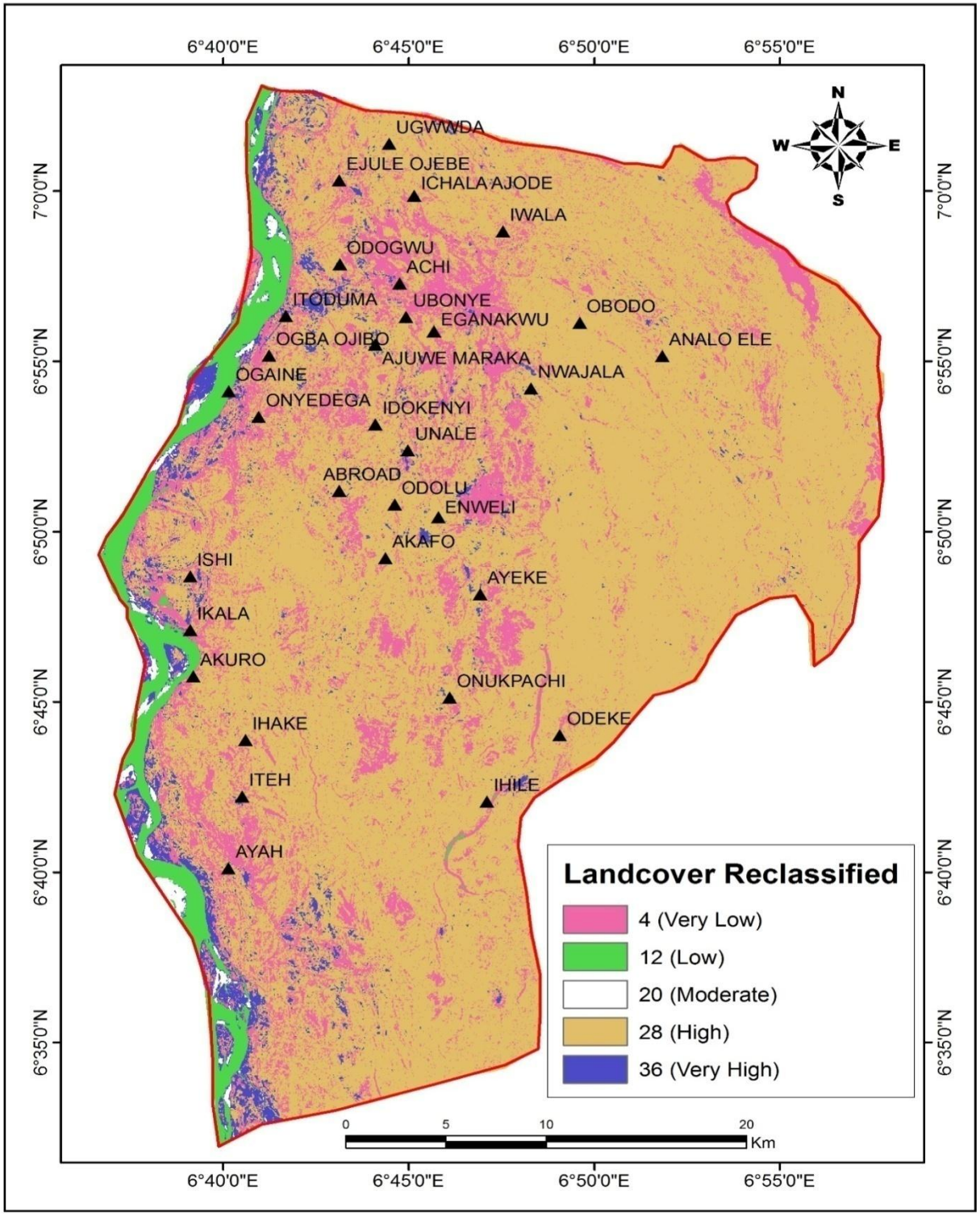

Figure 4.12: Reclassified Land Cover Map of the Study Area

Source: Field work analysis (2016)

The results on Figure 4.12 showed the reclassified land cover map using Reclass tool on Spatial analysis tools of ArcGIS 10.2. As a result of the reclassification, it revealed that built-up contributes more to flooding with a weight of 36, followed by Farmland 28, bare-land 20, vegetation 12 and water-body 4.

Combined Weights for all the Flood Causative Factors

Table 4.8: Combined Weights for all Factors

Factor	**Elevation**	**Slope**	**LULC**	**Drainage Density**	**Rainfall**	**Soil**	**Weight**	**Weight* 100**
Rainfall	1	9/7	9/5	9/5	9/3	9/7	0.25	25
Elevation	7/9	1	7/5	7/5	7/3	1	0.22	22
Slope	7/9	1	7/5	7/5	7/3	1	0.20	20
Drainage density	5/9	3/7	1	1	5/3	5/7	0.13	13
LULC	5/9	5/7	1	1	5/3	5/7	0.12	12
Soil	3/9	3/7	3/5	3/5	1	3/7	0.08	8

Consistency Ratio= 0.078

Source: Field work analysis (2016)

With a consistency ratio (CR) of 0.06, the judgment is consistent and result accepted.

The results on Table 4.8) showed the combined weights of all the flood causative factors using pair-wise comparison. The result revealed that rainfall has the greatest influence on flood occurrence in the study area with 25 as its weight, followed by elevation with 22, slope and drainage density accounted for 20 and 13 respectively, land cover 12 and soil the least with 8. This result reflects the results obtained by Lawal, Matori, Hasim, Yusof and Chandi (2012) whose study on Detecting flood susceptible areas in Perlis, Malaysia identified mean annual

rainfall as the major factor causing flooding in Perlis. Also Eguaroje *et al*. (2015) who work on flood vulnerability assessment of Ibadan City, Oyo state revealed that, mean annual rainfall contributed to flooding than any other factors considered in the model.

4.3 AREAS VULNERABLE TO FLOOD IN THE STUDY AREA

This section used the results of the pair-wise comparison carried out for the six flood causative factors on Table 4.8 based on Saaty's Fundamental scale of pair-wise comparison and generated flood vulnerability map. To determine vulnerability level of communities, these factors weight from the analytical hierarchy process (AHP) were overlaid using the weighted sum in ArcGIS 10.2 spatial tool to produce the flood vulnerability map of five level (very low, low, moderate, high and very high vulnerable areas) as presented on Figure 4.13.

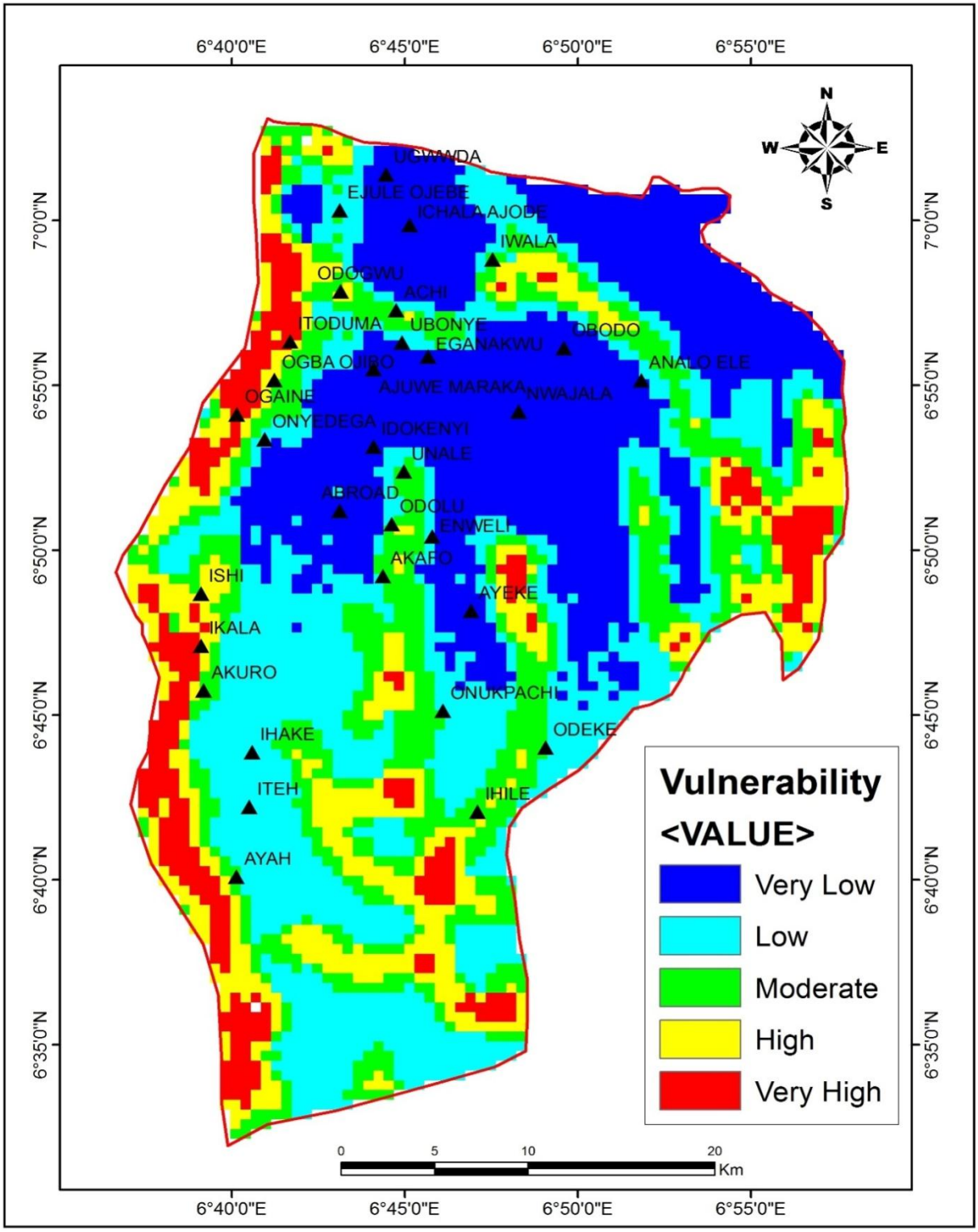

Figure 4.13: Flood Vulnerability Map of the Study Area

Source: Field work analysis (2016)

The results of the analysis carried out, showed that some communities (Itoduma, Ogba-ojibo, Ogaine and Ikala) are found to be within the very high vulnerable areas which means that there is high tendency for those communities to be more liable to flooding than other communities. In the results some communities (Odogwu, Ishi, Ihile and Odolu) are also found within the high vulnerable areas which means that the possibility of those communities to be more liable to flooding is high than those within moderate, low and very low vulnerable areas. The communities that are within moderate vulnerable areas are; Odeke, Iwala, Achi, Unale, Akaro, Onukpachi and Ayah, while those within the low vulnerable areas are; Iteh, Ihake, Onyedega, Ejule Ojebe, Ubony and Eweli. The communities that are least vulnerable (very low vulnerable) are; Ugwada, Ichala, Ajode, Obodo, Eganakwu, Ajuwe Maraka, Nwajala, Idokenyi, Abroad, Ayeke, Analo Ele.

From the survey it was observed that most of these communities that are vulnerable are located close to bank of the river Niger and are characterized with low elevation and slope. The observation of this study affirms Muhammad and Iyortim (2013) that areas that lie beside a river may not be liable to flood if it is at a great height while areas that lie far away may experience floods if the intervening land is flat, gentle sloping or if the area lies in a depression.

4.4 TREND OF FLOOD VULNERABILITY IN THE STUDY AREA

This section presents the trend of flood in the study area using the available flood records obtained from Kogi State Emergency Management Agency (KOSEMA). In order to determine the spatial trend of flood in Ibaji, flood records of 2002, 2007 and 2012 of the affected communities obtained was imported into Excel as X and Y and save in CVS format to be read/recognized by ArcGIS. The result of the analysis is shown on Figures 4.14 and Figure 4.15.

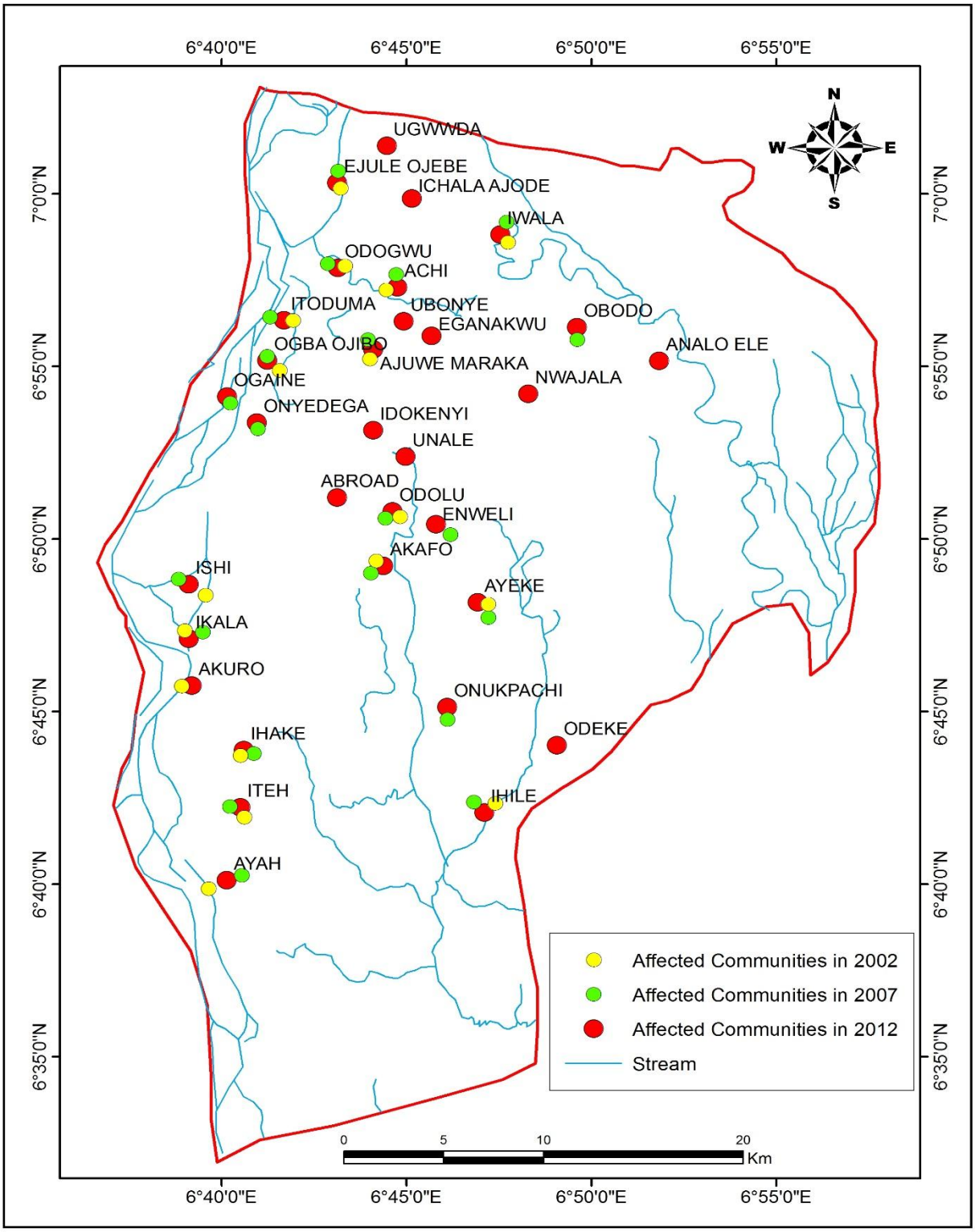

Figure 4.14: Areas Affected by Flood in 2002, 2007 and 2012.

Source: Field work analysis (2016)

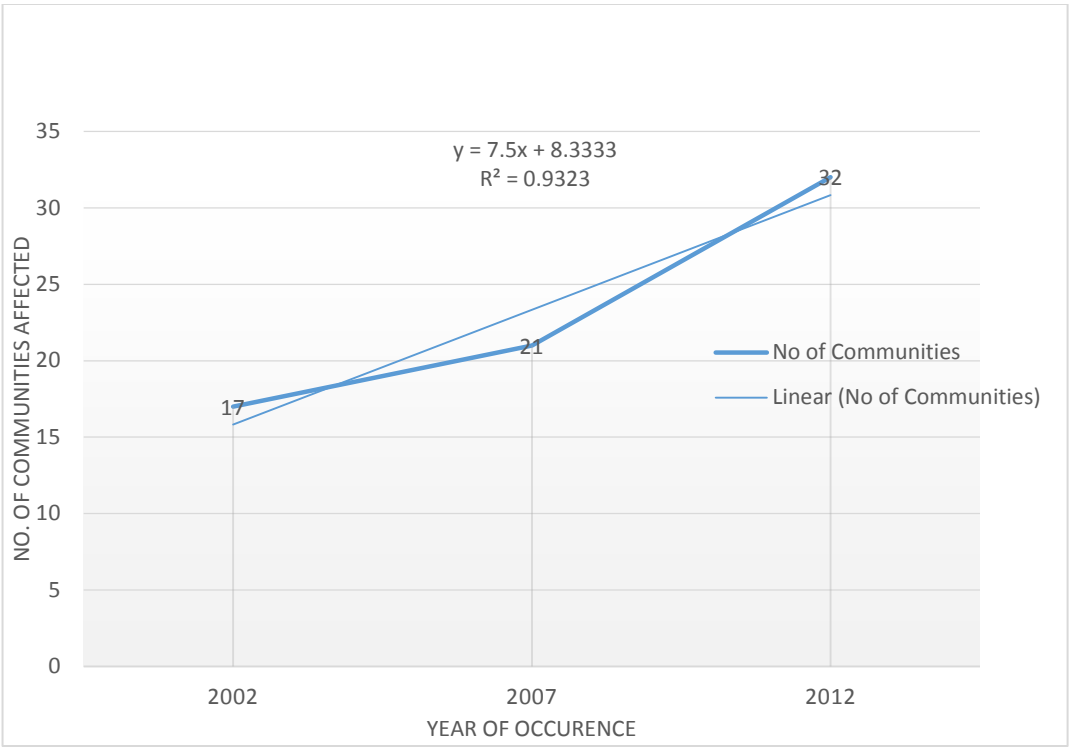

Figure 4.15: Areas Affected by Flood in 2002, 2007 and 2012.

Source: Field work analysis (2016)

The results shown on Figure 4.14 and Figure 4.15 revealed that, seventeen communities were affected in 2002. In 2007, the affected communities increased to twenty one and in 2012, the number of the affected communities increased to thirty two. It can be seen on Figure 4.14 that most of the flooded communities are not far away from rivers and the result also showed an increasing trend from the coastal areas to the hinter land. This agrees with the study of Jeb (2013) whose study on Flood risk analysis in Kaduna metropolis perceived increase in flooding in Kaduna because of proximity of settlements on the floodplains near the River Kaduna.

4.5 EFFECTS OF FLOOD VULNERABILITY LEVEL ON LIVELIHOODS OF RESIDENTS IN IBAJI LOCAL GOVERNMENT AREA

This section uses the perception of residents on effects of flood obtained from questionnaires and oral interviews as shown on Appendix I to examine the effects of flood on livelihoods of residents in the study area. Figure 4.16 and Table 4.9 showed the summary of damages caused by flood as perceived by people in the study area and how flooding affects properties and lead to human casualties in the study area.

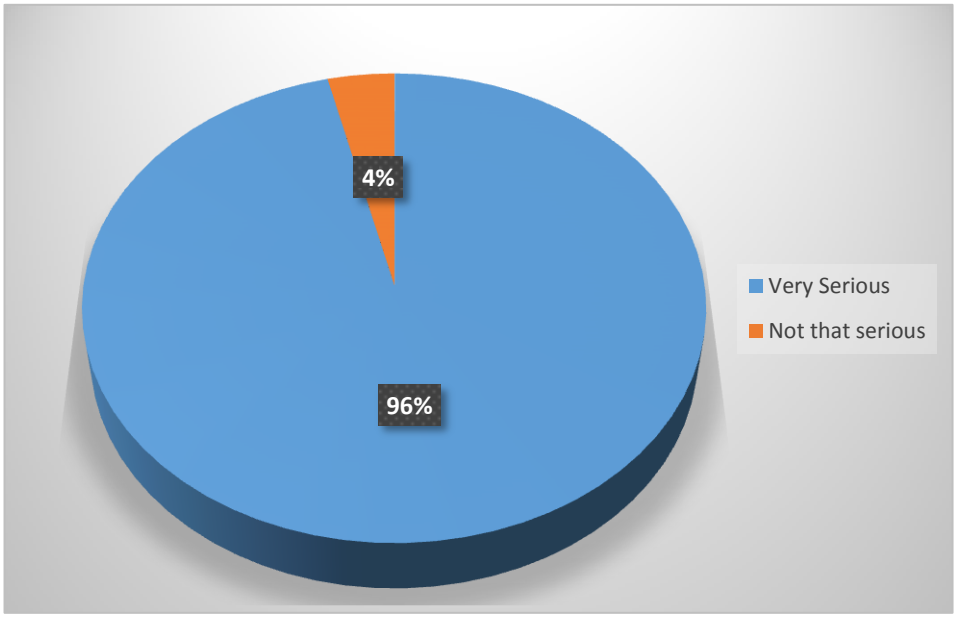

Figure 4.16: The damage caused by flood hazard as perceived by people in the study area
Source: Field Survey, 2016

The results on Figure 4.16 revealed that majority (96%) of the respondents believed that the damage caused by flood in the study area is very serious, while only 4% said it is not that serious.

Table 4.9: Effects of Flood as Perceived by Respondents

Effects of Flood	Frequency	%
Loss of lives	7	1.8
Disruption of livelihood	263	66.4
Destruction of houses/displacement of people	117	29.5
Others	9	2.3

Source: Field work analysis (2016)

The results on Table 4.9 also showed that, flood hazard had also impacted on human casualties. Thus, majority (66.4%) of the respondents believed that the impact of flood in the study area leads to disruption of livelihood, 29.5% of respondents results to destruction of houses/displacement of people, while 1.8% of the respondents believed that the occurrence of the flood also leads to loss of lives. The findings of this study is in harmony with that of Emmanuel, Ojinnaka, Baywood and Gift (2015) who work on flood hazard analysis and drainage assessment of 2012 flood in Anambra, the results revealed that, the major effects of flood along Anambra were disruption of public and personal property.

4.6 COPING STRATEGIES TO FLOOD VULNERABILITY BY RESIDENTS

This section attempt to see how people in the flood vulnerable areas cope with the flood situation within the study area, questionnaires were distributed to those that were evacuated in the event of previous flood to see the services made available to them at place of relocation, level of satisfaction of the services provided, flood control measure taken by residents and suggested flood control measures. The results of their responses are presented on Table 4.10.

Table 4.10: Coping Strategies to Flood Vulnerability by Communities

Coping Strategy	Frequency	%
Services made available to people at place of relocation		
Food	217	88.9
Medical care	27	11.1
Organization that provided the services		
Kogi State Emergency Management Agency	77	41.0
National Emergency Management Agency	48	25.5
Red cross	63	33.5
Level of satisfaction of services provided		
Very satisfy	5	1.8
Somewhat satisfy	33	11.7
Slightly satisfy	21	7.5
Not satisfy	216	76.9
Don't know	6	2.1
Flood control measure		
Barricade	85	23.1
Wind break	3	0.8
Channel	199	54.1
Drainage	32	8.7
Others	49	13.3
Measures for flood control		
Government policies	320	81.2
Public enlightenment	47	11.9
Community effort	27	6.9

Source: Field work analysis, 2016

The results on Table 4.10 showed that 88.9% of the respondents indicated that food was

the services made available for them at the point of the occurrence of the flood, while 11.1% of the services made available were medical facilities. On the other hand, 41.0% of the respondents indicated that the services were made available to them by the Kogi State Emergency Management Agency (KOSEMA), while 25.5% of the respondents indicated that the services were provided by the National Emergency Management Agency and 33.5% indicated that the services were provided by Red cross.

The result further showed that 76.9% of the respondents were not satisfied with the services made available to them, while 11.7% of the respondents were somehow satisfied and 1.8% of the respondents were very satisfied with the service provided to them. Furthermore, 54.1% of the respondent of the flood vulnerable areas make use of channel as their flood control measure in case of future reoccurrence, while 23.1% use barricades, 8.7% make use of drainages, 0.8% use wind breaks and 13.3% of the respondents indicates the use of other control measure. Finally, 81.2% of the respondents suggested the use of government policies as flood control measure in their area, while 11.9% prefer public enlightenment and 6.9% believes in community effort.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 INTRODUCTION

This chapter presents the summary of findings, conclusions drawn from the findings and recommendations made. It highlights issues that were revealed during the research with regards to factors influencing flood, areas vulnerable to flood, spatio-temporal trend, effects of flood and coping strategies adopted by residents in the study area.

5.2 SUMMARY

Spatio-Temporal analysis of flood vulnerability in Ibaji L.G.A. was carried out using AHP and GIS techniques. Medium resolution Landsat 8 imagery, elevation, slope, soil data, landuse, drainage density and rainfall data were imputed into GIS environment as factor maps to determine which has more influence on the occurrence of flood in the study area. The study revealed that rainfall plays the greatest role on the occurrence of flood amongst the factors considered in the study area. The study also generated a flood vulnerability map of the study area and the results showed the vulnerability level of communities in five classes; very highly vulnerable area, highly vulnerable area, moderately vulnerable area, low vulnerable area and very low vulnerable area. Knowing the factors that causes flooding and areas vulnerable to flooding will provide vital data and information to policy makers, scholars and is also required by local authorities in physical planning and in protecting citizens against future occurrence of this flood disaster.

The study showed that seventeen communities were affected in 2002, while in 2007, the

affected communities increased to twenty one and in 2012, the number of the affected communities increased to thirty two. This clearly showed that there is an increase in the flood trend. This can be use in predicting future flood disaster in the Ibaji Local Government Area. Furthermore, the study revealed that, flood hazard had also impacted on human casualties thus majority (66.4%) of the respondents believed that the impact of flood in the study leads to disruption of livelihood, about 29.5% results to destruction of houses/displacement of people, while 1.8% of the respondents believed that the occurrence of flood also leads to loss of lives.

Finally, the study showed that 88.9% of respondents believed that food were the services made available, while 11.1% of respondents indicated that medical facilities were provided. On who provided the services, 41.0% of the respondents indicated that the services were made available to them by the Kogi State emergency management agency, 25.5% of respondents indicated that it was provided by National emergency management agency and 33.5% indicated that the services were made available by red cross. On level of satisfaction with the services, 76.9% of the respondents were not satisfied with the services made available to them. Also, 54.1% of the respondents make use of channel as their flood control measure in case of future reoccurrence and 81.2% of the respondents suggested the use of government policies as flood control measure in their area, 11.9% indicated public enlightenment and 6.9% suggested the use of community effort.

5.3 CONCLUSIONS

The study analyzed flood vulnerability in the study area. Field survey, Satellite imageries, Global Positioning System (GPS), Shuttle Radar Topographic Mission (SRTM), Rainfall data and Questionnaires administration were the materials and methods used for the study. Medium

resolution Landsat 8 imagery, elevation, slope, soil data, landuse, drainage density and rainfall data were imputed into GIS as factor maps to determine which has more influence on the occurrence of flood. The results of the study revealed that rainfall has the greatest influence on flood occurrence in the study area. Other factors such as elevation, slope, drainage, landuse and soil types represent significant factors of flooding. The findings further showed that areas that lie along the rivers and on low elevations are more prone to flood than those on higher elevations. This means that all villages, populace and other facilities found within the area are at great risk of flood hazard.

Thus, it can be concluded from this study that although flood is a natural disaster, man contributes significantly to its occurrence due to his involvement in activities that disrupt the environment like encroachment of human activities on floodplain and violation of building regulations.

5.3 RECOMMENDATIONS

Based on the findings of this study, the following recommendations are hereby made:

i. Settlements that are within or adjacent to the areas liable to flooding should be relocated where possible and future settlements should be discouraged.

ii. The Local Government Authority and State Emergency Management Agency should try and work with other relevant agencies in providing improved relief services to flood victims.

iii. There is great need for further research on mitigation measures so that the menace of flooding can be minimized in the study area.

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APPENDIX I

Questionnaires Sample

DEPARTMENT OF GEOGRAPHY,

FACULTY OF SCIENCE,

AHMADU BELLO UNIVERSITY,

ZARIA, KADUNA STATE

Dear Respondent,

I am a student of the Department of Geography, Ahmadu Bello University Zaria, carrying out a research on Spatio-temporal analysis of flood vulnerability in Ibaji LGA, Kogi state. I solicit for your cooperation to respond to the following questions by ticking (√) at the appropriate option and where necessary you fill in the blank spaces. Your answers will be treated confidentially and your response will contribute greatly to the success of this study. I request your cooperation.

Thank you

SECTION A: Demographic and Socioeconomic Information for residents of the study area

1. Gender

   (a) Male [ ] (b) Female [ ]

2. Age

   (a) 18-27 [ ] (b) 28-37 [ ] (c) 38-47 [ ] (d) 48-57 [ ] (e) 58 and above [ ]

3. What is your status?

   (a) Single [ ] (b) Married [ ] (c) Separated [ ]

4. Highest level of formal education?

   (a) Primary [ ] (b) Secondary [ ] (c) Tertiary [ ] (d) No formal education

5. Occupation?

   (a) Farmer [ ] (b) Trader [ ] (c) Civil Servant [ ] (d) Artisan [ ] (e) Others (specify)……

QUESTIONS ON EFFECTS OF FLOOD ON LIVELIHOODS OF COMMUNITIES

6. Have you ever witnessed flood in Ibaji?

   (a) Yes [ ] (b) No [ ] (c) No idea [ ]

7. How severe are the damages caused by flooding in your area?

   (a) Very serious [ ] (b) Not that serious [ ]

8. Which of these is mostly affected by the flood disaster in your area?

   (a) Loss of lives [ ] (b) Disruption of livelihoods [ ] (c) Destruction of houses/displacement of people [ ] (d) Others (specify)…….

QUESTIONS ABOUT HOW YOU COPED WITH THE FLOOD SITUATION

FOR THOSE WHO WERE EVACUATED ONLY

9. Were any crisis related services made available to your family at your place of relocation?

A) yes B) no C) don't know

10. If Yes, did you use any service(s)?

(a) Yes (b) No (c) Don't know

11. Which one?

(1)

(2)

12. Who provided it?

(1)

(2)

13. How satisfied were you with the service (s)?

    (a) very satisfied (b)somewhat satisfied (c)slightly satisfied (d) not satisfied (e)don't know

14. Which flood control measures do people mostly used to stop flooding in your area?

    (a) Barricade [ ] (b) Wind breaks [ ] (c) Channel [ ] (d) Drainage [ ] (e) Others (specify)…….

15. What measures do you suggest for flood control in your area?

    (a) Government policies [] (b) Public enlightenment [] (c) Community effort (d) others (specify)……

    Thank you for your time.

APPENDIX II: Computed Average Annual Rainfall of Ibaji Local Government Area

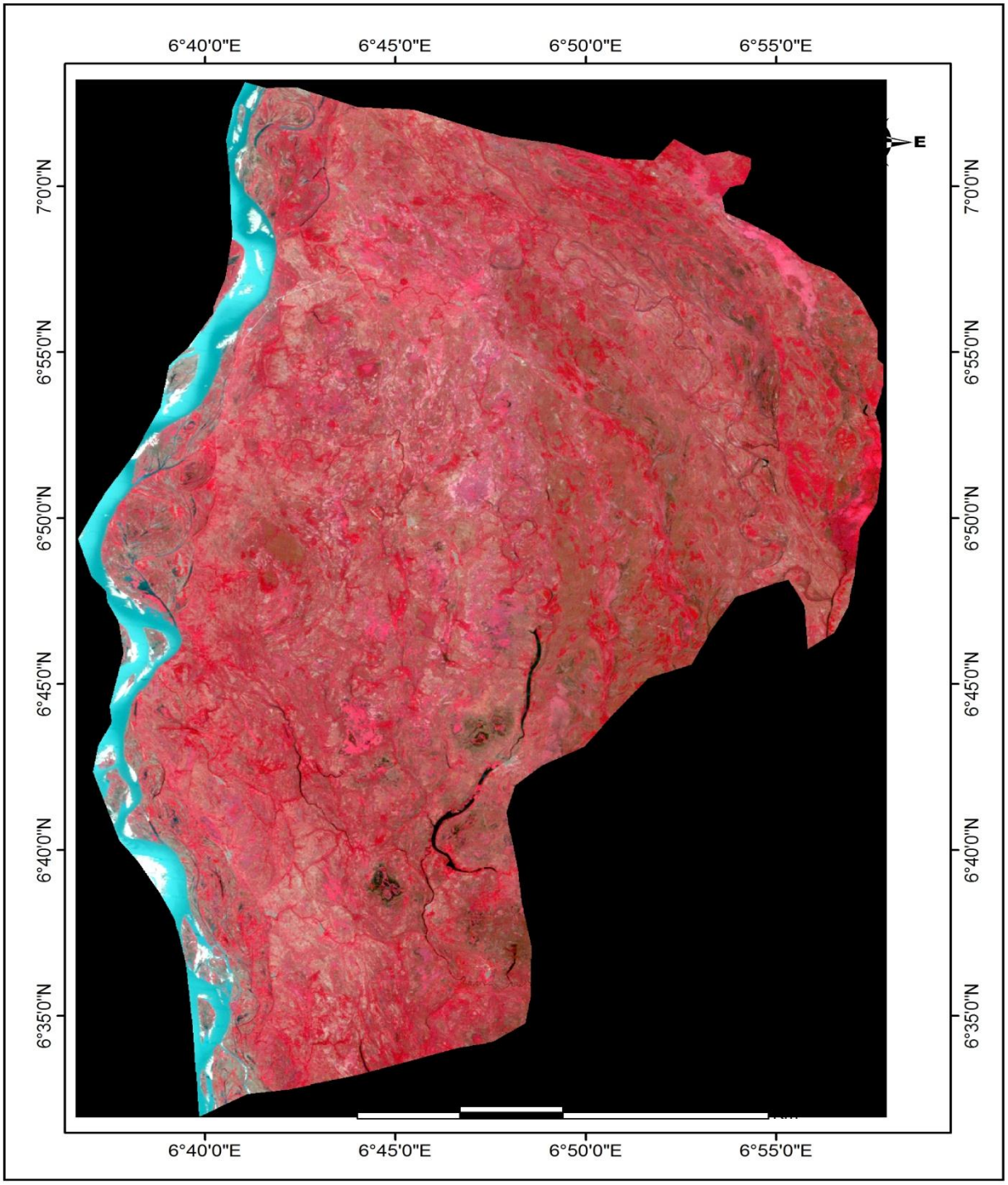
Loc	long	Lat	Average Annual Rain
Idah	6.73	7.11	1546
Nsukka	6.85	7.38	1446
Uromi	6.33	6.71	1672
Ukehe	7.41	6.55	1725
Itobe	7.56	7.72	1372

APPENDIX III: Coordinates of Ibaji Local Government communities

Location	Lat	Long
EJULE OJEBE	7.005083	6.718814
UGWWDA	7.03925	6.739917
ICHALA AJODE	7.001842	6.752364
ODOGWU	6.964139	6.719147
OGBA OJIBO	6.919378	6.68725
ITODUMA	6.930361	6.686333
OGAINE	6.902014	6.669158
ACHI	6.944167	6.745972
UBONYE	6.938333	6.748806
AJUWE MARAKA	6.924806	6.735081
EGANAKWU	6.935661	6.752481
NWAJALA	6.920278	6.801667
ONYEDEGA	6.889333	6.682583
ISHI	6.811389	6.651969
IKALA	6.785003	6.651969

AKURO	6.762472	6.65325
IHAKE	6.731278	6.676667
ITEH	6.703639	6.675222
AYAH	6.668381	6.669044
IDOKENYI	6.885639	6.735089
OBODO	6.935436	6.826778
ANALO ELE	6.919192	6.863889
IWALA	6.980194	6.792333
AKAFO	6.835542	6.751256
ENWELI	6.838056	6.751119
AYEKE	6.802689	6.782083
ODEKE	6.702167	6.815556
ONUKPACHI	6.752114	6.768414
IHILE	6.701122	6.785089
UNALE	6.873056	6.735939
ABROAD	6.868333	6.735078
ODOLU	6.840444	6.744333

APPENDIX IV: Landsat Imagery of Ibaji Local Government Area



APPENDIX V: Submerged Houses in 2012 Flood Disaster in Ibaji LGA

