INVESTIGATION OF 2017 FLOODING EVENT IN NASSARAWA HAYI IN NIGER STATE, NIGERIA

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ABSTRACT

Floods is among the environmental problems with the most devastating effect in the world, which has claimed so many lives and destroyed more property than any other natural phenomena. Nassarawa Hayi have had incidences of flash floods in the pasts, the one of Saturday, the 8th of July, 2017 experienced has not been witnessed in its recent history. This study assesses flood damage and loss in Nasarawa Hayi, Tafa Local Government Area of Niger State, Nigeria. The study identifies and map out factors responsible for flooding event in the study area; Map the flood risk zones in the area and assess the damage to assets and infrastructure in the study area. Qualitative and quantitative analysis techniques was used, personal observation was made in the field, structured questionnaire was used, remote sensing data (QuickBird Imagery) was used. Field data collected were subjected to descriptive statistics while remote sensing data was subjected to digital image processing which involve digitizing, generating of contours map, Digital Elevation Model map and flood risk map. The findings reveal factors responsible for flooding in the area, it shows that 42% of the respondent agreed that flooding the area is caused by excessive Rainfall, 52.7% of the respondent agreed that Not well constructed drainage, building and farming along the flood plan area are the causes of flooding in the area. The digital Terrain Model of the area showed areas vulnerable to flood hazard. The risk zone was classified into three categories, namely high-risk zone, medium risk zone and low risk zone, using digital terrain model and distance. The areas on terrain elevations 55m -57m were categorized as high-risk zone with total coverage area of 55,920.10 m^2. The medium risk zone was between 58m - 60m with total area coverage of 506,717.82 m^2 while low risk zone was 61m - 65m with area of 131,960.16m^2. The elements at the high-risk zone include residential buildings, a school building, and untarred roads among others. The elements at the moderate risk zone are uncultivated farmland, boats and humans while that of the low risk area are both cultivated and uncultivated farmlands, crops and economic trees. The study concludes that flooding cannot be completely avoided, as long as physical development extends to river channels traversing urban centers, but with effective flood prevention programmes, damages from severe flooding can be reduced if not eradicated. Thereby recommends that occupants and/or owners floodable areas aware of identified flood hazards and encourage individuals to take actions such as flood proofing and developing escape plans, to mitigate their flood potential.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to the Study

In Nigeria, news of about natural disasters of the environment has been making headline on air and front pages, causing havoc either on rural farmers or on urban residents at an alarming rate. So, the need for in-depth research into the impacts of floods on the environment and socioeconomic activities arises. Floods may be defined in a variety of ways according to type, origin and magnitude. According to Olajuyibe *et al.* (2012), a flood is as an overflowing of a great body of over land which is not usually submerged. This disaster has led to various degree of destruction that has disrupted socio-economic activities, transport and communication, collapse of infrastructure and erosional damages, loss of life and property, contamination of water resources and the environment in general (Nkwunonwo *et al.,* 2016).

Christopherson (2006) sees flood as a high water level that overflows the natural riverbank along any portion of a stream, therefore the spreads of water over adjoining grounds on which crops or valuable properties are presence would be destroyed; a flood is any water in an area that is not normally submerged. According to Oriola (2000), whenever the stream channel in an average section is overtaxed, causing overflow on an adjacent land definitely outside the usual channel boundaries, the stream is said to have reached flood stage. Adelekan (2010) and Magami *et al.* (2014) stated that there are various types of flood such as: flash floods, single event floods, multiple event floods, seasonal floods, coastal floods and estuarine floods. Flash floods are common in the city centres. A single event flood is caused by rainfall with one peak flood period and last longer than flash flood. The multiple event floods occur after long period of rainfall that comes in succession. Seasonal floods are very common in most riverine areas or river flood plain (Nwigwe and Emberga, 2014) pinpointed that flood are caused by extraneous forces in the physical environment that are harmful to men.

The cause of flood was attributed to three atmospheric factors, namely rainfall excesses, snow and ice, and coastal factors. Aderogba (2012) was of the opinion that man was the real cause of flood. In his quest for a vibrant economic, need for improvement in the standard of living and also through his inadequate understanding of how the rocesses of nature operate, he has altered the normal channel through water flows across the land by building dams, houses and industries in areas that are known to be in danger of flooding. In the advance world, the loss of life through flood, although terrible is relatively low, unlike the underdeveloped countries that lack sophisticated monitoring and warning systems. As the search for solution to flood hazards continues, it is essential to explore how the flood processes are shaped and threatened by the physical development pattern of Nasarawa Hayi community. It is in view this that this study attempts to assess flood damage and loss in Nassarawa Hayi community and identify the factors responsible for flooding in the area.

1.2 Statement of the Research Problem

Floods is among the environmental problems with the most devastating effect in the world, which has claimed so many lives and destroyed more property than any other natural phenomena. In Nigeria, the displacement of people and damages to properties by flood is more than any other natural disaster. At least 20 per cent of the population in Nigeria is at risk from any form of flooding Etuonovbe (2011). In Nigeria, flood disaster has been perilous to people, communities and institutions. In the past years, flooding in Niger State was limited to communities along river valleys/corridors of Niger and Kaduna especially those living downstream of Jebba, Kainji and Shiroro hydro dam.

However, the recent flooding has extended to other communities in most parts of the state including Bida, Tafa, Suleja and Minna the state capital (Ahmed, 2018). Causes of flood in these towns may not be unconnected to flat or low-lying terrains especially where little or no provision has been made for surface drainage or where existing drainage has been blocked by

municipal waste, refuses and eroded soil sediments (Aderoju *et al.,* 2014). It also occurs as a result of prolonged rainfall, lack of adequate drainage system/blocking of water ways and unplanned and uncoordinated physical growth of some part of the towns and intensification of land use development.

Nassarawa Hayi have had incidences of flash floods in the pasts, the one of Saturday, the 8th of July, 2017 experienced has not been witnessed in its recent history. The flood occurred as a result of the torrential rain which lasted about 12 hours (11:00pm to 11:00am) and seriously disrupted the functioning of the town with widespread human, material and environmental losses which exceeded the ability of the local authorities to cope with (NSUDB, 2017). The areas affected by the flood covered Suleja and Tafa Local Government Areas of Niger State. They include; Suleja (Bakin Uku area around Hairatu Gwadabe estate, Kantoma bridge area and Checheniya) and Nassarawa Hayin in Tafa Local Government Area.

However, lack of sufficient data has hampered the analysis of flood damage and loss, particularly those related to the triggering factors and development process (Suriya and Mudgal, 2012). Evidently, much work has not been done in regards to factors responsible for flooding and damages cause by flooding in terms of the impact of illegal development on river side, flood plain and flood prone zones of the study area. It is upon this backdrop that this study attempts to investigate the factors that aggravate the 2017 flooding and its impact on relevant on human livelihood.

1.3 Aim and Objectives of the Study

The aim of the study is to assess flood damage and loss in Nasarawa Hayi, Tafa Local Government Area of Niger State, Nigeria. The objectives are to:

i. Identify and map out factors responsible for flooding event in the study area
ii. Map the flood risk zones in the area and
iii. Assess the damage to assets and infrastructure in the study area

1.4 Justification of the Study

The need to provide an enabling framework for proper identification of flood hazard and its risk factors in the study area is paramount and essential. The rapidly growing urban centres in Niger State are witnessing frequent flooding as a result of unplanned and haphazard expansion, thereby intensifying flood hazards with adverse repercussions on the urban poor and the vulnerable (Ojigi *et al* 2013). Essentially, studies abound on general damages flooding left behind in various communities in developed and developing nations of the world (Suriya and Mudgal, 2012). Generally, flood risk affects lives directly and indirectly in terms of properties and urban infrastructure.

Nasarawa Hayi is a low-land area and is under-going frequent and constant flooding every year. This research work will provide vital data or information essential for effective flood disaster management and prevention. Identified hazard is going to be essential reference point for flood disaster managers in order to make proper projection or simulation (Dukiya, 2013).

Essentially, this research is aimed at examining the factors responsible for flooding the Nassarawa Hayi community. The study is meant to generating a flood risk and vulnerability database for the State, using tools such as Digital Elevation Model, Buffer and flood prone maps, spatial and temporal maps, land-use and land cover changes analysis, amongst others. The results of the research are expected to help decision makers to better understand the causes

and vulnerability of flood risks and its hazards, predict outcomes and put in place a sustainable flood risk control and remedial measure.

The research work will provide a baseline for future planning and environmental modeling, simulation and for making early warning systems. Tafa local government area stands to benefit immensely because, all abnormalities identified will be addressed by flood disaster management planners and environmental managers, and outcome of the research will be useful to Niger State Government. It will also serve as a reference material for further investigations and developmental processes to generate interest on the sector particularly how devastating flood hazard changes the lives of people in the study area and further more to examine the effects and benefits of flood hazard to Nasarawa Hayi in Tafa Local Government Area.

1.5 Scope of the Study

The work is confined to Nasarawa Hayi in Tafa Local Government Area. This study focused on causes of flood, impact of flood on people, infrastructure and socio-economic livelihood, existing flood preparedness measures and vulnerability. The major tasks that was carried out include identification of flood disaster causes, assessment of flood impact on the houses and farm and assessment of flood damage and loss done in Nasarawa Hayi, Tafa Local Government Area of Niger State during the 2017 flood event.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Flooding and its Causes

Flooding is one natural hazard which has the potential to generate disaster. Flooding causes loss of life and properties of the people and even causes severe economic setback, especially in developing countries (UNDP, 2015). Flood is a natural calamity which occurs by huge rainfalls followed by the overflow of riverbanks and which usually occurs at the bottom of a valley and in coastal areas.

2.1.1 Effect of Flood Hazard

According to UN-Water, (2011) flooding is one of the serious natural disaster which interrupt the economic progress, safety condition and social amenities of human settlements. The term flood refers to a flow of water over areas which are habitually dry (Amangabara and Godo, 2010). It covers a range of types of event, many of which can also include other sources of damage such as wind. Sources of floodwater can arise from the sea (in the forms of storm surge or coastal degradation), from glacial melt, snowmelt or rainfall (which can develop into riverine or flash flooding as the volume of water exceeds the capacity of watercourses), and from ground infiltration (Adedeji *et al.,* 2013). Ehiorobo and Izinyon (2014), were of the opinion that flooding is one of the waters related environmental problems the magnitude of which is very much dependent on land use practices in the watershed of each river or stream. It posited that riverine floods occur when the amount of run-off originating in a particular watershed exceeds the carrying capacity of natural or constructed drainage system. The water thus proceeds to inundate surrounding lands or settlements. Due to the nature of flood occurrence, full analysis of the effect of a flood requires correlative research linking physical hazard and socioeconomic impact. The most effective form of evaluating effects of any flood event including most

environmental disasters involves the assessment of such impacts within a past, present and future context.

Consequently, the impact of flooding does not only affect socio-economics activities, it also threatens the human survival with the spread of diseases and starvation. To be sure the impact on the following key areas is discussed below.

Impact on Housing:

The effect of flooding on house is that the materials used in the construction of the houses might get weak making some of the building to collapse especially building made of cheap materials Rahman (2014). The loss houses to flood would make most of the people to abandon their collapsed building and seek for shelter elsewhere, which million of cash would be needed to solve this problem. Also the flooding leads to the spread of diseases because the moisture and temperature would provide condition for disease to survival, therefore prevent the growth of the plant.

Impact on Agriculture:

According to Butzen (n.d) flooding affect the growth of crop negatively whereby it prevents the plant from carrying out the necessary function such as respiration, photosynthesis and transpiration by reducing the supply of oxygen to the plant and also it washes away the Nutrient required by the plants to grow. While Magami *et al.* (2017) pointed that several millions of Naira was lost due to the submerging of crops by the flood and this has hindered some states from increasing their agricultural output.

Impact on the Transportation Network:

Flooding of transportation network affects communication and the distribution of goods between community and towns (Rahman, 2014). The excess downpour by the rain will lead to excessive erosion of soil that support the road and bridges, causing the roads and bridges to

collapse, cutting accessibility between towns (Ezema, 2013). According to the report by Punch (2017), the flood in Lagos led to chaos with much gridlock fitness in several areas in the state, while commuters were stranded at various bus stations making the cost of transportation high.

Impact on Health:

Olaore (2014) pinpointed that flooding could be a threat to human survival such that it can lead to breakdown of human mental and health status as a result of losing their properties and related person. While Etunovebe (2011) stated that flooding could lead to the spread of water borne diseases such as diarrhea and pollutants carried by the flooded water consumption dangerous. According to Rahman (2014) flooding would deny people accessibility to health care services making their health condition to worsen the more since the health care worker might move to safe grounds in order to provide their people medical services which would prevent accessibility to health care services.

Impact on the Economic Activities:

Kwari *et al.* (2015) flooding has a great impact on the economy of the nation, whereby the flooding put all economic activities at hold such as business, transportation and manufacturing. This is due to fact that the flooding would lead to the collapse of bridges, disruption of power supply and communication link, limiting the movement of goods and people, preventing workers from going to work and finally traders wouldn't be able to carry out their business transactions. This effect would, in turn lead to loss of several millions of Naira and slow the growth of the Economy of Nigeria.

2.1.2 Causes of Flooding

Flooding is a phenomena caused by diverse but interrelated conditions. Generally, the causes of flooding have been classified into two, namely, Natural causes and Anthropogenic causes.

The natural causes of flooding are primarily linked to rain or heavy down poor. On the other hand, Anthropogenic causes of flooding are essentially tied to human activities (Adedeji *et al.,* 2013). By implication, flooding in terms of environmental hazard is not limited or restricted to a physical phenomenon. In the light of the foregoing, water overflowing its bank is not an issue but it becomes a hazard when it affects human lives and activities.. Based on this understanding, flood hazards also create socioeconomic phenomena and sociopsychological conditions of stress. Major causes of flooding have been linked to human interaction with the environment (e.g., urbanization and agricultural activity).

Marcellinus *et al.* (2015) observed that there are twelve causes of urban flooding: They are:

> ***Surcharges in water level due to natural or manmade construction of flood paths, sudden dam failures, inappropriate land use, deforestation of catchment basin, reclamation, construction site and solid waste, inadequate drainage capacity to cope with urbanisation and excess encroachment in flood ways.***

The aforementioned causes of flooding are not alien to Nigeria. For instance, Olaokun (2016) Ajiboye (2015) and Adedeji (2013) observed that flooding in Nigeria may be induced by substandard infrastructure, poorly planned and managed urbanisation process, high prevalence of urban poverty, absence of water drainage network, heavy torrential rain storm, dumping of waste/refuse in drainage and water channels, topographical characteristics and low infiltration capacity due to high water table and overflowing of river banks, It is unfortunate Nigerian authorities lack proper planning and orderly conduct when it comes to sound promotion of flood prevention (Adedeji *et al.,* 2013).

2.2 Urban development and Floods

The rate of rural to urban migration is increasing greatly on daily basis, therefore making the immediate need for construction of buildings and structures for shelter and other activities to increase. The risk of flooding increases due to inappropriate, or inadequately maintained infrastructure, low-quality shelters and low resilience of the urban poor (World Bank, 2016).

In some cases, construction of buildings and structures has come into close proximity to streams and other primary drainage facilities. This has made the drainage channels incapable of containing the high volume of water runoff during rainfall, which invariably carries large amounts of silt (Sam Jr, 2012). Many people have built haphazardly structures along stream channels putting human lives at risk to the dangers of flooding; this can be attributed to ignorance and contempt of building regulations. Paved roads and massive construction of buildings/shelters increases the imperviousness of the catchment areas. The catchment areas easily respond to rainfalls and subsequently increase their runoffs.

The challenges of urban floods are a serious concern for both developed and developing nations. They cause damage to buildings, utility works, housing and household assets, income losses and loss of employment and severe interruption to transport systems. The damage caused by urban floods is on the rise. It is therefore important to understand the causes of and impacts the different types of flooding have on urban areas. Urban floods typically stem from a complex combination of causes. The urban environment is subjected to the natural forces which the alteration in the natural environment as a result pressure of development has exacerbates the effect of flooding. Urban floods are also caused by the inadequate planning of land use system.

A rapid urbanization with rising population and high demands for land is a major challenge facing many urban areas. While political factors, economic or capacity or resource constraints has hindered the existing laws and regulations to control the construction of new infrastructure and the variety of building types. This leads to obstruction in the natural flow path of water, which causes floods.

In Nigeria most urban areas have been planned with little or no provision been made for surface drainage, while those with existing drainage has been blocked with municipal waste, refuses and eroded sediments, The occurrence of urban flooding is mostly on the flat or low-lying terrain (Olajuyigbe *et al.,* 2012). The persistence struggle with floods by some states in the Niger-Delta is because of the absence of drainage systems. Thus, whenever rain falls, the streets become flooded and hindering the free flow of traffic. In addition, due the water did not have a channel to flow through the roads do not last long and making it to develop pot holes. In most Nigerian cities where drainage systems exist, the drainages have been stuffed with or completely blocked with refuse. This has given rise to floods especially flash floods. This is usually experienced when short periods of heavy rainfall lead to run-off due to the inadequate channel capacity of the drainage system.

Most countries in the world has experienced huge losses annually as a result of flooding which has disrupted economic activities, damages to infrastructure, and preventing public health services. Long term data on natural disasters suggest that floods and wind storms have been by far the most common causes of natural disaster worldwide over the past 100 years (Ojigi *et al.,* 2013). Worldwide, there has been a rapid increase in number of people killed or seriously impacted by flood disasters.

2.3 Flood Occurrences

It is challenging to decide the extent of flood damage and to equate in a palatable manner one flood with another, mostly due to the comparative propensity to overestimate flood damage, especially at the time of the event. Flooding in Nigeria occurs in three main forms: river flooding, urban flooding and coastal flooding (Etuonovbe, 2011). In Nigeria, occurrence flood tends to cause a widespread fright nation. Flood events has caused massive hike in price of food crops, resulting to an estimated 2% rise in rate of inflation (Onwuka, *et al*., 2015). So far,

flood is the worst environmental disaster plaguing the Nigerian economy. Flood impacts are often felt all over most parts of the country. From 2012 to present, huge amount of money has been spent by the government on relief materials for flood victims. Flood disaster has predominately affected nearly all cities in the country, leaving many Nigerians with the opinion and perception that this events has come to stay, making the general population to rely on government control measures. Poor and unavailable flood prediction, flood control systems and techniques are seen as major causes that aggravate flood disaster nationwide.

2.4 Vulnerability, Hazard and Risk of Flooding

Vulnerability to disasters describes the degree to which a socio-economic system or physical assets are either susceptible or resilient to the impact of natural hazards (Birkmann, 2013). United Nations Disaster Relief Organization [UNDRO] (2011) defined it as "the degree of loss to a given element at risk or set of elements at risk resulting from the occurrence of a natural phenomenon of a given magnitude and expressed on a scale from 0 (no damage) to 1 (total damage)" Paul (2013) defined vulnerability as an internal risk factor of the subject or system that is exposed to hazard and corresponds to intrinsic tendency to be affected or susceptible to damage. While United Nations Development Programme [UNDP] (2015) said that it is "human condition or process resulting from physical, social, economic and environmental factors, which determine the likelihood and scale of damage from the impact of a given hazard". It is determined by a combination of several factors, including awareness of hazards, the condition of human settlements and infrastructure, public policy and administration, the wealth of a given society and organized abilities in all fields of disaster and risk management.

Recent studies have shown that in developed countries, more emphasizes have been placed on the significance of people's vulnerability to hazards, rather than holding a narrow focus on the hazards themselves. It is particularly important to operationalise the term vulnerability. In

addition, it is equally vital and crucial to recognize that vulnerability is balanced by peoples' capabilities and resilience, and that if they are perceived only or mainly as victims then the problem of what causes vulnerability may be evaded (Takemoto, 2011). Vulnerability analysis is developed from a range of socio-economic approaches to hazards and what we could call 'the disaster of everyday life). Social vulnerability is a set of characteristics of a group or individual in terms of their capacity to anticipate, cope with, resist and recover from the impact of a natural hazard. It involves a combination of factors that determine the degree to which someone's life and livelihood is at risk by a discrete and identifiable event in nature or society.

2.4.1 Relevant variables causing vulnerability to urban flood in the study area

The actual conditions that determine flood vulnerability are to a certain degree very site specific, location and hazard-dependent. The review of relevant literature showed that the variables that are most relevant for flood vulnerability. These indicators fit the local conditions and the flood characteristics best. The diverse social and physical character of Niger State makes it an ideal study site for testing the capability of the proposed methodology for deriving rigorous measures of urban vulnerability that can be utilized in subsequent research to understand the relative importance of social and physical variables in determining the overall vulnerability profile of urban areas in Niger State. This can help improve the understanding of vulnerability patterns in that region, and ultimately can aid in the formation of mitigation policies in anticipation of the problems that accompany urbanization processes and demographic shifts in that region.

Table 2.1: Relevant Variables for the assessment of flood vulnerability in the study area

No	Variable	Relevance	Reference
Physical vulnerability			
1	Main construction material for roof, walls and floor	Determines the physical fragility towards flood events and indicates the resistance to damage and also the social status	Schneiderbauer (2007); Taubenb¨ock (2007); Clark *et al.* . (1998); Cutter *et al.* (2003)
		Some types of construction material allow humidity to remain in the walls or floor after flood events which can lead to health problems	Müller *et al.* a (2011)
2	Position of buildings in relation to the street level	Determines the likelihood of constructions to suffer damage in case of a flood event,	Schneiderbauer (2007)
		People that live below or at street level show a much higher exposure to the floods	Müller *et al.* (2011)
3	Proportion of green spaces per building block	used to describe the social status	Stow *et al.* (2007)
		The higher the amount of green spaces in an area, the higher the retention potential and the lower the flood hazard	Niehoff *et al.* (2002)
4	Availability or application	Small walls and backflow flaps of flood protection infrastructure	Schneiderbauer (2007) reduce the exposure
Social vulnerability			
5	Age	the young and the elderly people are vulnerable to natural hazards both because of their physical condition and their financial dependence	Schneiderbauer (2007); Haki *et al.* (2004); Cutter *et al.* (2003)
		the vulnerability of the elderly is minimized by their experience	Clark *et al.* (1998)

6	Gender	women are generally described as more vulnerable to natural hazards than men because of their stronger involvement in family life, sector-specific jobs and lower wages	Wisner *et al.* (2004); Haki *et al.* (2004); Cutter *et al.* (2003)
		women are more emotional which makes them more vulnerable	Müller *et al.* (2011)
7	Level of education	strong relation to income and social status contributes to a better knowledge about natural extreme events and their origins and about methods to reduce and mitigate the hazard	Schneiderbauer (2007); Velasquez and Tanhueco (2005); Haki *et al.* (2004)
8	Household size	the higher the household size, the lower the social status and the higher the amount of people affected – and therewith the damage	Haki *et al.* (2004); Cutter et al. (2003)
		large households embody intrinsic social networks and manpower which can be valuable in emergency situations	Velasquez and Tanhueco (2005)
9	Employment status	Indicates the regularity of income and therewith the possibilities of a household to save money for flood mitigation measures or to cope with negative effects. It is distinguished between no employment, permanent employment and sporadic employment	Müller *et al.* (2011) (modified after Dwyer *et al.* 2004)
10	Experience with floods	Increases people's sensitivity to the problem, leads to the generation of private flood mitigation measures; positive influence on preparedness	Birkmann (2005a), Velasquez and Tanhueco (2005), Wisner *et al.* (2004), Cardona (2003)
11	Knowledge about flood hazard	The more knowledge and information available, the lower the vulnerability	Cardona (2003)
12	Knowledge about private protection measures	Diminishing of vulnerability, financial resources are not real constraint for the construction of protection measures – at least not for short-term protection measures such as sandbags	Wisner (2003), Müller *et al.* (2011)

Source: Müller *et al.*, 2011.

2.5 Factors Causing Urban Flooding Hazard in Nigeria

There are a numerous factors in Nigeria that are causing and increasing the effect of flooding. Some of these factors are as follows:

2.5.1 Low quality infrastructures

The causal relationships that exist among various elements of the modern built environment system provide a credible platform for understanding the peculiar challenge of FRM in Nigeria. While the government of Nigeria has made huge investment in terms of modern infrastructural for the increasing population, many of the structure tends to be substandard and collapse long before their expected life span due poor planning and construction process carried out. For instance, many a substandard bridges or road networks constructed have collapses so many times in Nigeria especially during the rainy season. The debris and concrete materials from these collapse structure end up been washed by the surface runoff into the stream channel thereby blocking or reducing the carrying capacity of the channel. This will eventually lead to flooding of the adjoining area close to the collapsed bridge. As a result of failed construction work, many commuters will try to change their routes to avoid traffic leading to stretching these other routes and this continues trend will cause more damage. For example, heavy truck drivers are forced to drive over bridges with a low carry capacity and this could collapse the structure creating more avenues for incident of flood. In conclusion, substandard infrastructure will increase the risk of flooding in a built environment.

The standards and type of materials used for many buildings in Nigeria cannot withstand mild floods. According to Oladokun (2016), his reviewed of "Abaje *et al.* (2015), was observed that about 69% of the houses in a state in Northern Nigeria were built with unbaked mud and on foundations of loose sandy soil, while Anosike and Oyebade (2012); Ewa and Ukpata (2013) reported that sandcrete blocks, used in over 90% of Nigerian urban houses, are below required standards. Consequently, these houses are highly exposed and vulnerable to flood damage".

The poor regulations and enforcement of law on the building activities can be attributed as one of the root cause for weak structures (Anosike and Oyebade, 2012).

2.5.2 Poor urban planning and poor management urbanization process

Over time there has been a poor management of the growth and expansion of urban communities in Nigeria. This is as a result poor land use management, inadequate spatial planning, inadequate control by the regulating authorities (Adedeji *et al.*, 2013). The inadequate material and technical ability to check the suitability of an area for construction project is lacking and also most town officials have shown lukewarm attitude toward this act or in many way have of compromised such that people in the society alter the design and use of buildings without proper approvals. Such act is potential cause of flooding in urban area.

2.5.3 High prevalence of urban poverty

Poverty is a serious challenge that has hindered the development of Nigeria. Record from demographic data has shown that major of the nation's population, of over 200 million, are subjected to poverty. Studies have confirmed that people from the lower income neighbourhoods are those worst hit by the impact of flooding especially women Ajibade *et al.* (2013). The Increasing poverty and insecurity situation in Northern Nigeria in recent times has forced people to migrate to the low-lying and coastal cities in the South. Unfortunately, the exorbitant cost of purchasing land and renting of housing in these cities has made migrants to move into 'affordable' shelter with poor condition or turn existing areas into shelter without the basic amenities and gradually turn into a slum. While swampy and low level areas may be cheaper to acquire per plot they are usually very costly to develop. Swamps and waterlogged lands require heavy investments in deep concrete foundations, high volume of sand filling and dredging, networks of drainage and other infrastructures required to minimize the impact of flooding.

The spread of slum in the major cities in Nigerian as a result of migration has placed a huge pressure on sewage systems, indiscriminate dump of refuse and waste along water channels therefore make the drainage networks to get blocked making flooding to be inevitable (Adeleke, 2013). So, poverty is the major agent behind urban flooding, the situation is further compounded when residents lose their properties and livelihoods to flood disasters. Hence, there is a vicious cycle of flooding, poverty and deprivation (Ajibade *et al*., 2013). Various attempts made in the past to relocate people from swampy slums have been abortive due lack of compensation and non-consultation of stakeholder involved. Involuntary resettlement from development projects should be properly managed to avoid long-term hardship and impoverishment of affected persons and communities. Unmitigated impacts often give rise to severe economic and social stress.

2.5.4 Lack or inadequate drainage network

In Nigeria, the increasing frequency of urban flooding can be pointed to Inadequate and poorly maintained drainage network. In relation to cities in developed nations, many of Nigerian urban areas lack drainage network for surface runoff and flood water. Many of the residents depend on nearby rivers and tributary streams flow as a means of drainage in those areas, Kolawole *et al.* (2011). From studies carried out by Abaje *et al*. (2015) has shown that 64.5% of the residents in some Northern cities of the Nigeria lack access to drainage systems.

2.5.5 Cultural resistance to change

Ignorance due to low level literacy, superstitious beliefs such as rivers regarded as deities to be appeased when they overflow their banks are common among many Nigerian tribes. In many cities, drainage systems have been blocked with refuse by residents who dump wastes in drainages (Abaje *et al*., 2015).

2.6 Damage and Loss Assessment of Flood Disasters

Damage and loss assessment of flood disasters fall within climate change spectrum and it is a new concept in climate change research (Van der Geest and Schindler, 2017). Damage and loss as concepts in the context of climate change or related areas may be referred to impacts of climate change that occur despite adaptation and mitigation efforts or simply the negative effects of climate variability and climate change that people have not been able to cope with or adapt to (Thomas, *et al.*, 2018). Damage was also defined as total or partial destruction of physical assets existing in the affected area and Losses are defined as changes in economic flows arising from the disaster. To make a clearer distinction the United Nations Framework Convention on Climate Change [UNFCCC] (2012) defined all Climate change impacts that are permanent and irreversible as 'loss' while 'damages' are seen as impacts where there is possibility of reparation or restoration.

Loss and damage assessment is part of risk assessment or post disaster assessment whose goal is to quantify, mostly in monetary terms, the impact of disasters on the society, economy and environment in order to estimate the cost of a specific event, either actual (post-impact) or hypothetical (Kelly, 2014). Damage and loss assessment during floods encompasses every systematic, scientific and objective appraisal of the permanent and temporary as well as economic and non-economic impacts of a flood disaster (Thomas *et al*., 2018).

The International Bank for Reconstruction and Development /World Bank (2010) outlines the following as basic steps for carrying out a disaster damage and loss assessment which is also applicable to flood disasters. According to them the typical steps to follow during an assessment of damage and losses are:

1. Define a pre-disaster baseline;
2. Develop a post-disaster situation;

3. Estimate damage and losses on a sector-by-sector basis;
4. Estimate overall amount of disaster effects;
5. Estimate macro-economic impact; and
6. Estimate impact on personal/household employment and income.

The assessment of these loss and damages follow several approaches and each are done for specific purposes as can be seen detailed as follows.

2.6.1 Uses of Flood Damage and Loss Assessment (DALA)

All assessments are carried out to achieve some purpose, flood disaster damage and loss assessments are also carried out to achieve several things among which Van der Geest and Schindler (2017) and International Bank for Reconstruction and Development/World Bank (2010) outlined as follows;

1. Damage and loss assessments serve as a means to determine the degree of severity of a disaster for a natural environment or an affected population. For the affected population it gives recognition of their plight and provides a strong basis for future policies to avert, minimize and address loss and damage thereby provides significant input for adaptation efforts to climate change.

2. Damage and loss assessments also helps to provide understanding of human contribution to the flood disaster toward suggesting solutions to the problem to change in pattern of interaction with environment and providing anthropogenic remedies.

3. Damage and loss assessments also serve as basis for relief supply as well compensations provision.

4. It can also be used for monitoring progress of economic recovery and reconstruction programs at short term and long term basis.

2.6.2 Damage and Loss Assessment Methodologies

Several Methodologies for loss and damage assessments exist in the literatures, and these methods vary from one another base on underlying principle or school of thoughts, the goal they intend to achieve, time needed to be complete as well as tools or instruments to be used. Thomas *et al*. (2018) opined that the two main directions in flood damage and loss assessment usually come from Climate Change Adaptation (CCA) perspective or Disaster Risk Reduction (DRR) perspective. According to them the Climate Change Adaptation perspective assesses loss and damage costs prior to a possible disaster to offer possible adaptation methods while the Disaster Risk Reduction includes pre and post disaster assessments of loss and damage but both include quantitative and qualitative techniques in their processes. In addition to these two methodologies for damage and loss assessments, Kelly (2014) opined that important social and environmental aspects of loss and damage, such as cultural heritage, environmental qualities, governance and trust, cannot be easily quantified, hence a purely qualitative approaches such as community based-disaster risk management (DRM) and vulnerability capacity assessment can be used to should complement other existing approaches.

Although each method for damage and loss assessment is faced with unique challenge, but in a general note, damage and loss assessment for floods are faced with challenges as out lined by Thomas *et al*. (2018) and Birkmann *et al*. (2011) as follows;

1. All methodologies rely either on available data or the collection of data. Lack of access to existing data, lack of collection of detailed data or inadequacy of available data could hamper robust assessment of loss and damage costs.
2. Due to large high dependence on estimates by most methodologies and in specific, models and tools rather than collecting data on actual damages. Using estimations increases the probability of inaccuracy

3. Technical knowledge and skills are necessary to conduct assessments adequately. Users of different methodologies need to be informed about limitations and uncertainties and also need skills to interpret outcomes.

2.6.3 Results from Case Studies of Flood Damage and Loss Assessment

Floods are among the most destructive of meteorological disasters, as a result there is a higher loss due to floods in monetary values among developed countries but greater economic impacts and fatalities are experienced among developing countries around the world (Suarez and Linnerooth-Bayer, 2011).

Evidences around the world of detailed findings from damage and loss assessments revealed that the exercise is worthy of undertaking as they provide necessary data for future prevention and adaption options as well as relief supply for the affected population. The following are specific case studies and associated findings related to flood disasters around the world; Kayode *et al.* (2017) carried out post disaster assessment of floods around Lokoja, Nigeria and the result reveals that; 'It was observed that 61.3% of the households rated the last flood event as extremely severe while another 20.0% rated it as severe. Losses arising from the flood disaster were pervasive as 11.7% of the households reported loss of lives, 53.3% loss of farmlands, 64.0% damage to roads and 68.0% loss of valuable properties. There were significant inter-neighborhood variations in quantified losses incurred by households in terms of farm produce, lives, properties, income and number of displaced people.

Furthermore, variations in losses of farm produce, lives, properties and income were significantly different in Sarkin Noma (a poor neighbourhood) from other neighbourhoods, while Lokongoma (a planned, middle income neighbourhood) accounted for a significant difference in the number of displaced persons. Households generally relied on individual and

community based coping mechanisms to manage the effect of the disaster as victims lacked institutional support and government interventions were limited in depth and scope'.

Brouwer *et al.* (2007) on the other hand states that Bangladesh is highly a flood prone country with over 80% of territory laying on floodplains and several other minor rivers. They further reveal that long term studies shows in every ten (10) years roughly one-third of the country gets severely affected by floods while in catastrophic years such as 1988, 1998 and 2004, more than 60% of the country was inundated. The impacts of flood in Bangladesh are felt in the areas of social disruptions and scarcity of drinking water as surface water are usually contaminated. Also in Bangladesh, there is a usual rise in cases of diarrhea, cholera and other diseases during and after floods with the hardest hit by these problems mostly being the poor and the vulnerable in the society. A study carried out in 2005 in Southeast Bangladesh confirms the positive relationship between environmental risk, poverty and vulnerability (Brouwer *et al.*, 2007).

2.7 Remote Sensing Approach to Flood Monitoring

As a result of the great capabilities in remote sensing technologies such as speed, up-to-datedness, accuracy and area-wide analysis of the urban landscape, the technique has become one of the most patronised in environmental monitoring (including flood) in recent years (Bishaw, 2012).

By remote sensing, we imply the science and technology of acquiring information about the earth using instruments which are remote (far away) to the earth's surface, usually from aircraft or satellites. A typical remote sensing system is composed of a 'Platform', that is the vehicle which carries a sensor such as satellite, aircraft, or balloon; 'Sensors', which are devices that receives electromagnetic radiation and converts it into a signal that can be recorded and

displayed as either numerical data or an image; receivers, which store sensed data and the human being who manipulates the data to generate results (Lwin, 2008).

In applying remote sensing techniques for flood monitoring and damage-loss assessments, very high resolution multispectral optical satellites data from GeoEye I, Quickbird, CARTOSAT, SPOT or RapidEye with geometric resolution ranging from 41 cm to 5 m, which is feasible for the small-scale objects typical in urban environments are used as data sources. The sourced data are then corrected for atmospheric disturbances such as clouds in an appropriate computer software such as ENVI or ILWIS, which further modeling and simulation of flood vulnerabilities may be estimated using related models (Bishaw, 2012).

The real time application of remote sensing in flood monitoring is prevalent in many literatures. Orimoogunje *et al*. (2016) used remote sensing techniques to carry out a flood vulnerability assessment in Part of Southwestern Nigeria. Also, Bishaw (2012) applied remote sensing techniques for flood hazard and risk Assessment in Dugeda Bora Woreda of Oromiya Regional State, Ethiopia. The practical application of remote sensing techniques from the these outlined case studies affirm the great capabilities in the method thereby commanding adaption by researchers interested in related problems as the case of this study.

2.8 GIS and Flood Risk Mapping

As a scientific technique which has the ability to receive, store, manipulate and produced spatially referenced data and convert them into usable day to day information, Geographic Information Systems usually referred to as GIS are also useful in flood risk mapping (Balan, 2014). Because of its capacity to accept data from remotely sensed source, field collected data as well as extract from databases and over them on one another alongside other needed data,

GIS has the ability produce map showing flood prone areas.

GIS generated flood risk maps are considered easy-to-read read and rapidly accessible charts which aids with the easier identification of flood risk areas and prioritize their mitigation effects as well as response efforts (Demir & Kisi, 2016). A flood risk map is a map that shows areas that would be flooded by stream discharges of a given magnitude for a given amount of rainfall. Flood risk mapping is very important for land use and planning in flood prone areas. They are used to determine areas prone to flooding when discharge of streams exceeds the bank-full stage or runoffs or flows exceed the capacities of their channels (Demir & Kisi, 2016). Flood risk mapping is also useful to assist with post-disaster recovery planning and management, likewise it is said to further aids in analysing the characteristics of the nature of the terrain of the study area and the drainage network system. These may contribute immensely to accurate and timely intervention strategies and curbing the impacts thereafter (Balan, 2014).

GIS methodology has been used in various studies around the world to generate map showing flood prone areas, some of these include Sanyal and Lu (2003); Demir and Kisi (2016); Balan (2014); and Orimoogunje *et al.* (2016).

CHAPTER THREE

3.0 MATERIALS AND METHODS

The chapter examines the different types of data use, data collection instruments, sample procedure and size, and finally, the data analysis techniques use in analyzing the data collected.

3.1 Study Area

3.1.1 Location

Nasarawa Hayi is a community in Tafa Local Government Area in Niger State, Nigeria adjoining the Federal Capital Territory. It is located on longitude of $7^0$51" E to $7^0$72"E and latitude 9^0'33" N to 9^0'51" N with the projected population of 71,074 people as at 2014 (NPC, 2015). The geographical location of Nasarawa Hayi in relation to Niger State and Nigeria is shown in Figure 1.1, 1.2, 1.3 and the aerial photo study area shown in Figure 1.1.

2015). The geographical location of Nasarawa Hayi in relation to Niger State and Nigeria is shown in Figure 1.1, 1.2, 1.3 and the aerial photo study area shown in Figure 1.1.

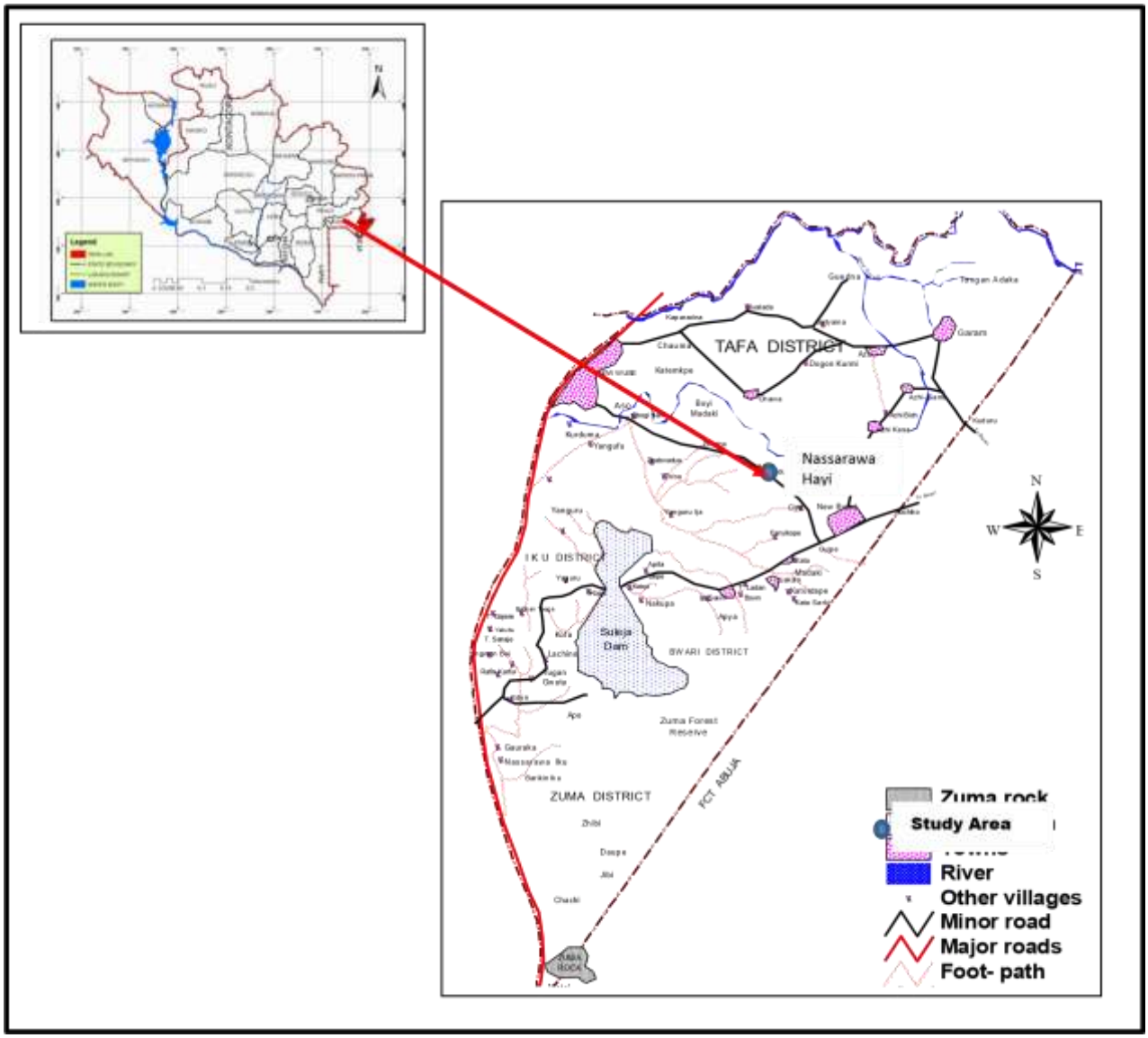

Figure 1.1: Location of the Study Area in Tafa LGA

Source: NIGIS, Minna, (2018)

3.1.2 Climate

Tafa under Köppen climate classification features a tropical wet and dry climate. Nasarawa Hayi experiences three weather conditions annually. This inclues a warm humid rainy season and a blistering dry season. In between the two, there is a brief interlude of harmattan occasioned by the northeast trade wind, with main feature of dust haze, intensified coldness and dryness.

The rainy season begins from April and ends in October, when daytime temperatures reach

28 °C (82.4 °F) to 30 °C (86.0 °F) and nighttime lows hover around 22 °C (71.6 °F) to 23 ° C (73.4°F). In the dry season, daytime temperatures can soar as high as 40 °C(104.0 °F) and nighttime temperatures can dip to 12 °C (53.6 °F). Even the chilliest nights can be followed by daytime temperatures well above 30 °C (86.0 °F) (Nasidi, 2015). The high altitudes and undulating terrain of Nasarawa Hayi at as a moderating influence on the weather of the territory. In the Nasarawa Hayi reflects the territory's location on the windward side of the Jos, Plateau and the zone of rising air masses with the city receiving frequent rainfall during the rainy season from March to November every year.

3.1.3 Vegetation

Nasarawa Hayi falls within the Guinean forest-savannah mosaic zone of the West African subregion. Patches of rain forest, especially in the rugged terrain to the south south-eastern parts of the territory, where a landscape of gullies and rough terrain is found. These areas of Niger state form one of the few surviving occurrences of the mature forest vegetation.

3.1.4 Relief

The study area has a long range of hills and ridges on the western side of the town, which has restriction in that direction slope in certain area of the developed town are up to 30% and that is responsible for the rapid erosion and gully formation which are common in the area.

3.1.5 Drainage System

The town is well drained in to a system of streams and as a result of the steep slopes there is incidence of flash flood in certain part of the town particularly in areas with high development density.

3.1.6 Soil

Like most alluvial soils, the soil in Nasarawa Hayi is the flood plain type and is characterized by considerable variations. The soil is of two main types which could be used for agriculture

and are rich in minerals for the manufacture of various products. The two types of soil are: the Ku-soil which has little hazards and the Ya-soil which has a better water holding capacity.

3.2 Sources of Data

Basically, two sources of data were used for this study, these are primary and secondary data. The primary data were source directly from the field, it is original in nature and directly related to the issue and current data. These are the data which the researcher collects through various methods like interviews, personal observation, questionnaire administration and oral interview. While the secondary data are the similar data to be collected by a researcher at different time in the past to gain initial insight into the research problem. These give the researcher the frame of mind and the direction of the study. These data include Journals, seminar, online Textbooks, newspapers, magazines, encyclopedia, library, etc.

3.3 Instruments for Data Collection

3.3.1 Questionnaire

According to American Statistics Association (ASA), (2012), Questionnaire is a measuring device used to query a population/sample in order to obtain information for analysis. The authenticity and validity of questionnaire as tools for collecting information is responsible for the choice of the method. A structured questionnaire was designed to collect useful data and information from the respondents. The questionnaire contains some multiple-choice questions respondents required to select the option that appealed to them. The questionnaire was structure in order to find out the damage and loss effect of flooding in the study area.

3.3.2 Focus Group Discussion

Qualitative data was collected through focus group discussion and this information was used to complement the questionnaire. For the purpose of this study, two FGDs was conducted to

obtain the experiences of men and women with impacts on structures and farm produce in term of damage and loss, preparedness, coping and adaptation to floods.

3.3.3 Oral Interview

An oral interview is an effective research technique which help the interviewer access his or her information needed to carry out his research effectively and efficiently. This method involved personal meetings with designated officials of the Niger State Emergency Management Agency (NISEMA), victims of flood hazard in the study area and their traditional ruler. The information generated from oral interview was integrated to that of questionnaire information and was analyzed using simple percentage.

3.3.4 GPS

The field survey aspects were use of GPS to capture the geographical coordinates of the prone areas, with computer assisted surveying method the coordinates were used to develop Digital Elevation Model (DEM). Satellite imagery of Nassarawa Hayi was used, the positions in terms of X and Y coordinates of the area were captured and reference on the map before on-screen digitization in order to provide flood prone map of the study area

3.3.5 Research Tools

The image of the study area was obtained through the use of Google earth image application. The image was taken to ARCGIS environment for onward processing. The image was georeferenced with the use of four known points on the image in ARCGIS environment under Universal Traverse Mercator (UTM) co-ordinate system. Furthermore, the image was digitized using polygon, lines and point features in ARCGIS to represent the various component of the image/map.

In order to identify the level of vulnerability of the various parts of the study area, one-hundred latitude/longitude and elevation data in the study area was picked from the study area with the use of Google Earth application. Distance of the various parts of the study area to the water body/river was also take accordingly. Since the two major determinant of vulnerability level of flooding in the study is its distance away from the water body and the general relief of the area, therefore the Lat/Lon/Elevation data was interpolated with the Distance from various part of the study area to the water in order to identify areas with likely high or low vulnerability to flooding in the area.

3.4 Method of Data Analysis

3.4.1 Factors responsible for flood event in the study area

The study provide analysis based on its design. The researcher made observation and use of questionnaire. Descriptive statistic is one of the statistical methods that was used to identify factors responsible for flood events and clarification of all variables in the research by using statistical package for social science (SPSS). Quantitative analyses which consist of descriptive and inferential data analysis toward accomplishment of research objectives. Descriptive statistic was used to express the respondent attribute and all variables that will be used in the study. While inferential analysis was used to investigate the relationship and the effect of independent variables on the dependent variables. This study also employs Pearson's Chi square and Binary logistic Regression Analysis by using SPSS.

3.4.2 Mapping the flood risk zones in the study area

Satellite imagery was subjected to digital image processing, the flood risk mapping depends on the use of computer-assisted interpretation of QuickBird Satellite imagery. Field survey data was complimented with satellite imagery, the terrain model of the area will be developed using. Buffer width of 300ft recommended by Palfrey and Bradley, 2002 was used to provide a buffer

zone along the river channel. This was performed in order to obtain and document element vulnerable to flood along the flood plain area. High Resolution Satellite imagery map was used for physical identification. Captured coordinates was referenced on the imagery for boundary demarcation. Surfer 10 software was used to develop Digital Elevation Model of the study area. It makes it easy and direct to identify flood prone areas in the study area. ArcMap 10.1 was used to develop the flood prone area map of the study.

A Digital Elevation Model (DEM) was created using the contours of interval 2m from the digitized topo sheet. A DEM is a digital representation of ground surface topography or terrain (ESRI, 2014). The triangular irregular network (TIN) model was the first generated and then the DEM subsequently generated (Forkuo, 2008). The Topo to Raster operation in ArcGIS was used to interpolate the elevation values for the study area using the contour data as input. The output of this operation was a DEM of the study area.

3.4.3 Assess the damage to assets and infrastructure in the study area

This study adopts thematic analysis method to condense the raw data obtained from the field into categories based on the conclusion and interpretation validity (Elo *et al.*, 2014). Content analysis was conducted based on the respondent's perception. The interview results was analysed using SPSS.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

This chapter reveal the assessment of flood damage and loss in Nasarawa Hayi, Tafa Local Government Area of Niger State, Nigeria. The chapter consists of four sections. The first section identifies factors responsible for flooding event in the study area. The second section map the flood risk zones in the area. The third section assess the damage to assets and infrastructure in the study area while the fourth section identify the level of flood hazard preparedness in the study area.

4.1 Factors Responsible for the Flooding Scenario

4.1.1 Flood experience

On Issue of flood experience of the respondents was analyzed. It was observed in Figure 4.1 that higher percentage of the respondents (81.6%) has experienced flood disaster in the area while 18.4% of the respondents have not experienced any flood in the area. It shows that the area is flood prone area and people within the areas are at risk of flood at any time.

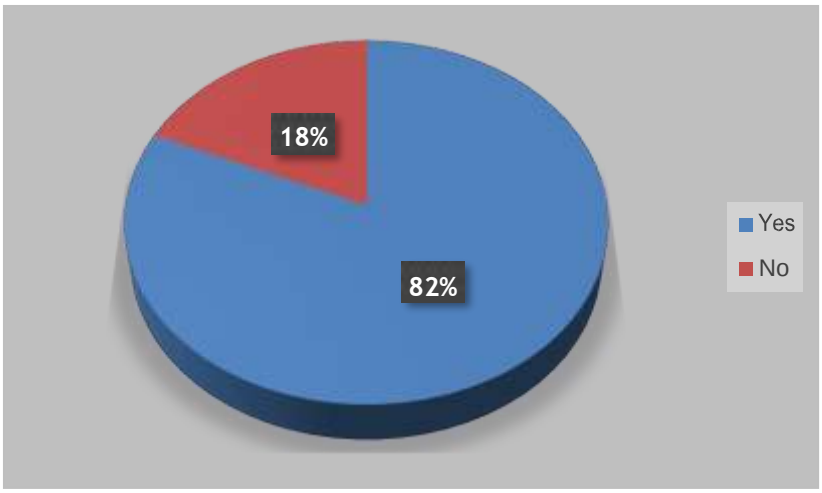

Figure 4.1 Experience of flood in the areas

Source: Authors Field Survey, 2019

4.1.2 Factors responsible for flood scenario

There were varying underlying causes of floods in the study area, it was observed that among the underlying factors responsible for flooding is proximity to the flood prone area (57%), while residing in flood prone area and poverty (8%) were identified as being the main underlying causes of flood in the community, 8% of the respondent attribute the causes of flood in the area to be Lack of alternative livelihood, 18% of the respondent attribute it to residing in flood prone areas and poverty as the causes of flood in the area while 9% attribute cause of flood to poverty and no alternative livelihood (Figure 4.2)

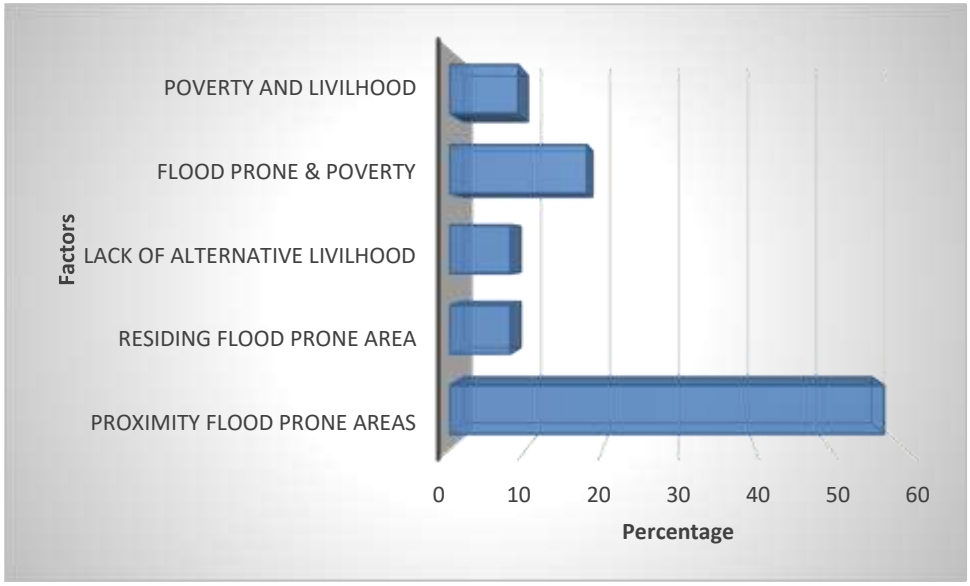

Figure 4.2: Factors responsible for Flood in Nassarawa Hayi

4.1.3 Rainfall pattern of the area

Owing to the distinctive demarcation between the wet and dry seasons in the region as indicated by the rainfall regime, River flows according to the season, the resultant effect is that the river is characterized with high average monthly flows of 122.0296/sec recorded in 2012 (Table 4.1). Average Monthly Rainfall Record of the area) this implies heavy rainfall result to flood which created serious impact on the socio-economic livelihood status of residents.

Table 4.1: Average monthly rainfall in the study area

Rainfall	mm
Jan	0
Feb	0
March	0.9
April	2.6
May	93.3
Jun	137.4
July	208.5
Aug	249.1
Sep	185.9
Oct	54.7
Nov	0.5
Dec	0.1

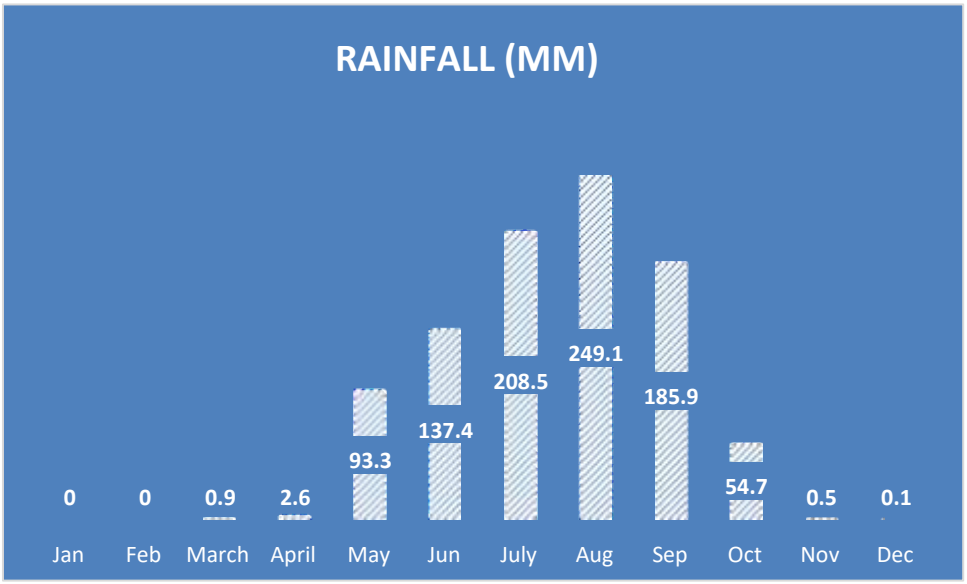

Figure 4.3: Graph showing the monthly rainfall pattern in Nasarawa Hayi

4.2 Flood Risk Zones in the Area

The probability of a flood occurring is normally investigated followed by flood vulnerability mapping which defines the areas that are at risk of flood inundation. The study shows that Nasarawa Hayi has high and low-lying area and the area have farmland, River and flood plain as shown in Figure 4.4. This section of the study carried out flood mapping in the flood-prone areas using satellite image and ArcGIS 10.01 to demarcate high, medium and low risk zones. The map produced by the interpolation of distance and elevation data from in the study area reveals that Nassarawa Hayi is on a relatively high land when compared to other surrounding areas. Although development is on a relatively high land when compared to its surrounding, the flood plain close to development on the western part of the area has increased the vulnerability level of the area as against the North-Eastern part of the study area. The study area has however, shown great disparities in the spatial temporal patterns of encroachment.

: **Figure 4.4: Quick bird Imagery of Nassarawa Hayi**

Flooding in Nassarawa Hayi is as a result of natural factors such as rainfall intensity, duration, terrain and presence of large bare exposed surface as well as human induced factors such as expansion of built up areas usually in the flood plains, the expansion of agricultural activities at the upper course of the river and deforestation leading to serious environmental, social and economic problems. Figure 4.5 is the digitized map showing drainage network.

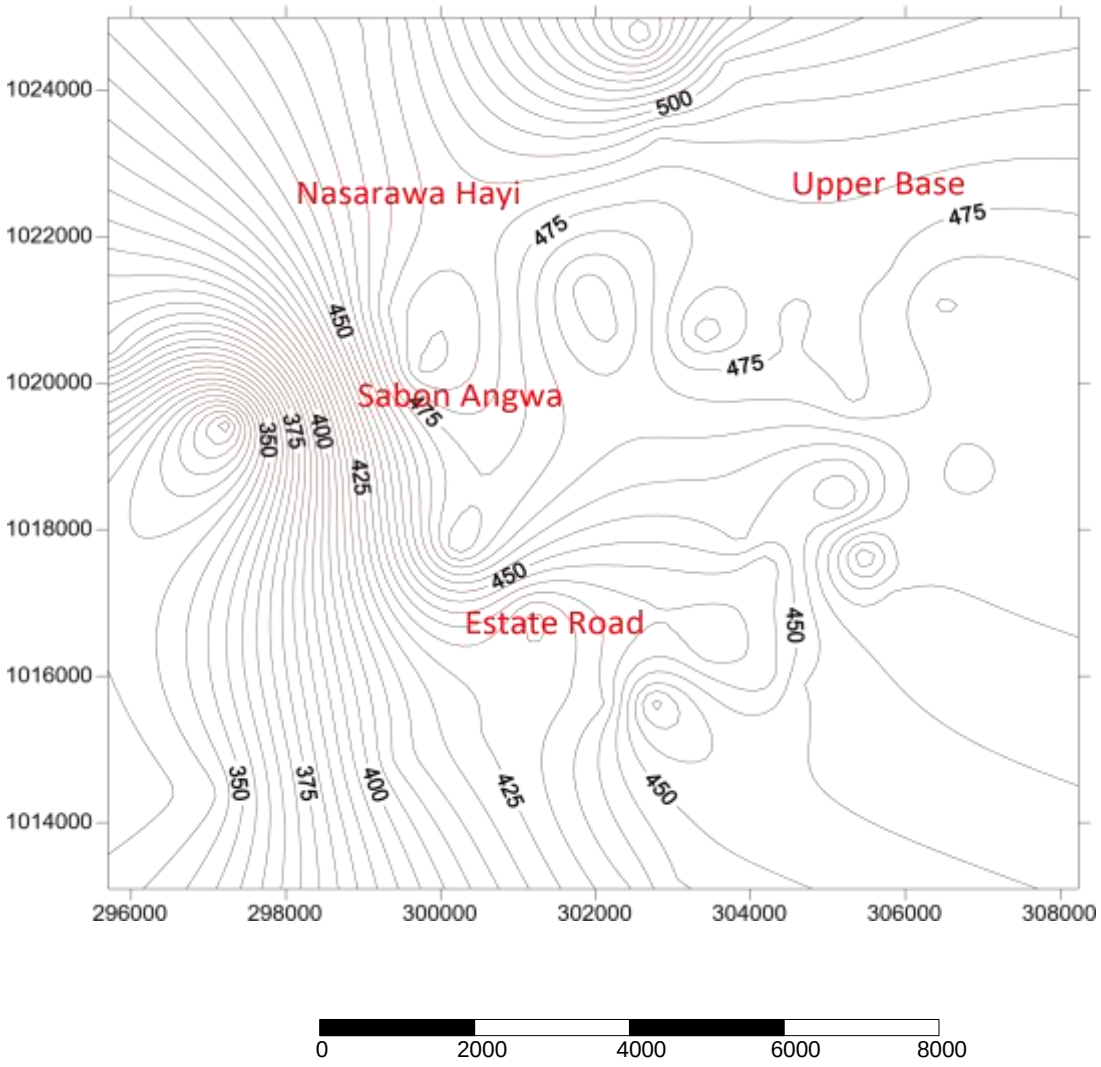

Figure 4.5 Contour Generated from the satellite imagery

The contour generated from both software shows information on the height of the study area, but in different ways. Surfer 9 shows information on height in relation to an absolute location (Longitude and Latitude) while IDRISI 32 shows information on height without absolute

location. Nevertheless, they both represent the height of the area in two dimensions (2D). The toposhape shows the types of hills in the study area, it classifies the hills based on the nature of the hill side, the terrain and the general relief of the area.

For this purpose, the drainage of the area is important. The drainage network of the area is shown in the flow direction. One of the objectives of the study is to map out vulnerable area that could be at risk in an event of flood. For this purpose, the drainage of the area is important. The drainage network of the area is shown in the flow direction. Naturally drainage flows from high terrains towards lower terrains. Convergence over the flat surface was observed which is in line with the topography of the area. This establishes the law which says water flows away from highlands. Once the DEM was created the GIS technique is then used to extract the flow direction of water. Surfer 9 and IDRISI 32 were used to extract the flow pattern and drainage pattern.

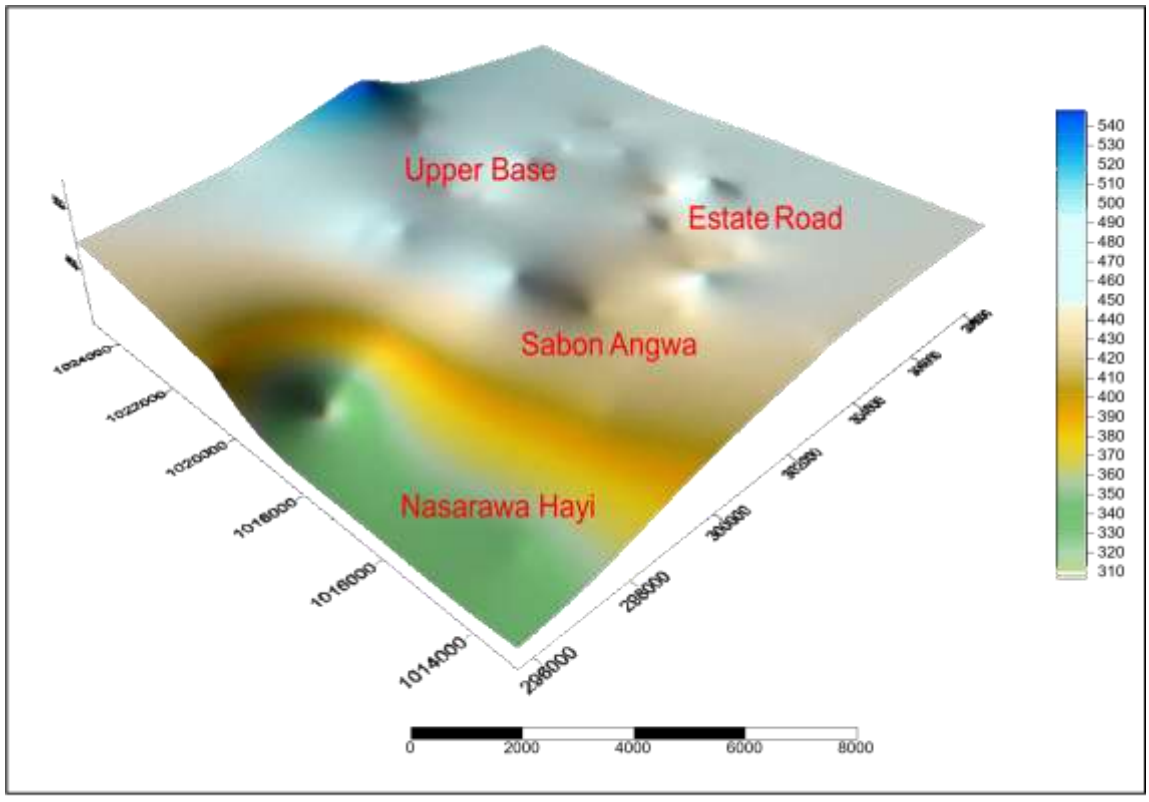

Figure 4.6: DTM of the study area

The 3D renditions of the study area places below 800ft are prone to flood, but places below 750ft are vulnerable to flood. Thus, an estimated 7.76sqkm is prone to flood while 10sqkm is vulnerable.

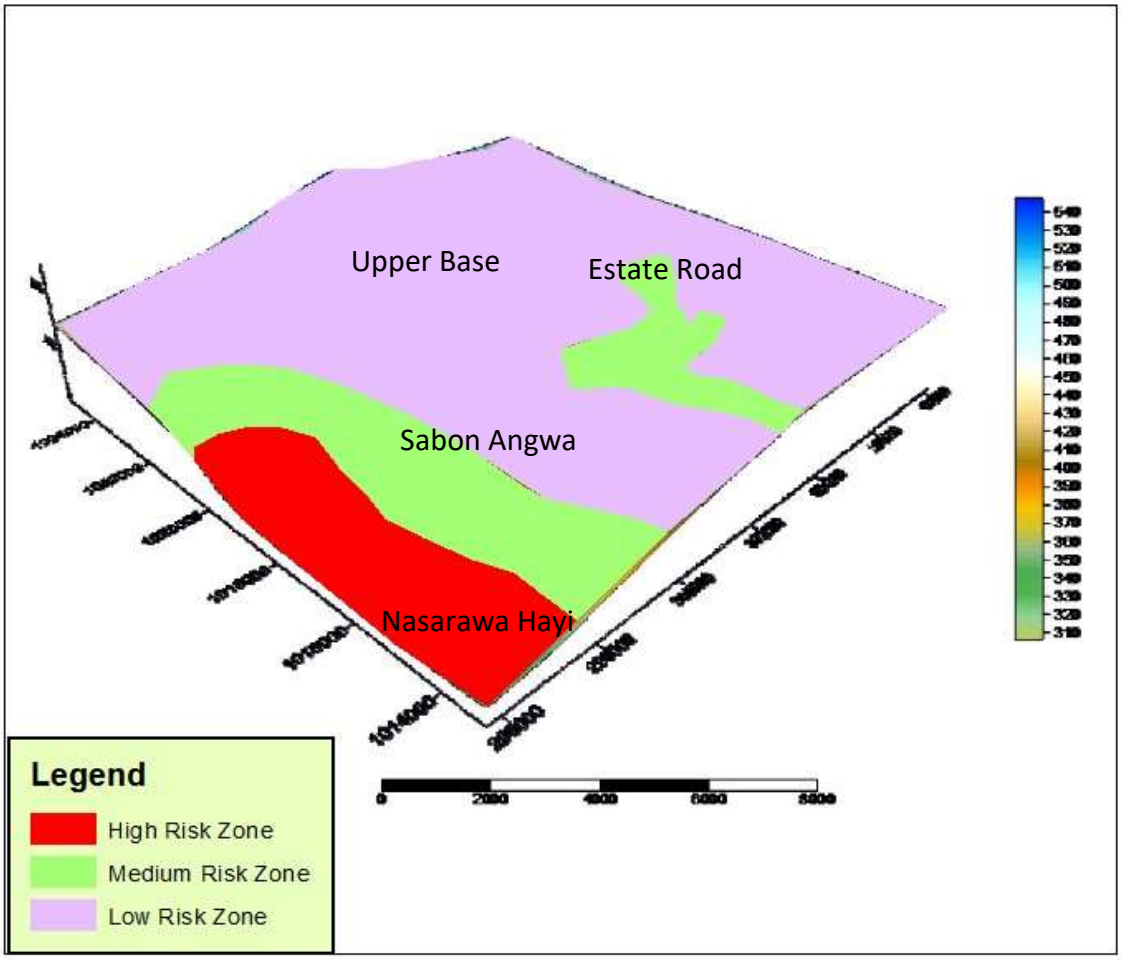

Figure 4.7: Flood Risk Zone Map

The digital Terrain Model of the area showed areas vulnerable to flood hazard. The risk zone was classified into three categories, namely high-risk zone, medium risk zone and low risk zone, using digital terrain model and distance. The areas on terrain elevations 55m -57m were categorized as high-risk zone with total coverage area of 55,920.10 m^2. The medium risk zone was between 58m - 60m with total area coverage of 506,717.82 m^2 while low risk zone was 61m - 65m with area of 131,960.16m^2. The elements at the high-risk zone include residential buildings, a school building, and untarred roads among others. The elements at the moderate

risk zone are uncultivated farmland, boats and humans while that of the low risk area are both cultivated and uncultivated farmlands, crops and economic trees.

4.3 Assessment of the Damage to Assets and Infrastructure in the Study Area

From the investigation carried out the subsequent analysis that follows; it was discovered that 21.2% of respondents said flood occurred once in every 15year and above, 32.1% respondents agreed that flood occurred once in 10 years, 23.1 % of the respondents ascertains that floods occurred on intervals of five years, while 35.3% of the respondents agreed occurrences of flood is on yearly bases thus they said devastating effect varies from year to years.

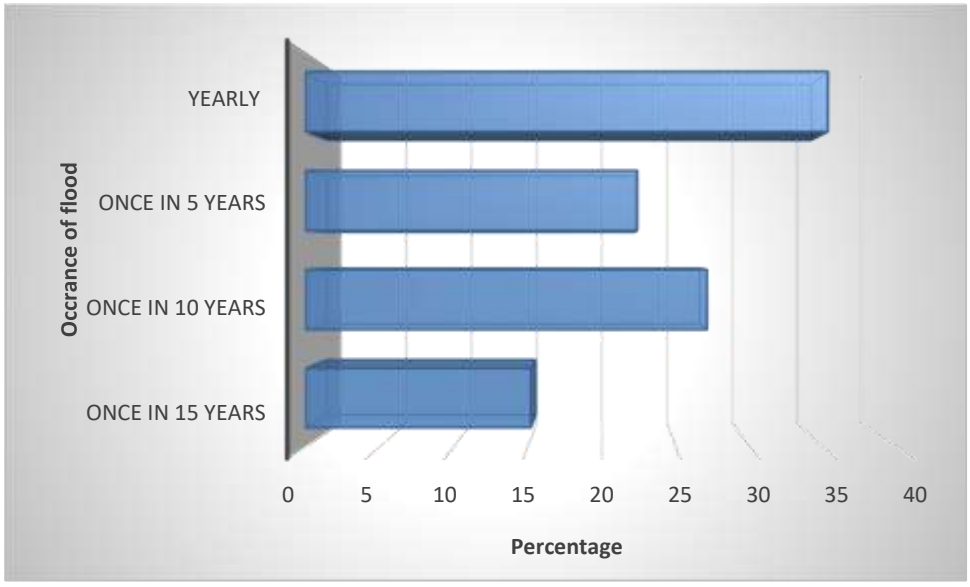

Figure 4.8: Occurrence of Flood in Nasarawa Hayi

4.3.2 Impact of floods on agriculture

Most of the sampled households (94%) indicated that their crop fields were damaged by floods. It was also evidence that, most of the damaged cropped are main staple crops such as rice. yam sugar cane, plantains sorghum and millet only 6% of respondents said that flood did not affect their farm produce. Although no data on area planted was collected, this show that there was

impact of flood on agriculture which is the main source of livelihood and income of the residence. (Figure 4.9).

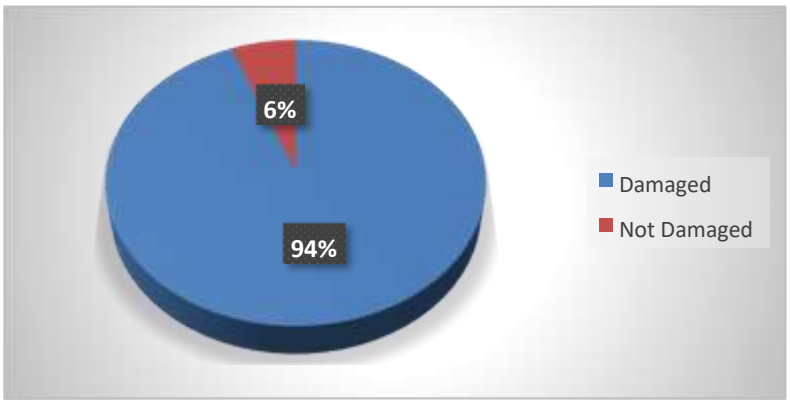

Figure 4.13: Impact of floods on Agricultural

4.3.3 Impact of floods on health

The research revealed that most of the sampled households (64%) indicated that health facilities were available in their communities. Furthermore, very few households (5%) had indicated that health facilities had been damaged by flooding in their communities. The study further revealed that 31% of the sampled households experienced disruption in access to health services due to damaged roads. Disruption in accessing health services implied an increase in disease incidence due to lack access to appropriate medication. (Figure 4.10).

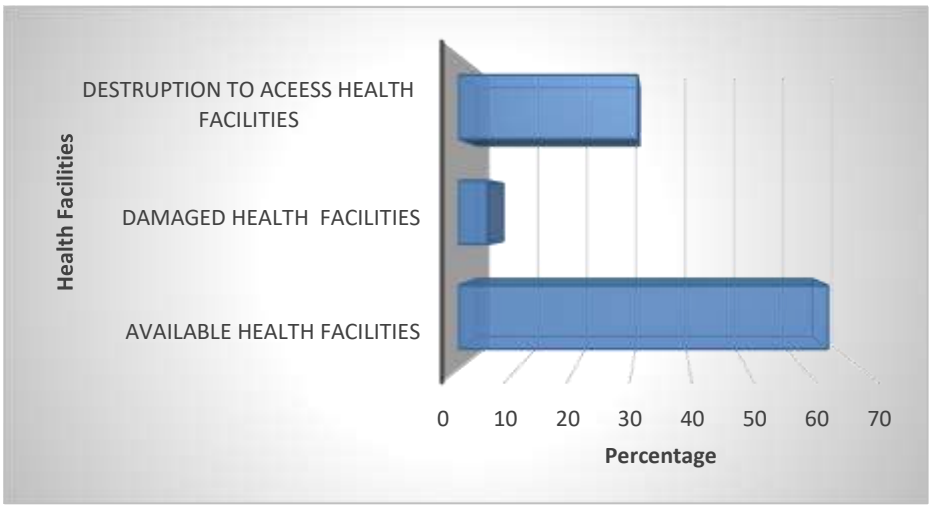

Figure 4.10: Impact of floods on Health
Source: Author's field work

4.3.4 Common diseases experienced

The research also revealed in Figure 4.11 that; out of the sampled households, 77% indicated having at least one member of their household felled sick during the floods. The most significant diseases experienced among the sampled households were, malaria/fever (56%), diarrhea (21%) and cough (15%). Furthermore, 8% of the sampled households indicated that they experienced other disease outbreak such as scabies, sores and rash during the floods.

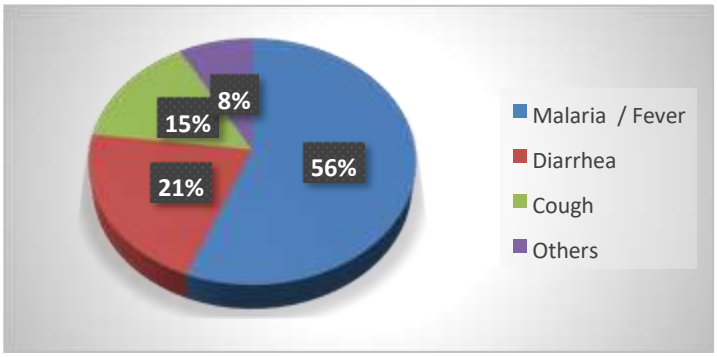

Figure 4.11 Diseases Experienced
Source: Author's field work

4.3.5 Water and sanitation

The sampled communities showed a lot of diversity on the type of drinking water sources they had. It was evident that rivers, boreholes and well were the most common water sources that communities used for drinking the survey established that 74% of the households indicated that their main source of drinking water was the river followed by borehole and hand dug wells at 8% and 18% respectively. Furthermore, among the sampled households, this indicated that their common water sources for drinking were affected by floods.

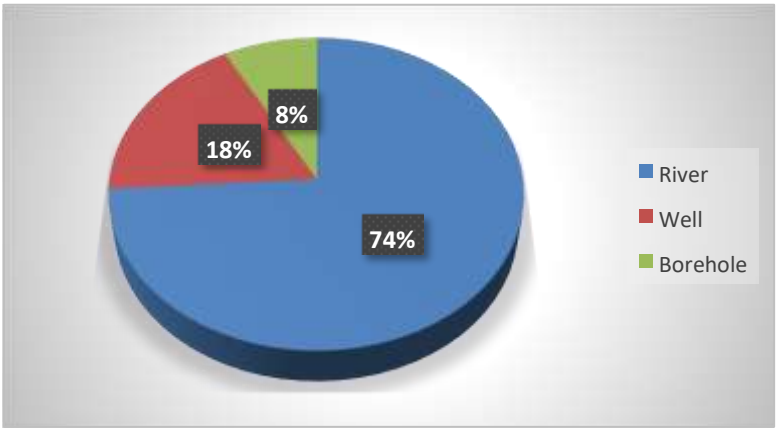

Figure 4.12 Sources of drinking water
Source: Author's field work

In terms of sanitary facilities, 74% of the sampled households had no sanitary facilities (i.e. using bush and rivers as alternatives). It is worth noting that bush and river in the context of sanitation are usually regarded as no sanitary facility even though they are used as alternatives for excreta disposal. The correlation between water drinking sources and health has been discussed under the health section. Furthermore, 26% of the households indicated having traditional pit latrines as their main sanitary facilities. Within the households that indicated having sanitary facilities, 12% had indicated that their facilities were damaged by floods. Furthermore, the survey established that 14% of households whose sanitary facilities were affected by the floods experienced coughing. This means that households will continue to be vulnerable to increased disease outbreak as long as the river continues to be their main source of drinking water. This is as a result of increased contamination that occurs during flooding. Despite borehole being the safest water source for drinking, past vulnerability assessments undertaken within the district have shown that handling of the water by households due to distance to the source has led to increased disease burden such as diarrhea.

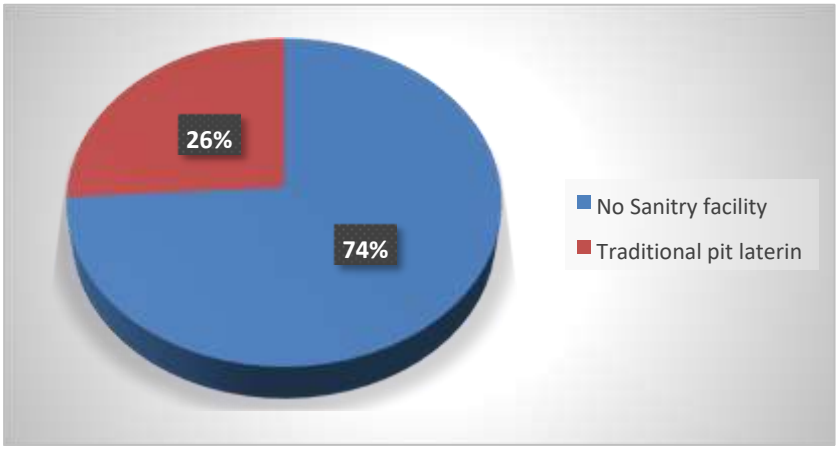

Figure 4.13 Type of sanitary facilities used by sampled households
Source: Authors fieldwork

4.3.6 Impact of floods on education

All the sampled households indicated availability of education facilities in their communities. Furthermore, 17% of the sampled households indicated that school infrastructure was damaged due to floods in one way or another. The study showed that 38% of the sampled households indicated that school going children experienced disruption due to floods. The disruption was attributed to various reasons such as road being impassable (32%) and school being submerged (13%).

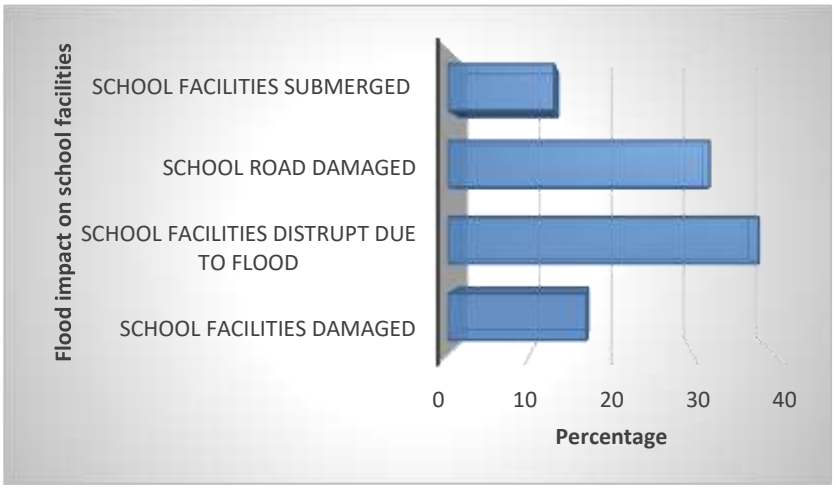

Figure 4.14 Flood Impact on Education
Source: Author's field work

4.3.7 Economic impact of floods on Property and Assets

The research revealed that a substantial number of productive and non-productive assets were damaged by floods. Of the productive assets which were lost farming tools 45%, 31% lost household utensils and 27% lost others things not specify. This indicated that they lost other property such as clothes and blankets. Most of the losses to these assets were attributed to households' proximity to flood prone areas. Discussions with the communities revealed that some households indirectly lost their assets in that after their houses collapsed, some of the income sources got disturbed. This forced them to off load some assets to raise money to meet other household basic requirements.

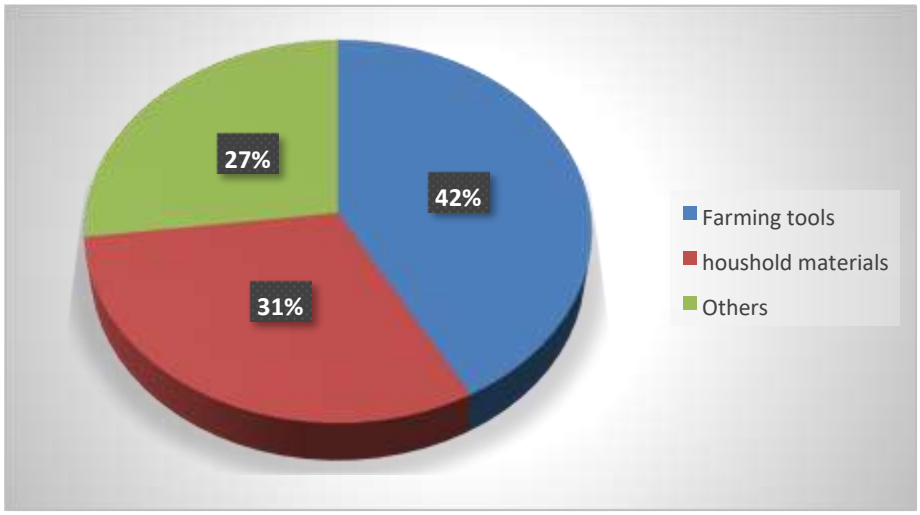

Figure 4.15: Impact on Property and Assets

Source: Author's field work

4.4 Level of flood hazard preparedness in the Study Area

Approximately 28 percent of the respondents said they prepared for flood disaster. While, a majority of 72 percent of them said their community was not prepared for flood disaster which shows their level of unpreparedness as presented in Figure 4.16.

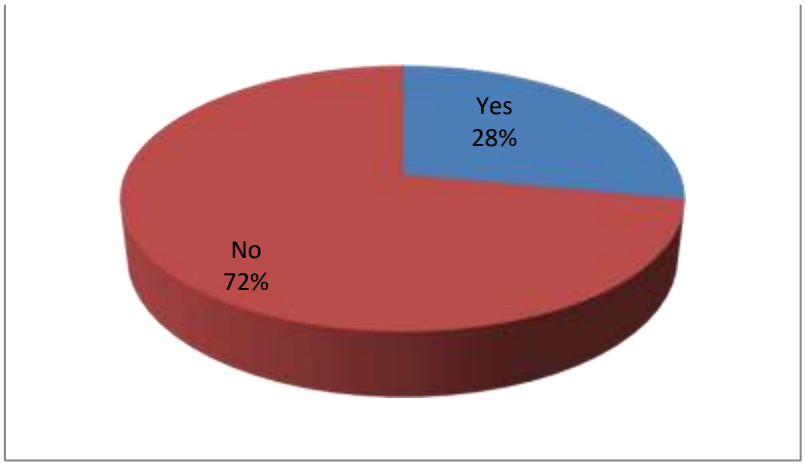

Figure 4.16: Flood Preparedness

In the area of preparedness, 41 percent of the respondents used flood embankment, 24 percent of them used public enlightenment, 20 percent of them used evacuation plan while 15 percent used local warning devices. This analysis shows that most of the respondents have prepared in one way or the other before the flooding events.

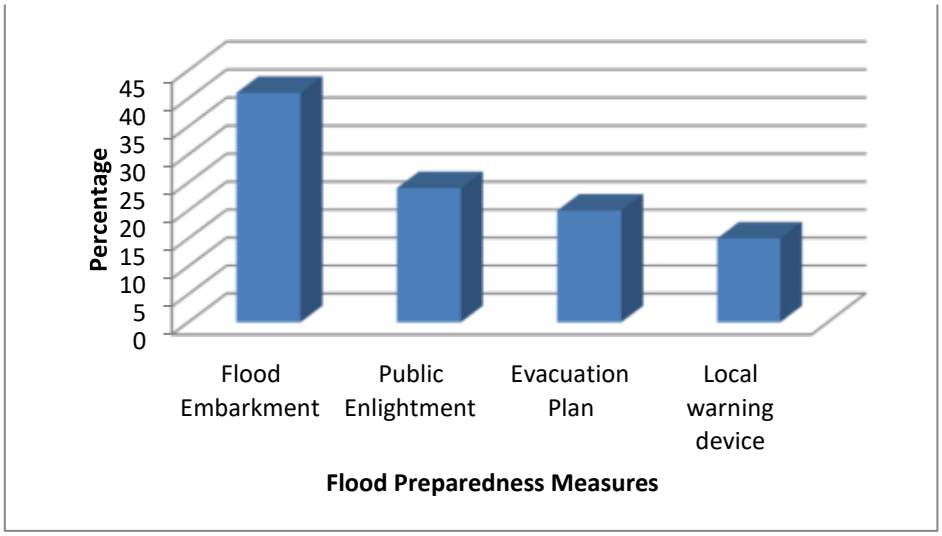

Figure 4.17: Flood Preparedness Measures

Majority of the respondents (65 percent) in the area claimed that there were no household preparedness measures while 35 percent of them said there were household preparedness

measures. Among those that said there were household preparedness measures in Suleja, further reveals that 15 percent of them construct local drainages, 10 percent of them used building setback while 10 percent of them uses sandbags in the area (Figure 4.18). This analysis further shows that household have some measures in place awaiting the flood events.

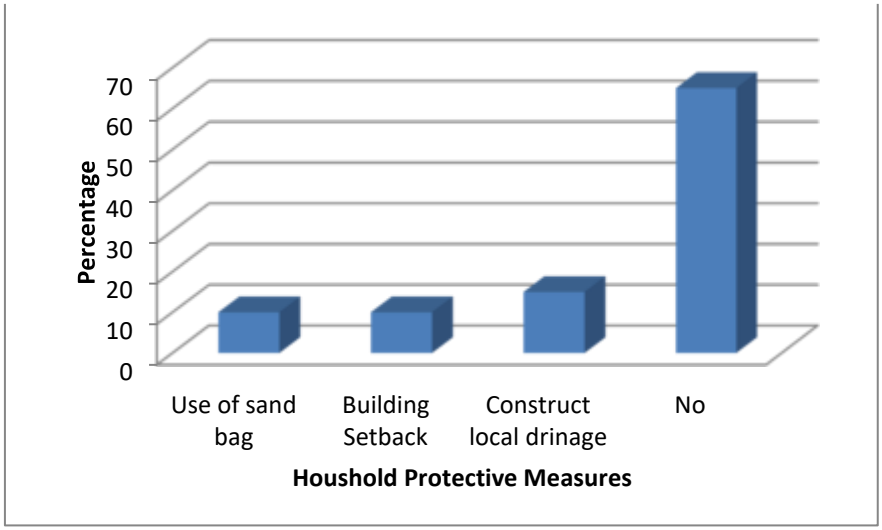

Figure 4.18: Household Protective Measures against Flooding

In Nasarawa Hayi, a majority of 41 percent of the respondents received help from relatives and friends, 37 percent of them engaged children in livelihood activities, and 17 percent of them received help from Government while 5 percent borrowed money from cooperative as coping strategies measures. The implication of the findings is that majority of the respondent that were affected by flood in the study area get help from relatives or friend only very few get help from Government. The shows that each household prepared for the flood disaster on their own and it also indicate that the capacity of Niger State Emergency Management Agency is week.

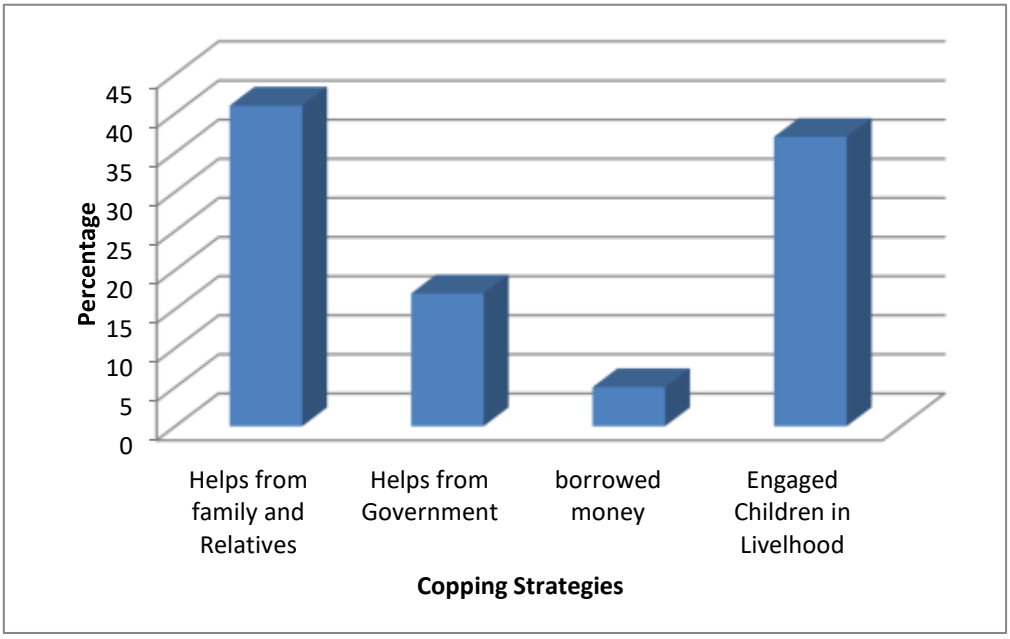

Figure 4.19: Coping Strategies Measures

4.5 Discussion of Findings

Flood hazards and its impact Nasarawa Hayi and to development. It demonstrates that the means of reducing the factors responsible for flood hazards is now available. The impact of flood on socio-economic and the factors responsible for flood. The socio-demographic characteristics of the respondents, from the analysis, it shows that 16.3% of the respondent are between the age group of 20-30 years, 23% of them are between 21-40 years, 36.6% of the respondent are between 41-50years and 22% of the respondent are 50years and above. The findings show that 90% of the respondent are indigene of the communities whom majority of them were born there and has never left the place since birth, while 10% of them were nonindigene from different part of the country, ranging from Yoruba, Hausa, Tiv, Igbo etc. it was discovered that higher percentage of the respondent are attend Arabic school which is the custom of the inhabitant of the area with 61%, 22% of the respondent attained primary schools, 9% of the respondent attended Secondary Schools while 8% of the respondent attended tertiary education.

Factors responsible for flooding in the area shows that proximity of houses to the river, poverty and excessive rainfall/ human activities along the river bank contributed mostly to the flooding in the study area. 42% of the respondent agreed that flooding the area is caused by excessive Rainfall, 52.7% of the respondent agreed that Not well constructed drainage, building and farming along the flood plan area are the causes of flooding in the area, 3.7% of the respondent says; dumping of refuse along the river and drainage channel are the causes of flooding while 1.7% of the respondent has no idea of the causes of flooding in the area. These facts were established in the process of visiting the study area and also asking the inhabitants questions and this was inline with the study of (Olorukoba, 2014), whose list human activities and rainfall among the factors that cause floods in Ibadan urban area.

The digital Terrain Model of the area showed areas vulnerable to flood hazard. The risk zone was classified into three categories, namely high-risk zone, medium risk zone and low risk zone, using digital terrain model and distance. The areas on terrain elevations 55m -57m were categorized as high-risk zone with total coverage area of 55,920.10 m^2. The medium risk zone was between 58m - 60m with total area coverage of 506,717.82 m^2 while low risk zone was 61m - 65m with area of 131,960.16m^2. The findings correlate with (Ojigi *et al.*, 2013) whose carried out geospatial mapping and analysis of the 2012 flood disaster in central parts of Nigeria. The elements at the high-risk zone include residential buildings, a school building, and untarred roads among others. The elements at the moderate risk zone are uncultivated farmland, boats and humans while that of the low risk area are both cultivated and uncultivated farmlands, crops and economic trees.

It was discovered that flooding in the study area is a yearly activity, and it every aspect of the community. From the information gather during the field work, it was discovered that the people of Nasarawa Hayi are seriously ready for government intervention in the study area.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

Flooding cannot be completely avoided, as long as physical development extends to river channels traversing urban centers, but with effective flood prevention programmes, damages from severe flooding can be reduced if not eradicated. The non-structural methods of mitigation of flood hazards are often less expensive as compared to structural ones. Among the nonstructural methods, modern flood forecasting and real-time data collection system have become the practice in countries prone to flood hazards. It also serves as a template for evaluating urban streams vulnerability to flood.

Geospatial techniques can now be used as an operational mechanism for flood disaster warning, monitoring and mitigation. Though remote Sensing and GIS applications have not been fully operational in flood risk reduction in this part of the world, incorporating it into environmental planning would reduce post disaster expenses. Considering the preceding information the following conclusion can be drawn; Floods are not subject to complete control but their damaging effects can be reduced. The upward flood cost trend can be moderated through comprehensive floodplain, storm water, and environmental management measures that are economically, environmentally, and socially cost effective.

5.2 Recommendations

The dangers of flood waters are associated with a number of different criteria, not necessarily independent on each other but creating different types of clearly recognizable hazards. Understanding all of these criteria makes the following flood risk reduction recommendations

efficient. Appropriate public awareness programmes should be implemented for the following purposes:

1 To make occupants and/or owners floodable areas aware of identified flood hazards;

2 To encourage individuals to take actions such as flood proofing and developing escape plans, to mitigate their flood potential;

3 To make individuals aware of the existence and operation of flood warning plans;

4 To encourage individuals to keep drainage channels clean and to report potential maintenance problems.

REFERENCES

Abaje, I. B., Ogoh, A. O., Amos B. B. & Abashiya M. (2015). Climate Change flood disaster assessment: Human security in Katsina State Nigeria. *American Journal of Human Ecology*, 4(4), 47-56.

Adedeji, O. H., Odufuwa, B. O. & Adebayo, O. H. (2012). Building capabilities for flood disaster and hazard preparedness and risk reduction in Nigeria: Need for spatial planning and management. *Journal of sustainable development in Africa*, 5(7), 73-76.

Aderogba, K. A. (2012). Substantive causes and effects of flood in south-western Nigeria and sustainable development of cities and town. *Journal of Emerging Trends in Educational Research and Policy Studies,* 3(4), 551-560.

Adelekan, I. O. (2010). Vulnerability assessment of an urban flood in Nigeria: Abeokuta flood 2007. *Natural Hazards,* 56 (1), 215-231. http://dx.doi.org/10.1007/s11069-010-9564-z

Aderoju, O. M., Jantiku, J., Fagbemiro, O. A., Aliyu, N. B. K., Ajonye, S. E. & Salman, K. S. (2014). Geospatial Assessment of 2012 flood disaster in Kogi. *Nigeria IOSR Journal of Environmental Science, Toxicology and Food Technology,* 8(1), 74-84.

Ahmed, T. A. (2018). Damned by dams: how hydro- dams affect Niger communities (Daily trust paper) https www. Daily trust.com.ng.

Ajibade, I., Bean, M. G. & Bezner-Kerr, R. (2013). Urban flooding in Lagos. Nigeria patterns of vulnerability and resilience among women. *Global Environmental Change,* 23(6) 1714-1725.

Ajiboye, O. J. (2015). Assessment of socio-economic effects of flooding in some communities in Anambra West Local Government area Anambra State, Nigeria. pp. 14-15.

Amangabara, G. T. & Godo, A.E. (2010). Perceptions and realities of flood hazards, flood mitigation and control in Nigeria. *Global Journal of Environmental Sciences,* 9(1&2), 13.

Anie, H. O. (2008). Flooding, the Environment and Socio-Economic Activities: A Study of Ozoro, Delta State. *Journal of Research in National Development,* 7(2), 1-24.

Anosike, M. N. & Oyebade, O. (2012). Sandcrete blocks and quality management in Nigeria building industry. *Journal of Engineering Project and Production Management,* 2(1), 37-46.

Balan, S. P. K. (2014). Flood Risk Mapping of Kadalundi River Basin Using GIS. *International Journal of Scientific & Engineering Research,* 5(7), 235-240.

Birkmann, J. (2013). *Measuring Vulnerability to promote Disaster-Resilient Societies and enhance Adaptation.* Discussion of conceptual framework and definitions in measuring vulnerability to Natural Hazards: Towards Disaster resilient societies. New York: United Nations University Press ISBN-13: 9789280812022 pp. 9-54 .

Birkmann, J., Chang Seng, D. & Suarez, D. C. (2011). Adaptive Disaster Risk Reduction: Enhancing Methods and Tools of Disaster Risk Reduction in the light of Climate Change. Bonn: DKKV (German Committee for Disaster Reduction). Retrieved on May 9, 2019 from: www.dkkv.org/DE/ressource.asp?ID=302.pdf

Bishaw, K. (2012). Application of GIS and Remote Sensing Techniques for Flood Hazard and Risk Assessment: The Case of Dugeda Bora Woreda of Oromiya Regional State, Ethiopia. A paper presented in the 2012 Berlin Conference on the Human Dimensions of Global Environmental Change, Germany.

Brouwer, R., Akter, S., Brander, L. & Haque, E. (2007). Socio-economic Vulnerability and Adaptation to Environmental Risk: A case study of Climate Change and Flooding in Bangladesh. *Journal of sustainable development in Africa,* 27(2), 313-317.

Butzen, S. (n.d.). Flooding Impact on crops pioneer Hi-Bred int'l https://www.pioneer.com/ home/site/ us/agronomy/crop management/ adverse-weather disease/flood-impact/accessed in May 2019.

Christopherson, R. W. (2006). *Geosystems: An Introduction to Physical Geography (6th ed.).* London: Prentice Hall. pp. 423.

Demir, V. & Kisi, O. (2016). Flood Hazard Mapping by Using Geographic Information System and Hydraulic Model: Mert River, Samsun, Turkey. *Advances in Meteorology*, 1(1), 10-16. DOI:10.1155/2016/4891015.

Dukiya, J. J. (2013). Spatial analysis of the impacts of Kainji Hydropower dam on the downstream communities an overview. *A Journal of Geoformatics and Geostatist.* http:// dx. Doi.org/10.4172/2327-4581.s-1009.1-3.

Ehiorobo, A. & Izinyon, E. (2014). L-Moments approach for flood frequency analysis of river Okluwan in Benin-Owena River basin in Nigeria. *Nigerian Journal of Technology,* 33(1), 10-18.

Etuonvobe, A. K. (2011). The Devastating effect of flooding in Nigeria. *Hydrography and the Environment,* 1(6), 19-31.

Ewa, D. E. & Ukpata, J. O. (2013). Investigation of the compressive strengths of commercial sandcrete blocks in Calabar Nigeria. *International Journal of Engineering technology,* 3(4), 447-482.

Ezema, O. (2013). Flood menace in Nigeria: Plateau state flood disaster. *Journal of Research in National Development,* 7(2), 23-29.

International Bank for Reconstruction and Development/World Bank (2010). Damage loss and needs assessment guidance notes. USA: Washington DC.

Kayode, J. S., Samuel, Y., Temi, E. O. & Anthony, K. (2017). A Post-Disaster Assessment of Riverine Communities Impacted by a Severe Flooding Event. *Ghana Journal of Geography*, 9(1), 17–41.

Kelly, C. (2008). Damage, needs or rights? - Defining what is required after disaster. Retrieved on August 19, 2018 from: http://reliefweb.int/sites/reliefweb.int/files/resources/ 447325058FB382F8C12574B20048 6639-Benfield-Jul2008.pdf.

Kolawole, O. M., Olayemi, A. B. & Ajayi, K. T. (2011). Managing flood in Nigeria Cities: Risk analysis and adaptation options- Ilorin city as a case study. *Archives of Applied Science Research*, 3(1), 17-24,

Kwari, J. W., Paul, M. K. & Luka, B. S. (2015). The impact of flooding on socio-economic development and agriculture in Northern Nigeria: A case study of 2012 flooding in Yola Numan areas of Adamawa state Nigeria. *International journal of Scientific & Engineering Research*, 6(1), 1435-1436.

Lwin, K. K. (2008). *Fundamentals of Remote Sensing and its Application in GIS.* VLM. University of Tsukuba.

Magami, I. M., Yahaya, S. & Mohammed, K. (2014). Causes and consequences of flooding in Nigeria: A review of Biological and Environmental sciences. *Journal for the Tropics,* 11(2), 156-159.

Marcellinus, A. H. & Joseph, C. U. (2014). An assessment of impact of flood events in Makurdi, Nigeria. *Civil and Environmental Research,* 7(10), 57-58.

Niger State Urban Development Board (NSUDB) (2017). Flood Assessment Report. Minna: Niger State Urban Development Board.

Nkwunonwo, U. C., Whitworth, M. & Baily, B. (2016). Review article: A Review and Critical Analysis of the Effortstowards Urban Flood Risk Management in the Lagos Region of Nigeria. *Natural Hazards and Earth System Sciences,* 16(1), 349–369.

Nwigwe, C. & Emberga, T. T. (2014). An assessment of causes and of effect of flood in Nigeria. *Standard Scientific Research and Essay,* 2(7), 2-4.

Ojigi, M. L., Abdulkadir, F. I. & Aderoju, M. O. (2013). Geospatial Mapping and Analsyis of the 2012 flood disaster in central parts of Nigeria. 8th National GIS symposium Dammam. Saudi Arabia (pp. 1067-1077).

Oladokun, V. (2016). Flood risk management: A review of the challenges and opportunities. International Journal of Safety and Security Engineering, 6(3), 489-492.

Olajuyibe, A. E., Rotowa, O. O. & Durojoye, E. (2012). An assessment of flood hazard in Nigeria: The case of Mile 12 Lagos. *Mediterranean Journal of Social Sciences,* 3(2), 367-386.

Olaore, A. Y. (2014). The impact of flooding on the social determinants of health in Nigeria: A case for North-South institutional collaboration to address climate issues, developing countries studies ISSN 2224-607XC.

Onwuka, S. U., Ikekpeazu, F. O. & Onuoha, D. C. (2015). Assessment of the Causes of 2012 floods in Aguleri and Umuleri, Anambra east local government area of Anambra state. *British Journal of Environmental Science,* 3(1), 43-49.

Orimoogunje, O. O. I., Fashae, O. A., Oke, T. O. & Akinwumiju, A. S. (2016). Flood Vulnerability in a Part of Southwestern Nigeria. *Academia Journal of Environmental Science*, 4(3), 055-061. DOI: 10.15413/ajes.2015.0101

Oriola, A. (2000). Flood and flood management. In H. I. J. Jimoh (Ed.), *Contemporary Issues on Environmental Management.* Ibadan: Haytee Press. pp 100-109.

Paul, S. K. (2013). Vulnerability concepts and its application in various fields: A review on Geographical perspective. Journal of Earth Science, 8(1), 63-81.

Punch (2017). First Rain in 2017 Causes Flooding, Gridlock in Lagos. Retrieved on March 29, 2019 from: https://www.google.com/ampls/punchng.com

Saleh, U. R. (2014). Impacts of flood on the lives and livelihoods of people in Banglabesh a Case study of a village in Manikgany District.

Sanyal, J. & Lu, X. X. (2003). Application of GIS in flood hazard mapping: a case study of Gangetic West Bengal, India. A poster presentation during the Map Asia Conference 2003, held at Singapore.

Suarez, P. & Linnerooth-Bayer, J. (2011). Insurance-related instruments for disaster risk reduction, Global Assessment Report on Disaster Risk Reduction, Geneva.

Suriya, D. & Mudgal, S. (2012). Impact of urbanization on the thirusoolam sub wAtershed-A case study 2012. *Journal of Hydrology*, 412(1), 210-219. https://doi.org/10.1016/ j.jhydro1.2011. 05 .008

Takemoto, S. (2011). Moving towards climate smarts flood management in Bangkok Tokyo. Unpublished Master thesis submitted to Massachusetts Institute of Technology.

Thomas, A., Menke, I. & Serdeczny, O. (2018). Loss and Damage Costing and Financing Mechanisms: Caribbean Outlook. A download on 7th, October 2019 from http://climateanalytics.org/files/Ind_costing_and_financing_mechanisms_caribbean_outlook.pdf.

United Nations Development Programme (2015). *An Overview of Disaster Management* (2nd ed.). USA: UNDP.

United Nations Framework Convention on Climate Change [UNFCCC] (2012). Decision 3/CP.18. Approaches to address loss and damage associated with climate change impacts in developing countries that are particularly vulnerable to the adverse effects of climate change to enhance adaptive capacity.

UN-Water (2011). Cities coping with water uncertainties. Media brief UN-Water decade programme on Advocacy and communication.

Van der Geest, K. & Schindler, M. (2017). Report No. 21: Handbook for Assessing Loss and Damage in Vulnerable Communities. United Nations University Institute for Environment and Human Security (UNU-EHS) Publication Series April 2017. Bonn, Germany.