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**FLOODING IN THE COASTAL REGION OF NIGER DELTA, NIGERIA**

verfasst von / submitted by
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# Contents

## ABSTRACT

The study examined respective literature on flooding in the coastal region of Niger Delta, Nigeria and determined differences in the analysis employed and based on the findings conclusions were made and discussed with reference to the subject matter of the study. The coastal region of Niger Delta is the central part of southern Nigeria bounded in the south by the Atlantic Ocean, with a coastline that spans about 500 km extending from Benin River to the Imo River. Secondary sources of data were employed for the study. The findings of the study revealed that majority of coastal communities are highly exposed and vulnerable to flooding due to peculiar issues relating to the causes, frequencies and magnitude of flood events overtime in the study area. Based on the community vulnerability index (CVI), flood prone areas due to their terrain characteristics and poor capacities to mitigate flood issues have suffered several socio-economic and environmental problems overtime. The costs of housing and socio-economic benefits have been major factors pushing people to live in flood prone areas of Niger Delta, Nigeria. It was therefore recommended amongst others that the coordination and integration of control measures at community, state and national levels should be embraced. This will enable the building up of resilient strategies for mitigation before and during a flood event.

## ABSTRACT

Die Studie untersuchte die einschlägige Literatur zum Thema Überschwemmungen in der Küstenregion des Nigerdeltas, Nigeria, und stellte Unterschiede in der verwendeten Analyse fest. Auf der Grundlage der Ergebnisse wurden Schlussfolgerungen gezogen und mit Bezug auf den Gegenstand der Studie diskutiert. Die Küstenregion des Nigerdeltas ist der zentrale Teil des südlichen Nigerias, der im Süden durch den Atlantischen Ozean begrenzt wird und dessen Küstenlinie sich über etwa 500 km vom Benin River bis zum Imo River erstreckt. Für die Studie wurden sekundäre Datenquellen verwendet. Die Ergebnisse der Studie zeigen, dass die meisten Küstengemeinden aufgrund der Ursachen, der Häufigkeit und des Ausmaßes von Hochwasserereignissen, die im Untersuchungsgebiet immer wieder auftreten, stark gefährdet und anfällig für Überschwemmungen sind. Auf der Grundlage des Community Vulnerability Index (CVI) haben die überschwemmungsgefährdeten Gebiete aufgrund ihrer Geländemerkmale und ihrer geringen Fähigkeit, Überschwemmungsprobleme abzumildern, im Laufe der Zeit mehrere sozioökonomische und ökologische Probleme erlitten. Die Kosten für die Unterbringung und die sozioökonomischen Vorteile sind die Hauptfaktoren, die die Menschen dazu bewegen, in den überschwemmungsgefährdeten Gebieten des Nigerdeltas in Nigeria zu leben. Daher wurde u.a. empfohlen, die Koordinierung und Integration von Kontrollmaßnahmen auf kommunaler, staatlicher und nationaler Ebene in Angriff zu nehmen. Auf diese Weise können vor und während eines Hochwasserereignisses widerstandsfähige Strategien zur Schadensbegrenzung entwickelt werden.

# CHAPTER 1: INTRODUCTION

## 1.1 Background to the Study

Flood is a natural and severe weather phenomenon induced by increasing global temperatures, which results in heavy rain, ocean thermal expansion, and glacier melt, all of which contribute to a rise in sea level, inundating coastal areas with salt water. Floods or flood waters are the brief flooding of typically dry land regions caused by the overflow of inland or tidal waters, or by the extraordinary and sudden buildup or discharge of surface waters from any source into territories utilized or exploitable by man that are not ordinarily covered by water (Okoye and Ojeh, 2015). Floods are one of the natural environmental risks that have ravaged mankind's terrain throughout the centuries, and whenever they occur, they result in the loss of property, deaths, and devastation of farmlands in the majority of the world's communities (Whitworth and Baily, 2015).

According to Uchegbu (2003), flooding occurs when runoff exceeds a river channel's discharge capacity, forcing water to breach its banks and spread throughout the flood plains. In essence, a flood is an irregular overland flow caused by a stream or river's inability to deal with its discharge or by a rise in sea level in a coastal region, resulting in severe adverse impacts. Ocean surges, riverine floods, urban flooding, flash floods caused by cloudbursts (high-intensity storms), and floods caused by dam breaches are all examples of floods. Flood plains form in flat or low lying regions when a large amount of silt is deposited and distributed over nearby low lying areas near a river. According to Ward (1978), when these sediments are deposited over time, generally fertile lowlands known as flood plains are formed. One thing is certain: flood plains are often saturated with water and hence serve as prospective places for more floods.

On a worldwide basis, the last two decades have witnessed a dramatic increase in the frequency of floods (Najibi and Devineni, 2017). The Intergovernmental Panel on Climate Change (IPCC) stated that susceptibility to flooding would almost certainly rise as rainfall occurrences increased (Njoku, Effiong, and Ayara, 2020). Flooding is rapidly becoming a global norm, with around 70 million people at danger of flooding and at least 800 million people vulnerable (Peduzzi, Dao, Herold and Mouton, 2010). Its consequences are also incalculable. For example, in the United States, floods yearly ruin $6 billion in property and kill 140 people (National Geographic, 2018).

Every year, numerous areas are affected by water-related disasters caused by rainfall or snowmelt, storm surges, tsunamis, landslides, or drought. 2013 in particular was a year marked by extreme floods (Kron, 2015). The Philippines (storm surge during Typhoon Haiyan), central Europe, and Uttarakhand (India) suffered the most in terms of loss of life and property, but there were also significant, and in some cases disastrous, events in Colorado (USA), Canada, Mexico, Indonesia, Australia, and southern Africa (South Africa/Mozambique/Zimbabwe) (Munich, 2014). Floods damaged significant regions in numerous Balkan nations in the first half of 2014, while a landslide in Afghanistan buried a hamlet, killing around 400 people (Kron, 2015).

According to Happy et al., (2014), Nigeria has had its fair share of flooding disasters; an early instance of flooding in Nigeria is the Ogunpa River flooding of Ibadan in 1963, 1978, 1980, and 2011, which resulted in an estimated property damage of at least 30 billion naira and 100 deaths. Between 2011 and 2012, at least eight flood episodes occurred in Lagos, killing at least 30 persons (Komolafe, Adegboyega &Akinluyi, 2015). Furthermore, a recent flood episode is seen in the broad disastrous flood catastrophe that rocked Nigeria from June to September 2012, cutting across major cities in about 31 states. Adamawa, Taraba, Benue, Niger, Kogi, Anambra, Bayelsa, Delta, Edo, Rivers, Cross River, and Akwa Ibom are the worst impacted states, followed by Adamawa,

Taraba, Benue, Niger, Kogi, Anambra, Bayelsa, Delta, Edo, Rivers, Cross River, and Akwa Ibom. This flood has been described as the most damaging in the previous 40 years. The flood inundated homes and cut off transit links across the impacted regions. Flooding is the most common natural hazard in Nigeria, according to Aderogba (2012), and the situation is grave. According to the National Emergency Management Agency (NEMA), the 2012 flood in Nigeria impacted 7 million people in 30 states, displaced 2.3 million people, killed 363 people, and cost the Nigerian economy an estimated US$ 9.6 billion (Amangabara and Obenade, 2015).

Flooding is one of the most prevalent and deadly natural disasters in Nigeria, claiming over 20,000 lives and displacing millions of people (Ologunorisa and Abawua, 2005). It is an ubiquitous problem that occurs globally in both semi-arid and extremely humid environments. It is a relatively prevalent natural hazard and one of the most catastrophic of all natural disasters. According to James (2000), as stated in Onifade et al, (2015), flood disasters cause terrible losses and a breakdown in way of life, and they occur on an annual and worldwide scale. According to Bradshaw (2007), as described in Onifade et al, (2015), a flood is an outpouring of water that covers the ground surface and has the potential to dry up over time.

Coastal towns are development engines for the country and are dynamic in terms of governing systems and capabilities. Millions of people visit and live in coastal regions as a result of their long-standing appeal for human settlements, owing to their stunning coastlines, scientifically significant geomorphologic structure, and cultural characteristics. The coastlines became attractive areas for living and upkeep due to their intrinsic ecological, geomorphic, and archaeological significance (McKnight, 1992). As more people are pushed into marginal areas, they become increasingly susceptible to floods (Cruz, 2007). Each year, over 75 million people worldwide are adversely impacted by floods, which claim the lives of over 20,000 communities, particularly in

Nigeria's Niger Delta area (UNISDR, 2006). As sea levels rise, the bulk of the population living near the shore becomes increasingly vulnerable to coastal flooding. 80% of Nigeria's South-South geopolitical region is flood plain, leaving it very vulnerable to recurring floods. Flooding is a frequent and recurrent phenomenon in coastal areas in Nigeria's Niger Delta. It is based on this background that the study examined flood incidences and its associated challenges in the coastal communities of Niger Delta, Nigeria. Thus attempts were made to review past studies in line with the subject matter of the study.

## 1.2 Statement of the Problem

Each year, severe flooding disasters have become a common occurrence for communities and governments throughout Nigeria. Although the nation faces a variety of risks, including droughts, landslides, gully erosion, wind storms, and flooding. Floods are by far the most prevalent hazard in the Niger Delta's coastline area. Nigeria has been impacted by multiple major flood occurrences in recent years, resulting in destruction and economic losses of millions of Naira in the afflicted villages in the Niger Delta's coastal area.

Flooding in Nigeria's Niger Delta area may be coastal, fluvial, or pluvial (Aderogba, 2012). In Nigeria, coastal and fluvial floods damage coastal and riverine landscapes and are caused by seasonal water rise from huge rivers such as the Niger, Benue, Cross River, and Kaduna. On the other hand, pluvial floods occur annually during the rainy season (July–October) and are more prevalent in urban areas (Nkwunonwo, Malcolm & Brian, 2015). Recent floods in Nigeria have been exacerbated, among other factors, by the release of water from Cameroon's Lagdo Dam (Udo, Ojinnaka, Baywood, and Gift, 2015), by the high intensity of rainfall in some regions (Eagle Online, 2018), and by the haphazard development of land in flood-prone areas (Eagle Online, 2018; Atufu and Holt, 2018).

The frequency and severity of flood catastrophes have become critical challenges in the development process in Nigeria, since flood disasters have resulted in significant environmental damage, human fatalities, and wanton destruction of economic assets (Ayeni et al., 2014). The loss of human life and development assets, the mounting expenses of restoration operations, and the resulting suffering are all concerns and difficulties that worry flood-affected communities (Aderogba, 2012; Ayeni et al., 2014).

Similarly, coastal settlements are at risk of flooding as a result of their general terrain and geographic position, as well as climate change and severe weather events. Thus, managing floods and the accompanying issues in the Niger Delta's coastal villages will be critical to the region's socioeconomic growth. This is because, in contrast to other natural catastrophes, flooding can be managed via careful planning and installation of appropriate infrastructure. Flooding in the Niger Delta is further worsened by people, mostly owing to induced bad urban design practises and insufficient environmental infrastructure. The susceptibility of communities in the Niger Delta to climatic variability and change exacerbates rural people's high levels of poverty (Ogbonna et al., 2017). Flooding has become a problem in the Niger Delta region's coastal urban and rural communities as a result of heavy precipitation and river runoff (Agumagu and Todd 2015).

The coastal regions of the Niger Delta are subjected to physical changes as a result of natural and human forces. Along with current and projected extreme events such as flooding, erosion, sea-level rise, and heat waves, other conflicting factors exacerbate the coastal Niger Delta's vulnerability, ranging from rapid demography change, urbanization, unsustainable land use, and insufficient application of appropriate policies to oil spills and gas flaring. All of these challenges, in addition to climatic unpredictability, exacerbate vulnerability and jeopardize the human and natural environment's resilience.

Flooding threaten sustainability by impairing the economics, health, social life, and environment of the inhabitants of Nigeria's Niger Delta. Flooding jeopardizes Nigeria's ability to achieve the global sustainable development objectives. The Sustainable Development Goals (SDGs) are a set of worldwide targets for environmental and human development by 2030. Similarly, nine (9) of the seventeen development objectives are directly impacted by floods. These objectives include the eradication of poverty and hunger, as well as the provision of safe drinking water and sanitation.

In line with these stated problems, the study attempted a review of past literature on the subject matter with emphasis on these research questions; and these are: what are the causes, frequencies and magnitude of flood in the coastal regions of the Niger Delta? What is the level of vulnerability of the coastal communities to flood? Why do people reside in the coastal areas? What are the impacts of flood on the socio-economic livelihood of the people? What are the mitigation strategies for adequate management of flood in the study area?

### 1.3 Aim and Objectives of the Study

The aim of the study is to examine flood incidences, associated challenges and problems and its mitigation strategies in the coastal region of the Niger Delta. The specific objectives are to:

1. Identify the causes and frequencies of floods in the study area
2. Investigate the reasons why people reside in coastal regions of the Niger Delta.
3. Examine the vulnerability level of coastal communities to flood.
4. Examine the socio-economic and livelihood impact of flood in coastal communities.

5. Explore the strategies of mitigating and resolving flood related issues in the coastal region of the Niger Delta.

## 1.4 Significance of the Study

The underlining concerns of flood in Nigerian coastal regions are due to the fact that they are more prone to coastal challenges and dynamics. The results of the study shall assist to reveal the causes of floods in coastal regions to assist in showing early warning indications for optimal management practices and aid building up of coping techniques at each community level.

Findings of the study shall aid the government and multinationals in core areas that need proper land use planning and relevant structures that will promote adequate resilient measures to help tackle flood issues in coastal communities.

Findings of the study shall help the government to be proactive in finding a lasting solution to the issue of accessible housing facilities which usually are the push factors driving people to living in coastal regions of the Niger Delta.

The findings of the study shall also be useful for exposing the socio-economic challenges faced by coastal communities as aftermath of flood incidences and this will serve as a pointer for the government, multinationals, non-governmental organizations and the likes to help residents in coastal areas adjust and cope with flood incidences in the study area. Findings of the study shall also serve as data bank for future researches in line with the subject matter of the study.

## 1.5 Scope and Limitation

The scope of the study describes in detail the area of investigation of the study. The study reviewed past literature in line with the objectives of the study and provided perspectives which aided the

study in putting forward recommendations based on the findings. Thus, the study is limited to only literature review by using results and findings discovered in literature to make recommendations that will aid in the proper management of floods in coastal communities of Niger Delta. Therefore, the authenticity of the data generated from these sources depends majorly on the writer and the publisher which may affect the findings of the study in one way or another. In essence, the data collected through secondary sources may not be as authentic as when collected directly from the source or the field. This is a very common disadvantage with online secondary sources due to a lack of regulatory bodies to monitor the kind of content that is being shared.

### 1.6 Definitions of Terms

This section gives short and descriptive information about some technical terms of importance to the study. These terms are key words with reference to the subject matter of study.

**Coastal region:** The term "coastal zone" refers to a location where sea and land processes interact. These zones are important since they are home to the bulk of the world's population. Coastal zones are always changing as a result of the ocean's dynamic interaction with the land (Nelson, 2018).

**Flood:** This is defined as an overflow of a large amount of water beyond its normal limits, especially over what is normally a dry land" (Oxford Dictionary, 2019).

**Mitigation:** This is defined as "the lessening or limitation of the adverse impacts of hazards and related disasters" (Cui et al., 2021).

**Socio-economic Livelihood:** People's ability to make a living and maintain a standard of life which is directly linked to their socio-economic status, and socio-economic aspects are considered in this context.

**Vulnerability:** This is defined as “the characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard” (Aven, 2016).

**Risk**: This is defined as “the combination of the probability of an event and its negative consequences” (Aven, 2016).

# CHAPTER 2: RESEARCH OUTLINE

## 2.1 Hypotheses

The following Null hypotheses were put forward for the study:

**$H_0$:** The causes of flood are the same in the study area overtime.

This is an assumption made and this was validated through the findings in literature if the causes of flood in the coastal communities of Niger Delta are the same overtime. Thus, if the causes have not changed overtime then the null hypothesis shall be retained.

**$H_0$:** The vulnerability levels of coastal communities in Niger Delta to floods are the same overtime.

This assumption will be validated through the results of several vulnerability analysis conducted overtime for coastal communities in Niger Delta in the literature. Therefore, the null hypothesis shall be retained if the vulnerability levels among communities to floods are the same overtime.

**$H_0$:** Flood has no significant impact on the socio-economic livelihood of the coastal communities.

This is an assumption made and this shall be validated through the findings in literature. Thus, the perception assessment of residents in flood prone overtime areas shall be used to justify this assumption made. Therefore, if flood impacts on the socio-economic livelihood of the people have been evident overtime, then, the null hypothesis shall be retained.

## 2.2 Research Questions

This section about the research questions exposes the central focus of the study/investigation. It shows in clear terms the subject matter of the study by providing enough information so that the focus of the study is well communicated without further explanation.

1. What are the causes and frequencies of flood in the study area?

Two to three studies in literature were examined and compared within a space of at least 10 years to ascertain the causes and frequencies of flood events in the study area.

2. Why do people reside in coastal regions of the Niger Delta?

The reasons why people reside in flood prone areas shall be examined from different perspectives overtime. Different studies with at least 8 years interval shall be examined for the purpose of understanding these reasons.

3. How vulnerable are the coastal communities to flood?

The different analyses conducted overtime and their findings as regards vulnerability index of coastal communities in literature shall be examined. Findings shall reveal the important parameters and indicators for assessment in relation to various vulnerability levels for the coastal communities in Niger Delta.

4. Do flood incidences have any impact on the socio-economic livelihood of the coastal communities?

Flood has several impacts on the people being affected by it especially on those living in flood prone areas due to the flood frequencies they experience at different time periods. Thus, perception studies in literature shall be examined and used as justifications.

5. What strategies are there to mitigate and resolve flood related issues in the coastal region of the Niger Delta?

The proffered strategies by various studies overtime shall be examined and put forward based on the subject matter of the study. Thus, studies that investigated flood related problems of coastal communities in Niger Delta and put forward mitigation strategies that can help tackle the problems shall be highlighted.

# CHAPTER 3: STUDY AREA

## 3.1 Location

The Niger Delta belongs to the South-east, South-west and south-south region of Nigeria. It is located between latitudes 5º 00'N and 6º 30'N and longitudes 5º 20'E and 9º 00'E (Figure 3.1). The Niger Delta region with the Niger River is sitting directly on the Gulf of Guinea on the Atlantic Ocean in Nigeria. The research area's position in southern Nigeria makes it one of the world's biggest arcuate fan-shaped river deltas (Britanica, 2014). The Niger Delta area is made up of nine states: Abia, Akwa Ibom, Bayelsa, Cross River, Delta, Edo, Imo, Ondo, and Rivers. However, the coastal regions belonging to the south-south area of the Niger Delta region, are often referred to as the BRACED states (Isumonah et al., 2001), which are Bayelsa, Rivers, Akwa Ibom, Cross River, Edo, and Delta states, were chosen as the research area (Figure 3.2).

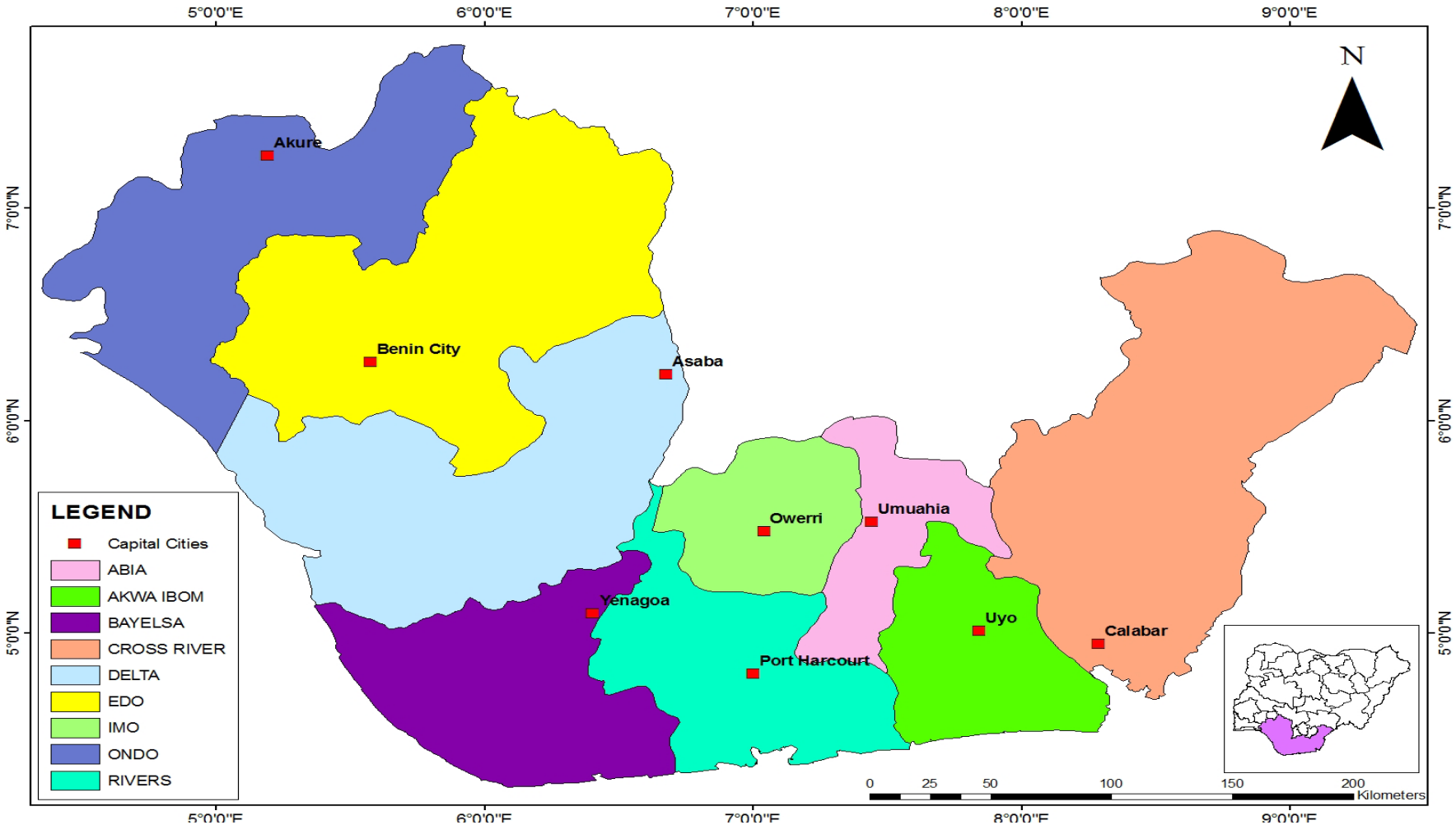


Figure 3.1: Niger Delta with Capital cities

Source: GIS Lab, Dept. of Geography & Environmental Mgt. Uniport

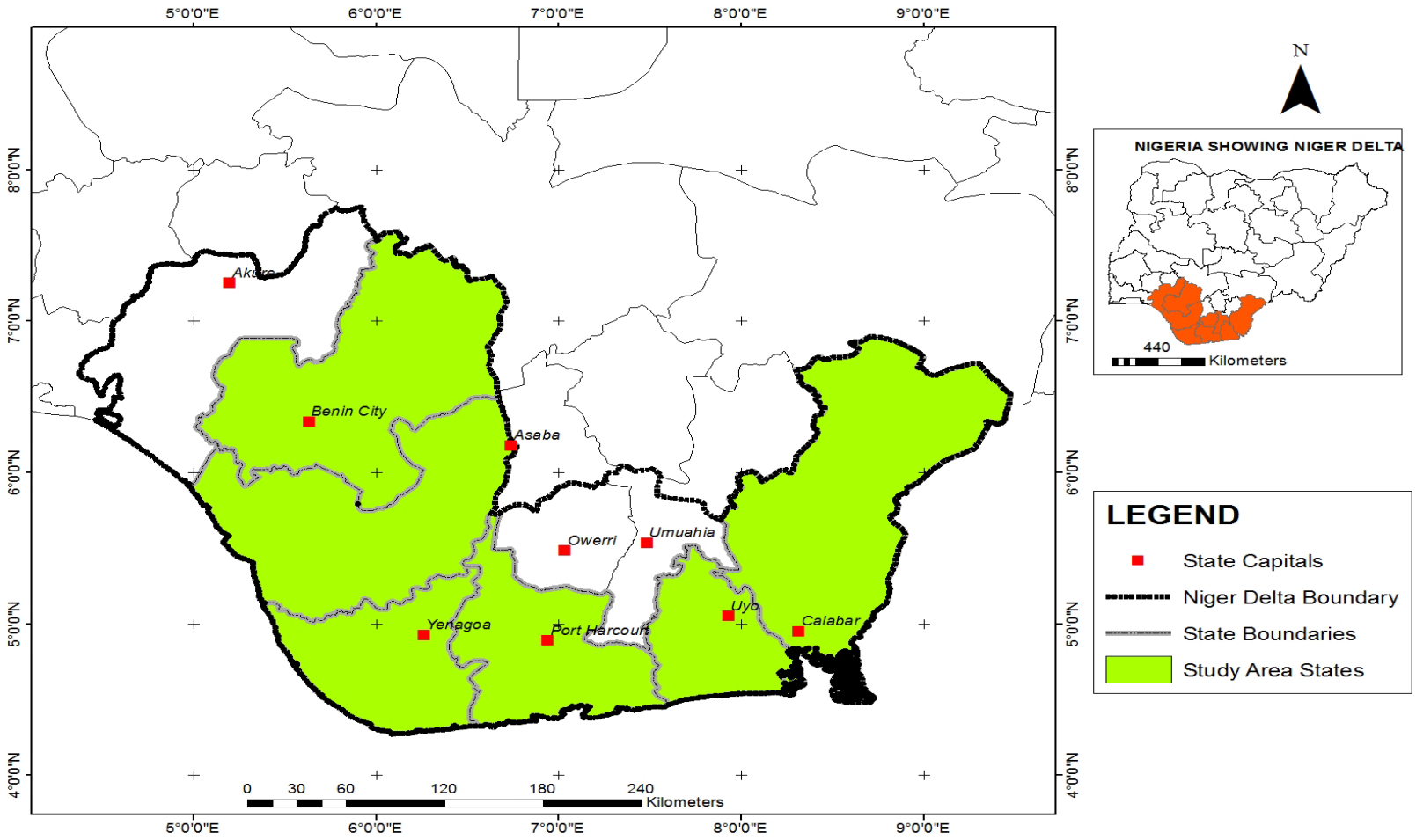


Figure 3.2: BRACED states and their Capital Cities
Source: GIS Lab, Dept. of Geography & Environmental Mgt. Uniport

## 3.2 Geology and Soil

The Niger Delta rocks are underlain by oceanic foundation rock, which is the basin's oldest rock and is basaltic in nature. The basement rock is overlain by the Akata Formation, which is Paleocene in age and is formed of thick shales, turbidite sands, and tiny quantities of silt and clay. This is followed by the Agbada Formation, which is marine farces characterized by both freshwater and deep-sea features and dates back to the Eocene. This is the main oil and gas-bearing field in the basin. The Agbada formation is overlain by the Oligocene and younger Benin Formation. It is made up of sands from the continental flood plains and alluvial deposits. It is thought to be up to 2,000 meters thick.

The soils of the Niger Delta are made mostly of coastal plain sand (Benin formation). The soils are sandy loam and range from mildly acidic to extremely acidic (pH 4.2-5.8).

## 3.3 Vegetation

Mangrove forest dominates the Niger Delta's vegetation. Approximately 80% of the Delta mangrove forest's vegetation is spread among three states (Bayelsa, Delta, and River States) (Afa, 2011). Despite the fact that the forest contains six mangrove species, mangrove development occurs largely on saline muddy stream banks. The Niger Delta is home to various mangrove species, the most prominent of which are the red (Rhizophora racemosa), black (Laguncularia racemose), and white (Avicenniagerminans) mangroves. Grass cutters, bush rats, antelopes, snakes, and other animals live in the surroundings. Because of human activity, this mangrove forest is being depleted of plant and animal species (hunting and lumbering). The delta features the biggest mangrove wetlands in Africa, covering around 1900 square kilometres. The area is in the tropical rain forest zone (Joe-Alagoa, 2002).

### 3.4 Weather and Climate

The southern area of Nigeria receives copious amounts of rain. Because of the region's closeness to the equatorial belt, these storms are often convectional in character. This area receives a lot of rain every year. Every year, the Niger Delta gets about 4,000 mm (157.5 in) of rain. The remainder of the southeast gets 2,000 to 3,000 mm (118.1 in) of rain every year (Afa, 2011). The southern part of Nigeria has two significant rainfall peaks, with a brief dry season and a longer dry season lying between and after each peak. The first rainy season starts around March and lasts until the end of July, with a peak in June (Afa, 2011). This rainy season is followed by a brief dry season in August known as the August break, which lasts two to three weeks. This respite is broken by the brief rainy season, which begins in early September and lasts until mid-October, with a peak time towards the end of September. The brief wet season ends in October, followed by a lengthy dry season. This season lasts from late October to early March, with peak dry conditions occurring between early December and late February.

### 3.5 Hydrogeology and Drainage

The hydrogeology of the Niger delta is dominated by the Benin Formation, which not only functions as an aquifer but also allows groundwater recharge in the area. The Niger Delta area is drained by large rivers such as the Niger and Benue systems, as well as a number of smaller rivers such as the Nun, Orashi, and Imo, which are part of the distributaries that flow into the Atlantic Ocean (Afa, 2011). The River Nun and Orashi's gradual meandering and twisting course has resulted in the geomorphological occurrences of degradation on the depressed side of the ocean and sedimentation on its most convex side.

### 3.6 Land use

The availability of dry ground and the nature of the topography influence the pattern of habitation in the Niger Delta Region. Low relief and poor ground drainage are the key reasons for the region's lack of significant communities. The major communities are placed in the Delta's interior, which has superior drainage and accessibility. The principal communities in the mangrove swamp zone, such as Port Harcourt, Sapele, Ughelli, and Warri, have evolved on dry land islands that interspersed the zone, with settlements placed at the head of the navigable limits of the coastal rivers or estuaries (Amangabara and Obenade, 2015). Compounds, which are tightly spaced groupings of modest structures housing 50 to 500 people, the majority of whom are fishermen or farmers, make up the average community. There are also bigger villages that are often isolated from other rural home clusters by their outside rotating farmlands, oil palm or latex plantation, bush, or expanses of forest areas.

### 3.7 People and Economic Activities

The inhabitants of Niger Delta region live in the country's south-southwest and south-east part. The entire population of the Niger Delta Region was around 20 million at the time of the 1991 Census, accounting for approximately 23 percent of Nigeria's total population. According to government projections, the overall population in 2005 was almost 27 million, with an annual growth rate ranging from 2.0 percent to 2.9 percent.

Small-scale farming is the primary occupation of the inhabitants in the villages. Cassava processing, hunting, fishing, logging, and small-scale business and industry are among the other social economic activities. Foodstuffs, especially palm oil and kernel, palm wine, and crafts are the main agricultural products in the districts (Onweagba and Nwaihu, 2014).

# CHAPTER 4: LITERATURE REVIEW

## 4.1 Conceptual Framework

### 4.1.1 Concept of Flooding

Flooding occurs when water exceeds its natural and man-made barriers into areas that are not normally flooded (Smith and Ward, 1998). Flooding occurs practically annually in varying degrees of intensity in the Niger Delta region of Nigeria, resulting in the loss of lives and livelihoods, as well as degradation in the environment and development (Wizor and Week, 2014). Flooding may occur as a consequence of prolonged rainfall, spilling water caused by a damaged dam, or an increase in the water level in rivers or oceans. Floods may be very harmful depending on the kind and amount of water.

Flooding is connected with significant economic loss and disruption of daily life. According to Wisner et al. (2004), flooding was responsible for the majority of economic losses and fatalities associated with flood catastrophes in the late 1980s and into the 1990s. While floods are works of God, flood losses are usually the result of human activity. The expansion of humans on river floodplains explains the high yearly total of flood losses (White, 1974). Thus, man's residence and development activities along the Niger Delta's shoreline constitute an act of man boosting flood incidents.

### 4.1.2 Concept of Ecological Resilience to Flooding

Ecological Resilience is the capacity for people and the environment to coexist in a sustainable manner (Holling 1973). Resilience is a system's capacity to absorb stress and recover from it (Mueller, Spangler and Alexander, 2013). Generally, the principle of resilience refers to an individual's capacity to acquire the skills and talents necessary to adapt to and cope with stress

(IFRC, 2014). The notion is concerned with people's capacity to recover from stress by reducing their vulnerability in order to advance sustainable development objectives (USAID, 2012; Frankinberger et al., 2013).

At the moment, a widely accepted definition of socio-ecological resilience includes the processes of reorganizing, learning, improving, and changing (Folke, 2006).

Ecological resilience is an effective framework for flood risk management because it focuses on resilience in a world that will continue to experience climate change (Adger et al., 2005). This notion of ecological resilience has developed into a sophisticated resilience theory that tackles the complicated link between man and the environment. It bridges the chasm created by the interplay of riverine and urban cities as a result of flood dangers. Managing flood danger in a resilient manner begins with the recognition of periodic floods as an inherent change in the environment that influences socioeconomic events in floodplains. Second, resilience theory suggests that periods of steady growth accompany abrupt shifts (Folke, 2006). In often stressed ecosystems, it is seen that resilience is facilitated by experience and awareness of pressures (Holling, 1973, Gunderson and Holling, 2002). Flooding has become a catalyst for resilience since each flood event provides cities with information to build upon and a chance to alter internal structures and processes, resulting in accumulated coping techniques (Folke, 2006, Smit and Wandel, 2006). Thus, resilience theory advocates a paradigm change in flood hazard management, emphasising resilience development over stability preservation. Additionally, since flooding is a component of the Niger Delta's catastrophes, resilience is just a means to an end of stability. This suggests that resilience is the capacity to endure in the face of adversity.

Community-based flood resilience may be defined as a community's ability to endure flooding, avoid losses and damages, restructure, and keep its present socioeconomic features. It is the ability to maintain a certain quality despite floods. The criteria may be based on food security, livelihood, or socioeconomic well-being (Adger, 2000; Cumming et al. 2006; Gunderson, 2010). The amount of flooding that a town endures until it hits a threshold is used to determine its resistance to floods. It is socially rather than scientifically defined. The required standard community flood acceptable range of socioeconomic changes is critical for community-based flood resistance (Figure 4.1) (Liao, 2012).

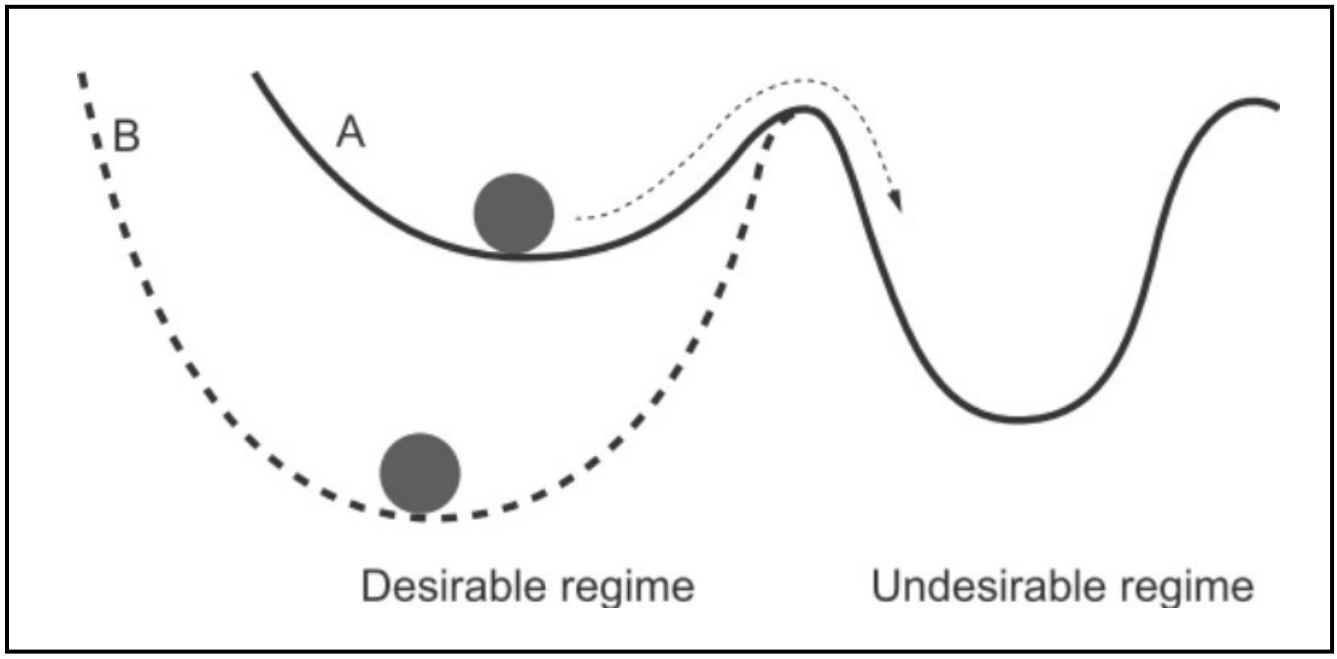


Figure 4.1: The Tolerable Range of Socioeconomic State

Source: Liao (2012)

When a community is flooded, it is considered to have transitioned to an unfavourable regime. This deluge may wreak havoc on the community's socioeconomic, human, and environmental systems (United Nations International Strategy for Disaster Reduction

2004). The unpleasant regime is primarily defined by a scarcity of sources of income and disruption of livelihoods, a high rate of population relocation, and a lack of food security (Adger 2000, Berkes et al. 2003). It is important noting that community-based resilience refers to the capacity of a community to avert a flood catastrophe. The resilience of the community is examined in order to avert physical and socioeconomic harm.

Human resilience is critical to our capacity to deal with flood threats and other types of calamities. This is true insofar as it involves the ecosystem's sustenance, the loss of which restricts adaptability possibilities (Adger, 2000; Berkes et al., 2003; Gunderson, 2010). It is self-evident why the environment is critical to communities that rely on local resources for survival (Adger et al., 2005). Numerous communities today are undoubtedly already in socially–ecologically unfavourable regimes as a result of significantly altered hydrology, geomorphology, biochemistry, and species composition, which have been rendered incapable of contributing significantly to the environment (Paul and Meyer, 2001; Groffman et al., 2003).

Low community-level flood risk awareness is a result of indigenes' limited flood experience (Correia et al., 1998), who are used to coping well during the dry season and have little knowledge on how to cope with flooding should the flood-control system fail. Community-based flood control solutions that rely on infrastructure tend to focus on the river rather than the built environment, since they foster a false feeling of security that negates the need for local flood response capability.

This idea was used in the research because flood disasters have a variety of socioeconomic consequences that may be minimized or decreased when coastal towns are prepared with on-ground coping techniques, which reduces the communities' susceptibility to flood hazard.

## 4.2 Flood and flooding

According to Alam et al. (2008), a flood or deluge is an overflow of water that submerges land and may be river (marine), estuary, coastal, or muddy in nature. Generally, the term "flood" has a negative connotation since it is connected with a feeling of economic loss. This implies that a flood may not be considered important if it does not threaten land regions inhabited by humans, such as towns, cities, or other populated places. Floods are essentially natural phenomena that occur when catchments get abnormally large volumes of water, such as rainfall or snowmelt, depending on the environment. River valleys serve as natural conduits for the evacuation of surface water from drainage basins or catchments. When the basin in issue gets more water than can be evacuated efficiently or speedily through the route ways, the apparent consequence for the area next to the river valley is floods. Thus, flooding or the buildup of flood is a visual manifestation of an excessive accumulation of surface water over a certain region.

### Causes of flooding

The literature on flood may be divided into two categories: the causes of flooding and the effects of flooding. The majority of floods are produced by excessive runoff from high-intensity precipitation, rainfall, or ocean surge, but they may also be caused by dam failure, an insufficient drainage system, stream channeling, growing urbanization, or development on flood plains. The area said that when the soil's infiltration capacity is surpassed, runoff occurs, resulting in flooding. Other types of floods are caused by snow melt, coastal storms, and landslides (Alam, et al, 2008). Additionally, by removing natural vegetative cover from a wooded region during construction, infiltration may be reduced to the point that runoff's intensity increases (Alam, et al, 2008). Under metropolitan areas, infiltration capacity is further diminished by the replacement of ground cover with impermeable urban surfaces; surface overland flow becomes the major means of disposing

of surplus rain water in these settings (Wu, et al, 2002). However, Alam et al. (2008) noted that flooding is induced not just by natural processes such as rainfall and snow melt, but also by human activities that change the regular hydrological regimes of rivers and drainage systems. Among them include the construction of dams, hydraulic mining, deforestation, and inefficient soil management. Thus, flooding is a result of both human activity and natural physical circumstances. When assessing the danger presented by floods, consideration should be given to the expected depth, speed, and extent of inundation, as well as the possibility of predicting actions to be taken in response to a flood warning. A quick flow caused by flash floods or inundation by the sea as a result of defensive failure poses a higher danger of death than a gradual increase in the water level. Additionally, the implications differ according to land usage. For instance, the danger of a flood defense overtopping and perhaps failing to protect a highly populated metropolitan region is quite high. Bell-Gam, 1990 stated in a study of flood patterns and control measures in Rivers State that the Niger Delta area is impacted by floods owing to river flooding and that local communities have taken measures to safeguard the land from bank and sheet erosion. These coordinated communal actions ensured that boat loads of river sand were dumped and dispersed across whole complexes. These actions are prevalent in the Omoku and Opobo towns in 1980, when the number of towns in need of protection exceeded one hundred, and the anticipated cost is so high that Nigeria could not pay it even during the oil boom. The country's current financial difficulties complicate matters, and hence alternatives to traditional flood and erosion prevention must be considered. For instance, the settlement of Otuokpoti is located along the Ekelo stream, one of the distributaries of the Nun River, which flows south of Yenegoa town and is positioned on one of the levees that define the Nun River's banks. The town's built-up section is a tiny strip of land less than ten acres in size, situated between the Ekelo creek's periodic flooding, which causes the rear to be marshy.

There are basically two main causes of flooding:

- Natural
- Artificial or manmade

**Natural Causes of flooding**

The effect of the interaction between natural forces and man can cause environmental hazards (Valentin. et al, 2016)

However, some conditions that result from this interplay of natural forces and man on our environment can be devastating. These natural occurrences that cause flooding include

Landslide or river bank failure:

- Torrential rain storm caused by typhoon or monsoon winds
- Overflow of Rivers, Sea or Creeks as a result of inadequate channel capacity
- Excessive and prolonged rainfall which may lead to storm surface or Sea surges
- Presence of impermeable top soil which trap rain water

**Artificial or Manmade Causes**

Social, business and developmental activities of man disrupt the orderly pattern of the environment thereby causing disaster such as flooding that would have been otherwise avoided (Valentin. et al, 2016). These are man-made or artificial causes of flooding and include:

- Collapse of existing dams or dykes
- Lack of adequate drains
- Improper planning and execution of development activities that causes blockage of natural drainage routes reduction in the channel capacity of adjoining creeks of streams or rivers

- Indiscriminate refuse disposal causing drainage channel blockages
- Unpaved city streets, resulting in the transportation and subsequent deposition of loses soil material into drains causing blockage of available drains
- Excessive hard surfaces especially in built-up areas which reduces infiltration thereby trepanning excessive run-off

### 4.3 Problems of Flooding

The first known flood produced by rain dates all the way back to the Biblical storey of Noah's deluge in 400BC (detailed in the book of Genesis chapter 7 of the Holy Bible). For forty days and forty nights, torrential rain fell. Tidal surges swept up the summits of steep mountains that rose more than 6m above the tallest peak. This flood persisted for 150 days, killing all life and property on the planet save for Noah's family and the animals on his ark. Floods that inflict the most property damage in Colorado, United States of America, occur between May and August and are triggered by widespread persistent rainfall over many days, often involving flash flood occurrences (Clark et al, 1998).

In July 1997, the City of Fort Collins, Colorado, nestled at the foot of the Rocky Mountains in Northern Colorado, was pounded by the highest rainfall ever recorded in a Colorado metropolitan region (Clerk et al, 1998). The ensuing flood tragedy claimed five lives, wounded 54, left 200 people homeless, and ruined several businesses. Lessons learnt from the catastrophe fueled attempts to regulate flood plains (Charlie and Doehring, 2000). However, flood plains remain popular places to reside due to the rich terrain and the fact that people often return to the same location once the flood passes. Flooding also contributes to a variety of other environmental concerns. Bangladesh has extensive regions of deforested land, which results in catastrophic floods and following droughts. According to Roy Ward, a British geographer, it is paradoxical that in a

region where the discharge from the world's second biggest river flows, floods are followed by droughts because the floods, which often inundate one-third of Bangladesh's entire land area, are not appropriately regulated. Destruction by flood is therefore followed by drought-induced agriculture in a seemingly endless cycle.

There is widespread recognition in both South America and Asia that floods and mudslides have grown increasingly regular and severe. According to a 1984 research conducted by Earth scan and the Swedish Red Ross, floods harmed 5.2 million people annually in the 1960's and 15.4 million annually in the 1970's (Valentin. et al, 2016).

In 2002, Europe was devastated by a series of devastating floods; Mexico was devastated by a storm; and Korea was devastated by a typhoon. In neighboring Austria, flood waters also cause devastation. China has a history of being one of the world's most often affected nations by national flood disasters. The flooding in Southwest China's Chugging Municipality and Sichuan Province is expected to be the worst since 1998, when severe rains in August and early September wrecked a great deal of property and claimed many lives (Valentin. et al, 2016). According to Agbonkhese et al. (2014), each flood season in various parts of Nigeria plays out tragically as people are murdered, houses are swept away, and furniture is wrecked by floods. Some recent reported flood disasters in Nigeria, as documented by NEST in 1991, provided insight into the country's flood and flood-related difficulties. Ilorin, Nigeria, had flood disasters in 1973, 1976, and 1979. In 1976, 24 homes were inundated and 56 others were evacuated, vegetable and sugar cane farmland swept away, and several highways were inaccessible (Agbonkhese, et al, 2014).

Omoku suffered a flood tragedy in 2012, with over 200,000 inhabitants of Omoku in Ogba EgbemaNdoni Local Government Region (ONELGA) in Rivers State fleeing their homes as a

result of the flood that submerged the streets and settlements in the area. They now live in terror of a repeat. It is the same narrative of flooded streets and houses practically every time it rains severely in Lagos, Nigeria's low-lying coastal metropolis. In June, the "Evening Times" headlined, "Floods disrupt classes." The report detailed how the majority of classrooms in Lagos' elementary and post primary schools were converted into pools of water during a downpour, causing lessons to be suspended for one week. In June 1988, during a three-day period of non-stop rain in Lagos, the river near the Lagos University teaching hospital (LUTH) in Surulere overflowed its banks and rendered impassable Ishaga Road, Ikeja, Awolowo Road, Ijora Causeway, Bodija, Apapa-Oshodi expressway, and the international Airport intersection, among others. As previously stated, this was due to the canal becoming clogged with solid garbage (Nest, 1991). In August 2000, the Ogunpa River, which runs through Ibadan, overflowed its banks and inundated any features approaching on its flood plains. That deluge claimed around 2000 lives (Oyo State year book, 2001).

Coastal flooding produces flooding in the Niger Delta, and river flow during the rainy season (heavy rainfall) coupled with the Niger Delta's low, flat topography and poorly drained soil results in widespread flooding and erosion. Seasonal flooding affects almost 80% of the Niger Delta, including all swamp forest. During the majority of years, only a few high regions stay dry. Flooding wreaks havoc on transportation in certain locations and contaminates drinking water supplies. Omoku, Opobo town, Brass town, Abonema, Bonny, Nembe, Andoni, and Yenegoa are among the cities impacted.

In 1988, 211 communities were completely or partly submerged for a duration of two weeks or more. Throughout September 1988, the water level increased at a pace of 5 to 7cm per day, causing

hundreds of people to seek refuge at higher altitudes, destroying crops and buildings (Ministry of Works and Transport, Rivers State Government Report, 1988).

Flooding is a cataclysmic event; flooding is therefore a result of both human action and natural physical factors.

## 4.4 Coastal flooding

Coastal flooding or inundation is the partial or total overflow of water on low-lying land caused by tidal invasion of streams and ocean surges, as a consequence of sea-level rise or the fast buildup of surface water runoff from any source, or both (Amangabara, and Gobo, 2010). In Andoni (like in other flood-prone locations), there are no tidal defences, no erosion control measures, and an abundance of substandard buildings to combat tidal floods, sea surges, and fast buildup of surface water runoff, resulting in yearly marine flooding. Seasonal flooding is a regular occurrence in the majority of riverine sections in the flood plain, which is a characteristic site in the Zone. These floods are primarily caused by sea-level rise, which results in sea surge, which also results in soil erosion and river bank slumping from cliff coasts, which are yearly occurrences when reinforced by local precipitation (Afa, 2011).

## 4.5 Vulnerability

The features and circumstances of a community, organization, system, or asset that predispose it to the harmful impacts of a danger are referred to as the area's vulnerabilities. "Vulnerabilities are the conditions determined by physical, social, economic and environmental factors or processes which increase the susceptibility of a community to the impact of hazards" Although vulnerability is often connected with poverty, it may also occur when individuals feel lonely, insecure, and helpless in the face of danger, shock, or stress. Individuals are exposed to risk differently

depending on their social group, gender, ethnic or other identity, and age, among other things. Vulnerability can also take different forms: poverty, for example, may mean that housing is unable to withstand an earthquake, flood, or severe storm; a lack of hazard awareness and information, or a lack of preparedness, may result in a slower response to a disaster, resulting in increased death or suffering. Capacity, on the other hand, may be defined as the resources accessible to people, families, and communities in order to deal with a danger or resist the effect of a hazard. These resources may be tangible or intangible, but they can also be found in the way a community is structured or in the abilities or characteristics of people and/or organizations within the community (Agbonkhase, et al, 2014).

To determine people's vulnerability, two questions need to be asked.

- To what threat or hazard are they vulnerable?
- What makes them vulnerable to that threat or hazard?

Counteracting vulnerability requires:

- Reducing the impact of the hazard itself where possible (through mitigation, prediction and warning, and preparedness).
- Building capacity to withstand and cope with hazards.
- Tackling the root causes of vulnerability, such as poverty, unemployment, ill health, low income, weak buildings and structures, desertification.

Physical, economic, social, environmental, and political aspects all contribute to a person's susceptibility and capability to resist, deal with, and recover from danger. Poor people are more likely to live and travel in places prone to dangers, and they are less likely to have the means necessary to cope in the event of a catastrophe. Secure livelihoods and increased earnings help

individuals build resilience and recover more swiftly from disasters. Environmental sustainability also mitigates risk and minimizes the environment's susceptibility (Agbonkhase, et al, 2014).

Risk refers to the potential for damage (danger) as a result of current processes or future occurrences, while sustainability refers to the continuation of a desired quality of life, given its preferred distribution in the environment and the carrying capacity of the available final means (ISDR, 2009).

# CHAPTER 5: METHODOLOGY

## 5.1 Research Design

The descriptive/longitudinal research designs were employed for this study, based on the fact that the study is dependent on both observational/historical researches in order to make valid conclusions for the study. Descriptive research designs aid in elucidating the who, what, when, where, and how of a given research topic; but, a descriptive study cannot definitely determine why. The descriptive method is used to elicit data on the present state of a phenomenon and to define "what exists" in terms of variables or circumstances in a scenario (Anastas, 1999). The longitudinal research was employed because the study is a type of study that involves looking at variables of interest over an extended period of time. Longitudinal can take place over a period of weeks, months, or even years or in some cases a decade or two. Thus, the study put forward illustrations from observations made from past researches on the subject matter by reviewing findings of past literature and using the same to make conclusions and recommendations. In other words, the study examined past literature in line with the study objectives. The findings of these literatures were used to make valid conclusions on the subject matter of the study.

## 5.2 Data Collection Methods

Data collection is a process of gathering information from all the relevant sources to find a solution to the research problem. It helps to evaluate the outcome of the problem. The data collection methods allow a person to conclude an answer to the relevant question. Hence, data collection for the study was based on secondary sources.

In identifying sources for this literature review, different information bases were utilized. At first, Google scholar was used to take an underlying example of what kinds of articles were accessible.

I utilized an essential hunt of Assistive Innovation Proficiency. From the article title and exploration, information got from Google scholar with that essential, I had the option to utilize a superior rundown of more refined terms while using other databases. I also accessed GALE databases, which help libraries establish connections with researchers who are looking for credible, timely content.

In addition to the database searching, a number of articles were located using forward and backward search methods. Forward Citation Search: A search to track down every one of the articles that refer back to a particular article. This search looks forward on schedule to perceive how this article added to the insightful discussion. Backward Citation Search: A search to find all of the cited references in a single article. Each of the search terms used was selected due to their appropriateness and relevance in consideration of the purpose of this literature review.

### 5.2.1 Secondary Data Sources

The study made use of secondary data sources which involved collecting information from past literature on the subject matter of the study. The data were sourced from published works and other relevant information for the study via the internet. Ergo, the study depended on historical and statistical documents based on the objectives of the study. Therefore, the authenticity of the data generated from the secondary sources depends majorly on the writer and the publisher which may affect the findings of the study in one way or another. Studies on the coastal communities within the BRACED states were gathered with reference to the study objectives.

## 5.3 Data Analysis

For the purpose of the research, the data analysis of the study focused on analyzing data obtained from other researchers who may have primarily collected data for another purpose which are not

particularly focused on the subject matter of the study. Thus, data obtained for the study were analyzed both quantitatively and qualitatively by applying statistical techniques to validate statements generated through numerical data and the provision of in-depth explanation on qualitative data. The stated hypotheses were validated through results provided by the secondary sources of information collected. Hence, the descriptive statistics was employed for data presentation. The descriptive statistics in form of Tables, charts and maps were employed for data presentation for clarity purposes in line with the stated objectives of the study. Inferential statistics in form of hypotheses validations were employed to make valid conclusions concerning the stated assumptions for the study in line with its findings from researches.

Sources were analysed according to a number of criteria. First, the source has to be in line with the purpose of the literature review based on the research questions of the article, the source has to be a peer-reviewed journal source. In addition to these criterias, I also looked for types of journals that would normally include research articles that were thematically aligned with my purpose. Ergo, I gave greater weight to articles that were focused on the purpose of my research and I examined journals that would be characteristic of their respective fields. Finally, I ensured that the journal used had the most recent publication date. After taking these factors into consideration, I analysed the data itself.

The relevance and credibility of all the sources were considered in the literature review. I evaluated the resources with the following criteria: (a) How current is the source? (b) Does the source align with my research question? (c) What are the credentials of the author of the source?. The majority of cited references were within the last 10 years. A few researchers were included from previous decades to establish a foundational concept that continues to this day.

# CHAPTER 6: RESULTS

## RESULTS PRESENTATION AND INTERPRETATION

### 6.1 Causes and Frequencies of floods in the study area

**Perception of Flood Experiences in Coastal communities**

The information on Table 1 exposes the flood experiences of coastal communities to flood disasters. It was revealed that 93.0% of respondents living in coastal floodplains of the Niger Delta have experienced flood disasters. It was revealed that 53.0% of the respondents were aware of the fact that the area they occupy as residence and for farming purposes is subject to flooding. In terms of the period of the year regarded as flood season, majority of respondents (76.0%) indicated the period between July and September. This period coincides with the peak of rainy seasons in the Niger Delta. The information concerning the severity of flood events revealed that 56.7% of respondents indicated severe while the remaining 43.3% of sampled respondents indicated not severe. It was also revealed that only 55.0% usually evacuates the area during flood while the remaining 45.0% stay and manage the consequences. It was revealed that majority of flood victims do not receive relief from flood disasters in the Niger Delta.

Table 1: Flood events in Coastal communities (upper and lower floodplain) of Niger Delta

| S/N | Flood Experiences | Percentage (%) | | |
|---|---|---|---|---|
| | | Yes | No | Not sure |
| 1 | Number of respondents who have experienced flood | 93.0 | 7.0 | 0.0 |
| 2 | Number of respondents who had knowledge about flood before moving into coastal areas | 53.0 | 47.0 | 0.0 |
| 3 | Period of the year flood is normally experienced in the Niger Delta (July – September) | 76.0 | 0.0 | 24.0 |
| 4 | Flood events is usually severe in the area | 56.7 | 43.3 | 0.0 |
| 5 | Evacuation during flood events | 55.0 | 45.0 | 0.0 |
| 6 | Victims of flood disasters receive relief for the losses they suffer | 31.0 | 69.0 | 0.0 |

Source: Adapted from Ologunorisa and Adeyemo (2005)

**Frequencies & Duration of Floods in the Study Area**

The information on Table 2 presents the frequencies and duration of floods as perceived by coastal communities in the Niger Delta. It was revealed that the frequencies of floods are usually between two and three time in 10 years as majority (43.3%) indicated; while in other communities flood frequencies are once in 10 years (13.4%); some experience it once in 5 years (7.17%); while some other coastal communities claimed that flood in their area is an annual event (21.3%). However, the severity of the flood definitely varied across coastal communities which according to Mmom and Aifesehi (2013) are sometimes termed as bad floods. Therefore, the believe among respondents is that some floods may be normal floods because they are not severe and have little or no effects because people are already aware of the nature of their surrounding residences as coastal regions which are subjected to seasonal floods.

However, as regards to the information on the duration of floods among coastal communities which is displayed on Table 5.2 revealed slight variations. The distribution showed that for some communities floods normally last for between 4 to 6 days (47.0%); 26.0% of sampled respondents indicated that it normally last between 1 and 2 days; 13.0% indicated between 2-3 days; while 14.0% of the respondents are not aware of the flood durations in their area. The majority of respondents indicated flood duration of between 4 to 6 days which means that flood events usually lasted for 6 days in the study area.

Table 2: Frequencies and Duration of Floods

| S/N | Responses | Percentage (%) |
|---|---|---|
| 1 | Once in every 10 years | 13.4 |
| 2 | Once in 5 years | 7.17 |
| 3 | Flooding is an annual event | 21.3 |
| 4 | Two to three times in 10 years | 43.3 |
| **Duration of Floods** | | |
| 5 | Floods normally lasts for about 4-6 days | 47.0 |
| 6 | Floods lasts for 1-2 days | 26.0 |
| 7 | Floods normally lasts for 2-3 days | 13.0 |
| 8 | Not aware of the flood duration | 14.0 |

Source: Adapted from Ologunorisa and Adeyemo (2005)

**Causes of Flood in the Coastal Communities**

**Perspectives from a 2005 study**

The information obtained as regards causes of floods is displayed on Table 3. The information revealed that the major causes of floods in the Niger Delta are heavy and continuous rainfall and river overflow especially from tributaries of the River Niger. The contributory factors were identified as the low-lying nature of areas known as floodplains and the poorly drained nature of the area. Another contributory factor is the blockages of river channels mostly caused by humans through their uncoordinated waste disposal methods.

Table 3: Causes of Floods in the Niger Delta

| **S/N** | **Major Causes** | **Percentage (%)** |
|---|---|---|
| 1 | Heavy and continuous rainfall | 66.0 |
| 2 | River overflow | 34.0 |
| | **Contributory factors** | |
| 3 | Low-lying and poorly drained nature of the area | 20.0 |
| 4 | Blocked river channels | 9.0 |

Source: Adapted from Ologunorisa and Adeyemo (2005)

**Causes of Floods in the Coastal areas of Niger Delta**

**Perspectives from a 2013 study**

The study further explored the recent causes of floods in the Niger Delta region and the information is presented on Table 4. It was revealed that physical terrain is a factor causing flooding in coastal communities as indicated by 88.8% of respondents; heavy rainfall was indicated by majority of respondents (96.0%); poor drainage (27.7%); poor land use planning (48.0%); and land use and land cover change (26.8%).

These findings are similar with the findings of Ologunorisa and Adeyemo (2005) on the causes of floods in coastal communities in the Niger Delta. Similarly, heavy and continuous rainfall is the same as heavy amount of rainfall; poor drainage is similar to blockage of river channels; poor land use planning as a lot to do with nature of land use which is a function of residential apartments being created by the dwellers; and the land cover change which mostly is farming which changes land use and land cover overtime. Thus, the study concluded that the causes of floods in coastal communities of Niger Delta are heavy rainfall, river overflow as a result of heavy rainfall and other factors, nature of terrain and poor land use planning.

Table 4: Recent perspectives on Causes of Floods in Coastal communities in Niger Delta

| S/N | Causes | Frequency | Percentage (%) |
|---|---|---|---|
| 1 | Physical Terrain | 400 | 88.8 |
| 2 | Heavy rainfall amount | 432 | 96.0 |
| 3 | Poor drainage | 125 | 27.7 |
| 4 | Poor land use planning | 216 | 48.0 |
| 5 | Land use and land cover change | 121 | 26.8 |

Source: Adapted from Mmom and Aifesehi (2013)

## 6.2 Reasons Why People Stay in Flood Prone Coastal Areas

**Perspectives from a 2005 survey**

The information on Table 5 presents the reasons or factors for respondents' continued stay in the coastal areas (flood prone areas) of the Niger Delta. It was revealed that despite the flood risk 32.4% of the respondents were born in the area and so probably perceived that there were no other alternatives; 28.7% of the respondents indicated housing problems; 27.8% of respondents have personal and family reasons; while others (11.1%) indicated the rich alluvial soil of floodplains due to river sediments. This group of respondents was farmers and will like to take advantage of the rich and fertile soils of the floodplains which is economically productive for them. The study highlighted the fact that most houses in the floodplain are low cost and affordable because other housing is expensive in Niger Delta fringes due to oil exploration activities; because whereas in the western part of Nigeria this is not an issue because oil exploration and exploitation is absent. It was asserted earlier by Ayoade and Akintola (1980) that people settle at the floodplain near Ibadan because of the rich alluvial soil of the Ogunpa and Kudeti streams.

Table 5: Reasons why people reside in Coastal areas of Niger Delta

| S/N | Reasons | Percentage (%) |
|---|---|---|
| 1 | Place of birth and no other alternatives | 32.4 |
| 2 | Housing problems (high cost of housing) | 28.7 |
| 3 | Personal and family reasons | 27.8 |
| 4 | Economic reasons | 11.1 |

Source: Adapted from Ologunorisa and Adeyemo (2005)

**Perspectives from a 2013 survey**

The information on reasons respondents live in flood prone coastal areas of Niger Delta are presented on Table 6. The distribution showed that 79.1% are living in the area due to family ties; 56.4% of respondents indicated livelihood opportunities; 59.5% of respondents were of the view that it is closer to their place/locations of business and work; 72.2% of respondents indicated it as their place of birth; while 26.8% of respondents indicated it as a result of low cost of housing.

These findings are similar with the findings of Ologunorisa and Adeyemo (2005) on the reasons people live in coastal zones (flood prone) in the Niger Delta. These similar reasons are family ties and reasons, place of birth, low cost of housing due to higher cost in less vulnerable areas, and economic reasons which also is represented by proximity to work/business.

Table 6: Recent perspectives on Reasons for Living in Flood prone areas

| S/N | Reasons | Frequency | Percentage (%) |
|---|---|---|---|
| 1 | To maintain family ties | 356 | 79.1 |
| 2 | Livelihood opportunities | 284 | 56.4 |
| 3 | Proximity to work/business location | 268 | 59.5 |
| 4 | Born in the community | 325 | 72.2 |
| 5 | Low cost of land and housing | 121 | 26.8 |

Source: Adapted from Mmom and Aifesehi (2013)

### 6.3 Vulnerability Levels of Coastal Communities in Niger Delta to Flood

**Vulnerability Assessment of Coastal Communities in Niger Delta Conducted in year 2004**

Several methods and analysis have been used to determine the vulnerability levels of coastal communities in the Niger Delta to floods overtime. For the purpose of the study three of such analysis between year 2004 and 2020 were employed for the study. The study by Ologunorisa (2004) was employed and the information on Table 7 present the environmental parameters selected for defining flood vulnerability zones in the Niger Delta. A total of nine (9) indices were utilized which based on previous studies (Cooke and Dorkamp, 1982) are important parameters to be considered when generating vulnerability components flood hazards.

These indices selected are easy to measure and can easily be used to quantify vulnerability levels among coastal communities in Niger Delta. These indices shall also help to generate internal variations in terms of flood vulnerability index of individual coastal communities in the study area.

Table 7: Environmental Indices/Parameters used to define Flood Vulnerability Zones in Niger Delta

| S/N | Indices |
|---|---|
| 1 | Depth of flooding (meters) |
| 2 | Duration of flood (Hours/Weeks) |
| 3 | Perceived frequency of flood occurrences |
| 4 | Percentage (%) extent of damage during flood event |
| 5 | Percentage (%) changes in volume of rainfall in relation to the mean |
| 6 | The elevation of communities above sea level (meters) |
| 7 | Closeness (proximity) to river (meters) |
| 8 | Dominant Land use activities |
| 9 | Level of adequacy of flood mitigation measures |

Source: Culled from Ologunorisa (2004)

The information on Table 8 revealed the graduated scaling used for categorizing communities into 3 flood risk classes (sores) which are: (1) Low flood risk; (2) Moderate flood risk; and (3) High flood risk using range of values, frequencies and land use characteristics. Thus, coastal communities that falls within the score of 3 are considered high flood vulnerability zones.

Table 8: Environmental Indices/Parameters used to define Flood Vulnerability Zones in Niger Delta

| S/N | Indices | Range of values | Scores |
|---|---|---|---|
| 1 | Depth of flooding (meters) | < 1.0 meters | 1 |
| | | 1-2.0 meters | 2 |
| | | >2.0 meters | 3 |
| 2 | Duration of flood (Hours/Weeks) | < 12 hours | 1 |
| | | 12-24 hours | 2 |
| | | > 24 hours | 3 |
| 3 | Perceived frequency of flood occurrences | Once in 5 years or more | 1 |
| | | Once in 3 years | 2 |
| | | Once in a year | 3 |
| 4 | Extent of damage (%) | < 25% | 1 |
| | | 25-50% | 2 |
| | | > 50% | 3 |
| 5 | % deviation of seasonal rainfall (mm) from mean | < 25% | 1 |
| | | 26-60% | 2 |
| | | > 50% | 3 |
| 6 | Relief (m) above sea level | > 15 meters | 1 |

| | | | |
|---|---|---|---|
| | | 5-15 meters | 2 |
| | | < 5 meters | 3 |
| 7 | Proximity to hazards (meters) | > 200 meters | 1 |
| | | 100-200 meters | 2 |
| | | < 100 meters | 3 |
| 8 | Dominant Land use or economic activities | Agricultural | 1 |
| | | Residential (planned or unplanned) | 2 |
| | | Industrial/commercial | 3 |
| 9 | Perceived adequacy of flood control measure | > 50% | 1 |
| | | 25-50% | 2 |
| | | < 25% | 3 |

Source: Culled from Ologunorisa (2004)

The result of the analysis based on the spatial variations of flood risk level zones in Niger Delta revealed that areas of severe or high flood risk include Sagbama, Yenagoa, Ekeremor, Ogbia (in Bayelsa state) and Ogba/Egbema/Ndoni, Ahoada, Gokana and Khana areas (in Rivers state). The Moderate flood risk zones include areas around Port Harcourt, Obio/Akpor, and Ikwerre areas (all in Rivers state). The third class of low flood risk and vulnerability include areas in Etche, Emohua, Oyibo, Tai/Eleme, and other areas in the salt water areas under tidal influence, such as Bonny, Opobo, Degema (Rivers state) and Southern Ijaw (Bayelsa). The salt water coastal areas do not usually experience severe flooding because they are under tidal influence. Tidal floods have a short duration and are less sever and therefore of low risk.

**Vulnerability Analysis of Coastal Communities in Niger Delta to Sea Level Rise (2014)**

The study conducted by Musa *et al*., (2014) was based on using Geographic Information System (GIS) to determine the vulnerability of coastal communities to river floods from sea level rise. The study produced a land cover map of the Niger Delta indicating the water bodies, mangrove forests, settlements, vegetation cover and bare land areas (Figure 6.1).

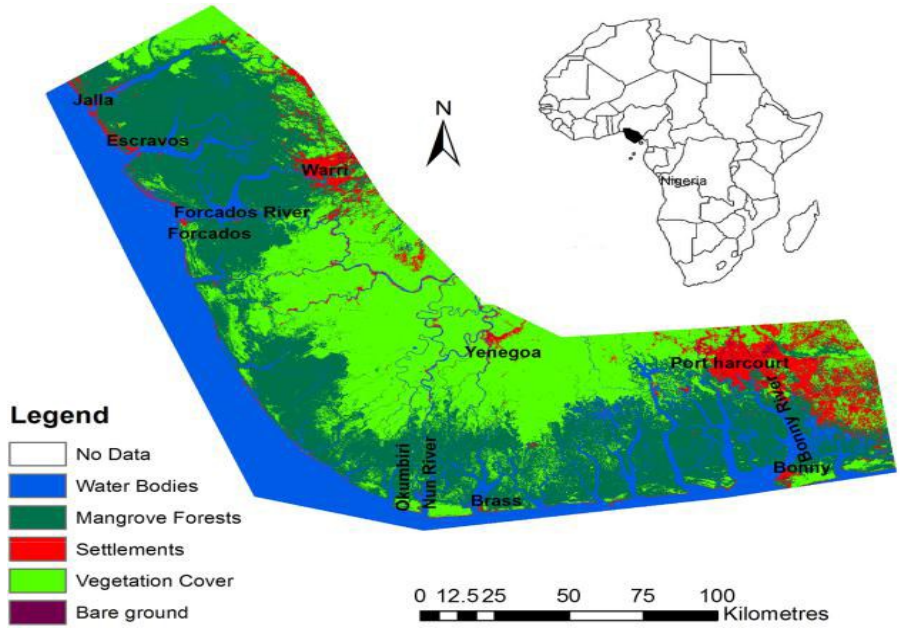


Figure 6.1: Niger Delta Land Cover (Source: Musa *et al*., 2014)

In addition, the study employed coastal vulnerability index (CVI) to assess the vulnerability of coastal communities to flood based on sea level rise (SLR). The CVI relates various factors influencing the degree of vulnerability of coastal communities in a quantifiable manner. This method was utilized after Gornitz et al., (1991) who introduced CVI as a concept that uses information about the coast to quantify the relative vulnerability of coastal segments to effects of SLR on a regional and national scale.

Therefore, based on these indices (topography, coastal slope, geomorphology, relative SLR rate, annual shoreline erosion rate, mean tidal range, mean wave height, population density (people per $km^2$) and proximity to coast) the study was able to quantify and ranked coastal communities based on their CVI using 5 ranking values like: very low (1), low (2), moderate (3), high (4) and very high (5) unlike the study earlier examined by Ologunorisa (2004) who utilized three (3) ranking

values of low, moderate and high based on certain quantifiable indices. For the current study, based on topography the ranking values were: very low (> 10m), low (8-10m), moderate (6-7m), high (3-5m), and very high (0-2m); while based on coastal slope the ranking values were: very low (>3-4%), low (2-3%), moderate (1-2%), high (0.5-1%), and very high (0.1-0.5%). The mapping analysis utilized by the study to describe the topography of coastal areas of Niger Delta is depicted on Figure 6.2 while Figure 6.3 depicts information concerning the coastal slope.

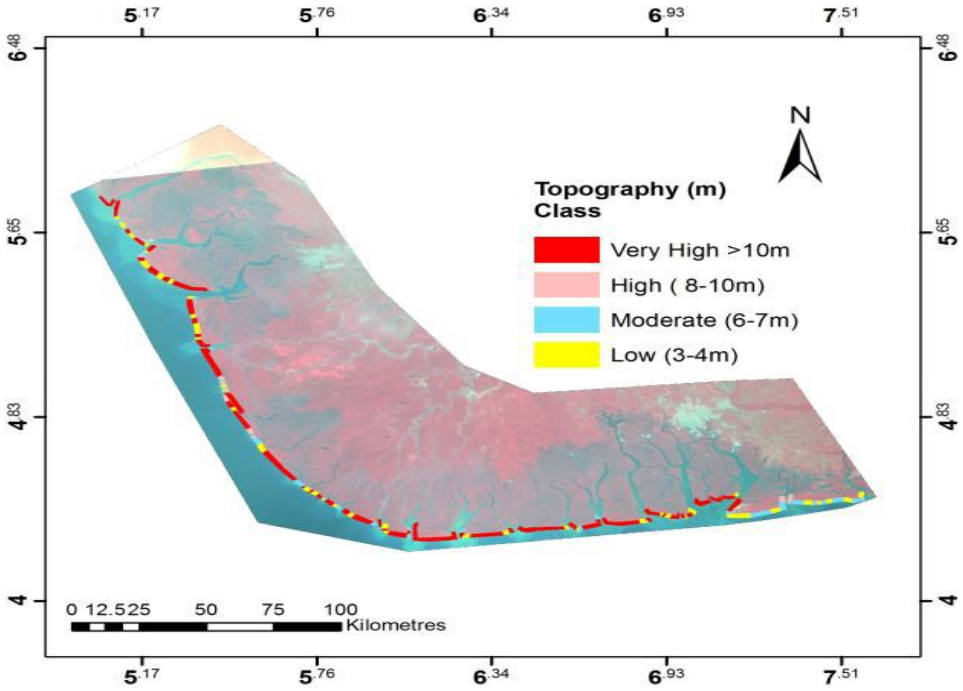


Figure 6.2: Niger Delta Topography Classification (Source: Musa et al., 2014)

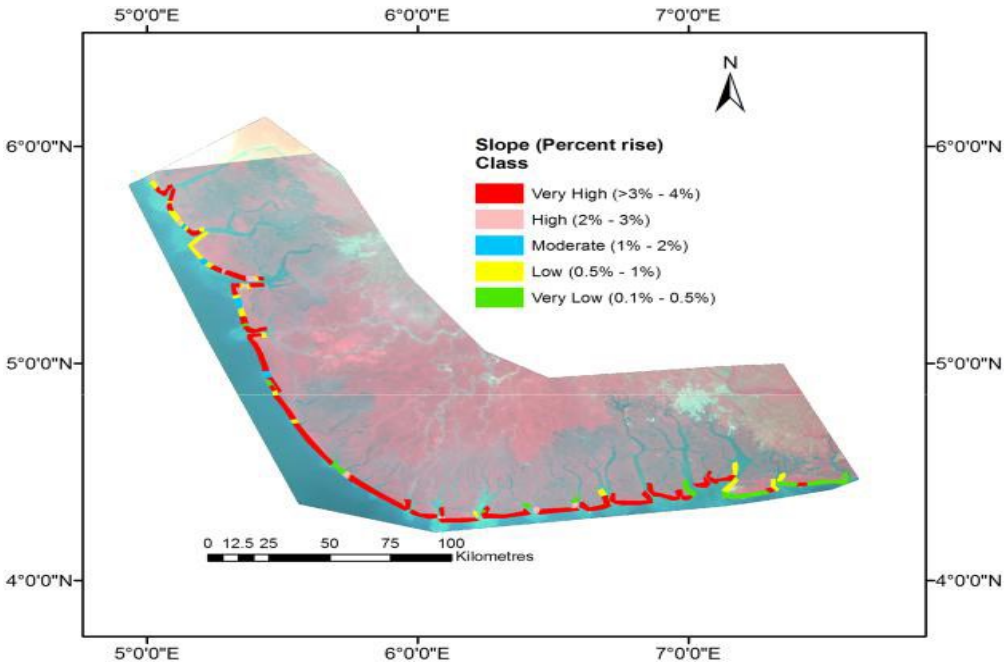

Figure 6.3: Niger Delta Coastal Slope Classification (Source: Musa et al., 2014)

Based on these two cited parameters from the works of Musa *et al*., (2014), it therefore posits that topography (elevation) of an area above the mean sea level will determine how much of it will be impacted by rising sea levels. This is because low-lying areas offer less resistance to flooding (inundation). This assertion was earlier justified by Van *et al*., (2012). Furthermore, as regards coastal slope classification, the degree of erosion of a coastal area will therefore serve as a factor promoting inundation from rising sea levels. Thus, the areas currently undergoing coastal erosion will be highly vulnerable to flooding from sea level rise. This was also earlier stated by Kumar and Kunte (2012) on the influence of coastal erosion in making coastal areas susceptible to floods.

Therefore, for the purpose of the research another consideration that can make a coastal area susceptible to flooding is the **mean tidal range.** The mean tidal range is the difference between high and low tides and it is linked to permanent and episodic hazards from SLR (Yin *et al*., 2012). Thus, in view of coastal communities vulnerability to floods, areas with large tidal ranges will

have higher CVI (coastal vulnerability index) when compared with those coastal areas with lower tidal ranges. In summary, the study of Musa *et al*., (2014) considered values published by NIOMR (2010) based on annual coastal erosion in areas of Delta, Bayelsa and Rivers states which covers the Niger Delta from east to west. The values given were: 20-25 mm yr (Escravos), 16-20 mm yr (Forcados), 15-20 mm yr (Brass), and 10-14 mm yr (Bonny). It was reported by NIOMR (2010) and retained by Musa *et al*., (2014) that these values stated show that the Niger Delta coastal areas has a 'high' to 'very high' CVI which therefore makes it more susceptible to more erosion from SLR.

**Vulnerability Analysis of Coastal Communities in Niger Delta to SLR (2016)**

The vulnerability index analysis conducted by Lawal *et al*., (2016) on coastal communities to sea level rise (SLR) for the BRACED states in Niger Delta was also examined in line with the study objectives. The study utilized five (5) ranking categories which were: 1 (very low), 2 (low), 3 (moderate), 4 (high), and 5 (very high). Thus, the variable employed for ranking coastal communities were: geomorphology, relief, shoreline erosion/accretion (m/yr), coastal slope (%), mean wave length (m), relative sea level changes (m/yr), and mean tidal range (m). These indices were taken after Thieler and Hammer-Klose (1990). The methods applied for the assessment were derived using the Shuttle Radar Topographic Mission (SRTM) data to generate the 30 meter digital topography map of Niger Delta coastal areas (Figure 6.4).

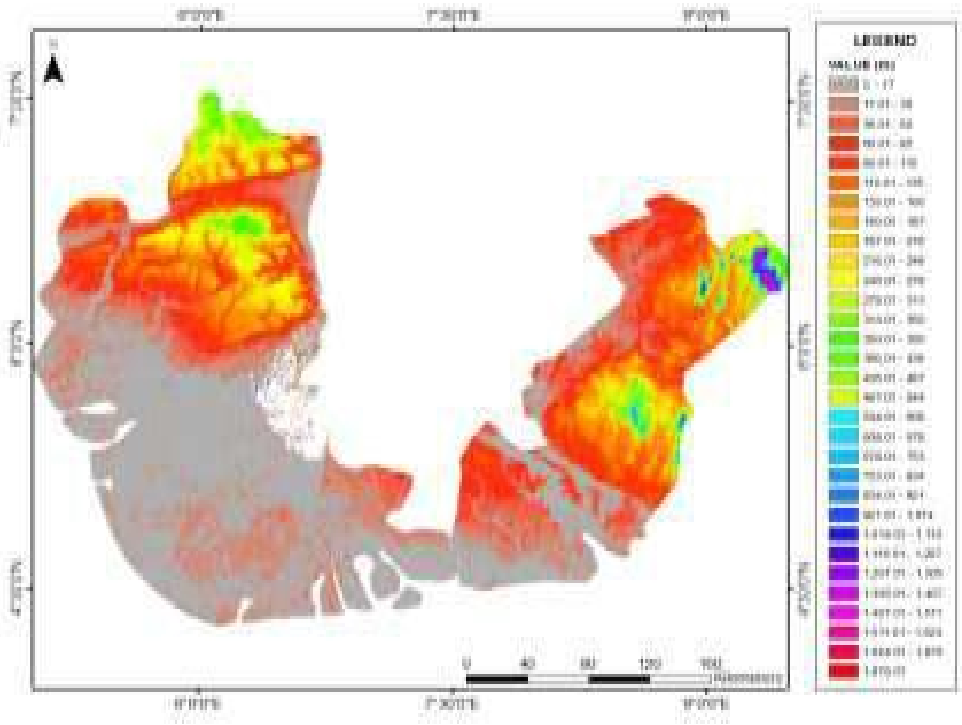


Figure 6.4: Digital topographic map of Niger Delta Coastal Areas (Source: Extracted from SRTM DEM and classified by Lawal *et al*., (2016))

The results of the analysis of the vulnerability assessment by Lawal *et al*., (2016) on the CVI of coastal communities in Niger Delta were presented on Table 9. The summary statistics of coastal communities' exposure to shoreline dynamics revealed that Cross River and Edo states enjoy a very high distance from the shoreline which resulted in a lower CVI value. That is, in terms of the vulnerability of coastal communities in Akwa Ibom, Cross River and Edo states were lower when compared to coastal communities in other states like Bayelsa, Rivers and Delta. The information on Table 5.9 further revealed that the coastal communities in Bayelsa, Delta and Rivers states were almost 50% exposed to coastline changes and other coastal perturbations in relation to their mean distances of between 14.86 km to 16.79 km.

Table 9: Coastal Communities Vulnerability to Coastline Dynamics in the Niger Delta

| States | Number of communities | Mean Distance to shoreline (km) | % Exposed (Very high exposure) | High exposure |
|---|---|---|---|---|
| Bayelsa | 95 | 16.10 | 49.4 | 50.6 |
| Rivers | 58 | 14.86 | 46.5 | 53.5 |
| Akwa Ibom | 24 | 34.87 | 12.5 | 87.5 |
| Cross River | 31 | 146.83 | 6.5 | 93.5 |
| Edo | 73 | 105.95 | 1.4 | 98.6 |
| Delta | 68 | 16.79 | 45.5 | 54.5 |

Source: Lawal *et al*., (2016)

### 6.4 Impact of Floods on the Socio-economic Livelihood

**Perspectives from a 2013 Survey of previous flood event**

Flood has several impacts on the people being affected by it especially on those living in flood prone areas due to the flood frequencies they experience at different time periods. The study of Mmom and Aifesehi (2013) examined for this study revealed the impact of previous floods especially the year 2012 floods on coastal communities in the Niger Delta. The information on Table 10 revealed that 76.0% of respondents indicated loss of houses; 71.0% indicated loss of crops/domestic animals; 4.7% indicated loss of lives; 45.7% indicated loss of properties; 58.7% indicated emotional trauma, stress and health risk; while another 27.77% indicated destruction of infrastructure.

Table 10: Impact of Previous Floods on coastal communities

| | | |
|---|---|---|
| Loss of houses | 342 | 76% |
| Loss of crops/domestic animals | 322 | 71% |
| Loss of lives | 21 | 4.7% |
| Loss of properties | 206 | 45.7% |
| Emotional trauma, stress/health risk | 264 | 58.7% |
| Destruction of infrastructure | 125 | 27.8% |

Source: Mmom and Aifesehi (2013)

**Perspectives from a 2020 Survey**

The study employed the finding of Wizor and Week (2020) on the socio-economic impacts of floods in the Niger Delta. The study discovered that the major source of livelihood of the people is farming (34.7%), fishing (21.0%), gin production (16.6%), boat carving (15.3%), hunting (6.6%), and lumbering (5.7%). Thus, flood impacts therefore had serious impact on these highlighted livelihoods of the people. The socio-economic impacts of floods are presented on Table 6.11. The impacts include disruption of movements, damage to roads, loss of valuable properties, loss or washing away of farmlands and environmental degradation and pollution. Thus, all these highlighted implications normally determines the severity of flood events which are evidences of the impacts on income and livelihood of the people of the flood prone coastal communities in Niger Delta.

Table 11: Socio-economic Impact of floods

| Socio-economic Impacts | Percentage (%) |
|---|---|
| Disruption of movement | 14.5 |
| Damage of roads | 13.9 |
| Loss of valuable properties | 13.7 |
| Loss/washing away of farmlands | 13.1 |
| Environmental degradation/pollution | 11.5 |

Source: Wizor and Week (2020)

### 6.5 Strategies for Mitigating Floods in Coastal Communities

The findings of the study as regards the frequencies, duration, causes, exposure and vulnerability of flood events in coastal communities in the Niger Delta, Nigeria has shown that deployment of mitigation measures and strategies to tackle these challenges cannot be overemphasized. However, several researches have proffered best mitigation practices that will help to mitigate the associated challenges of floods in the study area. Therefore, based on the purpose of the study some of such studies that investigated flood related problems of coastal communities in Niger Delta and put forward mitigation strategies that can help tackle the problems are highlighted on Table 12.

Table 12: Strategies for Mitigation of Floods in Coastal Communities of Niger Delta

| Authors | Mitigation Strategies | Measures to be Followed |
|---|---|---|
| Ologunorisa and Adeyemo (2004) | Channelization and canalization | The government and community efforts should be directed at channelization,canalization, dredging, and building of flood walls and embankments. |
| | Relief and Compensation | Government should ensure the provision of relief materials and compensation to help affected people to cope and alleviate the challenges of floods. |
| | Need for environmental education | Through literacy programmes and mass media people in such areas can be sensitized and informed. |
| Ologunorisa (2009) | Flood abatement schemes | Control of flood through land use management. By altering run-offs and flood hydrograph. |
| | Flood protection scheme | Building structure adjustment designed to reduce flood damage. Raising buildings above flood levels |
| | Public relief funds | Relief fund will help affected people to adjust to flood effects |
| | Flood insurance | Even though this measure will not help prevent flood or reduce it but it will allow for payment of flood relief to be made over a period of time because of apparent limitations |
| | Floodplain zoning :<br>(i) A prohibitive zone<br>(ii) A restrictive zone<br>(iii) A warning zone | Zoning floodplain will help reduce flood by controlling floodplain development |
| | Flood forecasting and warning<br>(i) Evaluation<br>(ii) Dissemination | Early warning signs. Flood warning dissemination |

| | | |
|---|---|---|
| | (iii) Response | Response to flood warning signs |
| Akukwe and Ogbodo (2015) | Evacuation during peak period | Well planned emergency organization for evacuation plans |
| | Building low-cost houses | Building temporary structures to reduce probability of damage. |
| | Demolition of illegal structures | Structures built along flood waters in coastal zones should be demolished, and re-sited |
| | Awareness creation | Sensitizing the people living in coastal communities during pre-flood and post flood events |
| | Monetary compensation | Provision of adequate compensation to support victims during post flood events |
| Lawal *et al*., (2016) | Building contingency plans | Continuous vulnerability mapping of coastal communities' sequel to a rise in sea level as this will help to build effort for contingency plans towards flood management |
| | Provision of institutional framework | Adequate framework that will mitigate flood impacts should be on-ground in coastal communities |
| | Integrated coastal management plans | This will ensure that all agencies responsible for the management of floods within and outside communities are active are response ready |
| Omuta and Aitokhuehi (2020) | Avoid building in flood prone areas | Building in flood prone areas should be discouraged amidst the benefits it has to the people. |
| | Elevations of buildings | There is need to obtain data on mean level of flood so as to ensure that buildings are constructed above such levels |

| | | |
|---|---|---|
| | Construction of concrete drains | Concrete drains should be provided in flood prone areas to channel out flood waters from residential areas |
| | Drain de-silting | Adequate cleaning of drains will help to remove impediments to water flow and surface run-off |
| | Reserving natural channels for river flow and water movements | Encroaching natural water channels will only promote more flood effects. Thus, property development should not be done on natural water drainage and channels |
| | Flood insurance | The government should consider a property flood insurance policy |

Source: Culled from the Authors Highlighted

# CHAPTER 7: DISCUSSION

## 7.1 Discussion of Findings

The perception of flood events in the study area tells us more about the challenges faced by the people living in the coastal regions of Niger Delta. Flood frequencies according to research occurs at least once in every five to ten years especially the sever once and the flood duration varies among coastal communities depending on rainfall events, flood depth and magnitude which are due to rising sea levels. The study discovered that causes of floods in coastal communities of Niger delta overtime are related as revealed by researches. It thus showed that the population of the Niger Delta is aware of some of the causes of flood hazards which were identified as heavy and prolonged rainfall events and rise in sea level as the most important. Structural control of flood hazards in the study area is imperative (Ologunorisa and Adeyemo, 2004; Mmom and Aifesehi, 2013).

The findings of the study based on stated assumptions revealed that the causes of floods in the study area are the same overtime as exposed by past findings which were examined in this regard. Thus, the null hypothesis ($H_0$) earlier stated was retained for the first stated assumption.

The people who live in the coastal settlements of the Niger Delta do so at their personal risk; some believe they have no other choice since their ancestors originated from the region, while others do so due to the cheap cost of residential units and other economic considerations. According to Ologunorisa and Adeyemo (2005), inhabitants of the Niger Delta continue to dwell there despite their hopeful and complacent views concerning the flood situation. Their choice to stay is likely impacted by their jobs, particularly fishing and subsistence farming, their feeling of the study region as home, and a perceived or actual lack of options. There are presumably substantial incentives to stay, including closeness to town, fishing ports, and rivers, as well as proximity to

one's place of employment, which is likely critical for low-wage workers who are least able to afford transportation expenditures. For some, there is little practical alternative but to accept the flood risk and remain in the area. Furthermore, as regards the reasons why people reside in coastal areas which mostly is based on the fact that affordable lands and housing are usually available in these areas which should be pointers to the government on the need to provide more affordable housing to the citizens especially at the grass root level as this will help reduce the population of people living in coastal regions and reduce the impact of floods in the Niger Delta.

However, whichever the reason for living in flood prone areas, one thing is certain, the aftermath of flood is usually substantial and affects majority of people living in the coastal areas of the Niger Delta. According to Ologunorisa and Adeyemo (2005), the likely extent of damage in the event of a flood revealed that 46% of respondents indicated that the loss would be severe (80–100%); 34% indicated that the loss would be substantial (21–79%); and 16% suggested that the loss would be minor (1–21%).

The coastal region of the Niger Delta is noted for its low elevation which makes the area susceptible to flooding due to sea level rise. The studies on the vulnerability assessment of coastal communities in Niger Delta examined overtime showed that some areas are highly vulnerable while some are at low risk of vulnerability. Several studies (Ologunorisa, 2004; NIOMR, 2010; Musa *et al*., 2014; Lawal *et al*., 2016) conducted a community vulnerability index (CVI) which utilized three (3) to five (5) ranking categories (high, moderate and low and very high, high, moderate, low, and very low) which places several communities within the coastal region of the Niger Delta at their various vulnerability index. The findings of the study revealed that important indices like depth of flood, elevation, proximity to river, and volume of rainfall, flood duration and frequency can help to understand the level of vulnerability of coastal communities. The

vulnerability analysis conducted by these highlighted studies and others that were not mentioned are all geared toward exposing the fragility and level of exposure to flood risk for settlements found along coastal Niger Delta. Thus, the fragility and vulnerability of coastal communities are dependent upon their elevation characteristics which are important factors and determinants exposing communities' level of exposure to flooding. Findings are therefore geared toward promoting mitigation measures that will help decision makers at community and national levels.

The findings of Popescu *et* al., (2010); Jonoski and Popescu (2012); and Popescu *et al*., (2014) revealed the fact that vulnerability studies help decision makers to explore measures in mitigating floods in prone areas. This standpoint therefore exposes the fact that the coastal regions of the Niger Delta are fragile and highly vulnerable to flood events. Therefore, based on the findings of the study, it was concluded that the vulnerability levels of coastal communities are not the same over time and space. Several indices were used to categorize the vulnerability levels of coastal communities according to the highlighted studies (Ologunorisa, 2004; NIOMR, 2010; Musa *et al*., 2014; Lawal *et al*., 2016). The variations were therefore significant as findings revealed that those in the upper floodplain are less vulnerable than those in the lower floodplains of the Niger Delta. Thus, the null hypothesis earlier stated for the study was rejected while the alternative hypothesis ($H_1$) was accepted which means that the vulnerability levels of coastal communities in Niger Delta to floods are not the same

The impact of floods on the socio-economic livelihood of the people cannot be over-emphasized. The findings of Mmom and Aifesehi (2013) revealed the post flood impacts which were evident on the people and their livelihood with other associated impacts on the health status of the people. The findings of Wizor and Week (2020) also revealed similar impacts which were also evident on the socio-economic livelihood of the people in coastal communities in the Niger Delta.

The findings of the study as exposed by the reviewed literatures showed that floods event have recorded several significant socio-economic impacts on the people in coastal communities' overtime between 2005 and 2020. The stated assumption as regards the null hypothesis ($H_0$) for the study was therefore rejected while the alternative hypothesis ($H_1$) was accepted. Thus, floods have significant effect on the socio-economic livelihood of the coastal communities.

Conversely, based on these findings it will be appropriate as one of the measures of adjustment to flood impacts will be the provision of adequate relief materials and compensation schemes geared toward providing assistance to the affected population during and after any flood event. This will help the people to cope with flood impacts. When flood victims do not get compensation or relief; it will limit their chance of survival and put them at more risk. Therefore, government assistance at local, national and international levels is therefore needed moreover, the victims have little knowledge of a flood alleviation measures, and therefore loose several valuables to flooding. Most people in the study area are not aware of flood alleviation measures by government, or any agency. It is poverty and ignorance that limit adjustments to flood hazard in developing countries (Ologunorisa and Adeyemo, 2005). Flood will continue to be a menace to the coastal communities except the dwellers embrace total evacuation as it is obvious in the study that certain levels of resilience may not be enough to resolve or reduce the socio-economic impacts of floods in the study area. The findings of Mmom and Aifesehi (2013) indicated that coastal communities claim to have been used to the flood menace despite the losses they incur during flood events. Therefore, this means that changes in orientation and awareness can go a long way in helping residence of coastal areas to reduce the impacts of floods. Sivell*et al*., (2008) and Diane *et al*., (2012) believed that coastal communities can increase their strength and resilience towards flood menace through

changes in awareness, procedure and management and rely more on their coordinated strategies for effective flood management.

This takes us to the strategies for flood management in coastal regions of Niger Delta. The findings of the study revealed that several studies have put forward mitigation measures to tackle flood in the study area. These studies especially the ones conducted before the 2012 flood events is evidence that community resilience and mitigation strategies was not efficient in the management of flood based on the post-impact analysis carried out on the 2012 floods in the Niger Delta. The findings of Akpokodje and Giadom (2014) who analyzed the floods of the 2012 and the impacts on the Niger delta coastal communities (lessons learned) described the flood event has the most severe in the history of Nigeria. The study discovered that the Niger Delta coastal region recorded the most devastating impacts due to its elevation and location in the lowest part of Nigeria where the Niger and Benue rivers empty into the Atlantic Ocean. It was stated that flood height attained a maximum of 3.68 m thereby covering areas below this elevation. People were exposed to hazardous wastes and contaminated water which was compounded by social pressures arising from displacement and migration.

Perception studies carried out in 2017 concerning the post-impacted problems of the 2012 flood events in riverine communities in Lokoja by Samuel et al., (2017) showed that low awareness and low resilience strategies made the people in the area to be more vulnerable due to low flood occurrences in the study area. Thus, riverine communities in Nigeria are poor and less equipped as regards their coping capacities to combat flood menace. The mitigation strategies put forward by past researches will be useful and adequate when they are factored in line with the peculiarity and nature of flood related problems in coastal communities in the Niger Delta as this will help promote effective flood management system overtime. This perspective of the study aligns with

the findings of Adelekan, (2010); Ologunorisa and Durowoju, (2014); and Samuel et al., (2014) that the ability of the people to cope and recover from flood disaster will depend on the communities' socio-economic profile, extent of social network and institutional framework for disaster mitigation. The study also stands with Ologunorisa (2007) on the need to intensify flood control management in coastal communities in Niger Delta, Nigeria.

# CHAPTER 8: SUMMARY/CONCLUSION

## 8.1 Summary

The study set out to achieve five objectives which were; to identify the causes and frequencies of flood events in the coastal communities of Niger Delta; to investigate the reasons why people reside in coastal plains of the Niger Delta; to examine the vulnerability level of coastal communities to flood; to examine the socio-economic and livelihood impact of flood in coastal communities; and to explore the strategies of mitigating and resolving flood related issues in the coastal region of Niger Delta. The stated null hypotheses for the study were that the causes of flood are not the same in the study area overtime; vulnerability levels of coastal communities in Niger Delta to floods are not the same overtime; and that flood has no significant impact on the socio-economic livelihood of coastal communities in Niger Delta.

Findings of the study revealed that major causes of floods were heavy and continuous rainfall events and river overflow. Flood events is usually sever in the study area flood normally occur during the peak of rainfall season which is between July and September in Niger Delta. The frequencies of flood events are usually between two to three times in 10 years with at least 6 days' time duration. The other associated causes of flood in the study area are the nature of the physical terrain; poor drainage network, poor land use planning and changes in land cover overtime.

The study discovered that the reasons why people decide to stay in flood prone areas are due to their place of birth and other beneficial factors which ranged from low cost of housing to nearness to place of work, family ties and reasons and economic reasons. Thus, majority of the dwellers are aware of the dangers of living in flood prone areas but still believe in the pay offs they are getting from residing in such areas to be higher than the probable flood disaster that can occur anytime.

The vulnerability assessment understudied revealed that there are variations in the level of vulnerability of coastal communities to flood in the Niger Delta area. However, such indices as depth of flood, duration, perceived frequencies of flood events, percentage extent of damage and percentage changes in volume of rainfall amongst others are factors used to predict community vulnerability index (CVI). Researchers have used different classes of scales to categorize the level of vulnerability of coastal communities to flood. Three to five ranking order were prescribed for CVI which were: (1) Low flood risk; (2) Moderate flood risk; and (3) High flood risk using range of values, frequencies and land use characteristics for a three ranking model. On the other hand, using 5 ranking values like: very low (1), low (2), moderate (3), high (4) and very high (5) were also prescribed for CVI classifications. The vulnerability index level therefore puts some areas in the coastal regions in Niger Delta to be highly vulnerable to flooding.

The findings as regards the socio-economic and livelihood impacts of floods in the Niger Delta therefore revealed that it has serious impact on the people. The socio-economic impacts of floods therefore include disruption of movements, damage to roads, loss of valuable properties, loss or washing away of farmlands and environmental degradation and pollution. Thus, all these highlighted implications normally determine the severity of flood events which are evidences of the impacts on income and livelihood of the people of the flood prone coastal communities in Niger Delta.

Based on the past challenges experienced as regards flood events in Niger Delta, several mitigation strategies were put forward which can help to reduce the impact of flood on the coastal communities. The stated assumptions (null hypotheses) made in line with the study objectives revealed that the causes of flood are the same in the study area. Vulnerability levels differ in space which is a function of several factors one of which is elevation (m) which has several implications

on sea level rise. The study further revealed that floods have significant effect on the socio-economic livelihood of the coastal communities.

## 8.2 Conclusion

The study on flooding in the coastal communities of Niger Delta has revealed that several challenges abound as regard flooding in the study area. Despite the fragility nature of the coastal regions of Niger Delta people still prefer to live in such areas. Flooding is a serious socio-economic and environmental issue, thus, adequate mitigation strategies and measures must be on ground at all times to help limit and reduce flood impacts in the study area. In the same vein, flood issues in Niger Delta have exposed the fact that measures to tackle the menace have been poor or inadequate overtime, therefore, its severity have been evident on the people residing in these areas. Shelter is one of the basic needs that support human development index overtime; thus, access to affordable housing can be a key factor that can help reduce the population of people residing in coastal plains of the Niger Delta irrespective of their vulnerability levels. Thus, the recommendations considered based on the findings of the study are that: the government need to be proactive in ensuring that people have access to quality and affordable housing in the Niger Delta region especially at the grassroots; the government should intensify efforts on flood control management strategies in the coastal areas of the Niger Delta; since findings revealed that flood hazard and vulnerability factors are very high in the Niger Delta coastal areas. It is therefore necessary to discourage investment of any type in these areas through legislation and environmental education; community dwellers should be adequately sensitized on the need to avoid embarking on activities that promotes erosion that will further increase the vulnerability levels of the area to flooding. Thus, legal measures can be undertaken to ensure the zoning, restrictions and control of activities that may further increase the level of vulnerability of the area; the coordination and integration of control measures at

community, state and national levels should be embraced. This will enable the building up of resilient strategies for mitigation before and during a flood event; temporary or permanent flood defenses may be constructed in certain areas and locations as this will help to reduce the impact incased of any flood occurrences; lastly, continuous research is needed as this will serve as one of the ways of reducing the risk to the people and property in flood prone areas of Niger Delta.

# KAPITEL 8: ZUSAMMENFASSUNG/SCHLUSSFOLGERUNG

## 8.1 Zusammenfassung

Die Studie verfolgte fünf Ziele: die Ermittlung der Ursachen und Häufigkeit von Überschwemmungen in den Küstengemeinden des Nigerdeltas; die Untersuchung der Gründe, warum Menschen in den Küstenebenen des Nigerdeltas leben; die Untersuchung der Anfälligkeit der Küstengemeinden gegenüber Überschwemmungen; die Untersuchung der sozioökonomischen Auswirkungen von Überschwemmungen in den Küstengemeinden und die Erforschung von Strategien zur Abschwächung und Lösung von Problemen im Zusammenhang mit Überschwemmungen in der Küstenregion des Nigerdeltas. Die für die Studie aufgestellten Nullhypothesen lauteten, dass die Ursachen von Überschwemmungen im Untersuchungsgebiet im Laufe der Zeit nicht dieselben sind, dass die Anfälligkeit der Küstengemeinden im Nigerdelta für Überschwemmungen im Laufe der Zeit nicht dieselbe ist und dass Überschwemmungen keine signifikanten Auswirkungen auf die sozioökonomische Lebensgrundlage der Küstengemeinden im Nigerdelta haben.

Die Ergebnisse der Studie zeigten, dass die Hauptursachen für Überschwemmungen schwere und anhaltende Regenfälle und Flussüberflutungen sind. Überschwemmungen sind im Untersuchungsgebiet in der Regel schwerwiegend und treten normalerweise während des Höhepunkts der Regenzeit auf, die im Nigerdelta zwischen Juli und September liegt. Die Häufigkeit von Hochwasserereignissen liegt in der Regel zwischen zwei und drei Mal in 10 Jahren mit einer Dauer von mindestens 6 Tagen. Weitere Ursachen für Überschwemmungen im Untersuchungsgebiet sind die Beschaffenheit des Geländes, ein schlechtes Entwässerungsnetz, eine schlechte Landnutzungsplanung und Veränderungen der Bodenbedeckung im Laufe der Zeit.

Die Studie ergab, dass die Gründe für die Entscheidung der Menschen, in überschwemmungsgefährdeten Gebieten zu leben, in ihrem Geburtsort und anderen vorteilhaften Faktoren liegen, die von niedrigen Wohnkosten über die Nähe zum Arbeitsplatz, familiäre Bindungen und Gründe bis hin zu wirtschaftlichen Gründen reichen. Die Mehrheit der Bewohner ist sich also der Gefahren bewusst, die mit dem Leben in überschwemmungsgefährdeten Gebieten verbunden sind, glaubt aber immer noch, dass die Vorteile, die sich aus dem Wohnen in solchen Gebieten ergeben, größer sind als die wahrscheinliche Flutkatastrophe, die jederzeit eintreten kann.

Die untersuchte Bewertung der Anfälligkeit ergab, dass die Anfälligkeit der Küstengemeinden für Überschwemmungen im Nigerdelta unterschiedlich hoch ist. Indizes wie Überschwemmungstiefe, Dauer, wahrgenommene Häufigkeit von Überschwemmungsereignissen, prozentuales Schadensausmaß und prozentuale Veränderungen des Niederschlagsvolumens sind jedoch Faktoren, die zur Vorhersage des Anfälligkeitsindexes von Gemeinden (CVI) verwendet werden. Forscher haben verschiedene Klassen von Skalen verwendet, um den Grad der Anfälligkeit von Küstengemeinden für Überschwemmungen zu kategorisieren. Für den CVI wurden drei bis fünf Rangfolgen festgelegt, die da wären: (1) Geringes Überschwemmungsrisiko; (2) Mäßiges Überschwemmungsrisiko; und (3) Hohes Überschwemmungsrisiko unter Verwendung einer Reihe von Werten, Häufigkeiten und Landnutzungsmerkmalen für ein Drei-Rang-Modell. Andererseits wurden für die CVI-Klassifizierungen auch 5 Rangwerte vorgeschrieben: sehr gering (1), gering (2), mäßig (3), hoch (4) und sehr hoch (5). Der Vulnerabilitätsindex stuft daher einige Gebiete in den Küstenregionen des Nigerdeltas als stark überschwemmungsgefährdet ein.

Die Ergebnisse hinsichtlich der sozioökonomischen Auswirkungen von Überschwemmungen im Nigerdelta zeigen, dass diese schwerwiegende Folgen für die Menschen haben. Zu den

sozioökonomischen Auswirkungen von Überschwemmungen gehören die Unterbrechung der Bewegungsfreiheit, die Beschädigung von Straßen, der Verlust von wertvollem Eigentum, der Verlust oder die Abschwemmung von Ackerland sowie Umweltzerstörung und -verschmutzung. All diese Folgen bestimmen normalerweise die Schwere von Überschwemmungen, die sich auf das Einkommen und den Lebensunterhalt der Menschen in den überschwemmungsgefährdeten Küstengemeinden im Nigerdelta auswirken.

Auf der Grundlage der in der Vergangenheit gemachten Erfahrungen mit Überschwemmungen im Nigerdelta wurden mehrere Strategien zur Abschwächung der Auswirkungen von Überschwemmungen auf die Küstengemeinden vorgeschlagen. Die in Übereinstimmung mit den Studienzielen aufgestellten Annahmen (Nullhypothesen) ergaben, dass die Ursachen für Überschwemmungen im Untersuchungsgebiet dieselben sind. Die Anfälligkeit ist räumlich unterschiedlich, was von mehreren Faktoren abhängt, von denen einer die Höhe (m) ist, die mehrere Auswirkungen auf den Anstieg des Meeresspiegels hat. Die Studie ergab ferner, dass Überschwemmungen erhebliche Auswirkungen auf die sozioökonomische Lebensgrundlage der Küstengemeinden haben.

## 8.2 Schlussfolgerung

Die Studie über Überschwemmungen in den Küstengemeinden des Nigerdeltas hat gezeigt, dass es im Hinblick auf Überschwemmungen im Untersuchungsgebiet mehrere Herausforderungen gibt. Trotz der Anfälligkeit der Küstenregionen des Nigerdeltas ziehen es die Menschen immer noch vor, in diesen Gebieten zu leben. Überschwemmungen sind ein ernsthaftes sozioökonomisches und ökologisches Problem. Daher müssen jederzeit angemessene Strategien und Maßnahmen zur Abschwächung der Auswirkungen von Überschwemmungen im Untersuchungsgebiet ergriffen werden. Ebenso haben die Überschwemmungen im Nigerdelta

gezeigt, dass die Maßnahmen zur Bekämpfung der Bedrohung im Laufe der Zeit unzureichend waren, so dass die Schwere der Folgen für die Menschen, die in diesen Gebieten leben, offensichtlich war. Eine Unterkunft ist eines der Grundbedürfnisse, die den menschlichen Entwicklungsindex im Laufe der Zeit unterstützen; daher kann der Zugang zu erschwinglichem Wohnraum ein Schlüsselfaktor sein, der dazu beitragen kann, die Zahl der Menschen in den Küstenebenen des Nigerdeltas unabhängig von ihrem Gefährdungsgrad zu verringern. Die Empfehlungen, die sich aus den Ergebnissen der Studie ergeben, lauten daher: Die Regierung muss proaktiv dafür sorgen, dass die Menschen in der Region des Nigerdeltas Zugang zu qualitativ hochwertigem und erschwinglichem Wohnraum haben, insbesondere an der Basis; die Regierung sollte ihre Bemühungen um Strategien zum Hochwasserschutz in den Küstengebieten des Nigerdeltas intensivieren, da die Ergebnisse zeigen, dass die Hochwassergefahr und die Anfälligkeit in den Küstengebieten des Nigerdeltas sehr hoch sind. Es ist daher notwendig, durch Gesetzgebung und Umwelterziehung von Investitionen jeglicher Art in diesen Gebieten abzuraten. Die Bewohner der Gemeinden sollten angemessen sensibilisiert werden, um Aktivitäten zu vermeiden, die die Erosion fördern und die Anfälligkeit des Gebiets für Überschwemmungen weiter erhöhen. So können rechtliche Maßnahmen ergriffen werden, um die Zonierung, Einschränkung und Kontrolle von Aktivitäten zu gewährleisten, die die Anfälligkeit des Gebiets weiter erhöhen könnten. Die Koordinierung und Integration von Kontrollmaßnahmen auf kommunaler, staatlicher und nationaler Ebene sollte in Angriff genommen werden. Dies wird die Entwicklung von widerstandsfähigen Strategien zur Abschwächung vor und während eines Hochwasserereignisses ermöglichen; temporäre oder permanente Hochwasserschutzanlagen können in bestimmten Gebieten und an bestimmten Orten errichtet werden, um die Auswirkungen von Überschwemmungen zu verringern; schließlich ist eine kontinuierliche Forschung

erforderlich, um das Risiko für Menschen und Eigentum in den hochwassergefährdeten Gebieten des Nigerdeltas zu verringern.

# CHAPTER 9: PERSPECTIVES

The underlining concerns of flood in the coastal regions of the Niger Delta are due to the fact that they are more prone to coastal challenges and dynamics. The findings of the study can assist are indicated pointing to the fact that it is imperative to build up strategies that can help show early warning signs followed by on-ground frameworks to help minimize flood impacts and reduce its effects on residents of coastal regions. Findings of the study are clear indicators for the government to be pro-active and up to the task as regards the management of activities of oil multinationals who operates more in coastal regions by creating frameworks for proper land use planning and adequate provisions of relevant structures that will promote resilient measures to help tackle flood issues in coastal communities. The findings of the study are clear indications for the government to ensure they find a lasting solution to the issue of accessible housing facilities which usually are the push factors driving people to living in coastal regions of the Niger Delta.

## REFERENCES


Adelekan, I. O. (2010): Vulnerability of poor urban coastal communities to flooding in Lagos, *Nigeria. Environment and Urbanization, 22*, 433-450.

Aderogba, K. A. (2012). Qualitative studies of recent floods and sustainable growth and development of cities and towns in Nigeria. *International Journal of Academic Research in Economics and Management Sciences, 1*(3), 1–25.

Adger, W. N. (2000): Social and ecological resilience: are they related? *Progress in Human Geography 24*(3), 347-364.

Adger, W. N., Hughes, T. P. and Folke, C. Carpenter, S. R. and Rockström.J. (2005).Social–ecological resilience to coastal disasters. *Science, 309*, 1036-1039.

Afa, J. T., (2011), Climatic and Environmental Effect in the Niger Delta, Munich, GRIN Verlag,

Agbonkhase, O., Aka, E.O., Joe-Abaye, J., Ocholi, M., and Adekunle, A. (2014): Flood Menace in Nigeria; Impacts, Remedial and Management Strategies, *6*, (4), 2-8.

Akpokodje, E.G., and Giadom, F. (2014). The Nigeria floods of 2012: impacts in the Niger Delta and lessons learned. Available at: https://www.researchgate.net/publication/2806/...

Akukwe, T. and Ogbodo, C. (2015). Spatial analysis of vulnerability to flooding in Port Harcourt Metropolis, Nigeria. *SAGE,* 1-15

Alam, K., Herson, M., O'Donnel, I. (2008): Flood disasters; Learning from previous relief and recovery operations. Prevention Consortium and ALNAP.

Amangabara, G. T. and Obenade, M. (2015). Flood Vulnerability: Assessment of Niger Delta States Relative to 2012 Flood Disaster in Nigeria. *American Journal of Environmental Protection, 3*(3),76-83

Anastas, J.W. (1999). *Research Design for Social Work and the Human Services*, Chapter 5, Flexible Methods: Descriptive Research. 2nd ed. New York: Columbia University Press.

Aven, T. (2016). Risk assessment and risk management: Review of recent advances on their foundation. *European Journal of Operational Research, 253*(1), 1-13

Ayeni, B., Adagbasa, E., and Samuel, K.J. (2014). A geospatial; analysis of flood risks and vulnerability in Ogun-Osun River Basin, Nigeria. *Advances in Geographical & Environmental Sciences,* 1-18

Ayoade, J.O. and Akintola, F.O. (1980), 'Public Perception of Flood Hazard in Two Nigerian Cities,' *Environment International 4*, 277–280.

Bell Gam, W I (1990) Development of Coastal and Estuarine Settlement. New Delhi: Sterling Publishers

Berkes, F., Colding, J.andFolke, C. (2003). Navigating social–ecological systems: building resilience for complexity and change. Cambridge University Press, Cambridge, UK.

Clark, G.S., Moses, S., Ratick, K., Dow, W., Meyer, S., Eman, W., Jin, J., Person, K., Kasperson, R., and Schwartz, H., (1998). Assessing the Vulnerability of Coastal Communities to Extreme Storms: The Case of Revere, MA USA. Mitigation and Adaptation Strategies for Global Change *3* (1), 59-82

Cooke, R.U., and Dorkamp, J.C. (1982). *Environmental Geomorphology*. Oxford, University Press London, 104–127

Correia, F. N., M. Fordham, D. G. Saraiva, and F. Bernado. (1998). Flood hazard assessment and management: interface with the public. *Water Resources Management 12*(3), 209–227.

Cui, P., Peng, J., Shi, P., Tang, H., *et al*., (2021). Scientific challenges of research. *Geography and Sustainability, 2*(3), 216-223

Cumming, G. S., D. H. M. Cumming, and C. L. Redman. (2006). Scale mismatches in social–ecological systems: causes, consequences, and solutions. *Ecology and Society 11*(1), 14.

Folke, C. (2003). Freshwater for resilience: a shift in thinking. Philosophical Transactions of the Royal Society of London: *Series B Biological Sciences*, 358 (1440), 2027-2036.

Folke, C. (2006). Resilience: The emergence of a perspective for social-ecological systems analyses. *Global Environmental Change*, *16* (2), 253-267.

Frankenberger, T.; Mueller, M.; Spangler, T. and Alexander, S. (2013). Community resilience: Conceptual framework and measurement feed the future learning agenda. Rockville, MD: Westat.

Gornitz, V., White, T., and Cushman, R.: (1991). Vulnerability of the US to future sea-level rise, Proceedings of 7-th Symposium on Coastal and Ocean Management, Long Beach, CA, USA, 8–12, 2354–2368.

Groffman, P. M., D. J. Bain, L. E. Band, K. T. Belt, G. S. Brush, J. M. Grove, R. V. Pouyat, I. C. Yesilonis, and W. C. Zipperer. (2003). Down by the riverside: urban riparian ecology. *Frontiers in Ecology and the Environmen*t *1*(6), 315-321.

Gunderson, L. H. (2010). Ecological and human community resilience in response to natural disasters.*Ecology and Society* 15(2), 18. Available at: http://www.ecologyandsociety.org/

Holling, C. S. (1973). Resilience and stability of ecological systems. Annual Review of Ecology and Systematics, *4* (1), 1-23.

IFRC (2014). Framework for community resilience, 6-14

ISDR (2009) UNISDR Terminology on Disaster Risk Reduction: Manual and Guideline. Published by the United Nations International Strategy for Disaster Reduction (UNISDR) Geneva, Switzerland, May 2009.

Isumonah, V. A., and Gaskia, J. (2001). *South-south zone of Nigeria*. Programme on Ethics and Federal Studies, Simbine, H.S. Galadima.

Joe Alagoa, E. and Derefaka, A. A., (2002) The land and people of Rivers State: eastern Niger Delta. Onyoma Research

Jonoski, A. and Popescu, I. (2012). Distance Learning in Support of Water Resources Management: An Online Course on Decision Support Systems in River Basin Management. *Water Res. Manage., 26*, 1287–1305

Kron, W. (2015). Flood disasters- a global perspective. *Water Policy, 17*, 6-24

Kumar, T. and Kunte, P. (2012). Coastal Vulnerability Assessment for Chennai, East coast of India using Geospatial Techniques, *J. Nat-ural Hazards, 64*, 853–872.

Lawal, O., Oyegun, C.U., and Ogoro, M. (2016). Vulnerability of coastal communities in Niger Delta to sea level rise. *Journal of Research in Environmental and earth Science, 2*(8), 2348-2532

Liao, K. (2012). A theory on urban resilience to floods – a basis for alternative planning practices.Ecology and society, *17*(4), 48

Mmom, P.C., and Aifesehi, P.E.E. (2013). Vulnerability and resilience of Niger Delta coastal communities to flooding. *Journal of Humanities and Social Sciences, 10*(6), 27-33

Munich, R. (2014). *Topics Geo Natural Catastrophes 2013* – Analyses, Assessments, Positions. Munich Re, Munich, 60 pp.

Musa, Z.N., Popescu, I., and Mynett, A. (2014). The Niger Delta vulnerability to river floods due to sea level rise. *Nat. Hazards Earth Syst. Sci., 14,* 3317-3329

Nelson, S.A. (2018). Natural disasters: Coastal zones. Available at: https://www.tulane.edu/~sanelson/Natural_Disasters/coastalzones.htm

NEST, (1991). Nigeria's threatened environment: A national profile. Intec Printers Ltd, Ibadan, 124-131.

NIOMR (2010). Marine. Geology/Geophysics, available at: http://www.niomr.gov.ng

Ologunorisa, T. E. and Durowoju, O. S. (2014): Extreme Rainfall and Urban Flooding in a Coastal Mega City: Case Study of Lagos, Nigeria. In T.K.S. Abams et.al. (eds.) Flood and Erosion Prevention, Protection and Mitigation. Port Harcourt: Rivers State University of Science and Technology, 85-102.

Ologunorisa, T.E. (2004). An assessment of flood vulnerability zones in the Niger Delta, Nigeria. *International Journal of Environmental Studies, 61*(1), 31-38

Ologunorisa, T.E. (2009). Strategies for mitigation of flood risk in the Niger Delta, Nigeria. *J. Appl. Sci. Environ. Manage., 13*(2), 17-22

Ologunorisa, T.E., and Adeyemo, A. (2005). Public perception of flood hazard in the Niger Delta, Nigeria. *The Environmentalist, 25*, 39-45

Omuta, G.E.D., and Aitokhuehi, O. (2020). *Flood risk mitigation in Niger Delta region*: Strategies for protecting buildings and properties. CPED Policy brief series 2020, 1

Onweagba, A. E., and Nwaihu, E. C. (2014) Palm Fruits Processing and Rural Infrastructural Development in Imo State, Nigeria. *Journal of Agriculture and Food Science, 2* (2), 91-97

Oxford Learners English Dictionary (2019). Flood. Retrieved https://www.lexico.com/definition/flood

Popescu, I., Cioaca, E., Pan, Q., Jonoski, A., and Hanganu, J. (2014). Use of hydrodynamic models for the management of the Danube Delta wetlands: The case study of Sontea-Fortuna ecosystem. *Environ. Sci. Policy, Envsci*., *1*(12).

Popescu, I., Jonoski, A., van Andel, S. J., Onyari, E., and Quiroga, V. G. M. (2010). Integrated modelling for flood risk mitigation in Roma-nia: Case study of the Timis-Bega river basin. *Int. J. River Basin Manage., 8*, 269–280

Samuel, K. J., Ayeni, B., Adebayo, O. H., Adagbasa, G. E. (2014): A Geospatial Analysis of Flood Risks and Vulnerability in Ogun-Osun River Basin, Nigeria. In M. Singh et

al. (eds.), Landscape Ecology and Water Management: Proceedings of IGU Rohtak Conference vol.2, Advances in Geographical and Environmental Sciences, 307-320, Springer, Japan.

Samuel, K.J., Yakubu, S., Ologunorisa, T.E., and Kola-Olusanya, A. (2017). Post-disaster assessment of riverine communities impacted by a severe flooding event. *Ghana Journal of Geography, 9*(1), 17-41

Smit, B., and J. Wandel. (2006). Adaptation, adaptive capacity and vulnerability. *Global Environmental Change 16*, 282-292.

Thieler, E. R., & Hammer-Klose, E. S. (1999). National Assessment of Coastal Vulnerability to Future Sea Level Rise:Preliminary Result for the U. S. Atlantic Coast (G. S. O.-F.Report, Trans.). U.S.

Uchegbu, S.N. (2003). Management of flood plains and wetlands in Nigeria. *Journal of Nigerian Environmental Society, 1*(1), 69-76

UNISDR (International Strategy for Disaster Reduction) (2004). Living with Risk: A Global Review of Disaster Reduction Initiatives, 2004 version, Geneva: UN Publications.

Valentin A., Bakary K., Fred F. H., and Eva N. P., (2016). Time Series Analysis of Floods across the Niger River Basin. *Water*, 8, 165

Valentin A., Bakary K., Fred F. H., and Eva N. P., (2016). Time Series Analysis of Floods across the Niger River Basin. *Water*, *8*, 165

Van, P. D. T., Popescu, I., van Griensven, A., Solomatine, D. P., Trung, N. H., and Green, A.: A study of the climate change impacts on fluvial flood propagation in the Viet-nameseMekong Delta, Hydrol. Earth Syst. Sci., 16, 4637–4649, doi:10.5194/hess-16-4637-2012, 2012.

Ward, R.C. (1978) Floods: A geographical Perspective, London, Macmillan publishers.

Wizor, C.H., and Week, D.A. (2020). Geospatial mapping and assessment of flood-prone communities in the core Niger Delta, Nigeria. *Asian Journal of Advanced research and Reports, 9*(3), 6-20

Yin, J., Yin, Z., Wang, J., and Xu, S.: National Assessment of Coastal Vulnerability to Sea-Level Rise for the Chinese coast, J. Coastal Conserv., 16, 123–133.