The Impact of Land Use and Land Cover Change on Flooding along Epie Creek, Nigeria: A Multi-Stakeholder Approach.

Ladebi Martha Sapere-Obi

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Abbreviations

LULC	-	Land Use, Land Cover
LULCC	-	Land Use, Land Cover Change
LUC	-	Land Use Changes
GIS	-	Geographic Information System
GIST	-	Geographic Information Science and Technology
UNISDR	-	United Nations International Strategy for Disaster Reduction
NEMA	-	National Emergency Management Agency
NGOs	-	Non-Governmental Organisation
BYSEMA	-	Bayelsa State Emergency Management Agency
GPS	-	Global Positioning System
RS	-	Remote Sensing
IPCC	-	International Plant Protection Convention
FOA	-	Intergovernmental Panel on Climate Change
NCDMB	-	Nigerian Content and Development Monitoring Board
NDDC	-	Niger Delta Development Commission
APFM	-	Associated Program on Flood Management
WHO	-	World Health Organisation
GWP	-	Global Water Partnership
IFM	-	Integrated Flood Management
USGS	-	United States Geological Survey
UTM	-	Universal Transverse Mercator
LAI	-	Leaf Area Index
HIC	-	Higher Income Countries
LIC	-	Lower-Income Countries
LMIC	-	Lower Middle-Income Countries
EAP	-	East Asia and Pacific Region
ECA	-	Europe Central Asia
SAR	-	South Asian Region
SSA	-	Sub-Saharan African

MNA	-	Middle East and North Africa
LAC	-	Latin America and the Caribbean
IDW	-	Inverse Distance Weighting
AOI	-	Area of Interest
NAST	-	National Assessment Synthesis Team
NIHSA	-	Nigerian Hydrological Service Agency
SFDRR	-	Sendai Framework for Disaster Risk Reduction
BHDA	-	Bayelsa State Housing and Property Development Authority
FRRF	-	Flood Risk Reduction Framework
FME	-	Federal Ministry of Environment
SEMA	-	State Emergency Management Agency
FEMA	-	Federal Emergency Management Agency
NIHSA	-	Nigerian Hydrological Services Agency
NIMET	-	Nigerian Meteorological Agency
NESREA	-	National Environmental Standards and Regulations Enforcement Agency.

Abstract

Flooding is becoming more severe due to changes in land use and the effects of climate change, posing a serious environmental threat to tropical developing countries like Nigeria. Nigeria's unique characteristics, including rapid population growth, urbanisation, inadequate planning, deforestation, and inefficient land use management, exacerbate this concern. The increasing frequency and scale of flooding incidents are partially attributed to changes in land use practices, which directly impact the well-being of people, their economic activities, and the environment.

Flooding is a global environmental issue, with its ramifications becoming more severe due to ongoing climate change. The Niger Delta region, particularly around Epie Creek, is experiencing increased frequency and severity of flooding due to rapid urbanization and significant changes in land use and land cover. These changes, including deforestation, conversion of wetlands to urban areas, and improper land management practices, disrupt natural drainage systems and exacerbate flood risks. Despite various flood management interventions, there is a lack of integrated, sustainable strategies that involve all relevant stakeholders, leading to ineffective flood mitigation and continuous environmental degradation.

This research focused on examining the effects of land use alterations on flooding along Epie Creek in the Niger Delta region, utilizing a multi-stakeholder approach to develop sustainable urban planning and flood management. It adopted an interpretive philosophical perspective and employed qualitative methodology, selecting the Saunders research onion model as its methodological framework. Single case study and survey strategies were employed with an abductive approach for the investigation.

To achieve the study's objectives, Geographic Information System (GIS) and remote sensing (RS) techniques were utilized to generate land use and land cover information, rainfall, and flood risk maps. Semi-structured interviews were employed to address the other objectives of the study. The GIS analysis revealed significant deforestation and urban expansion in the Epie Creek area, leading to reduced natural drainage and increased flood risk while the stakeholders' interviews highlighted a lack of coordinated efforts, and insufficient infrastructure to manage flooding effectively.

This study contributes to the field by providing a comprehensive analysis of the impact of land use and land cover change on flooding, which advances the theoretical understanding of the interplay between urbanisation, land use changes, and flood risk. It introduces a novel multi-stakeholder framework that can be applied to similar contexts facing urban environmental challenges.

Acknowledgment

I begin by expressing my heartfelt gratitude to the Almighty God for His unwavering guidance and blessings throughout my research journey. I am deeply thankful for the opportunities, good health, and resilience that enabled me to complete this thesis. My sincere appreciation goes to my supervisor, Professor Bingu Ingirige, whose inspiration, insightful feedback, suggestions, and motivation played a pivotal role in achieving this significant milestone. His constructive criticism and positive perspectives enhanced the quality of this research. Discussions during our meetings have been invaluable, enriching my understanding and knowledge. Thank you sincerely.

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This work is dedicated to my father, Emmanuel Akedeso, and my sister, Ebidei Akedeso whom I lost along the way.

CHAPTER ONE: INTRODUCTION

1.1: Research Background

Land use changes are cumulatively a major driver of global environmental change (Turner et al., 2017). Virginia (1997) noted that during the next few decades, global environmental changes are expected to have major impacts on ecological, social, economic, and political aspects of human society. The ecological impacts include changes to biodiversity, productivity, migration, and sustainability (Virginia, 1997). Another publication by Kolawole in the European-American Journals stated that the world's global climate has been changing for many decades now. Climate change has increased the frequency and magnitude of extremes in climate variables (temperature and precipitation), thereby causing extreme weather events such as tropical cyclones, droughts, flash floods, or rainfall-triggered landslides (IPCC, 2021). Numerous terrible climate disasters have occurred in different regions of the world in the past year alone, including Cyclone Idai, deadly heatwaves in India, Pakistan, and Europe, and flooding in southeast Asia. From Mozambique to Bangladesh, millions of people have already lost their homes, means of livelihood, and loved ones due to more hazardous and frequent extreme weather events (Oxfam, 2022).

In addition to climate change, the conversion of natural lands into human-dominated landscapes has dramatically accelerated during the last decades and is expected to continue in the future (Hurtt et al. 2020). One contributor to climate change is land use activity and changes in land cover patterns are one way in which the effects of climate change are expressed (Virginia, 1997). Land cover describes both natural and synthetic coverings of the earth's surface, including topography, soil, biota, groundwater, and human structures. It refers to the vegetation and artificial constructions covering the land (Seyam et al., 2023).

A related concept is land use, referring to the way the biophysical attributes of the land are manipulated and the purpose for which the land is used. It is the human activities on the land that are related to the land (Rawat & Kumar, 2015).

Land cover and land use are connected since changes in land use can change land cover, and changes in land cover can change land use. Numerous socio-economic, political, cultural, technological, and biophysical factors influence land use and land cover change (De Sherbinin, 2002). The largest threat to ecological systems is land cover change, one of the most significant drivers of environmental change due to urbanisation (Foody, 2002). Land use and land cover (LULC) change and any consequent hydrological response has been prominent topics of research in recent years (Amini et al., 2011; Chen et al., 2009; Fox et al., 2012).

With the changing climate and the increasing frequency of flooding events across the world (Collins, 2009; Hurkmans et al., 2009; Xu et al., 2009), the effects of LULC changes on extreme runoff events are likely to draw further attention. Soil, topography, and land cover are the most principal factors that control rainfall-runoff processes at the scale of single flood events in river basins. As alterations in soil and topography are insignificant in the short term, changes in land cover are the key element in modifying rainfall-runoff processes (Miller et al., 2002). Wan & Yang (2007) concluded that anthropogenic land-use change is one of the major drivers of the increased frequency of flooding incidents. The rate of land use and cover change and the frequency of flooding make it an important focus of research. Land use change effects on floods entail a variety of intricately interconnected process dynamics, which makes it extremely difficult to analyse and anticipate any implications at the watershed scale. A conceptual picture of some of the process interactions thought to be relevant is shown in the schematic in Figure 1.1. For instance, clear-cutting reduces evapotranspiration and interception in forest plantations, which increases antecedent soil moisture and reduces soil storage capacity (Brown et al., 2005).

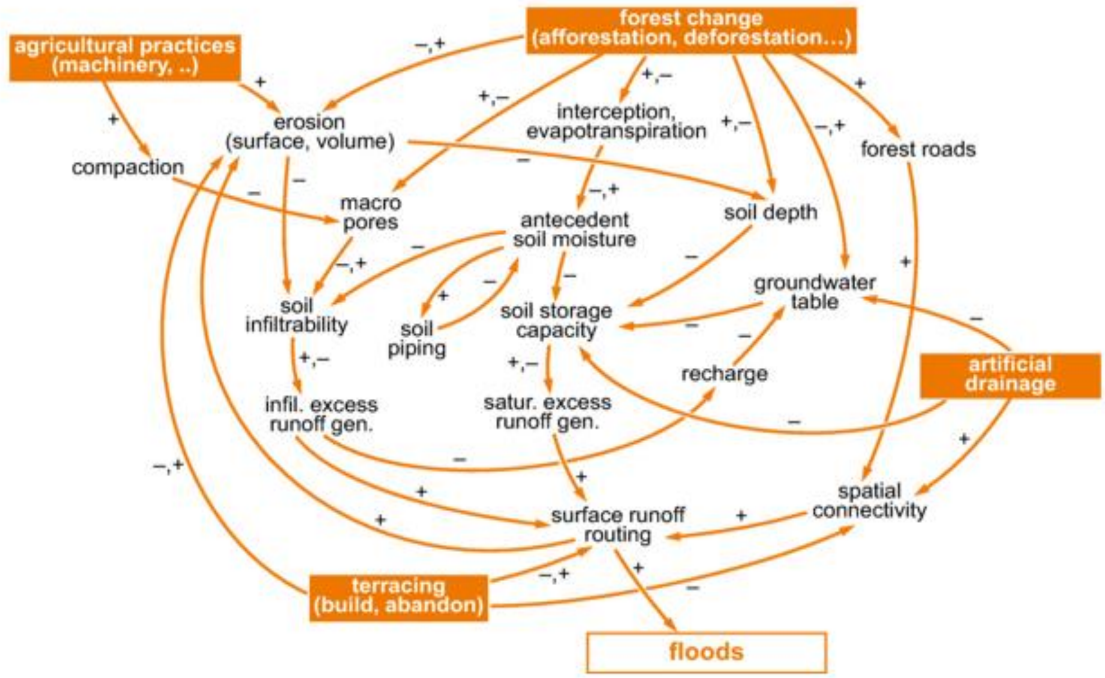

Figure 1. 1: Schematic of process interactions in land use change effects on floods at the catchment scale (Rogger et al., 2017).

The plus and minus signs indicate whether an increase in one variable increases or decreases another variable. The processes shown here are embedded in a broader context of environmental and socioeconomic processes. Heavy machinery use on agricultural land usually results in soil compaction and a reduction in soil infiltration, which leads to an increase in surface runoff. Other changes, such as deforestation and the construction of roads, can also impact climate-related natural hazards by increasing their frequency and/or intensity and changing their spatial distribution (Bradshaw et al., 2007; Depicker et al., 2021; Tanyas et al., 2022). Furthermore, unsustainable economic development, growing energy use, and uncontrolled and informal rapid urbanisation also contribute to climate change and increase risks (Merz et al., 2021; Raju et al., 2022).

Climate change may be a significant driver of changes in flood frequency, which has been widely investigated (Merz et al., 2014; Hall et al., 2014; Viglione et al., 2016). However, there are only a few studies on the role of land use change in modifying river floods (Rogger et al., 2017). Climate change can directly affect land use in several ways, but its effects on agriculture are the best known. (Virginia, 1997) Direct climate effects on land use include changes in crop yield and spatial shifts in agricultural potential (Parry, 1990; Easterling et al., 1993). Other changes include changes in rainfall patterns and temperature, which will determine what kind of crops can be planted, at what time, and when they will be harvested. In a review of the literature that studied the relationship between land-use change and climate change, Virginia (1997) concluded that in recent centuries, land-use change has had much greater effects on ecological variables than has climate change, and humans will change land use, and especially land management, to adjust to climate change, and these adaptations will have some ecological effects. These ecological effects will cause a shift in ecosystems and threaten species diversity due to rising temperatures and flooding. However, as the Intergovernmental Panel on Climate Change (IPCC) 2021 noted in its special report on extremes, it is increasingly clear that climate change “has detectably influenced” several of the water-related variables that contribute to floods, such as rainfall and snowmelt. In other words, while our warming world may not induce floods directly, it exacerbates many of the factors that do. There are studies on the connection between climate and land use change and its numerous impacts, one of which is flooding as shown in Figure 1.1. Flooding, which is a global phenomenon in most cities, affects the livelihoods of people and makes life difficult for many when their source of livelihood is taken away. Floods can be beneficial, such as in the deposition of alluvium to form fertile soils being brought to the Nile Delta by annual flooding. However, large floods are mostly known for their catastrophic loss of life and property, as experienced in China. Bangladesh and Nigeria have been repeatedly devastated by floods. Bangladesh lost 300,000 people in November 1970 and more than 130,000 in April 1991 from cyclone-induced flooding, and the massive flooding of the Yangtze River in China in 1931 caused more than 3 million deaths, with a further 2 million in 1959 from flooding and starvation. In Nigeria, flood events of particular interest were the two major flood events of 2012 and 2022 (Olaniran, 2002). The recent flood event of 2022 was the worst in the history of Nigeria. The increasing concern for the management of natural resources in recent times has been necessitated by the increase in demographic pressure and its associated anthropogenic activities, which have led to serious environmental stress and ecological instability. (Eludoyin et al., 2017). Flooding events also lead to the destruction of resources.

1.2: Research Motivation

The quest and strive towards industrialization, technological innovations, and the drive to modernism have resulted in modifications and changes in land use and land cover in a geographical setting, which in turn affect other aspects of the environment. Urban development on flood plains increases the risk of flooding, especially during increased peak discharge and volume. The impacts of flooding are numerous and can be devastating. This is the case with Epie Creek, as there is an increased severity of flooding, and buildings that have encroached into the floodplain areas are the worst hit. The presence of several structures and the absence of proper regulations for maintenance create an artificial flood (Mohapatra and Singh, 2003). Land cover change during Urbanisation, deforestation, and cultivation of land are all anthropogenic activities that have increased the frequency and severity of flooding along the area of study. Such activities give rise to vegetation loss, soil compaction, reduced infiltration capacity of the soil due to an increase in paved surfaces, lower evapotranspiration, and soil porosity. The effect of these is increased run-off and eventually overflow of water. According to the National Emergency Management Agency (NEMA, 2012), Nigeria lost over N2.6 trillion to the 2012 floods in 23 states. The agency also reported that 5,970 houses were submerged in 256 local government areas, adding that the floods displaced 2.1 million people (about the population of New Mexico) and caused the deaths of 363 people. 7,000,000 people were affected across the country. The 2022 Nigerian floods affected many parts of the country. According to federal government data, the floods displaced over 1.4 million people, killed over 603 people and injured more than 2,400 people. About 82,035 houses had been damaged, and 332,327 hectares of land had also been affected (Oguntola, 2022). According to the Guardian (2022), as of October 2022, over 200,000 homes were completely or partially destroyed by the floods. On October 7th, a boat carrying people fleeing the floods capsized on the Niger River, causing 76 deaths.

The Niger Delta Region has been one of the most affected by 2012 and 2022 flood episodes due to the region's monotonously flat topography and Epie Creek in Yenagoa local government area is situated on the Niger Delta. Also, in the last few decades, the Niger Delta Region has witnessed steady land use changes resulting from Urbanisation, infrastructural development, etc., which could trigger recurrent flood events in the region. In Yenagoa, a city in the Niger Delta Region of Nigeria, the flood incidences of 2012 and 2022 were disasters that have not been recovered from. Rapid Urbanisation in Yenagoa has led to an increase in human settlements, industrial growth, and infrastructure development on flood plains and natural drainages. This, in addition to climate change and heavy rainfall, has resulted in annual flooding that has caused suffering and untold hardship as people's houses and farmlands are submerged, drinking water is contaminated, movement is restricted, most sources of livelihood are taken away, and means of communication and transportation are disconnected due to the destruction of roads and cable lines. Schools, churches, and most social activities are put on hold till the floods recede. This leads to the clean-up and fumigation phases to get rid of reptiles and snakes that could have taken refuge in people's homes and the onset of diseases due to ingesting contaminated water and food.

1.3: The Study Area and Geology

Epie Creeks is situated within the Yenagoa Local Government Area of Bayelsa State in Nigeria.

The development of Yenagoa took the form of a linear settlement, encompassing numerous villages that extended along the old Mbiama/Yenagoa primary distributor road, spanning four local government areas: Kolokuma/Opokuma, Ogbia, Yenagoa, and Southern Ijaw. The geographical coordinates of the Yenagoa area fall between 4°48’00” North and 5°24’10” East latitude and 6°12’00” East and 6°39’30” East longitude. Yenagoa is surrounded by Rivers State to the north and east, Delta State to the northwest and west, Ogbia LGA to the southeast, and Southern Ijaw LGA to the southwest. The area of study is a lowland, which makes it already prone to flooding; compounding this problem further is unplanned development and the absence of drainages. The study area has experienced river flooding for over twenty years, and the flood level has continued to rise, with the worst flooding so far recorded in 2012 and 2022. Bayelsa State has a total land area of 9,059 sq. km (about the area of Puerto Rico). The climate of Yenagoa LGA is an equatorial type of climate. Rainfall occurs every month of the year. The mean monthly temperature is 25°C to 31°C. The hottest months are December and April. Relative humidity is high throughout the year and decreases slightly during the dry season. Yenagoa is an urban area with a mixture of tropical rainforests and mangrove swamps. It experiences perennial flooding due to its high rainfall density, low terrain, high tides, and overflow of rivers, making most towns within it prone to flooding. Figures 1.2-1.5 below present maps of Nigeria, Bayelsa State, and Yenagoa local government area showing elevation, major rivers, and communities in the study area.

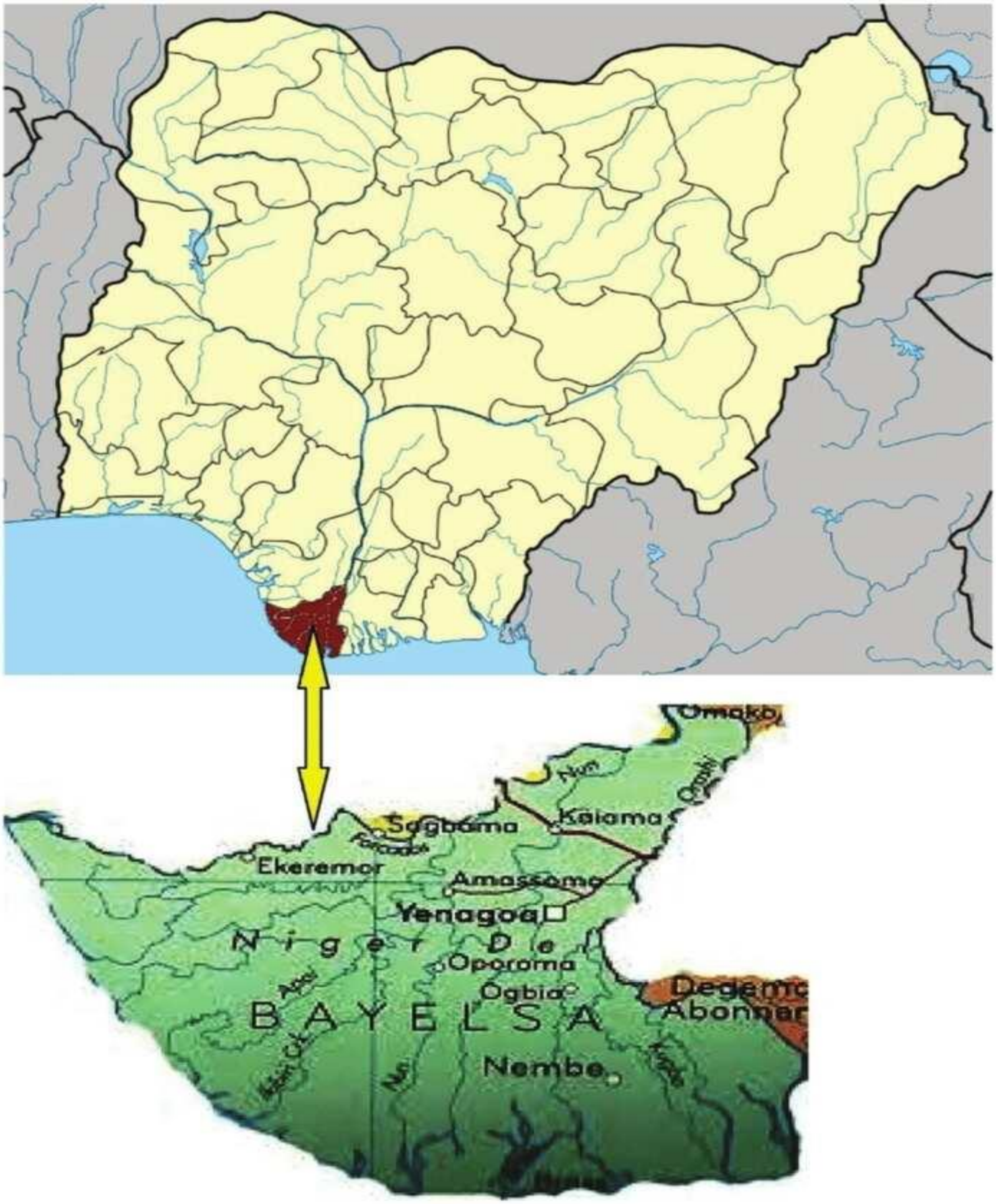

Figure 1. 2: Map of Nigeria showing Bayelsa State.

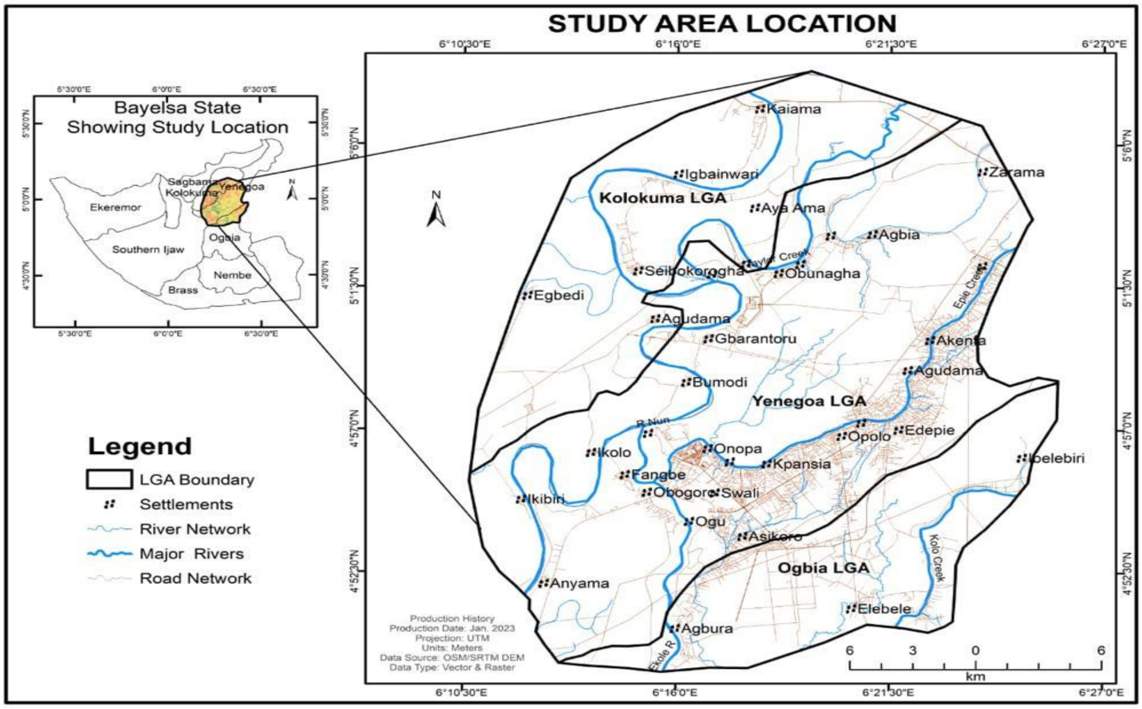

Figure 1. 3 Map of Bayelsa State showing the study area.

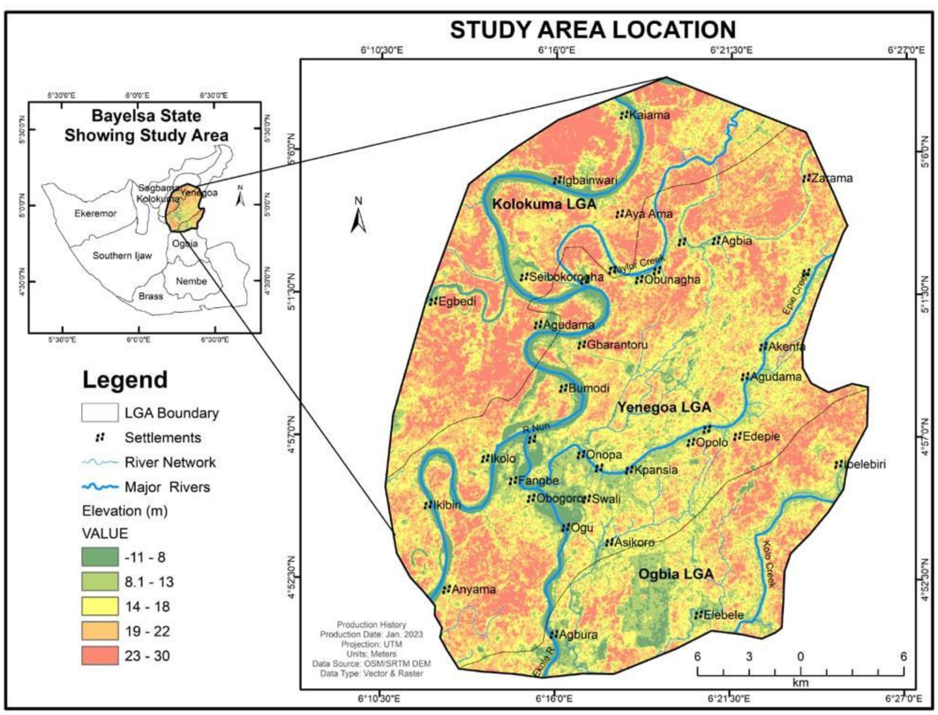

Figure 1. 4: Map of the area of study showing elevation.

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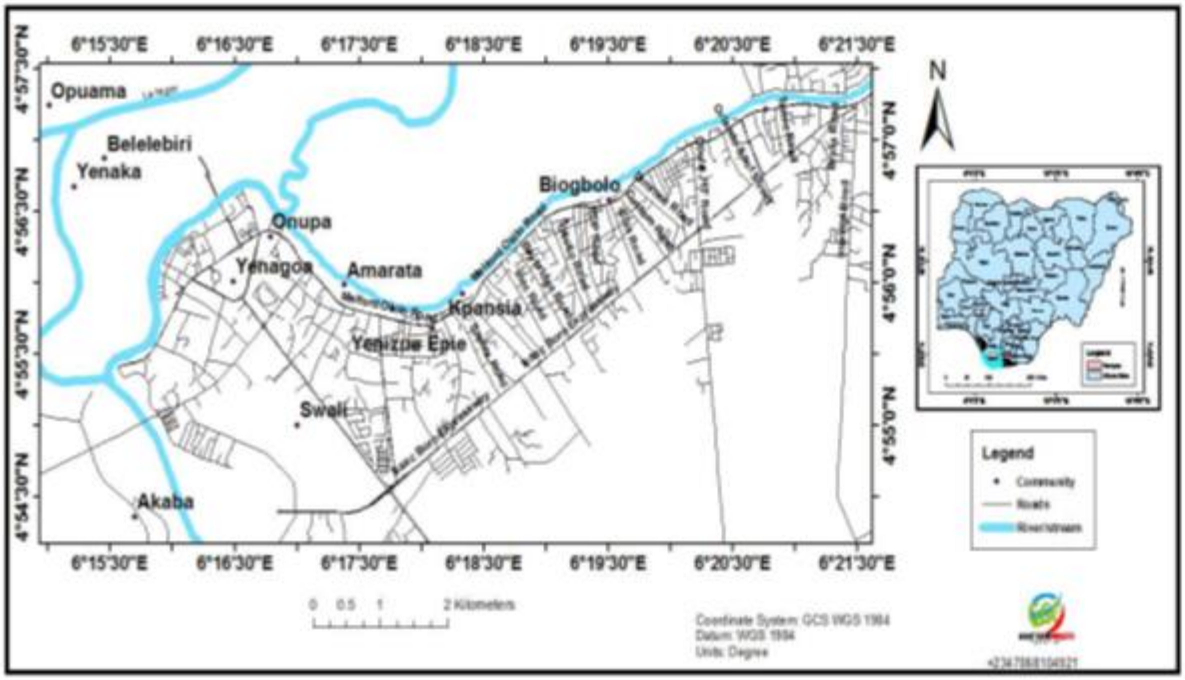


Figure 1. 5: The study area showing major communities. (Adapted from Journal of Geography, Environment, and Earth Science).

Epie Creek, located within the lower delta plain, is believed to have formed during the Holocene of the quaternary period through the accumulation of sedimentary deposits (Oyadongha, 2018). Serving as a vital linkage among communities along the Mbiama-Yenagoa road, extending from Igbogene to Ovom, the creek lies between latitudes 40′ 5’ N to 50′ 02’ N of the equator and longitudes 60′ 16 E to 60′ 24’ E of the Greenwich meridian. Characterized by a mean annual rainfall exceeding 4,000mm, the area experiences two distinct climatic seasons: a prolonged wet season lasting seven to eight months from March to October, with a brief respite known as the "August break," followed by a dry season from late November to February or early March spanning about three months (Bariweni & Amukali, 2017; Twumasi & Merem, 2006). Vegetation primarily consists of freshwater swamps with elevations ranging between 3 and 12 meters above sea level, while the geology comprises sedimentary formations housing back-swamp deposits and the floodplain (Oladimiji & Owho, 2022).

Historically, Epie Creek served as a vital waterway for transportation, recreation, and fishing, while also serving as a source of potable water. However, it has now deteriorated into a dumping ground for poorly managed waste, overrun by water hyacinths and grasses. The unchecked activities of a burgeoning population have led to adverse impacts on resource utilization, reversing the creek's once navigable and draining functions (Seiyaboh et al., 2013). The designation of Yenagoa as the capital of Bayelsa State in 1996 precipitated a rapid influx of population, exacerbating sediment deposition due to heavy vegetation (Yenagoa Master Plan). Human-induced land use and cover changes, spurred by rapid urban growth and developmental activities, have further heightened flooding risks, reducing the rivers' carrying capacity and intensifying inundation (Abbas, 2006; Onwuteaka, 2014; Ejemeyovwi, 2015). Additionally, the absence of dredging activities in Epie Creek, attributed to concerns about water quality and adverse effects on fisheries, underscores the complex interplay between natural and anthropogenic factors in exacerbating flooding vulnerabilities (Ohimein et al., 2008; Seiyaboh et al., 2013).

1.4: The Research Problem

Identifying the research problem serves as the catalyst that propels and directs the necessity of conducting a research study, forming the cornerstone for the entire investigation (Pardede, 2018). This process involves conducting a background study, which encompasses exploring previous research in the area, discerning gaps in existing knowledge that require attention in the current study and understanding the nature of the research problem under scrutiny (Lango, 2020). Consequently, Chapter One of the study embarks on this background study, aiming to pinpoint the research gaps to be addressed, define the scope of the study, and elucidate its objectives. In this pursuit, a variety of sources, including journal articles, conference proceedings, books, and other publications, were consulted. Through the background study, land use changes and their impacts on flooding along Epie Creek were investigated and the research problem was established.

The research problem is the urbanization and deforestation within the Epie Creek watershed in the Niger Delta Region of Nigeria that have transformed natural landscapes into impermeable surfaces and reduced vegetation cover. These changes are believed to significantly increase surface runoff and alter the hydrological cycle, thereby exacerbating flood frequency and intensity. However, the specific extent to which these land use changes contribute to flooding in this region remains unclear.

Limited empirical data and comprehensive studies quantifying the relationship between different types of land use changes (e.g., urbanization, deforestation, and agricultural expansion) and their specific impacts on flood frequency, intensity, and duration in the Epie Creek watershed. Existing research primarily focuses on broader regional analyses without delving into localized hydrological impacts and the interplay between land cover changes and flood dynamics specific to Epie Creek

1.5: The Research Aim and Objectives

This study aims to analyse the impact of land use changes, specifically urbanization, deforestation, and agricultural expansion, on flood frequency, intensity, and duration in the Epie Creek watershed of the Niger Delta Region, Nigeria. The specific objectives of the study are to;

1. Characterizing the spatial variations in land use patterns from 1987 to 2022.

2. Conducting a qualitative evaluation of the causes of flooding, its impacts, and adaptive strategies.

3. Review land use policies and the involvement of stakeholders in flood management.

4. Develop a flood risk reduction framework.

5. Propose measures to address land use and flooding issues.

1.6: Research Questions

1. What are the spatial variations in land use and land cover between 1987 to 2020?

2. What are the causes of worsening floods along the Epie communities, their effects, and how have they coped?

3. What policies guide the people, and what have the government and stakeholders done to mitigate flooding?

4. How can flood risk be mitigated along Epie Creek?

5. What measures can help reduce the frequency and severity of flooding and land misuse?

1.7: Significance and Expected Contribution of the Study

This study is significant because its findings will have a direct implication for proper land use management practices and flood risk reduction. To tackle urban flooding, significant efforts have been made to develop flood assessment methods or frameworks (Hirabayashi et al., 2013; Jenkins et al., 2017; Morrison et al., 2017), which are essential to support decision-making for investment in flood management schemes such as the sponge city initiative in China (Jia et al., 2017). However, the current practices are not holistic as most research such as (Izonfuo & Bariweni, 2001; Nwakwoala et al., 2011; Rim-Rukeh & Agbozu, 2013; Sieyaboh et al., 2016b; Ben-Eledo et al., 2017a; Mbha et al., 2017; Seiyaboh, 2018) focused on surface water quality, land use and the assessment of flood risk, i.e., the product of the likelihood of flooding and the related consequence. These studies often fail to integrate other critical aspects such as groundwater interactions, ecological impacts, socio-economic vulnerabilities, and long-term climate change projections, which are necessary for a comprehensive flood management approach.

Hence this research takes an integrated approach to considering interactions in land use management, flood risk management, including natural flood management measures, and human resource policies as appropriate in the case study context in a holistic manner.

The study is significant for the Epie community and potentially significant for cities with similar environments and factors, as it aims to develop a flood risk reduction framework that will help tackle the problem of flooding after looking at the changes in land use, flood frequency, vulnerability, and the underlying causes. The expected contribution of the study includes the following:

1. An innovative integration of GIS and the qualitative insights from expert interviews will be used to develop a flood risk reduction framework that incorporates both spatial data and stakeholders' perspectives in a meaningful way. Also, the interview process will involve a diverse range of stakeholders and link their insights directly with GIS findings.
2. Actionable recommendations for policymakers that are grounded in both empirical data and stakeholder needs and preferences will be made.
3. The flood risk reduction framework that will be developed can be adapted and applied to similar regions facing similar challenges, contributing to broader applications in urban planning and environmental conservation.

1.8: Structure of the Thesis

The thesis is structured into seven chapters, as described below:

Chapter 1: provides the background of the research and introduces the research topic. It includes the problem statement, research gap, research aim and objectives, the study's contribution to knowledge and practice, and the outline of the thesis.

Chapter 2: discusses the current state of literature on land use and land cover change and its impact on flooding. This is followed by a thorough review of the literature on flooding, land use, and land cover change. It also includes the development of the conceptual framework.

Chapter 3: Introduces the case study area; Epie Creek. This chapter discusses the history and geographical setting of Epie Creek, hydrology, drainage, and major flood events. It will also discuss the impacts of flooding, measures of flood management, land use policies, and the challenges of the application of these policies.

Chapter 4: describes in detail the research design and methodology. It presents the method of data collection and explains how primary and secondary data will be collected in line with the aim of the research. It will also include the philosophical stance of the researcher that leads to the selection of a suitable research approach, strategy, and technique to fulfil the research aims and objectives. The reliability and validity of the adopted research techniques are also addressed. This is followed by a summary of the research process along with ethical considerations.

Chapter 5: This section presents the findings from the interviews and the GIS maps. The GIS data will be examined to determine changes in land use, rainfall patterns, flood risks, and vulnerability. Additionally, vulnerability maps will be scrutinized to evaluate flood vulnerability and adaptation strategies. NVIVO 14 will be employed to perform thematic analysis on the semi-structured interviews.

Chapter 6: discusses the key findings of the study by triangulating the results from the literature review in Chapter 2, the interview findings in Chapter 5, and the critical links between the concepts and factors presented in developing the final flood risk reduction framework. The final framework and its validation are then discussed at the end of the chapter.

Chapter 7 (Conclusion): provides a summary of the study by revisiting the research aim and objectives and presenting the key findings of the study. It will underline the theoretical and practical contributions, along with the limitations of the study and suggestions for future research areas. References and appendices will be presented at the end of the thesis.

1.9: Summary

Chapter one presents the research area, Epie Creek, and the justification of the research context. The research problem areas and significant gaps in knowledge were discussed, and the research aim, and objectives were identified to address these issues. The expected contribution of this study to knowledge and practice and a brief description of the structure of the thesis were presented. Overall, this chapter sets the context of the research areas, which will be discussed in detail in the following chapters. The next chapter is a review of the literature.

CHAPTER TWO: LITERATURE REVIEW

2.1: Introduction

The aim of this study is to investigate the impact of changes in land use and land cover on the occurrence of flooding along Epie Creek in Bayelsa State, Nigeria. This study is of utmost importance as it explores the consequences of both natural and anthropogenic activity on land, leading to alterations in its utilization and cover. The study aims to comprehend the role of these alterations in causing flooding and the overall impacts of flooding, including its adverse effects on the environment and the welfare of the local inhabitants. The literature review for this research is structured topically. Nevertheless, this chapter centers on scrutinizing and assessing prior studies to identify precise deficiencies that the current research can tackle. The following section delves into the disparity of land use and land cover, scrutinizes the dynamics of land use alterations in developed as well as developing nations, and investigates how they relate to flooding. The next parts explore the evaluation of variables that worsen flooding, the vulnerability of communities to floods and their adaptive strategies, and the analysis of government land use policies and actions taken to address flooding problems.

2.2: Comparison between Land Use and Land Cover

Land use and land cover are sometimes used interchangeably, but they have distinct meanings. Land use refers to the series of human activities carried out on land to obtain products and/or benefits from natural resources (Ellis et al., 2019). Land cover refers to the vegetation and structures found on the earth's surface, including both natural and cultivated flora as well as synthetic structures such as buildings and highways (UNEP/FAO 1993). According to Rosan et al. (2021), land use refers to the specific activities carried out on a piece of land, whereas land cover refers to what physically covers the land, such as vegetation, buildings, water, bare soil, etc. Land cover encompasses various surfaces such as ice, exposed rock, water, sand, and similar terrain.

The land cover does not indicate how the land is being used, and areas with the same land cover can have different land uses. They also believe that the choices about the type of land use and human activities that have affected the land can either raise or decrease carbon emissions from the land. Table 2.1 presents various land cover categories and examples.

Table 2.1 Classification Scheme (Anderson et al, (1971))

Land Cover	Description	References
Built-Up	All residential, commercial, and industrial areas (villages, settlements, transportation infrastructures) Gala and	Boakye (2020).
Waterbody	River, permanent open water, lakes, ponds, canals, reservoirs.	Das &Angadi, (2021).
Vegetation	Trees, forests, and old, vegetated lands	Mishra et al., (2020)
Agriculture	Farmlands, Plantations	Hao et al., (2021)
Bare land	Grassland, cultivated areas, earth and sand lands, infillings, and solid waste landfills.	

For example, the land's vegetation, such as a forest, can have multiple functions, such as providing fuelwood, conserving wildlife, or supporting leisure activities. It also refers to a wide range of areas, including privately owned land, protected watersheds, and well-visited state parks. Land usage primarily concerns the activities and actions of humans on the land, whereas land cover specifically refers to the observable attributes and features of the land. Satellite and aerial photography, as depicted in the illustration below, facilitate the evaluation of land cover, thereby assisting in the determination of land use. Land cover maps offer useful data for academics to enhance their comprehension of the current landscape. To understand changes that occur over time, researchers examine land cover maps from various years (Mushtaq et al., 2022). This data enables them to assess previous land management techniques and predict prospective ramifications. Occasionally, a hierarchical classification system integrates land use and land cover into a unified category. In such cases, land cover is assessed on a larger scale, such as the classification of land used for agriculture (Ologunorisa et al., 2022). On the other hand, land use is used to improve the level of detail on a map, such as by highlighting specific features like grazing areas. Although land use and land cover are related, it is important to note that they are not interchangeable terms. A modification in land use might have an impact on land cover, but they are distinct concepts. The next table, Table 2.2, presents the differences between land use and land cover.

Table 2.2 Differences between land use and land cover change.

S/N	Land use	Land cover
1.	This relates to an alteration in the way certain area of land is used or managed by humans (Rosan, 2021).	Land cover describes the surface cover of the soil, whether it is vegetation, urban infrastructure, water, bare soil, or something else (Mushtaq et al., 2022).
2.	Land use change requires human intervention. Mainly driven by urban growth (human) drivers	Land cover is changed by both human and climate drivers
3.	For example, the forest could be used for fuel wood, wildlife conservation, or leisure;	For example, land can be covered by forest (plants), water, soil, or bare.
4.	Land use type is determined from the land cover of the area by Geographic information systems or remote sensing.	Geographic information systems and remote sensing can be used to identify the land cover types of an area

The alteration of land use and land cover (LULC) is a multifaceted socio-economic and environmental concern that requires a thorough comprehension of the interaction and connection between human activities and the environment (Brown et al., 2013). The complex and dynamic relationship between the modification of land use and cover and the underlying factors results in the modification and deterioration of ecosystems. Demographic dynamics, such as population increase, density, and dispersion, are the main factors that affect changes in land cover, according to several studies (Mather and Needle, 2000; Lambin et al., 2003). Some individuals contend that economic factors have a pivotal impact (Lambin and Geist 2001). Socioeconomic factors like poverty, insecure land tenure, and limited access to markets and credit all have an impact on land cover changes (Campbell et al., 2005). Diverse patterns and commonalities have arisen across various locations and countries. Emphasizing the correlation between changes in land use and land cover (LULCC) and human activities, specifically the economic drivers behind these activities, is crucial. Therefore, it is important to consider the wide range of factors that contribute to changes in land use while also addressing the differences that exist between regions (Lambin and Geist 2006).

The present study examines land use and land cover to determine their impact on flooding in the study area. Land use encompasses the various activities and purposes for which the land in the Epie Creek ecosystem is utilized, while land cover refers to the ever-changing physical characteristics of the land surface in that environment. The study focuses on investigating the influence of changes in land use and land cover (LULC) on flooding in Epie Creek and surrounding areas.

2.3: Land Use and Land Cover Changes and Patterns

The distinction between land use and land cover change has been elucidated, highlighting that while land use concerns the utilization of land, land cover refers to its physical covering, both falling under the purview of land dynamics. Over time, the utilization and coverage of land by humans have exhibited dynamic shifts. As noted by Winkler (2021), significant alterations in land usage have occurred, with changes in land use proving to be four times more substantial than previously thought. Land transitions may involve conversions from grasslands to agricultural fields or from wilderness to grazing areas for livestock. These evolving applications and scopes exert diverse impacts on both human societies and the environment.

Land use change, as defined by Verburg et al. (2000), encompasses alterations to Earth's terrestrial surfaces over time due to human activities and natural processes like climate fluctuations. These modifications, according to Verburg et al. (2000), contribute to environmental challenges such as climate change, land degradation, air and water pollution, flooding, and biodiversity loss. Changes in land use and land cover affect the distribution of energy across the Earth and the biogeochemical cycles, playing a significant role in climate change and influencing ecosystem services' availability (Turner, 2007; Foley et al., 2005).

Climate change is an increasingly pressing global issue that prompts adjustments in land usage, particularly land management practices, as highlighted by Virginia (1997). While land management adaptations can address critical global challenges like food security, climate change, and biodiversity loss (Winkler et al., 2021), studies by Tesser (2005), Xuejun & Zhonghua (2017), and Xhoa et al. (2022) have documented associated increases in ecosystem service values and carbon emissions. Recognizing human-induced alterations in land use is vital for effective ecological service management, given the significant implications of climate change on various aspects such as plant types, water quality, agricultural production, and ecosystem vulnerability (NAST, 2001; Elliott & Baker, 2004; Gutowski et al., 2008; Milly et al., 2008; Woodhouse & Overpeck, 1998; Karl et al., 2009; EPA, 2007, 2008; Alig et al., 2004; Gan, 2004). Changes in land use significantly contribute to greenhouse gas emissions, with estimates suggesting that approximately 23 percent of global emissions are attributable to these changes (Mushtaq et al., 2022). Winkler (2021) further estimates that land use change has affected approximately 32% of the Earth's surface area over six decades (1960–2019), driven by various societal motives and serving diverse purposes such as agriculture, urbanization, industry, and recreation. Table 2.3 below shows the land use types and examples.

Table 2.3 Land use types

Land use types	Explanations	Examples	Land use changes	References
Agricultural	Agricultural land is land altered for the cultivation of crops to generate different agricultural goods or the raising of cattle for human consumption.	Crop Farming Agroforestry Livestock farming	Residential Industrial	Arya & Singh, 2021
Institutional	Land used for schools, colleges and universities, government offices, and Hospitals.	Schools Government Offices Hospitals	Residential	Aik et al. 2021
Residential	The construction of homes is a form of residential land use. This could be urban, suburban, or rural.	Houses	Transportation Commercial	Din and Mak, 2021
Industrial	Industrial land use is the production and manufacturing of assorted items, including large-scale sites	Factories	Residential Transportation	Nuissl & Siedentop, 2020
Commercial	Commercial land use is converting land for commercial use and enables the sale of goods and services.	Markets Shopping malls Offices	Residential	Bufebo & Elias, 2020
Transportation and Infrastructure	Land use for transportation involves modifying it to accommodate	Railways Highways Roads Airports	Commercial Residential	Winkler, 2021

	different modes of transportation.	Ports		
Recreational	This involves converting land so that people can enjoy it, like in parks.	Parks Stadium Fields Nature reserves	Agricultural Residential Transportation Commercial	Winkler, 2021

These main land use types can also be changed from one type to another and then to another type. For example, agricultural land used for the cultivation of crops can be converted to a residential area and then to transportation use. With these changes in land use comes a change in the cover of the land. Between 1960 and 2019, an estimated 17% of the Earth's land surface has changed at least once. The total land change extent, which accounts for all individual change occurrences (as well as areas of multiple change), is 43 million km², or a third of the world's land area. This indicates that, since 1960, an area of land that is twice the size of Germany (720,000 km2) has changed annually on average (Winkler et al, 2021). Below in Fig 2.1 is the global presentation of single and multiple land use change events. The pie charts show the total extent of change as a percentage of global land cover.

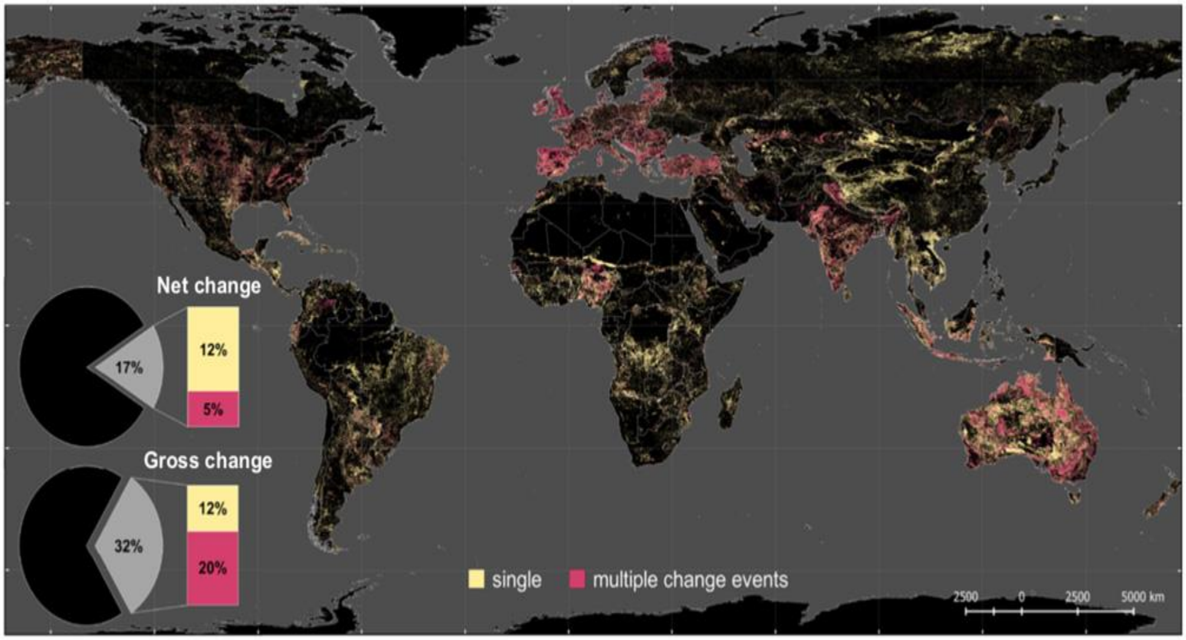


Figure 2. 1 Global instances of single (yellow) and multiple (red) land-use-change events. Source: Winkler et al. (2021)

2.3.1: Agricultural Impacts on land use and land cover change

Xiao-Peng et al. (2018) conducted a thorough analysis spanning 35 years of satellite data, offering a comprehensive overview of global land dynamics from 1982 to 2016. In contrast to the widely held belief of a global decline in forested areas (FOA, 2015), their findings unveil a significant increase in tree cover, expanding by 2.24 million km2 (+7.1% compared to 1982 levels). This overall positive trend is attributed to a net gain in extratropical regions counterbalancing a net loss in tropical areas. Additionally, the global extent of bare ground has contracted by 1.16 million km2 (approximately -3.1%), primarily observed in agricultural regions of Asia.

Their research underscores that 60% of all observed land changes result directly from human activities, while 40% are influenced by indirect factors such as climate change. Given that land use frequently entails the transformation of natural landscapes into urban areas to meet societal and economic needs, issues related to land use inherently translate into environmental challenges.

The primary concern lies in the ongoing loss of natural areas as Urbanisation intensifies or expands. Agriculture emerges as a significant driver of deforestation, responsible for approximately 80 percent of global land-use change. The type of food consumed by humans and animals significantly influences agricultural land-use change, with population growth being the primary driver. Estimates indicate that animal agriculture accounted for 65 percent of the total change in land use worldwide between 1961 and 2011, while agricultural productivity exhibited a consistently higher growth rate between 1981 and 1995, followed by a much lower rate from 1996 to 2000 in Nigeria (Ayinde et al., 2011; Oladimeji & Ohwo, 2022). Since the inception of human-induced transformations of formerly wild areas into farmland and urban areas, the global landscape has undergone significant changes. The United Nations Food and Agriculture Organization (FAO, 2019) estimates that 420 million hectares of global forest cover were eradicated in just three decades, from 1990 to 2020, representing approximately 45% of the world's forest cover. Changes in land use continue to pose a potential threat to people's livelihoods. As depicted in Fig 2.4, such alterations in land use/land cover systems have a significant impact, among others, on agrobiodiversity, soil degradation, and the sustainability of agricultural production (Lambin et al., 2003; Sala and Knowlton, 2006). Changes to land use are also a major contributing factor to the decline of biodiversity (Arya & Singh, 2021), particularly affecting communities dependent on basic primary economic activities like agriculture.

2.3.2: Impacts of Deforestation on land use and land cover change

Deforestation, which is the deliberate clearance of forested terrain is another type of land-use change that occurs and can cause global problems according to a study on the effects of tropical deforestation on climate. Lawrence and Vandecar (2014) in this study state that “these are physical effects from removing trees that are not simply related to the loss of carbon dioxide stored inside them. Tropical deforestation results in immediate climate impacts independent of, and in addition to, its contribution to the greenhouse effect." The study also looks at changes that have already happened as forests have been cleared. In Brazil, for example, the rainy season starts 11 days later in deforested areas, and scientists think that the loss of trees in central Africa may have caused a more than 20 percent decline in rainfall from the Congo basin to the east coast. Lawrence and Vandecar (2014) suggested that deforestation can also cause longer dry seasons and delays in the start of the rainy season. Because forests help moderate high daytime and low night-time temperatures, cleared land is more susceptible to temperature extremes, which some crops may not tolerate. Limiting deforestation is therefore important for farming as well as tackling climate change (Lambin et. al., 2003; Sala and Knowlton, 2006). In addition, it will help to balance temperature and regulate carbon dioxide in the atmosphere. Studies on LULCC have also done a great deal in predicting and projecting future changes and effects of the uses of land on the soil. According to Tellen and Yerima (2018), land use changes from natural ecosystems into managed ecosystems may have deleterious effects on soil structure and quality. The results revealed that deforestation and subsequent cultivation of soil had negative effects on the measured soil properties. Bufebo and Elias (2020), also agreed that Land use change from natural ecosystems to managed agroecosystems is one of the main causes of soil fertility decline. The results indicated that Severe soil erosion caused by agricultural expansion and poor management worsened soil nutrient depletion in the cultivated outfield and there was a significant difference for most parameters evaluated, the most favourable soil properties were observed in the forest land, followed by homestead garden fields, while the least favourable soil properties were found in intensively cultivated outfields.

2.3.3: Urbanisation as a contributory factor of land use and land cover change

Urbanisation is another major factor contributing to land use/land cover change. It is the urban shift of population from rural to urban areas that is responsible for most of the modern problems facing humanity and has detrimental environmental consequences. Urbanisation is one of the major driving forces behind the formation of today's land use systems. It always involves the conversion of land use from non-urban to urban uses. A great deal of contemporary Urbanisation has been characterized as urban sprawl, which is a highly extensive form of land taken for urban uses that has environmentally detrimental effects. However, urban land use change can occur in diverse forms in terms of layout, building density, and speed of change, to name but a few aspects. According to Nuissl & Siedentop (2020), the rapid conversion of open, mostly agricultural land into settlement areas has been accompanied by pronounced criticism since the heyday of Industrialisation in the nineteenth century. Even at that time, the rapid growth of industrial urban centres raised great suspicion and was blamed not only for the accumulation of human disorder, vice, and despair but also for the destruction of the traditional (pastoral) landscape due to its greed for land. In recent decades, researchers have made substantial progress in empirically addressing the various forms of urban land use and its change over time. Hence, the global dimension of Urbanisation-related land use change is now on the agenda of policymakers and researchers worldwide (Nuissl & Siedentop, 2020).

Below in Fig 2.2 is an adaptation showing the major drivers of land use, land cover change, the link, and the impact on climate and society. It highlights land use and land cover change driven by agriculture, urbanisation, and deforestation which contributes to greenhouse gases, carbon dioxide, methane, nitrous oxide, and water vapor which makes the atmosphere warm up. The impact of LULCC on the environment includes habitat loss and degradation, biodiversity loss, species extinction, extreme flood and heat events, crop failure and damage, and infrastructure damage.

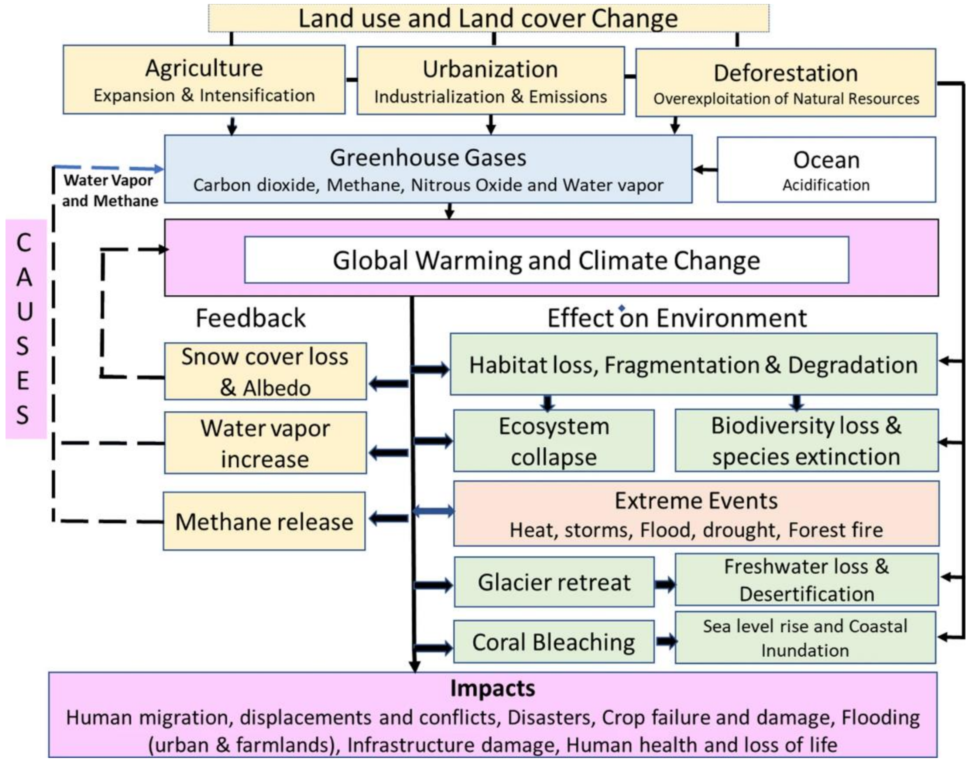


Figure 2. 2 Drivers of land use and land cover changes and impacts on climate and society (Roy et al., 2022)

As illustrated in Fig 2.2 above, agricultural expansion is a major driver of deforestation. Therefore, while agriculture creates room for expansion and intensification, deforestation leads to overexploitation of resources, biodiversity loss, and Urbanisation results in Industrialisation and emissions. All these in one way or another contribute to changing land and affect the balance of the environment which has adverse effects like high or low temperatures and flooding. Most studies both in developed and developing countries have been dedicated to case studies of different situations and in some instances, a comparison of cities and nations on how these problems have been tackled holistically. The next section discusses and compares land use and land cover changes in developing and developed nations.

2.3.4 Land Use Changes in Developing Nations.

The study of land use changes in developing countries is vital in quantifying the dynamics of land use change which is critical in tackling global societal challenges such as food security, climate change, and biodiversity loss. One major trend observed in the changes that occur in the use of land and land cover is the quest for Urbanisation and the gradual transformation of rural settlements to megacities. Deforestation, land conversion, and agricultural land expansion in low and middle-income countries are major features of the economic development occurring in developing nations. Much of the "frontier expansion" in these economies consists of rapid land use change, mostly the conversion of forests, woodlands, and other natural habitats to agriculture and other land-based development activities (Barbier, 2010). A small number of developing nations have, over the last few decades, been successful in implementing a change in land use that has increased both their forest cover and their agricultural output. Global population increase has been a major source of worry in recent decades (Daramola et al., 2022). Developing nations are a significant concern because of their high concentrations of human populations (Brisibe & Brown, 2019). Urbanisation, global warming, and climate change are all predicted to have a greater effect on impoverished people and areas in emerging nations. In a very recent study, Din, and Mak (2021) studied the land use and land cover changes in Pakistan with an emphasis on urban expansion dynamics. The study notes that in terms of global climate changes and urban form distribution, land-use, and land-cover change (LUCC) is a major issue in developing nations. In Pakistan and other developing nations, since the 1900s, Urbanisation has become a major contributor to LUCC, with cities housing more than 55 percent of the World's population. Rapid Urbanisation, development, and expansion, rapid population increase, land scarcity, the need for additional manufacturing, and technological advancements are among the current drivers of LUCC around the world. The urban growth or spread, as well as the spatial patterns of Hyderabad, Pakistan, were investigated in this study over the last four decades.

Din & Mak (2021) relied on satellite data Landsat pictures from 1979 to 2020 for its reviews. These raw photos were subjected to radiometric and atmospheric corrections before being trained using a Gaussian-based Radial Basis Function (RBF) kernel within a 10-fold support vector machine (SVM) controlled classification framework. To confirm the trustworthiness of the proposed space-based retrieval process, multiple metrics such as Producer's Accuracy (PA), User's Accuracy (UA), and Kappa statistics (KC) were used to assess spatial precision after spatial LUCC maps were retrieved. In the end, the study revealed that there was an expansion in built-up areas and a decrease in undeveloped land. After 40 years, the developed area has expanded to 65.04 percent of the total area, up from 30.69 percent in 1979. Agricultural land, forestry, waterbodies, and barren terrain, on the other hand, steadily decreased. Following the above findings, Din & Mak (2021) deduced that agricultural land, vegetation, waterbodies, and barren terrain have all reduced by 13.74 percent, 46.41 percent, 49.64 percent, and 85.27 percent, respectively, over the last four decades. The spatial features of "rural to urban transition" and economic growth within a modernized city, are highlighted and symbolized by digitally observed changes, which set up new prospects for discovering potential land-use modifications and laying down viable future urban plans.

In another study, Maitima, et al. (2010) investigated the impact of land use changes on the sustainability of production activities in Lake Victoria shared by the borders of three countries-Uganda, Kenya, and Tanzania. The study notes that changes in land use, their cover, and their impact on the soil happen slowly in most cases even those in charge of managing the situation may not know in time what needs to be done to ameliorate the situation. This can also be attributed to the fact that what is done in the Lake Victoria environment is mostly subsistent farming activities, which may pass as non-threatening to the land and the properties of the soil. However, as the study observed, little attention is paid to the fact that land use change in the lake basin is extremely sensitive to erosion and degradation due to the character of the landscapes and geomorphologic processes. Based on the above, Maitima, et al., (2010) recommend a regional outline and approvals for sustainable land management, comprising all segments of land use such as farming, grazing, and Urbanisation, which are urgently needed to save the environment.

Another study by Musakwa & Niekerk, (2013) investigated the positive and negative sides of land use and land use cover. Musakwa and Niekerk, (2013) observed in a study of the emerging city of Stellenbosch in South Africa that land use changes over ten years (2000-2010) show that the city, which was previously known for agricultural production in 2010 had lost so much land as of 2010 due to recreation facilities being built and the provision of cluster houses. Also, open space land in the city was reduced in the period by 19%. These radical changes were driven by the quest for urbanisation and a rapid transformation from an informal sector-driven society to a more formal setup. However, there are also instances where the changes in land use cover are not driven solely by urbanisation but by the quest to have an economic output (enhancing and extending a country's production capacity) for export and development schemes for the survival of the community not as resettlement schemes but economic expansion driven by the quest to have more export. In the case of Kayah State in the developing country of Myanmar, Aye and Htay, (2019) found out that the export of wood, which is a major economic earner for the country is the leading cause of deforestation in the country as the study shows that between the year 1990-2010, 7,445,000 ha, which is about 19.0% of the forest area of Myanmar had been cleared. This makes the country the seventh foremost deforestation zone and rate in the world. This also has created problems, for instance, 70% of the total population of Myanmar lives in rural areas where there is a great dependence on the proceeds from the forests. Also, forest land cover averts soil depletion and erosion, sediment deposition in streams and rivers, and the decline of biodiversity (Cunningham & Cunningham, 2006). This has also led to recurring flooding in the country. This is not a trend that is common to developing nations alone but also to developed nations, where land use changes (LUCs) are gradually reducing farming spaces and open spaces.

Srinivasan and Rogers, (2015) did a comparative study of the nature of land use change (LUC) in India and China. India is a developing nation in the Asian continent while China is a developed nation in the same region. Srinivasan and Rogers attempted to investigate if the phenomenon of land use and land cover are the same in the context of both nations. The study notes that the rapid changes in the percentage of people that lived in developing nations of India and China are a major factor that has influenced LUC. As of 1950, about 18% of persons were living in urban cities in the two nations but as of the year 2000, this figure has risen to slightly more than 40% with a projected increase to about 56% in the year 2030. Hence, Srinivasan and Rogers, (2015) observed that the chief causes of land use are demographic issues such as the magnitude of the population and density; the level of technological advancement and its use; the level of influence and affluence of the country; the political structures; economic factors: the systems of land ownership; attitudes and values placed on the use of land in the nation Srinivasan and Rogers, (2015). The study then concludes that the land use of both countries has soared high due to Urbanisation. China's Urbanisation rate is around 40% lower than that of rich countries and many developing ones.

The encroachment into land areas that were hitherto open spaces and agricultural spaces caused by Urbanisation is a phenomenon found in most growing cities of the world. For example, in Lagos, which is one of the most populated cities in Nigeria and Africa. Tijani, et al. (2018) found out that in as much as more land has been recovered from areas covered by the sea and houses and industries built on them, the development is not on the part of sustainability as there are antecedent negative impacts. One such negative presented by Tijani, et. al, (2018) is the toll on the livelihood and well-being of the people such as diseases that come from groundwater vulnerability to saline intrusion and contamination. Also, there is a decline in soil fertility and quality, a reduction in the production of livestock and the quality and quantity of fish in the coastal city of Lagos (cf. Ubaekwe, & Engwoh, 2020; Onilude & Vaz, 2020).

Other studies have also been reported from Nigeria, which focused on the impact of LULCC in coastal cities. Dekolo et al. (2015) deployed a multi-temporal Remote Sensing (RS) and Geographical Information System (GIS) analysis to uncover urban sprawl and agricultural land loss in Ikorodu Municipality, Lagos State, covering 40 years. The study showed that agricultural areas have been reduced by a significant amount of 25%, which is a direct consequence of rapid urban developmental activities. Also, Olayiwola and Igbavboa (2014) did a study that covered the LULCC in the ancient town of Benin City using remotely sensed data that investigates the trend of urban growth and its impact on land use arrangements. The study then concluded that the expansion of Benin City had an inverse spill-over effect on the vegetative resources of the surrounding rural settlements. This is made more possible by the fact that the forest areas of the surrounding communities must give way to accommodate new housing layouts, roads, and industries.

It is important to note that the conditions that apply to Lagos and other coastal areas in the previous studies may be like other coastal cities and growing cities in modern-day Nigeria. However, Tijani, et al. (2018) did not focus on the impact of these changes in land use and covers as it relates to erosion in the city. In recent times, most states in the coastal areas of Nigeria have experienced an elevated level of flooding. Researchers are looking into the relationship between changes in land use, these flooding incidents, and the frequency of occurrence, especially in Yenagoa. This is an intriguing puzzle that a study such as this may be poised to answer.

2.3.5 Land Use Changes in Developed Nations

The study of land use changes in developed nations is crucial for understanding how these nations address land use change issues. These transformations and developments, with both positive and negative impacts on people and land, are significant. Forest area expansion is observed in wealthy countries of the Global North, while arable land is decreasing. Changes in forest cover differ from agricultural areas, with the decline of farmland noted in Europe and the United States. Other notable changes include shifts in Siberian vegetation due to climate change and the spread of woody plants onto rangelands in the United States and Australia. Developed economies of the Global North (including the United States, Europe, and Australia) and rapidly growing economies experience more changes compared to those experiencing only one (e.g., Nigeria, India) (Nkeki et al., 2022).

Major changes in the agricultural sector such as transition from subsistence crops to commodity crops, have taken place during the past few decades in the European Union and the United States. Agricultural land use changes (those connected to cropland or pasture/rangeland) account for 86% of all multiple change occurrences. Agricultural intensification and other forms of land management have been blamed for some of these changes. Transitions from cropland to pasture to rangeland make up 11% of all multiple change events; this may provide light on regions that use crop rotation or mixed crop-livestock systems, such as the United States, Australia, and Europe. Seventy-five percent of multiple shifts happen between managed and uncontrolled land, such as the abandonment of cropland due to agricultural development on more suitable terrain in post-communist eastern European states. Agroforestry systems in Western Europe, rangeland-shrub encroachments in Australia, and rotational grazing in the Mediterranean are all examples of similar ecosystem-level shifts (Nkeki et al., 2022).

A study by Ová et al, (2017) examined the impact of Urbanisation and long-term land use on the environment with a case study on Trnava City in Slovakia. Like many other cities, the study highlighted the fact that Trnava City has undergone radical changes due to transformations from a central town planning system into a market economy, which has increased the pressure on the ecosystem and the land especially. Hence, Mederly and Petrovic, (2017) evaluated the land use changes which occurred rapidly but went mostly unnoticed in the city. The study found that within 35 years (1980-2015), Trnava city had undergone different changes in land use in comparison with other major cities in Europe. Firstly, it is observed that the changes in land use reflect more the various technological, social, and political changes in the city and country. For example, the study noted that novel economic settings reflect the changes in Trnava. Such that production structures of numerous enterprises vanished 'due to economic non-profitability and brownfields begin to appear' (p. 19). It is important to note that most of the changes in land use evaluated were more for positive development such as improved housing systems and enhanced town planning. Little or no attention is paid to the negative effects of land use changes such as erosion and flooding whereas this area is classified as a substantial risk for flood hazard which means that potentially damaging and life-threatening river floods are likely to occur at least once in the next ten years. This also makes it prone to erosion. The reduction of crop and pastureland due to land use change is not peculiar to developing nations alone as Wu, (2008) in a study, established that land use changes in the United States of America within 25 years (1982-2003), decreased with 76 million acres in many states, 'while the total area of developed land increased by 36 million acres or 48%'.

2.2.6: Comparing land use patterns between developing and developed nations.

According to one view of development, all countries are situated on a hilly slope, with Japan, one of the richest industrialized countries, at the top and Burkina Faso, one of the poorest developing countries, at the bottom. The wealthiest developing countries are those that have recently industrialized, including South Korea. These would be located behind the least developed countries, like Hungary, halfway up the slope (BBC Bitesize). Below in Fig 2.3 is the map showing the position of the developed and developing countries.

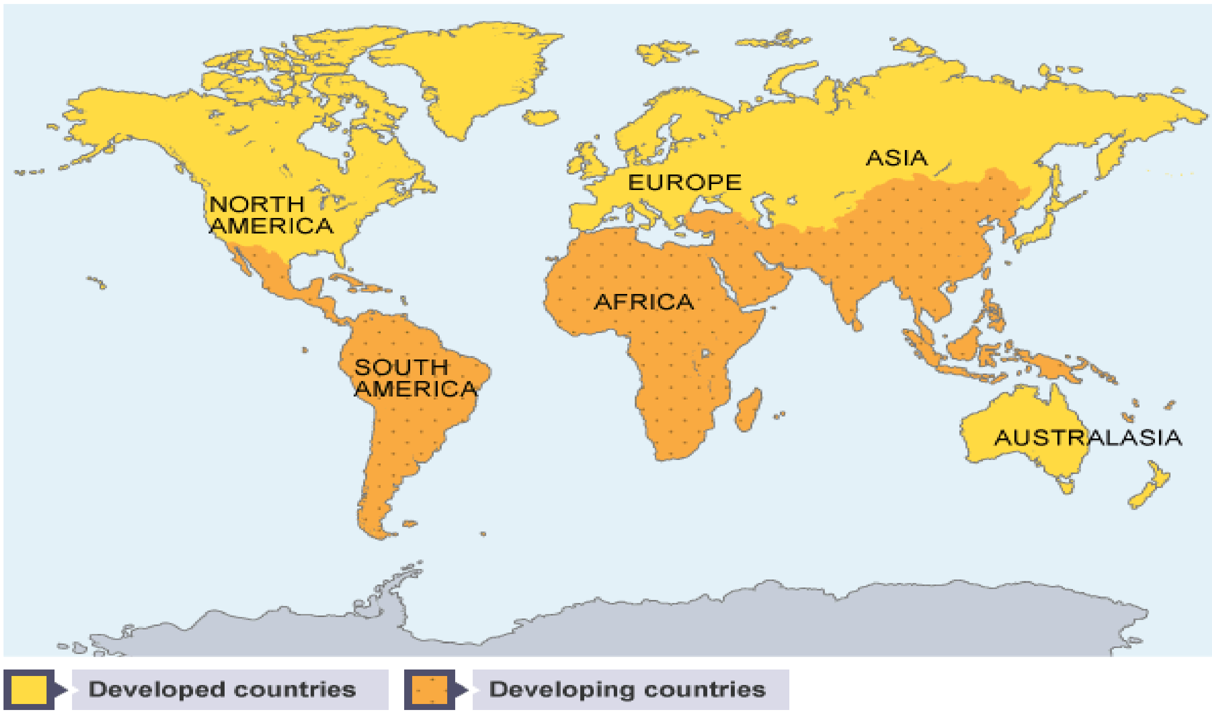


Figure 2. 3 Global presentation of developing and developed countries.

The rate of change in global land usage has not been steady over time. distinguish two distinct phases: an acceleration phase from 1960 to 2004 that saw an increasing rate of change; and a deceleration phase from 2005 to 2019. As seen in Figure 2.3, production and export of commodity crops expanded in South America, Africa, and Southeast Asia most noticeably during the 2000s, and this acceleration phase is especially noticeable in the Global South. A significant driver of land use change, particularly deforestation for commodity crops in the Global South, is shown to be the expanding influence of tele-connected markets (Ordway et al.2017). Globally, forests have decreased by 0.8 million km2, but crops and pasture/rangeland have increased by 1.0 and 0.9 million km2, respectively. Global tendencies in land use change, however, obscure numerous locally unique paths. Forest areas have significantly decreased in emerging countries in the Global

South while increasing in the Global North, notably China. However, global agricultural regions show a North-South divergence in forest gains and losses as they have grown in the global South and shrunk in the North. Numerous studies have shown support for these globally disparate land use change processes, such as the expansion of forests prompted by political reforestation incentives in China (Bryan et al.,2018; Chen et al., 2019; Feng et al., 2016), the abandonment of agricultural land in Europe(Kaplan et al., 2012), and the United States (Kauppi et al., 2006; Oswalt et al., 2017; Rumankutty et al., 2010), the shift in Siberian vegetation caused by climate change (Esper et al., 2004; Kharuk et al., 2013; Tchebakova et al., 2009), and the encroachment of trees on rangelands in the United States (Van, 2000) and Australia (Holmes, 2002). Tropical forests have been removed to cultivate livestock, sugar cane, and soybeans in the Brazilian Amazon (Barona et al.,2010; Macedo et al., 2012; Austin et al., 2019); oil palm in Southeast Asia (Austin et al.,2019; Gaveau et al., 2016; Nomura et al., 2019; Wick et al., 2011); and cocoa in Nigeria and Cameroon (Chatham House, 2018; Kroeger et al., 2017; Ordway et al., 2017). In China rangelands have also considerably encroached upon marginal lands (Bryan et al., 2018; Hua & Squires, 2015). Below in Fig. 2.5 is a spatial distribution of forest, cropland, and pasture between 1960 and 2019 as presented by Karina et al., 2021. The Area charts on the right show the stacked share of gains, losses, and multiple change areas (on which both gains and losses have occurred) related to the total area under the respective LUC category along each geographic latitude. Forests had a steady 36.4km2 with a loss of 4.1km while cropland gained 5.3km2 of land.

Shafri, et al. (2010) observed that because of rapid growth and industrialisation, there has been a fast change in land use and land cover across the world. Although these changes may not always imply a degradation of the land, in some cases, poor land management might result in a landslide impact that creates additional challenges. Excessive deforestation practices in the Himalayas (the mountainous areas of Asia and India) have exacerbated erosion, which has led to severe floods in the lowland plains (Mishra, 2020). Aik, et al. (2021) noted that in Cameroon Highlands, disasters such as erosion, landslides, water table rise, and soil instability, were common and several other land collapses have occurred for the past 30 years or more in the area. Further findings revealed the extension of cities and forest development over slopes greater than 35 degrees, resulting in soil structural instability. When comparing the reference years of 2009 and 2019, mean land surface temperature measurements suggest that temperatures have risen by 7.5°C, with a mean of 3 to 4°C across the region. The effect involves changes in precipitation like rain and snow. Patterns in precipitation may change or become more extreme. Over the course of the 20th century, precipitation increased in eastern parts of North and South America, northern Europe, and northern and central Asia. However, it has decreased in parts of Africa, the Mediterranean, and parts of southern Asia. Several research on land use and land cover in high-elevation environments have been undertaken, with a focus on slopes, mountains, coastal regions, and raised terrains of various landscape patterns. Environment changes surely affect a place both positively and negatively. Yang, et al. (2019) replicated a land use transition in remote regions in the Ganjingzi District of China. They discovered that between 2000 and 2015, the overall landscape transformation happened in mostly agricultural farmlands and garden areas, which were converted to building land towards urban growth using a multiple Markov Chain sub-area composite model. Multi-state models are representations of a process, such as portraying the life history of a land, which can be in one of several stages at any given time. This might refer to a variety of probable situations for a single land or the interdependence of multiple actions (cf. Vassiliou and Georgiou, 2021). It should be highlighted that the application of this paradigm can help with land use planning.

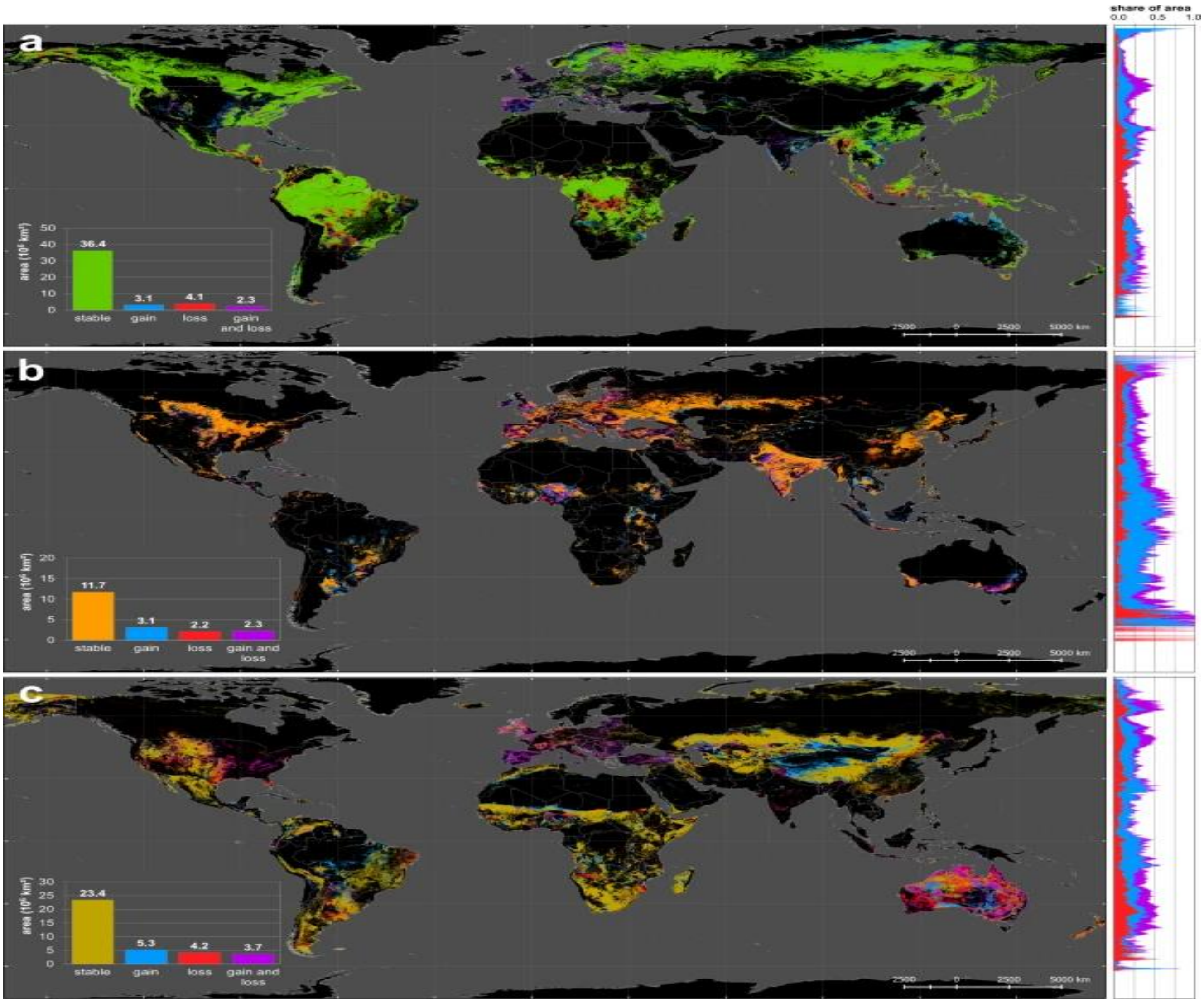


Figure 2. 4 Spatial distribution of a forest, b cropland, and c pasture/rangeland extent (stable area) and change (gain and loss) between 1960 and 2019.

2.2.7: The impact of Land Use, Land Cover change

From the previous section, researchers agreed that changes in land use and land cover have an impact on watershed runoff, microclimatic resources, land degradation processes, landscape biodiversity, soil erosion, and sediment load at the local level and downstream flooding. Whilst land use and land cover impact local communities widely, this section focuses on flood impacts caused by land use land cover changes. The influence of land use changes on flood risk is now a central feature of flood management discussions. Numerous studies have been carried out to understand how land use changes, deforestation, Urbanisation, and agricultural practices, may increase the occurrence and intensity of floods, together with exposure and vulnerability of people thereto (Ramesh, 2013). The relationship between land use and land cover, and how they cause flooding exists at various levels. There is evidence that land use changes have altered runoff generation processes and the flooding regimes of river basins by reducing rainwater infiltration and increasing surface runoff (cf. Bronstert et al 2001, Ghosh and Dutta, 2011, Ramesh, 2013, Beckers et al, 2013, Santato et al, 2013). The removal of vegetative cover and greater cover of impervious surfaces inhibits infiltration and significantly increases surface runoff volume and peak discharges, consequently raising the risk of urban flooding (Li et al., 2019). For example, Miller and Hess (2017) identified the impact of urbanisation on runoff generation from storm events along a rural-urban gradient in the south of the UK and observed clear differences in hydrological response between rural and urban catchments.

One of the critical concerns of the world today is land use/land cover change because of the consequences they have on weather and climate, surface run-off with erosion and flooding, ecological biodiversity, and socioeconomic and health (cf. Lambin et al., 2003). This is largely because land use/land cover change has considerable effects on the bio-physical, bio-geophysical, bio-geochemical, and hydro-meteorological processes (cf. Abubakar et al., 2002; Ndabula et al., 2013). This means that land use change and cover affect the nature of the life of organisms, the physical environment, the nature of chemical components of the organisms that dwell in this natural environment, and the nature of rainfall and consequently flooding. This flooding comes through critical watersheds that people rely on ordinarily for their livelihoods (Flotemersch, et al., 2019). However, they are also channels for persistent flooding. Urban watersheds, on average, lose 90% of the storm rainfall to runoff, whereas non-urban forested watersheds retain 25% of rainfall

(Shang & Wilson, 2009). Changes in land use associated with urban development affect flooding in several ways. Removing vegetation and soil, degrading land surface, and constructing drainage networks increase runoff to streams from rainfall and snowmelt. As a result, the peak discharge, volume, and frequency of floods increase in nearby streams. Changes to stream channels during urban development can limit their capacity to convey floodwaters. Roads and buildings constructed in flood-prone areas are exposed to increased flood hazards, including inundation and erosion, as new development continues. Some consequences of flooding on individuals and communities include loss of human life, damage to property, destruction of crops, loss of livestock, and deterioration of health conditions owing to waterborne diseases. As communication links and infrastructure such as power plants, roads, and bridges are damaged and disrupted, some economic activities may come to a standstill, people are forced to leave their homes, and normal life is disrupted. Similarly, disruption to the industry can lead to loss of livelihoods. Damage to infrastructure also causes long-term impacts, such as disruptions to the supply of clean water, wastewater treatment, electricity, transport, communication, education, and health care (Wilson, 2009). Loss of livelihoods, reduction in purchasing power, and loss of land value in the flood plains can leave communities economically vulnerable (Echendu, 2020).

Several studies on land use and land cover change in the Niger Delta have been reported in the literature. For instance, Mmom, (2008) investigated the impact of land use change on urban floodplains in Port Harcourt Metropolis. Chukwu-Okeah and Mmom, (2012) studied the implication of land use change on hydro-meteorological events in Port Harcourt, Rivers State, Nigeria. Kurotiminipre and Winston, (2013) investigated land use and land cover changes between 1998 and 2008 in Yenagoa but not much has been done on the land use and land cover change impact on flooding along Epie Creek. The study utilised NVIVO 14, a Collaborative, qualitative analysis software with Powerful Statistics and Interactive Visualization to Make Informed

Decisions Quickly. The study of land use/land cover change is important to have proper planning and utilization of natural resources and their management.

Pattison and Lane, (2012) reviewed relationships between land-use change and downstream flood risk. They pointed out that while it is common to find an association between land-use change and stream flow behavior at field and plot scales, it is quite challenging to upscale this effect to show similar hydrological responses for large catchments. The impact of anthropogenic changes on the hydrology of developing watersheds can be measured in terms of the ratio: flood peak after development to flood peak before development over a range of return periods (Kibler et al., 2007).

Drawing a link between flooding and land use/cover changes is not limited to Nigeria and Africa alone. The first experimental investigation, in which a proposed land use change was carried out to allow observation of its impacts on river flows, began in 1910 at Wagon Wheel Gap, Colorado. According to Piereira (1973), river flows from two basins were compared for eight years. The recordings were then compared after clearing one valley. After the clear falling, the annual water supply was 17 percent more than expected based on the valley's flows. Peak flows have also risen.

In another study, Gilbert (1971) proved that hydraulic mining in the Sierra Nevada Mountains of California in Western North America resulted in massive silt deposits in the range's river basin. This alone boosted the river's bed level, altered the channel layout, and resulted in the flooding of unaffected territories before then.

In other instances, Knox (1972) determined that land use changes in the upper Grant River watershed, which is a tributary in Southwestern Wisconsin, US following European settlement enhanced highland erosion and run-off and resulted in significant changes in stream and floodplain morphology.

Swank and Douglas (1974) found that changing one forest type for another had an impact on stream flow. In his work, Tollan (2002) found that land use change effects on floods are most pronounced at small scales and for regular flood magnitudes, citing the Norwegian HYDRA research program on human impacts on floods and flood damage.

Wegehenkel, (2002) used a conceptually hydrological model to investigate the influence of afforestation and found a substantial decrease in discharge and a rise in evaporation for a semi-humid mesoscale watershed in Eastern Germany.

Weissman et al. (2004) studied the link between land cover changes and flood outflows in the Cedar River (United States of America) watershed between 1991 and 1998, before settlement. The study concluded that the flow was higher in 1991 and 1998 than it was before 1991 and that the risks of flooding are increasing as land cover changes. Furthermore, according to the CEC (2004) and the UN (2018), the main driving force of flood disaster damage in Europe is not growing danger, but increasing susceptibility, owing to substantial construction in flood-prone areas. Similar findings were reported by Ott and Uhlenbrook (2004). Below is a summary of studies of relevant literature on the impacts of land use/cover change on the environment.

Table 2.4 Relevant literature on land use and cover.

Author and Year	Title of the Article	Research Objective	Significant Findings
Roy et al., (2024)	Dynamic assessment and prediction of land use alterations influence on ecosystem service value: A pathway to environmental sustainability.	This study investigates LULC changes in Dhaka City, Bangladesh, from 2010 to 2021 and forecasts their future impacts on ES in 2030 and 2040.	Results showed an increase in built-up areas from 31% to 42% between 2010 and 2021, with a projected decrease to 34% and 32% in 2030 and 2040, respectively. Water bodies, vegetation, and agricultural land declined from 2010 to 2021 but are expected to increase in 2030 and 2040. This trend indicates a growing awareness of the

			need for a sustainable environment and resilience in urban ecosystem development
Winkler et al., (2021)	Global land use changes are four times greater than previously estimated.	"Quantifying the dynamics of land use change is critical in tackling global societal challenges such as food security, climate change, and biodiversity loss."	This study estimates that land use change has affected almost a third (32%) of the global land area in just six decades (1960-2019) and, thus, is around four times greater in extent than previously estimated from long-term land change assessments.
(Brown et al., 2022)	Dynamic World, Near real-time global 10 m land use land cover mapping	"A review on change detection method and accuracy assessment for land use land cover"	The findings revealed that unregulated Urbanisation, poor planning laws, corruption, and a poor waste management system are the major causes of flooding in Nigeria.
Barati et al., (2023)	Interactions of land-use cover and climate change at a global level: How to mitigate the environmental risks and warming effects.	"To investigate the interactions between LUCC and climate change over the period of 1966–2015 (50 years) as a complex system at the global level. CO_2 emissions and surface temperature are considered as the main indicators of climate change (CC). ".	The results showed that arable and rangeland use changes (LUC) affect CO_2 emissions in both direct and indirect ways. However, the direct effect of rangeland use change is positive, and its indirect effect is negative. In addition, deforestation has increased CO_2 emissions indirectly.
Wang et al. (2023)	Land cover change in global drylands: A review	"Identifying land cover change in drylands"	While most studies found that drylands were experiencing vegetation greening, some evidence showed decreases in vegetation and large increases in bare land due to inconsistencies in the datasets and the study phases. the dominant factors affecting land cover change in drylands are precipitation, agricultural

			activities, and urban expansion.
Gaur & Singh, (2023)	A Comprehensive Review on Land Use/Land Cover (LULC) Change Modeling for Urban Development: Current Status and Future Prospects	"To review existing LULC modeling techniques and novel approaches used by the research community and compare each technique's applications, utility, drawbacks, and broader differences"	The findings will help researchers and policymakers to achieve better land management practices and assist in achieving Sustainable Development Goal-15 (SDG-15) (i.e., life on land).
Rosan et al., (2021)	A multi-data assessment of land use and land cover emissions from Brazil during 2000–2019	''An evaluation of LULCC datasets for Brazil, including those used in the annual global carbon budget (GCB), and national Brazilian assessments over the period 2000–2018.''	Results show that the latest global HYDE 3.3 LULCC dataset, based on new FAO inventory estimates and multi-annual ESA CCI satellite-based land cover maps, can represent the observed spatial variation in LULCC over the last decades, representing an improvement on the HYDE 3.2 data previously used in GCB.
Ma et al., (2024)	Land use/land cover change and soil property variation increased flood risk in the black soil region, China, in the last 40 years.	"To quantify the water yield response to long-term land use/land cover change and soil property variation in agricultural regions is critical for flood risk control."	The results showed that cultivated land and urban land expanded from 1980 to 2020. The plant available water capacity decreased by 2.10% and 7.27% in the black soil area and typical black soil area, respectively, and the water yield increased by 5.52% and 8.49% in the black soil area and typical black soil area, respectively
Rashidiyan & Rahimzadegan, (2024)	Investigation and Evaluation of Land Use–Land Cover Change Effects on Current and Future Flood Susceptibility	"The study aimed to predict LULC of the future using land change modeler (LCM), and then investigate the effects of LULC changes on the flood	The findings demonstrated the performance of the LCM method in forecasting the LULC map and the capability of the selected ML algorithms to produce flood susceptibility maps in the study area.

		susceptibility map using ML algorithms in the Talar watershed, Iran."	
Tola & Deyassa, (2024)	A modeling approach for evaluating and predicting the impacts of land use land cover changes on groundwater recharge in Walga Watershed, Upper Omo Basin, Central Ethiopia	" The research aimed to understand and predict the impacts of LULC changes on groundwater recharge in Walga watershed."	The evaluation of LULC changes pointed out that the Walga watershed has undergone high-intensity LULC changes (1990–2021) due to anthropogenic activities and is predicted to instantly change in the coming (2021–2035). The hydrological assessments indicate that groundwater recharge has declined over the last three decades by 20.84 mm and is predicted to decline in the future (2021–2035) by 6.17 mm.
Amanze C. T. et al., (2024)	Effects of Land-use Systems and Depths on Organic Carbon Storage and Texture-related Properties of Soil at Umuahia, Nigeria	"To examine the effect of land-use systems and depths on organic carbon storage and texture-related properties of soil"	The results showed that the lowest bulk density (BD) in the range of 1.26 – 1.60 mg/kg was obtained under OP at 0 – 100 cm. The most rapid hydraulic conductivity (Ksat) in the range of 3.62 – 1.90 cm/hr was obtained under AFL at 0 – 60 cm. The oil palm plantation had the highest range of organic carbon (OC) storage of 51.92 – 30.81 ton/ha at 0 – 40 cm, while at 40 – 100 cm, FL had the highest range of OC storage of 22.33 – 13.42 ton/ha. The undisturbed soils had higher OC storage and reduced BD at the various depths.
Ahmad et al., (2023)	An analysis of LULC changes for understanding the impact of anthropogenic activities on food	''The objective of this study is to investigate the effects of urban development on food security parameters in the Dudhganga	The results indicate a 21.66% increase in barren areas, at the expense of snow-covered lands, during the 2000–2020 period. The primary land cover

	security: a case study of Dudhganga watershed, India.	watershed area, India, from 2000 to 2020, by evaluating LULC changes''.	transition observed is towards barren areas.

2.2.8: Importance of GIS in Land Use and Flood Management

GIS and the remote sensing component have long been accepted as a useful technique for land cover mapping (Kushwaha, 1990; Townshend et al., 1991; Cihlar, 2000), and it is now a potent tool for evaluating rapid land use issues because of urban growth (Kushwaha, 1990; Townshend et al., 1991; Cihlar, 2000). (Alberti et al., 2004). Remote sensing and geographic information systems (GIS) are the finest approaches for analysing land cover and changes of geographic phenomena in connection to land use and land cover changes, as well as quantifying these changes currently (Popovici et al., 2013). The use of remote sensing and geographic information systems (GIS) in the assessment of land use changes is growing over time (Asnawi & Choy, 2016; Gulinck et al., 2001; Mousazadeh et. al., 2015; Padonou et. al., 2017; Pasha et. al., 2016; Sabr et. al., 2016; Sari & Ozsahin, 2016; Serra et al., 2008; Waser and Schwarz, 2006). The various governments of the world and scientists are confronted with a general shortage of high-quality data on the types and scope of land use changes, as well as far less systematic data on the sources and impact of these interventions. According to Loveland et al. (2002), a lack of reliable local, regional, and national data, as well as chronological and geographic details, might lead to the failure of a project. Remote sensing images and geographic information systems (GIS) can be particularly useful in detecting the spatial component of floods for management. Remote sensing provides a comprehensive picture of the geographical distribution and dynamics of hydrological events like flooding and erosion. They are used to quantify the land area and infrastructures impacted by flooding and erosion, as well as to monitor and evaluate the extent of flooded areas (Izinyon, 2011). GIS is a useful and efficient way of evaluating the world and provides a variety of skills for handling tasks. Whether it’s streamlining logistics for transportation businesses or tracking the location of equipment using Internet of Things sensors, GIS continues to innovate. Geographic Information Science and Technology (GIST) plays a vital role in scientific research, with a wide range of applications in earth science for spatial data and visualizations. Professionals who collect, analyse, modify, and interpret geographic data using these methods can reveal amazing insights about our globe and even other worlds. When you look at how GIST is used in different domains, geospatial thinking is becoming increasingly important for expanding our worldview of earth science and exploring newer ways of investigation.

Experts in geographic information systems (GIS) map out aspects of the earth’s surface and provide advice on natural resource management. The availability of open data portals means that geologists all over the world have access to a wealth of useful information. The United States Geological Survey, for example, offers a diverse set of GIS data to scholars and Organisations, including topographic details for the entire country and interactive maps of the North American shoreline. It is feasible to estimate subsurface water flow or analyze the stability of terrain for oil and gas exploration using comprehensive spatial information. In the mining business, where mineral exploration using remote sensing and GIS leads to effective exploration, geospatial data, and spatial reasoning are especially essential. Companies generate maps with surface features and use spectrum analysis to look for evidence of chemical reactions to determine where deposits are most likely to be found. Leaders can work quickly and make informed choices on where to drill because of substantial data and the ability to use spatial thinking abilities.

Environmental mapping, flood control, mineral exploration, hurricane predictions, agriculture, forestry, geology, water, oceans, infrastructure, strategic planning, rescue operations, and management, all rely heavily on remote sensing and Geoinformation. For the past few decades, remote sensing, and geographic information systems (GIS) have become important tools for gathering data on every aspect of the world. Satellite data with extremely high spatial and spectral resolution has become available in recent years, and applications for many purposes have developed. For the past four decades, remote sensing and geographic information systems (GIS) have played a vital role in India's development efforts. In addition, GIS can be utilized for a variety of purposes relating to groundwater occurrences and movements. One of the key advantages of combining GIS with water modeling systems is that simulated results may be geo-referenced, permitting more in-depth study and visualization of the model and topological relationships with other visual objects. How the GIS application works is different from traditional cartographic frameworks, which get real-world data and store them in a fixed form without processing it digitally. GIS takes information from the real world as raw data, then, the application processes them as digital images with varying outputs depending on the target of the research.

In the context of the current study, the GIS application would be deployed to obtain land use changes by looking at the difference in land cover over time. This will then be correlated with flood frequency and level to determine how it may have impacted flooding along Epie Creeks in Nigeria. In Nigeria, GIS application has been used by a few studies to investigate flooding and how to mitigate it in various parts of the country but not in Epie Creek, which is my focus area in this study. For example, Clement (2013) applied the GIS to the mapping of seasonal flooding in Makurdi, North Central Nigeria. He found that GIS mapping technologies are critical in assessing flood risk zones. The study concludes that Makurdi town is at risk of flooding in the event of a protracted or strong downpour, which might cause flash floods and force the river Benue to overflow its banks. As a result, places near the banks of the river Benue should be avoided at all costs to prevent properties and human lives from being harmed by floods, as these communities have been discovered to be particularly vulnerable.

In another study, Ezekiel (2018) carried out a study that compared the GIS images of flooding in Nigeria in 2012 and 2018. The study relied on the images from the Nigerian Satellite Vision, which the study revealed is what has been guiding the government in distributing relief materials and emergency rescue operations. The study, however, is thrilled by the fact that this information is usually not at the disposal of the teeming population, which stays in this flood-prone environment as they are usually caught in the flood disaster.
Both images were retrieved from the GIS application and they both show an extremely elevated level of increase and impact of the flooding situation in Nigeria. However, only a few Nigerians have access to these images, and they do not reflect the widespread nature of flooding in all parts of the country in detail. A study such as the present can mirror an area (Epie Creek) and present more succinct images.

Nigeria has been slow to recognize the possibilities of remote sensing and geographic information systems (GIS) in disaster mitigation. The response to the past flood disasters, which impacted more than 23 states across the country, took many lives destroyed property, and jeopardized natural biodiversity, demonstrates this. Only when precise knowledge of the projected frequency, type, and scale of hazardous events in an area, as well as the sensitivities of people, homes, infrastructure, and commercial sectors in a lethal location, can flood disaster mitigation be successful. Sadly, in most cities in developing countries, such as Nigeria, specific knowledge is always inadequate (Ishaya et al, 2009). The above makes the application of the GIS in the present study suitable and apt as more data for flooding caused by land use and land use changes are needed.

2.4: Land Use Policies, Application, and Challenges

Land-use policies refer to deliberate efforts by governments to control the use and ownership of land in a country. In Nigeria, land use policies play a crucial role in guiding sustainable development, managing natural resources, and fostering equitable land distribution. One notable policy is the Land Use Act of 1978, which vests all land within each state in the hands of the state governor. This act regulates land tenure, land administration, and the allocation of land for various purposes, aiming to prevent land speculation and ensure efficient land use planning (Oluwasegun & Ayoade, 2017).

Additionally, the National Urban Development Policy of 2012 provides a comprehensive framework for urban planning and development, emphasizing the need for integrated land use management, infrastructure provision, and environmental sustainability. This policy seeks to address the challenges of rapid urbanization, informal settlements, and inadequate infrastructure by promoting participatory planning processes and land regularization initiatives (Oni, 2016).

Furthermore, the Environmental Impact Assessment (EIA) Act of 1992 mandates the assessment of potential environmental impacts of proposed projects before approval, ensuring that development activities are carried out in an environmentally sustainable manner. For example, in the oil and gas sector, the EIA process is used to evaluate the environmental implications of exploration and production activities, helping to mitigate adverse effects on local ecosystems and communities (Osinowo et al., 2019).

Overall, these land use policies in Nigeria aim to balance the competing demands of economic development, environmental conservation, and social equity, providing a legal framework for sustainable land management and spatial planning. However, challenges remain in terms of enforcement, stakeholder engagement, and capacity building, highlighting the ongoing need for effective implementation and governance reforms (Oni, 2016; Oluwasegun & Ayoade, 2017). The high prevalence of poverty in slums, coupled with the absence of clear legislation regarding land rights, has led to significant social conflicts related to land (Azadi, 2020).

Kryspin-Watson et al., (2017) observed that cities should combine land-use policies that address the nature of flood dangers in a community. Also, these policies should be largely community-acceptable, can be enforced with local funding and technological capability, and be incorporated across sectors of the economy, geographic scales, and stakeholders (such as local government, the private sector, and NGOs) (Kryspin-Watson et al., 2017, p. 23). Every country faces difficulties in planning, implementing, and enforcing risk-based land-use plans.

To succeed here, the political backbone and continuous interactions with citizens (often in the aftermath of a recent flood disaster), education of decision-makers and communities about the role of land use plans in flood risk management, constructing technical and governance capacity to manage planning processes, and coordination among various stakeholders and formal and informal organisations would be greatly needed. (Kryspin-Watson et al., 2017, pp. 23-24).

It is widely addressed in related previous studies ((Critchley et al., 2023; Lawry et al., 2023; Adekola et al., 2023; Azadi, 2020) that land policies, land management laws, and guidelines in Sub-Saharan African countries, particularly in West Africa, are wide-ranging but unorganized, and that urban design laws have been fragile and unable to protect settlements in low-lying areas, floodplains, and wetlands (Ouikotan et al., 2017). National policy in Kenya, for example, specifies a 6 to 30m zone along riverbanks upon which most permanent structures are considered unconstitutional, but this has been demonstrated as unworkable, and many people have settled in this area within shantytowns such as Nairobi's Kibera settlers; one estimate in 2009 recommended that implementing this policy would necessitate evictions (Mulligan et al., (2016, pp. 271– 273, 276).

In Nigeria, the land use policy is documented mainly in the Land Use Act of 1978 in which it is stated that the ownership of land belongs to the state governments through individuals and organisations can be granted sole rights of ownership and they may also wish to resell the lands to other individuals or organisations. However, when the states need any land for public use, the state can take any, paying the right compensations as deemed fit. The act also maps out the areas to be used as building sites following standard town planning rules.

The problem however in a town like Nigeria is the ability to implement many of these plans. This has led to people building in waterways hitherto not designed for residential buildings. The effects are what is seen in the recurring flooding in many urban cities in Nigeria. Land-use policies and new construction regulations are significant instruments for reducing the danger of flooding in cities (cf. Jha et al., 2012, p. 35). Once rapid Urbanisation compromises natural runoff and storage space, increases impermeable cover, limits soil infiltration, and contributes to urban slums in flood-prone places with no infrastructure or social networks to buffer the impact of natural risks, flood risk intensifies (Kryspin-Watson et al., 2017, p. 3).

Land-use policies in poor nations like Nigeria are frequently hampered by unplanned settlements and uncertain land ownership, as well as a lack of ability and resources to build standard houses that can withstand frequent floods. Building low-standard houses may not be fully attributed to the poor nature of most Nigerians that reside in these areas but also the fault of approving agencies, who in most cases do not go through the rigor of physical inspecting construction at different stages of execution of the building if it meets the approved standard or limit.

The fast and massive encroachment of communities to the low-lying wetland areas in Calabar, Nigeria, without building permits has boosted flooding susceptibility; in most cases, the land selection procedure is informal, with local leaders and even state officials acting outside of the formal (lawful) process (Adekola et al., 2020, p. 842). Likewise, in Ibadan, Nigeria, where statistics from the Oyo State Government in 2011 revealed 26,553 houses inside the authorized legal distance of waterways, development in coastal areas and other wetland regions is a significant flood risk issue (Egbinola et al., 2017, p. 551). There is therefore a need for proper land use planning and management.

Land use planning is defined as

"The process by which public bodies identify, assess, and decide on different options for the use of land, taking into account long-term economic, social, and ecological goals, as well as the implications for various communities and special interests, and the consequent formulation and codification of plans that define the permitted or appropriate uses" (UNISDR, 2009, cited in Kryspin-Watson et al., 2017, p. 4).

The ideals of safe location, safe building design, and safety actions are used in land use planning to decrease flood risk while maximizing economic and recreational advantages and ecosystem services. These principles include managing the type, density, and timing of growth; lowering bad design and development and supporting constructions or designs that are modified to deal with floodwater; and controlling proper land use. Spatial plans, which direct land-use predicated on flood risk analysis; regulatory tools such as zoning (to assign floodplains or open spaces) and building regulations through imposing adherence has been challenging; economic instruments like land-based funding and performance rewards; and influencing commuting patterns are all examples of land use tools used to control flood risk (Kryspin-Watson et al., 2017, p. 2).

A 2019 study used systematic literature to investigate the cost-benefit of flood zoning initiatives from all over the world, and after evaluating 445 reports on zoning policies, only nine studies presented benefit-cost analyses, all of which looked at instances in the United States, Canada, or the Netherlands (Hudson & Botzen, 2019). In the end, the study shows that the average benefit-cost ratio across all these case studies was 3.9 (Hudson & Botzen, 2019), with lows of 0.61 (for one research that did not evaluate environmental benefits) and highs of 20.2 (Hudson & Botzen, 2019). When both environmental and economic implications are evaluated, the findings show that zoning regulations have good cost-benefit results, although they point out that in some of the research, the reviewer did not consider the full array of diverse costs (or in some cases, benefits). The fact that they did not consider the full array of diverse costs may be because it was not part of their scope, which limits their findings. They point out that the research on cost-benefit analysis of zoning and land-use policies for handling flood risk is constrained, possibly due to the difficulty of simultaneously assessing the environmental, social, and economic effects of a changing land and supplying financial value for both market and non-market effects, possibly given the complexity of jointly considering potential, social, and economic consequences of a change in land-use and offering financial value both for the global economy and non-market implications (Hudson & Botzen, 2019, p. 17). It is worth noting that while such a cost-benefit analysis has been done for most developed nations of the world, sadly, it is not the same for developing nations like Nigeria. A study that investigates the benefits of efficient land use and land cover systems in developing countries is important because it can provide the needed information for policymakers and advocacy groups to work with. It is in that purview that the present study is relevant in the field of flood study.

In another study, Ologunorisa (2009) investigated the land-use policies that can be implemented in the Niger Delta region of Nigeria to stem the tide of frequent flooding. The study notes that land-use zoning is required in the Niger Delta. Ologunorisa (2009) observed that new regulations in the use of land can be divided into three categories: The first is the legal means for enforcing land zoning and other rules that restrict functional use of land (kind of activity), density, and the pace of development. The second is taxation mechanisms to direct development away from high-risk areas, and the last is the government action needed to acquire land through compulsory purchase and change existing land use. It is critical to understand that land-use policy and regulation govern not just the sort of development specified by disaster risk assessment, but also the pace or rate of development. Land-use regulations for flood risk management are one of the factors in the suggested paradigm of development plans for the land, and it is a technical issue of major significance that should be complemented by stringent land development regulations. Furthermore, the importance of following building codes cannot be overstated. Building codes should be considered an important part of flood disaster avoidance.

These codes, which apply to buildings and structures, provide standards for design, construction, operation, and upkeep, all of which are linked to the building's expected lifetime. Well-designed buildings can help to reduce property losses during natural disasters. If the building is standard enough, the loss would be minimal; human suffering would be less, and recovery would be better.

However, it is saddening to note that most houses in the waterways of the Niger Delta region of Nigeria which the focused area of study falls into do not have the level of standard needed to withstand the amount of water from the persistent flooding. Most houses in these areas are makeshift tents, built on water and they can easily be washed away by a flood. In this context, the use of land, the building of houses, and the general structure of buildings may need to be regulated in the Epie Creeks axis if the risks from constant flooding are to be reduced.

2.4.1 Application and Challenges of Land Use Policies

2.5: Flooding and Flood Vulnerability

Flooding is an inevitable and natural part of the environmental cycle (Cullingworth and Nadine 2006). As such, there is no way of eliminating the risk of flooding, but the environment and human influence can affect the likelihood of flood disasters. Floods cause enormous damage around the world every year and the damage caused varies depending on the area affected and the origin of the flood itself. Floods may affect an entire region or a limited area and can cause numerous health-related problems such as infectious and waterborne diseases, disruption of services, and loss of crops due to submerged farmlands. It is a natural occurrence that is brought on by both natural processes and the actions of humans. Floods can cause both physical harm and severe damage to the surrounding ecosystem (Brisibe & Brown, 2019). Flooding can be caused by a variety of human activities, including the development of new residential areas, the increase in population, and changes in land use and land cover (LULC), all of which influence the hydrological cycle and the amount of water that is readily available. Because of these additional causes, there was a cumulative increase in the amount of runoff and infiltration that occurred. The amount of vegetation cover also influences the pace of evaporation, which in turn influences the relative humidity and the formation of clouds (Ali et al., 2021; Li et al., 2019; Schoener, 2018; Yao et al., 2017)). The land surface, the soil, and the vegetation can all have a significant impact on the flow of water through the hydrological system. Some of these characteristics include properties such as roughness, albedo (which is the fraction of sunlight that is diffusely reflected by a body), infiltration capacity, root depth, architectural resistance, leaf area index (LAI), and stomatal conductance (Brisibe & Brown, 2019). The influence of vegetation on hydrological flows can also be considered substantial. All three of these processes—runoff, infiltration, and groundwater recharge are affected by the characteristics of the environment and the land cover. In the process known as the water cycle, which refers to the recirculation of precipitation through the processes of evaporation, runoff, and soil infiltration, the surface of the soil plays a vital role. The surface type determines the amount of water that is absorbed or infiltrated, evaporated, or flowed as runoff.

2.5.1: Types of Floods

- Flash floods are rapidly flowing waves that destroy everything in their path. Heavy rains or a quick thaw of snow can result in flash floods. Flash floods typically last less than six hours, cover a small region and are unpredictable. Heavy items like vehicles, rocks, and trees can be moved by the raging water torrents.
- Coastal floods are caused by Storms or intense winds that approach a shore at high. The area is typically inundated when strong waves breach the dune or dike along the coast. The most vulnerable coastal areas are those with less fortifications and lower altitudes.
- River floods: The slow overflowing of riverbanks that occurs during river floods because of heavy rain over a long length of time. The areas affected by river floods vary depending on the river's size and precipitation levels. Although river floods seldom result in fatalities, they can nonetheless cause significant economic harm.
- Urban floods: When a city or town's drainage system is unable to adequately absorb the water from a strong downpour, urban flooding results. In an urban setting, poor natural drainage can also lead to flooding. Driving is quite unsafe due to water spilling onto the road. Urban floods can seriously harm structures even though the water is only a few inches deep.
- Pluvial floods: These occur in flat locations where the ground cannot absorb the rainwater. Pluvial flooding primarily resembles urban flooding.

The study area Epie Creek suffers from river, urban, and flash floods as Epie communities are linear settlements along the Epie Creek where people have encroached into the flood plains and built houses with no proper plan for drainage. The area is also susceptible to heavy rainfall.

2.5.2: Factors that Contribute to Flooding

Flooding is caused by several factors ranging from heavy rainfall, the release of water or failures of dams, natural water protection, and the change in land use and land use covers. Saru, (2012) classifies the causes of flooding into three categories: meteorological, hydrological, and human. He went on to explain that floods generated by meteorological events such as prolonged and intense precipitation, cyclones, typhoons, storms, and tidal surges account for most flood losses and damages. Meteorological floods, according to Hirschboeck et al (2000), occur when heavy precipitation over a watershed exceeds the capacity of the basin's storage space reservoirs and drainage network. Also, the increased runoff from ice and snow melt, impermeable surfaces, saturated ground, low infiltration rates, and land erosion can all contribute to flooding.

Greenhouse gases in water catchments exhibit anthropogenic influences, which dramatically increase the magnitude and intensity of storms in a variety of ways. As a result, human activities related to land use change, such as deforestation, intensive agriculture, and so on, are the most significant contributors to flooding, followed by population growth, socioeconomic and development activities, Urbanisation, climate change, and global warming. While some of these causes of flooding may affect some countries in some zones, especially developing countries, some causes tend towards universal effects. Future developments, according to Ezemonye and Emeribe, (2011), may lead to an increase in the global risk of flooding. Global warming's effects, such as rising sea levels, more intense precipitation, and larger river discharges, may increase the frequency and intensity of flooding on a global scale. Increased Urbanisation in emerging countries, as well as agricultural, residential, and industrial activity in coastal and river plain areas, are some of the key factors that will contribute to increased flood susceptibility. Floods occur when the soil gets saturated and its infiltration capacity is zero, runoffs are unable to be retained in stream courses, natural ponds, or artificial reservoirs, and the land surface is swamped, sweeping away all its contents. Floods occur on numerous rivers regularly because of severe rains, generating a region known as the flood plain. Global population expansion, increased Urbanisation in flood-prone areas, and a lack of long-term flood-control solutions will0020all exacerbate the potential repercussions of floods (cf. Jonkman, 2005).

On the other hand, different studies have investigated the causes of flooding based on the peculiarity and aim of their study. In a study that focused on the causes of constant flooding in Indonesia, Kodoatie and Syarief, (2006) observed that factors that cause floods include changes in land use and cover, 'waste management, erosion and sedimentation, slums along rivers, improper flood control systems, high rainfall, river physiography, inadequate river capacity, effects of high tides, land subsidence, water structures, and damage to flood control structures' (p. 1). However, Kodoatie and Syarief, (2006) note that in the context of Jarkater, Indonesia, people-built houses in areas marked out for the flow of water account for a more potent reason flooding occurs regularly in the country. This position is corroborated by Sholihah et al., (2020), whose study went a step further in investigating the impact and implication of the environmental law situation in the country and what can be done to those who block the waterways for their personal needs and satisfaction.

In another study, Braimah et al, (2014) investigated the causes of flooding in the Bolgatanga Municipality, Upper East, Ghana, and its effect on the people. The study employed a descriptive survey design that applied both the qualitative and quantitative methodologies of research. The study concluded that as many as 82% of respondents indicated a lack of drainage system, while 70% of them indicated improper waste or refuse disposal which implies that human causes such as building on waterways, and inappropriate disposal of waste are the major causes of flooding in the study area. while the data gathered from the respondents indicated otherwise. This may only point to the direction of failing infrastructure in the country as a contributory cause of flooding.

This applies to many developing countries. For example, Olawumi et al, (2015) studied the causes of flooding in the ancient city of Ibadan in Nigeria. The study deployed a questionnaire as a method of eliciting information from the affected residents on the causes of flooding in the city. Following the evidence from the data, many of the respondents attributed flooding to more than one cause, however, many went for both lack of drainage and buildings on waterways. On this basis, Olawumi et al. (2015) found that indiscriminate dumping of waste was the major cause of flooding in the Ibadan metropolis (accounting for 33.2%), followed by poor channelization of the drainage system (accounting for 29.4%), floodplain encroachment (19%), and pave surface (13.2%) and excessive rainfall (5.3%). In line with this, studies in developed countries have similar findings.

The European Environment Agency, (2001) stressed that the main driving forces behind floods are climate change, land sealing, changes in catchment and floodplain land use, population growth, Urbanisation and increasing settlement, roads and railways, and hydraulic engineering measures. In addition, the recent causes for frequent flooding in some areas are due to unplanned land use, construction, and operation of dams upstream. If a hydraulic structure is not designed properly then it could even lead to catastrophe - the dam can fail, the highway can be flooded, and bridges can collapse thus increasing the risk of flood (Gebeyehu, 1989). Despite this, the obvious reason for flooding especially in municipalities and coastal areas in Nigeria lies in the wide distribution of low-lying coastal areas and river floodplains, and because these areas have fast become a long-standing attraction for human settlement (Ologunorisa and Abawua, 2005). Other relevant studies of flooding in Nigeria are presented in Table 2.6 below.

Table 2.5 Summary of the major existing studies regarding floods in Nigeria.

Author and Year	Title of the Article	Research Objective	Significant Findings
Obi et al., (2021)	Indigenous flood control and management	‘‘To identify its effectiveness in risk reduction of flood	The result shows the existence of eight types of indigenous flood control and

	knowledge and flood disaster risk reduction in Nigeria's coastal communities: An empirical analysis	disasters in Nigeria's coastal communities''	management knowledge in the coastal communities, and they were 61.2% effective in flood risk reduction
Chioma et al., (2019)	Impacts of flood disasters in Nigeria: A critical evaluation of health implications and management	"To review flood disasters in Nigeria and how they have been managed over the past two decades"	This study found that flood-related health indicators are poorly managed and that flood response and planning are not well coordinated.
Echendu, A.J (2020)	The impact of flooding on Nigeria's sustainable development goals (SDGs)	"To highlight the impact flooding has on Nigeria reaching SDGs and enumerates the specific SDGs most directly impacted"	The findings revealed that unregulated Urbanisation, poor planning laws, corruption, and a poor waste management system are the major causes of flooding in Nigeria.
Daramola et al., (2022)	Recent retreat and flood-dominant areas along the muddy Mahin coastline of Ilaje, Nigeria	"To understand the present evolution of the coastal area to manage the environmental and human risks in the future."	In recent years, the retreat has dominated areas that were once accreting. It is interesting to note that some areas are gaining more land compared to those that have receded.
Obi et al., (2021)	Indigenous flood control and management knowledge and flood disaster risk reduction in Nigeria's coastal communities: An empirical analysis	"To examine indigenous flood control and management knowledge with the intent to identify its effectiveness in risk reduction of flood disasters in Nigeria's coastal communities"	The finding shows that indigenous flood control and management practices account for 61.2% of flood risk reduction strategies in coastal communities in Nigeria.
Ifetu, (20201)	Examination of international law and flood management	"To evaluate the efficiency and effectiveness of legal and institutional framework on flood-related disasters in Nigeria"	The findings revealed that effective disaster risk management at the national, regional, and global levels depends on disaster risk governance.
Buba et al., (2021)	Assessment of flood vulnerability in some communities in Lokoja, Kogi State, Nigeria, using Participatory	"To conduct a vulnerability assessment in Lokoja as a pre-flood strategy that involves the communities"	The results revealed that there is a strong correlation between flood vulnerability and elevation, as well as land use, among other parameters

	Geographic Information Systems		
Olufemi et al., 2020	Impacts of Flood on Food Crop Production and the Adaptive Measures Among Farmers in Northern Guinea Savannah of Agro-ecological Zone of Kaduna State, Nigeria	"To analyze the impact of the flood on food crop production and the adaptive measures among farmers in northern Guinea savannah of the agro-ecological zone of Kaduna State"	The findings revealed that flood has a multidimensional impact on crop production. The impact is viewed differently by farmers.
Cirella and Iyalomhe (2018)	Flooding Conceptual Review: Sustainability-Focalized Best Practices in Nigeria	"To utilize a conceptual framework to assess and identify areas within Nigeria prone to flooding and examine possible means of alleviating damage and harm"	The results of this study indicate that several factors contribute to the frequency of flooding, including different precipitation patterns, Urbanisation, and increased paved surfaces.
Ajaero, (2017)	A gender perspective on the Impact of flood on the food security of households in rural communities of Anambra state, Nigeria	"To examine gender perspectives of the implications of the severe 2012 flood on household food security in rural Anambra state, Nigeria"	The findings revealed that households in Nigeria may be able to remain food secure after future floods by diversifying their income away from agriculture, building early warning systems, and improving women's education.
Nkeki et al. (2013)	Geospatial Techniques for the Assessment and Analysis of Flood Risk along the Niger-Benue Basin in Nigeria	"To assess the spatial impact of the October 2012 flooding of the Niger-Benue basin on the surrounding areas"	The findings of this study indicate that flooding along the Niger-Benue basin can be mitigated and monitored using geospatial methods
Danhassan et al. (2023)	Flood Policy and Governance: A Pathway for Policy Coherence in Nigeria	''To examine and understand how flood governance and policy coherence are approached, as well as institutional design and implementation for coherence in Nigeria''.	The findings revealed that there is no single flood policy in Nigeria.

The compilation of research articles on flood control in Nigeria offers a complete overview of several issues about this crucial matter. The research undertaken by various authors over the years provides unique insights into indigenous knowledge, disaster risk reduction, health consequences, sustainable development goals, coastal evolution, vulnerability assessment, and policy coherence. The amalgamation of these articles highlights the intricate nature of flood management in Nigeria, requiring a comprehensive and unified strategy that considers local knowledge, health consequences, sustainable development objectives, coastal dynamics, gender viewpoints, geospatial methods, participatory approaches, and efficient policy coherence and governance.

2.5.3: Flood Vulnerability

Flooding is a yearly occurrence that threatens people's lives, natural resources, and the environment while also draining the economy and harming people's health. It is an unavoidable part of rivers and natural drainage systems everywhere. The frequency of flood occurrence is increasing all over the world and the concept of vulnerability has evolved during the last two decades. Due to an ever-increasing global population that is prone to natural catastrophes, such as floods, the consequences of floods have become more important in recent years. Most vulnerability assessments are designed to identify the necessary steps that may be performed to minimise vulnerability before the probable damage is realised by strengthening community resilience through adaptation and mitigation strategies (Ighile et al., 2022). Finding regions that are more vulnerable to flooding might lead to better decisions about how to deal with flood disasters.

Approximately 1.81 billion individuals, which accounts for 23% of the global population, reside in areas that are susceptible to a considerable degree of flood hazards. These areas are at risk of experiencing flood depths exceeding 0.15 meters during a 1-in-100-year flood event, or they face a minimum level of medium risk (Fig. 2.6). Put simply, with a worldwide population of 7.9 billion

(World Population, 2021), about 25% of the world's population faces substantial danger from flooding (Rentschler et al., 2022). According to the study by Rentschler et al. (2022), the East Asia and Pacific region, with a population of 668 million, has the largest proportion of people, almost 28% of the entire population, who are at serious risk of flooding. Within the South Asia region, a substantial flood risk affects 576 million individuals, which accounts for around 30.4% of the population. A considerable proportion, ranging from 9% to 20% of the populations in Sub-Saharan Africa, Europe and Central Asia, the Middle East and North Africa, Latin America, and the Caribbean, as well as the United States and Canada, face a substantial danger of flooding. Figure 2.6 presents a comprehensive analysis of regional exposure estimates, both in terms of absolute values and relative proportions. China, India, and Egypt specifically have a significant impact from regional exposure in East Asia and the Pacific, South Asia, the Middle East, and North Africa (Rentschler et al., 2022). (a) displays the proportion of the population that is subjected to flood risk of at least a moderate level at the subnational level.

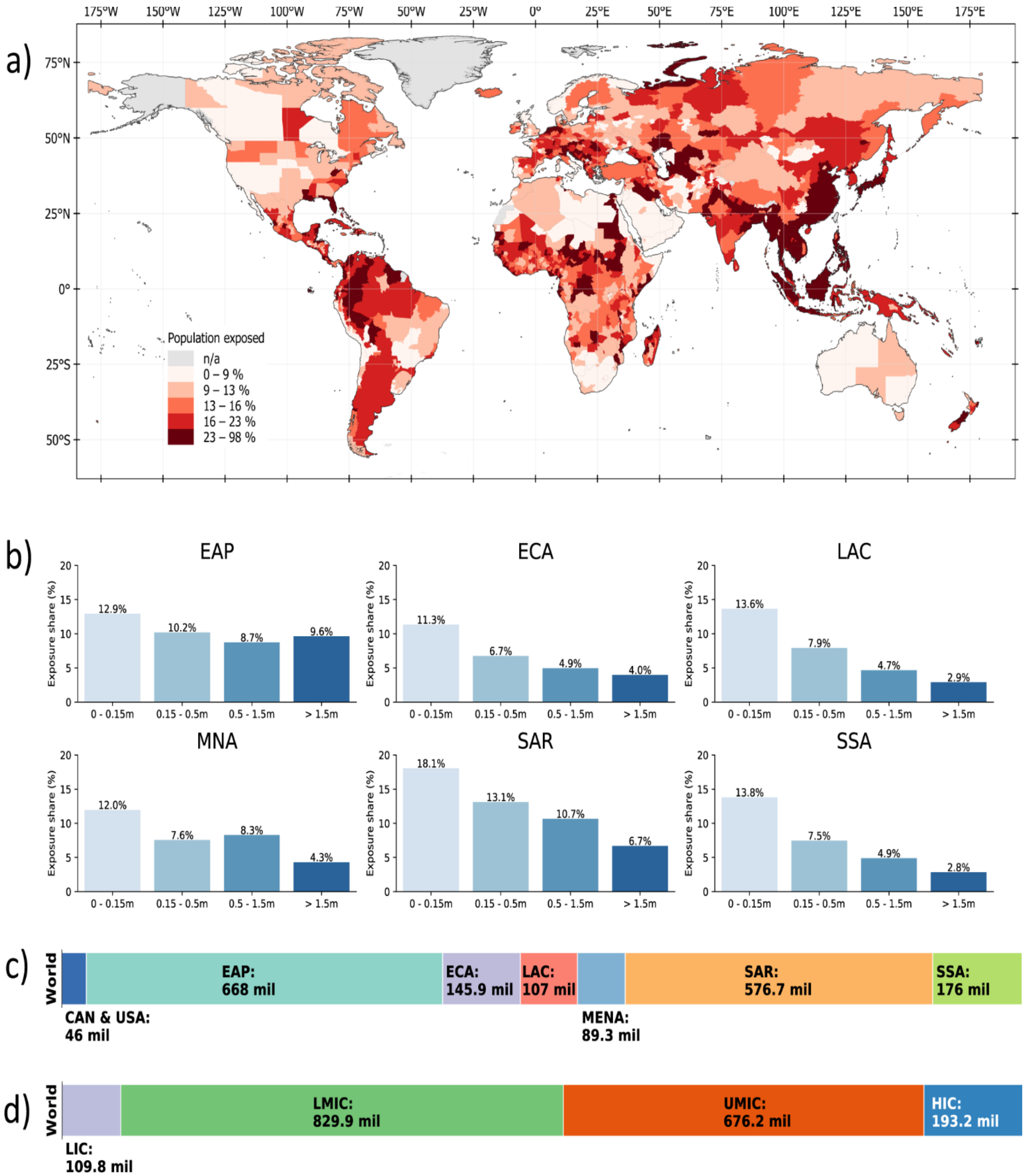


Figure 2. 5: Global population exposed to flooding (Rentschler et al., 2022).

Fig 2.6 above, (b) illustrates the proportion of the population that is subjected to varying degrees of flood risk in each geographical area. Figures (c) and (d) represent the aggregate number of individuals who are exposed to flood risk at a medium level. These figures are categorised based on geographical regions and the income classification of countries, respectively. EAP refers to the East Asia and Pacific region, ECA stands for Europe and Central Asia, SAR represents the South Asia region, SSA denotes Sub-Saharan Africa, MNA refers to the Middle East and North Africa, LAC is for Latin America and the Caribbean, and CAN and USA represent Canada and the United States. The United States and Canada are classified as high-income countries (HIC), whereas upper-middle-income countries (UMIC), lower-middle-income countries (LMIC), and low-income countries (LIC) are used to categorise other nations (Rentschler et al., 2022).

The concept of vulnerability is a wide, suitable approach for investigating the basic, direct, and indirect causation of flood disasters. Despite this, few vulnerability researchers explore the recurring impact of disasters on some places, as is the case with floods. Some of them are presented here as part of the review. Though it has been noted earlier that vulnerability is difficult to define as a concept, some researchers, such as Thywissen (2006) and Gaillard (2007), have offered a summary of the definitions (Wisner et al., 2012; Wisner et al., 2012). The United Nations International Strategy for Disaster Reduction (UNISDR) has a widely acknowledged definition of the term: "the conditions dictated by physical, social, economic, and environmental elements or processes that raise a community's sensitivity to the effect of hazards" (UNISDR, 2015, p. 10). Based on the above, Bang et al., (2019, p. 233) define vulnerability as 'determining sensitivity and exposure to specific perturbations, disturbances, and risks are referred to as vulnerability.'

Porio (2011) investigated the nature of vulnerability, adaptation, and resilience of poor households living in urban riverine towns in Venezuela. The study focused on 14 communities in 300 poor urban households for the survey. The selected communities were in what was identified as the flood basins of the country. The study found out that though poor households were targeted for the survey, the major population of the people who live in these riverine environments which have been identified as flood-prone are poor people. This may indicate the fact that the influential people in the society must have seen the dangers of living in such a flood-prone environment and they have the financial capacity to fund such relocation, but the poor cannot. Many of the households are low-income, live-in shantytown communities, and lack access to drinkable water, power, and health, sewage, and sanitation services. Furthermore, Porio (2011) observed that in the aftermath of each episode of flooding, typhoons, and tidal/storm, there are usually losses to about two-thirds of income, work, health/sickness, household appliances/things, and housing damage, but only a small portion of them received assistance from government and charitable agencies.

In terms of resilience, the government and the concerned households in the studied environment have developed adaptation techniques. Few local governments constructed river barriers, upgraded the drainage systems, deployed water diversion techniques and disaster warning systems, and strengthened their officials' capacity to help during evacuations. Meanwhile, some urban poor households have adapted to a "water-based lifestyle" (for example, raising the floors/increasing the number of floors of their homes, erecting impromptu bridges among households in swampy areas, and constructing Styrofoam boats for transportation). However, both urban poor residents and formal institutions (national agencies) require resources and competence building to strengthen their capacity to adapt to climate change's effects. While the response of the government may differ in locations, the response of people to flood disasters is mostly similar.

In a similar study, Bang et al., (2019) investigated the vulnerability and resilience to flooding in Africa with Cameroun as a focus point. The study was designed using qualitative and deductive methodologies and relied on secondary and empirical procedures, and semi-structured qualitative interviews, which were analysed by senior disaster managers. The outcomes of the study revealed

Northern Cameroon's physical and social susceptibility to flooding. The findings also reveal that Cameroon's institutional flood control performance is inadequate, and its adaptive capacity is severely lacking. From earlier investigations carried out in this review, it seems like a trend for governments of developing nations to be slow and inadequate in flood management especially when the vulnerability has been well-established. Also, the government and residents depend more on resilience and flood management in reaction to each episode of flooding instead of taking proactive measures like clearing drains and obstructions before the floods. However, on the part of the people, findings from Porio (2011) and Bang et al. (2019) establish the fact that it is instinctive for people to develop stronger resilience and coping strategies to flooding. The reactions and subsequent actions seem similar in both instances.

In a study, Taiye (2014) investigated the numerous ways through which local inhabitants in Nigeria cope with the vulnerability to flooding disasters. Taiye notes that these coping mechanisms can be grouped into five groups which include: technological/structural and social coping mechanisms. Economic coping mechanisms are defined as economic activity and diversity, which includes community tactics related to materials, goods, and resources, such as having many sources of income. The technological/structural coping mechanism considers actions that flood-prone families utilize to deal with flood liability. These include flood-resistant house construction and the use of materials that reduce flooding risks and damage. Residents in flood-prone places such as Lagos, Ibadan, and Abeokuta, for example, have begun to build buildings with reinforced materials and some with a 2nd floor to secure their livelihoods from flooding. The social/Organisational coping mechanisms are the activities and or social relationships and networks among the local community's government that can assist people in minimizing flooding risks and damage (for example, the provision of disaster relief and the institution of camps to accommodate refugees until the flood retreats).

In the study of vulnerability, much evidence from the literature shows a huge reliance on certain demographic and structure delineation which can reveal the extent to which a group is vulnerable and the nature of their resilience. Madajewicz (2020) notes that structures and demographic groupings are deployed in most cases to identify antecedent characteristics of populations that are thought to show the populations' vulnerability and resilience. The underlying human and societal capacities that drive vulnerability and resilience are assumed to be well-captured by the proposed groupings. The indicators are used by decision-makers to identify vulnerable people and the activities that are required to reduce vulnerability and promote resilience. Individual demographic and socioeconomic variables such as income, age, gender, and health status are the most prevalent markers of both susceptibility and resilience when it comes to flood disasters (cf. Clark et al. 1998; Wu et al.2002; Cutter et al. 2003, 2008, 2014; Sherrieb et al. 2010). According to Cutter et al. (2014), individual factors like those mentioned above reflect social and economic resilience, whereas other variables reflect communal, institutional, housing/infrastructure, and environmental resilience. Following the above, Ajibade et al. (2013) conducted a study to determine the vulnerability of women in the coastal city of Lagos, Nigeria to flash flooding. The study notes that the vulnerability is independent of gender. This implies that Nigerian women and men developed and executed similar coping strategies and strengths. However, the fact financial power is needed to bounce back from flood losses puts women from lower income in a group with a higher risk. This finding from Ajibade, et al. (2013) is in tandem with Madajewicz (2020), which focused on determining who is vulnerable to flooding using the Sandy Hurricane in New York as a case study. A point of difference would be that earlier cited works in the context of vulnerability have all focused on developing countries, but Madajewicz (2020) is dedicated to a developed country. Also, the findings are different because the variables are not the same. He used structural and demographic groupings to investigate the characteristics that frequently form the indices that reflect susceptibility and resilience to coastal flooding in metropolitan settings. The study by

Madajewicz (2020) creates vulnerability and resilience measures that are independent of proposed indicators and then utilizes regression analysis to see which indicators have an impact on these measures. Based on actual data documenting the consequences of and recovery from Hurricane Sandy in New York City, Madajewicz (2020) observed that middle and low-income homeowners are less financially resilient than poorer dwellers of the city. The recovery costs middle to low-income homeowners 2.4 times their annual per capita incomes, while renters had to pay out half of their incomes. Resilience rises with income, but only if you possess assets that are in jeopardy. Furthermore, many outcome indicators show that residents who are disabled or chronically ill are more vulnerable and less resilient to flood. Food access is disrupted more frequently in non-white households. Information, community groups' hazard-specific capacities, and pre-hazard access to resources like food and health care are all crucial markers of vulnerability. These findings show that independent of government interventions, people in developing nations and developed nations face various levels of vulnerability and resilience determined by clear demographic indicators, chief among which is the financial strength of the group involved.

In a study that attempts to establish a link between vulnerability to flooding, resilience, and adaptive capacity, Gallopin (2006) deployed a systemic perspective within the socioecological systems of flood disaster study to investigate the theoretical relationships between vulnerability, resilience, and the capacity to adapt. The model depicts a linked system of adaptation and resilience, which is a part of the capacity of response in a core situation where vulnerability is extremely high. The study then reveals that resilience and adaptability are two components of vulnerability linked to social systems' ability to restore stability and adjust to change. In addition, Gallopin (2006) considers social capital as a component of either "resilience" "vulnerability," or both. Vulnerability is defined as a system's tendency to undergo significant changes because of its interaction with external or internal processes or events, and is defined as a function of "sensitivity," "capacity of reaction," and "exposure." “Sensitivity” is defined as the degree to which a system is influenced or modified by an external or internal disturbance (Gallopin, 2006, p. 295), and is therefore distinct from the system's “capacity of response,” which is also distinct from “exposure.” The degree, duration, and/or extent to which the system is in contact with, or subjected to, any disturbances or perturbations is referred to as “exposure” (Gallopin, 2006, p. 296). Flood vulnerability remains a critical concern worldwide, exacerbated by climate change-induced extreme weather events and urbanization trends. Across regions, communities, and ecosystems, the vulnerability to flooding is influenced by a complex interplay of factors. One significant contributor to vulnerability is the increasing exposure of populations and infrastructure to flood-prone areas. According to recent studies, rapid urbanization has led to the expansion of settlements into floodplains and coastal zones, placing millions of people at heightened risk of flood-related disasters (Dilley et al., 2005). Moreover, the encroachment of infrastructure, such as roads, bridges, and industrial facilities, into flood-prone areas further amplifies the potential for severe impacts and economic losses.

Sensitivity to flooding is another critical aspect of vulnerability, shaped by factors such as building materials, construction standards, and socioeconomic conditions. Research conducted in flood-prone regions has revealed disparities in vulnerability, with marginalized communities often bearing the brunt of flood-related impacts due to inadequate housing, limited access to resources, and poor infrastructure (Brody et al., 2008). Vulnerable populations, including low-income households, elderly individuals, and people with disabilities, are disproportionately affected by flooding events, facing challenges in evacuating, accessing emergency services, and recovering from losses.

In addition to exposure and sensitivity, adaptive capacity plays a crucial role in determining flood vulnerability. Recent assessments emphasize the importance of proactive measures, such as early warning systems, community-based disaster preparedness initiatives, and ecosystem-based adaptation strategies, in enhancing resilience to floods (IPCC, 2019). However, barriers such as inadequate funding, institutional fragmentation, and limited public awareness continue to hinder effective adaptation efforts in many regions (Adger et al., 2005). Strengthening adaptive capacity requires integrated approaches that engage stakeholders, build local capacity, and promote sustainable land use planning and infrastructure development.

As communities grapple with the escalating risks of flooding, fostering resilience emerges as a key imperative for reducing vulnerability and enhancing long-term sustainability. The research underscores the value of holistic approaches that combine structural and non-structural measures, including green infrastructure, flood-resistant building designs, and community-based risk reduction strategies (UNDRR, 2021). By investing in resilient infrastructure, enhancing social safety nets, and fostering participatory decision-making processes, policymakers and practitioners can empower communities to withstand and recover from flooding events while promoting equitable and sustainable development paths.

2.5.4: Types of Vulnerability

This section explains what vulnerability is especially from the perspective of Cannon (2000). In the opinion of Cannon (2000) vulnerability can be deliberated in terms of five modules. These include Initial well-being: This assesses people's current nutritional and health (physically and mentally) status in ordinary life (or before the effect of a hazard). It reflects their ability to cope with the disease and some sort of injury because of a disaster such as a flood. Livelihood resilience: It is a measure of an individual's and/or their household's ability to cope with the consequences of a certain hazard and re-establish their earning or livelihood patterns. This could include their likelihood of continuing their jobs and businesses, their level of income and savings, the loss of welfare benefits, the death or injury of supportive family members, and hazard damage to their normal livelihood activity. Self-protection: This is focused on an individual’s personal or household's ability and willingness to provide proper protection, or to prevent working and living in dangerous areas (with a given level of knowledge of perceived risks). This will be impacted by people's ability to implement physical treatment and their depth of understanding of them. Societal protection: This relates to socio-political structures at political or social levels above the individuals or average household willingness to provide a defence (particularly structural and technological preparations) from specific threats. Local Governments, State Governments, the Federal Government, appropriate Organisations (e.g., Fire Departments, Civil Defence, NEMA, NGOs), and community-based initiatives are all examples of this. And then, social capital: Refers to the ‘soft' security offered by group or community capacities to improve (or decrease) a person's resilience. This could include the level of cohesiveness or rivalry in the group, which could hinder rescue and recovery efforts. Social support (belonging to a church or other group), some of which could provide humanitarian relief in times of distress, are examples of social assets that may help or hinder rehabilitation.

2.5.5: Impacts of Flooding

Flooding is a natural ecological process, and as such, it plays an important part in the process of bringing about biological diversity and productivity in the area that it affects. To put it more simply, it is nature's way of ensuring that the ecological balance of the earth is not disturbed. However, humans are more concerned about the negative impact of flooding because floods can result in adverse environmental degradation in addition to causing short-term damage to life and property. This is because flooding can result in adverse environmental degradation (Nkeki et al., 2022), and have the potential to cause extensive damage to the surrounding environment, which is difficult to repair. Because of this, it is necessary to have a solid understanding of the various mechanisms that can result in damage and to implement appropriate countermeasures to at the very least significantly mitigate this damage. Flooding is a natural phenomenon that might take place at any time. It has occurred ever since the beginning of recorded history, and it will continue to happen in the future as well but the effect of floods in less developed countries is more as they are linked to poverty, lack of knowledge, low livelihood sources, lack of insurance, weak institutions and above all, a lot of problems with emergency response and early warning preparation (Collins & Week, 2014).

When a region is hit by flooding, it has a devastating effect on the environment and the ecosystems that live there. They have an immediate influence not only on people but also on social life, the economy, and the environment. Floods can have both positive and negative effects, and these effects vary depending on the area affected, the depth of the water, the amount of time, and the speed of the water. Floods may be beneficial, for example, flooding may help transfer rare minerals from riverbeds to broad expanses of agricultural land, replenishing the rich topsoil that is necessary for optimum growth. This may be beneficial to both the environment and agricultural production. This may be to the advantage of both people and the production of agricultural goods. This sediment may also help to keep land above sea level by preventing subsidence and regenerating the top layer of the soil. This function is accomplished by a combination of factors. The procedure known as pedogenesis is responsible for this outcome. On the other side, flooding has the potential to hurt the environment of the surrounding area. This may have a terrible effect on the surrounding flora and fauna, leading to widespread starvation, pollution, and death.

The severity of the flood determines the number of people who are affected, while the total population of the areas affected by the flood determines the number of fatalities. More cases are likely to be reported in regions with higher population densities than in regions with lower population densities. Flooding along a riverbank occurs gradually and gives people time to move to safer areas, which in turn reduces the number of people who are killed or injured. On the other hand, people are likely to be caught off guard by flash floods, which results in a higher number of fatalities (Ighile et al., 2022).

Riverbanks are worn away when floodwaters move at a rapid pace. In such a scenario, developed and urban areas suffer the greatest impact. Rivers become clogged with sediment, which also reduces the capacity of wetlands and dams to store water. When floodwaters recede, they leave behind deposits containing many of the sediments they carried with them. Floods have the potential to have a significant negative impact on water quality, as well as on industrial use and the supply of water to humans. In areas that have been developed and populated by humans, flooding destroys property (Oladimeji & Ohwo, 2022). This may be the case in urban areas as well as plains. There is a break in the provision of necessary services such as the supply of potable water, electric power, and transportation. In many locations, floods cause different households to become inundated with water, and in the most severe cases, floods even carry them away. People and animals alike can suffer injuries and even perish because of floods.

Also, flooding can hurt the environment by leading to erosion and sedimentation of the soil, particularly in the areas along the riverbanks. When floods strike, the water level in the rivers rises to levels that are higher than the riverbanks, which causes widespread damage to the region's fertile topsoil. There is a significant chance that the soil will be washed away and carried away to another location, which increases the possibility that the land will lose its fertility permanently. On the other hand, sedimentation is yet another issue that the affected area might have to deal with (defese , 2020). This issue can result in the clogging of streams and riverbeds, in addition to a reduction in the capacity of wetlands and riverbeds to store water. The accumulation of sediment over time pollutes the water supply, which in turn endangers the natural habitat that exists in and around riverbeds. Extreme sedimentation can also have a momentary impact on the water supply that is used for municipal, industrial, and recreational purposes in areas that have been flooded.

The quality of life of the livestock and humans who live in an area can be negatively impacted by flooding, which can spread local pollutants throughout the region. When floodwater flows quickly through an area, it carries debris and pollutants in the ground with it and distributes them all over the region that has been flooded. Some of these pollutants could be harmful chemicals, pesticides used in agriculture, or industrial wastes that would otherwise be localized in the areas where they were produced (Damachi, 2022). However, if they are carried downstream by floodwater, they have the potential to contaminate the ground and the water in distant areas. The contamination of the flooded area with toxic chemicals poses a threat to the human and animal life that resides there. In addition, floodwaters can do severe harm to the environment that is situated surrounding highly inhabited locations. This damage may include the loss of wildlife and vegetation. This is because large volumes of water have the potential to wreak havoc on sewage systems, which may then result in the discharge of raw sewage into the surrounding environment. This is a threat since it will increase the number of germs and pollutants that are found in lakes and other natural environments. It is possible for agricultural chemicals such as fertilizers and pesticides, in addition to other types of pollutants such as paint, gasoline, or diesel, to make their way into the habitats of various species of wildlife. This can result in significant problems for the animals that make those habitats their home. The same floods that assisted in the preservation of healthy topsoil minerals may have the reverse impact if they brought filthy water with them as they moved through an area. The repercussions of this might be devastating. Even after the floodwaters have receded, the contaminated soil and other silt may get attached to grass or plants, which are subsequently ingested by grazing animals such as sheep and cattle. Other silt may also become attached to plants.

There is nothing that people can do to stop natural disasters like floods, earthquakes, cyclones, or volcanic eruptions from happening. These cataclysmic events are predictable, but there is nothing that can be done to stop them from happening. As a result, it is essential to acquire knowledge regarding the potential dangers posed by such catastrophes to lessen the impact they have.

2.6: Flood Risk Frameworks and Models

Urban areas are becoming more vulnerable to flooding because of global warming, which can have disastrous consequences in terms of human life and property damage. As a result, accurate assessments of urban flood processes and improved pre-disaster mitigation strategies are critical. Users of urban flood modelling can analyse, evaluate, and predict flood conditions and their consequences. It is challenging to select the right model for a given context, especially when it comes to modelling floods in urban areas. Flooding is a hydrological phenomenon of extreme magnitude. Humanity's greatest challenge is coping with the destructive power of floods (Nkeki et al., 2022). Extreme flood events have become increasingly common. China for instance because of its geographical location has been plagued by floods for a long time, posing a serious threat to the country's long-term social and environmental progress. Effective flood management methods urgently need to be implemented to minimise the losses caused by floods, which not only has an important theoretical contribution but also strong practical significance. Non-engineering measures used in flood simulation and management include hydrological and hydraulic models, which are the most used.

Flood risk reduction frameworks are critical for mitigating the impacts of flooding, which is increasingly prevalent due to climate change and urbanization. Despite the proliferation of various frameworks, there are notable deficiencies that hinder their effectiveness. Many existing frameworks often lack comprehensive integration of local knowledge and fail to address socioeconomic disparities, which are crucial for sustainable risk reduction (Jongman et al., 2012). Furthermore, the focus on structural measures, such as levees and dams, often overshadows nonstructural approaches like community-based risk management and policy interventions (Di Baldassarre et al., 2015).

One major deficiency in current frameworks is the inadequate incorporation of real-time data and advanced modeling techniques. Traditional methods rely heavily on historical data, which may not accurately reflect future flood scenarios exacerbated by climate change (Kundzewicz et al., 2013). This can result in either overestimations or underestimations of flood risk, leading to inefficient allocation of resources. Advanced frameworks should integrate real-time monitoring and predictive modeling to enhance the accuracy of flood risk assessments. This dynamic approach allows for timely adjustments and more effective preparedness and response strategies (Mazzorana et al., 2014).

Additionally, many frameworks do not sufficiently engage local communities in the planning and implementation process. Community engagement is vital for ensuring that risk reduction measures are culturally appropriate and socially accepted. It also helps in harnessing local knowledge, which can be invaluable in identifying vulnerable areas and effective mitigation strategies (Few et al., 2007). Frameworks that prioritize top-down approaches often miss out on these critical insights, resulting in measures that may be technically sound but practically ineffective or poorly received by the community. Detailed explanations of flood models and frameworks and their existing gaps are presented below.

2.6.1: The Hydrological Model

A hydrological model is a mathematical representation of the water cycle processes within a watershed or river basin. These models simulate the movement, distribution, and quality of water across various components of the hydrological system, including precipitation, evaporation, infiltration, runoff, and groundwater flow. They are essential tools for understanding and predicting water resource dynamics, flood risks, and the impacts of environmental changes. Hydrological models aid in the planning and management of water resources, helping to inform decisions related to flood control, irrigation, water supply, and environmental conservation. By integrating various data inputs and utilizing complex algorithms, hydrological models provide critical insights into how natural and anthropogenic factors influence water behavior and availability (Beven, 2012; Singh & Woolhiser, 2002).

2.6.2: Hydraulic Model

The Hydraulic model focuses on the behaviour of water within river channels and floodplains. They consider factors like channel geometry, riverbed characteristics, and flow dynamics to simulate how water levels change during flooding. This model with greater accuracy has been developed because of advances in numerical simulation technology and systems theory. (Aprioku & George, 2020). Hydraulic properties can also be better simulated by these models, which can provide more hydrological spatial information. As remote sensing and 3S (GIS, RS, and GPS) technology have improved in recent years, hydrologists and hydraulic researchers have begun to pay more attention to 2D models, and hydraulic models have grown rapidly in sophistication.

2.6.3: Integrated Water Resource Management (IWRM)

Integrated Water Resource Management (IWRM) is a holistic approach to managing water resources sustainably and equitably. It recognizes that water is a finite and vulnerable resource, essential for human well-being, economic development, and the health of ecosystems. IWRM seeks to balance the competing demands for water among various users and uses, considering both the quantity and quality of water, while also considering social, economic, and environmental factors.

The framework of integrated water resources management contains the idea of flood management as one of its core components. The latter encourages the coordinated management of water resources to maximise the resultant economic and social welfare without jeopardizing the viability of ecosystems. This is done in the name of optimizing the overall economic and social welfare (Nkeki et al., 2022). This concept is supported by Integrated Flood Management (IFM), which seeks to maximise the overall benefits derived from flood plains while simultaneously minimising the number of lives lost.

2.6.4: Integrated Flood Management (IFM)

Integrated flood management is a holistic approach to flood management that emphasizes collaboration, sustainability, and a holistic understanding of the entire process. It considers all aspects of flood-related issues, including prevention, preparedness, response, and recovery. The idea of integrated flood management is predicated on the concept of the river basin as a one-of-a-kind dynamic system. Within this system, interactions between the land resources and the water resources ensure that every change affects the other components, either positively or negatively. Below in Fig 2.7 shows Integrated Flood Management as any intervention to improve the use of the assets of the river must consider the fact that flood risk and its consequences cannot be completely controlled. The idea of integrated flood management (IFM) therefore introduces a novel idea, which is that although lowering the number of fatalities should continue to be the top priority, the objective of lowering flood losses should take a back seat to the overarching goal of making the most of floodplains (Damachi, 2022).

Figure 2. 6: Flood Risk Management model (Damachi, 2022)

Integration is the defining characteristic of Integrated Flood Management (IFM), and in this sense, integration can refer to both the horizontal and the vertical directions. The first one refers to a decision-making process that involves multiple sectors, while the second one involves an approach that is both participatory and transparent. Collectively, they materialise in a variety of forms, including a suitable combination of strategies, carefully selected points of intervention, and suitable types of measures for both structural or non-structural, short, or long-term. The objective of the Associated Programme on Flood Management (APFM), which is a joint initiative of the World Meteorological Organization (WMO) and the Global Water Partnership (GWP), is to promote the concept of Integrated Flood Management (IFM) as a novel approach in dealing with and coping with floods. To accomplish this objective, it acts as a facilitator of dialogue and offers guidance on flood management to governmental agencies, the National Meteorological and Hydrological Services (Ohwo, 2018). To be more specific, the objectives of the APFM are to encourage the implementation of Integrated Flood Management principles (IFM) which involve diverse stakeholders, preserving ecosystems, adopting adaptive management, focusing on risk reduction and risk management, and integrating flood management into sustainable development goals. IFM encourages multi-sectoral collaboration across sectors, focusing on early warning systems, capacity building, and clear legal frameworks. It is crucial for addressing challenges posed by floods, especially in the context of climate change and Urbanisation. By adopting IFM principles, communities and governments can work together to build resilience, reduce vulnerabilities, and effectively manage flood risks.

2.6.5 The SENDAI Framework

The Sendai Framework for Disaster Risk Reduction 2015-2030 stands as a pivotal global agreement, emphasizing proactive strategies to reduce the impacts of natural disasters and enhance resilience. Developed by the United Nations Office for Disaster Risk Reduction (UNDRR), the framework outlines seven targets to guide nations in mitigating disaster risk and building resilience at local, national, and international levels. With its focus on understanding risk, strengthening governance, investing in resilience, and enhancing disaster preparedness, the Sendai Framework provides a comprehensive blueprint for sustainable development in the face of escalating disaster risks (UNDRR, 2015).

Recent studies underscore the significance of the Sendai Framework in shaping disaster risk reduction (DRR) efforts worldwide. Research highlights the framework's role in promoting a paradigm shift from reactive emergency response to proactive risk reduction and resilience-building strategies (Kellett & Caravani, 2019). Furthermore, the framework's emphasis on inclusive, community-driven approaches has been lauded for empowering vulnerable populations and fostering social cohesion in disaster-prone regions (Mercer et al., 2021). By integrating disaster risk reduction into broader development agendas, the Sendai Framework facilitates synergies with climate action, sustainable development goals, and poverty alleviation efforts, thus promoting holistic and resilient development pathways (UNDRR, 2021).

Despite its overarching goals, challenges remain in the implementation of the Sendai Framework. Recent assessments highlight the need for enhanced monitoring, evaluation, and reporting mechanisms to track progress towards the framework's targets effectively (Scheer et al., 2020). Additionally, ensuring adequate financial resources and technical capacity at the national and local levels is crucial for translating policy commitments into tangible action on the ground. Moreover, fostering international cooperation and knowledge-sharing platforms is essential for leveraging lessons learned and best practices in disaster risk reduction, ultimately advancing the objectives of the Sendai Framework on a global scale (UNDRR, 2021).

Efforts to mitigate flooding in Nigeria encompass a variety of strategies, including structural interventions like dams, bridges, and drainage systems, as well as policy formulation, social measures, and research initiatives (Olorunfemi, 2011; Odunuga, 2008; NIHSA, 2013; Obeta, 2014). These endeavors involve a collaborative approach involving government ministries, local communities, humanitarian organizations, and international bodies, as well as the media and academia. The institutional framework for flood management in Nigeria, dating back to the inception of disaster management in the country, predominantly involves agencies and departments under the Federal Ministry of Environment (FME), such as the Federal Emergency Management Agency (FEMA), National Emergency Management Agency (NEMA), State Emergency Management Agency (SEMA), and others (Ibitoye, 2007).

Under the coordination of NEMA, specific actions to address flooding in Nigeria include policy development, data collection, public education, distribution of relief aid to affected populations, and environmental protection efforts enforced through relevant agencies like NESREA. Furthermore, the Nigerian Meteorological Agency (NIMET) and the Nigerian Hydrological Services Agency (NIHSA) play crucial roles in providing hydrological data, flood forecasts, and weather reports to support flood preparedness and response efforts nationwide (Ibitoye, 2007).

Through these coordinated measures, Nigeria aims to enhance its resilience to flooding and minimize the adverse impacts on communities and the environment.

This study's proposed framework addresses these deficiencies by integrating real-time data analytics, advanced predictive modelling, and active community participation. Research evidence suggests that incorporating these elements significantly enhances the effectiveness of flood risk reduction measures. For instance, a study by Lyu et al. (2018) demonstrated that frameworks utilizing real-time data and predictive models could reduce flood damage by up to 30% compared to traditional methods. Additionally, community-based approaches have been shown to increase resilience and recovery speed post-disaster, as highlighted by Allen (2006).

Furthermore, it emphasizes the importance of socioeconomic considerations in flood risk reduction. By adopting a more holistic approach that includes socioeconomic vulnerability assessments, we ensure that the measures are equitable and benefit all segments of the population. This is crucial for addressing the disparities often observed in flood impacts, where marginalized communities tend to suffer disproportionately (Cutter et al., 2003). Our approach not only aims to reduce flood risk but also to promote social equity and resilience, thereby providing a more comprehensive and effective solution to flood risk management. Below in Table 2.6 Are some frameworks on flooding and their gaps.

Table 2.6 Summary of some frameworks on flooding and existing gaps.

S/N	Framework	Details	Gaps
1.	Integrated Flood Management Framework (IFM)	The Integrated Flood Management Framework (IFM) emphasizes the holistic management of floods by integrating various aspects such as land use planning, infrastructure development, and community participation (UNESCO, 2006).	Lack of comprehensive implementation due to challenges in coordinating across sectors and stakeholders.

2.	Multi-Hazard Early Warning Systems	Multi-Hazard Early Warning Systems utilize technology and community engagement to provide timely and accurate warnings for multiple hazards, enabling proactive measures to reduce risk and enhance resilience (UNDRR, 2015).	Inadequate coverage and accessibility of early warning systems in remote or vulnerable areas.
3.	Disaster Risk Reduction Framework	Disaster Risk Reduction Framework aims to minimize vulnerabilities and enhance capacities to cope with disasters through measures such as risk assessment, preparedness planning, and community empowerment (UNDRR, 2005).	Insufficient emphasis on addressing underlying drivers of risk, such as poverty, inequality, and unsustainable development.
4.	Climatic Adaptation Strategies	Climatic Adaptation Strategies involve adapting infrastructure, policies, and practices to mitigate the impacts of climate change, including increased frequency and intensity of flooding events (IPCC, 2014).	Limited consideration of non-climatic factors influencing vulnerability and adaptation options.
5.	Community-based Flood Management	Community-based Flood Management involves empowering local communities to take an active role in flood management through measures such as community-led early warning systems, land use planning, and disaster preparedness training (UNESCO-IHE, 2011).	Limited engagement and empowerment of marginalized or vulnerable groups in decision-making processes.
6.	Sustainable Urban Drainage Systems (SUDS)	Sustainable Urban Drainage Systems (SUDS) manage surface water runoff in urban areas using nature-based approaches such as green roofs, permeable pavements, and constructed wetlands, promoting sustainable water management and reducing flood risk (CIRIA, 2015).	Inadequate enforcement and compliance with SUDS regulations and guidelines, leading to inconsistent implementation and maintenance.
7.	Resilience based approach	Resilience-based Approach focuses on building the resilience of communities and ecosystems to withstand and recover from flood events by enhancing adaptive capacity, strengthening social networks, and promoting ecosystem services (UNISDR, 2016).	Challenges in balancing short-term disaster response with long-term resilience-building efforts, requiring flexible and adaptive approaches.

8.	Nature-based Solutions (NBS)	Nature-based Solutions (NBS involve using natural processes and ecosystems to address flood management challenges, such as restoring wetlands, implementing green infrastructure, and promoting natural floodplain storage, providing multiple benefits for both people and the environment (IUCN, 2020).	Uncertainty regarding the long-term maintenance and management requirements of natural infrastructure.

2.7: The Relationship between land use, land cover, and flooding

Changes in land use and land cover in upstream watersheds will modify the features of drainage systems, causing these systems to have an impact on surface overflow and the infiltration capacity of a land surface. Both factors are variables that contribute to flooding (Nkeki et al., 2022). Changes in land use and land cover in downstream watersheds will have the same effect. Extreme climatic conditions, such as those that cause significant rainfall in particular portions of the Indonesian archipelago, are also contributors to the regular occurrence of flooding in watershed areas (Ighile et al., 2022). These conditions can be found in other places across the world. In addition to being linked to conditions upstream, such as land use and land cover change (LULC), these floods are also associated with the climates of the affected areas (Ali et al., 2021). The occurrence of floods is becoming a problem not just in Indonesia, but also on a global scale as a direct result of the disturbance that has occurred in the ecosystem. A change in land use patterns has occurred because of the growing demand for land for agriculture and other land uses. This shift in land use patterns is the most significant reason for concern over the occurrence of frequent flooding. Since Indonesia has been experiencing severe rainfall as of late, accurate information regarding the danger zone that has been supplied by LULC is necessary for the country (Ighile et al., 2022). During the rainy season, LULC may make floods and erosion of riverbanks worse; however, during the dry season, it may cut down on the amount of water that is available in the area. Flooding is a natural occurrence that is brought on by both natural processes and the actions of humans. Floods can cause both physical harm and severe damage to the surrounding ecosystem (Brisibe & Brown, 2019). Flooding can be caused by a variety of human activities, including the development of new residential areas, the increase in population, and changes in land use and land cover (LULC), all of which influence the hydrological cycle and the amount of water that is readily available. Because of these additional causes, there was a cumulative increase in the amount of runoff and infiltration that occurred. The amount of vegetation cover also influences the pace of evaporation, which in turn influences the relative humidity and the formation of clouds (Ali et al., 2021). The land surface, the soil, and the vegetation can all have a significant impact on the flow of water through the hydrological system. Some of these characteristics include properties such as roughness, albedo, infiltration capacity, root depth, architectural resistance, leaf area index (LAI), and stomatal conductance (Brisibe & Brown, 2019). The influence of vegetation on hydrological flows can also be considered substantial. All three of these processes—runoff, infiltration, and groundwater recharge are affected by the characteristics of the environment and the land cover. In the process known as the water cycle, which refers to the recirculation of precipitation through the processes of evaporation, runoff, and soil infiltration, the surface of the soil plays a vital role.

Rapid population development has led to significant growth of urban lands as well as rapid reduction of agricultural land, along with floodplains, water bodies, and wetland areas, all of which have extensive impacts on the dynamics of floods (Fantaye, 2022). In addition to this, the expansion of urban areas and the development of infrastructure are both linked to alterations in hydrological and ecological systems, the removal of drainage systems, besides an overall rise in the likelihood that certain areas will be flooded. Even though flooding cannot be stopped entirely, efforts can be made to reduce the harm it causes to both people and property by locating flood-prone areas and the factors that contribute to it. The process of urbanisation invariably entails the transformation of the natural environment into an environment created by humans (Arya & Singh, 2021). This contributes to changes in land use besides land cover patterns and in the landscape besides the hydrology of areas that have been developed. These changes, in turn, harm the natural environment since these changes always tend to arise in the trouble of the delicate ecosystems in which the natural environment exists and strives to maintain its equilibrium. Additionally, because of the changes, the land that was previously utilised for things like natural ecosystems may be transformed into impervious land (Eteh et al., 2021). This can make people more susceptible to flooding, which can result in losses of both people and property.

Concentrating human populations and things of value in regions that are prone to natural disasters such as earthquakes, floods, storms, and tornadoes is risky (Nkeki et al., 2022). Furthermore, the expansion of the city unquestionably necessitates the creation of a circumstance in which the natural environment is converted into built surroundings. The rise in the number of urban centres is correlated with a decline in the amount of previous land available for things like grass, vegetation, wetlands, and forests (Ali et al., 2021). The situation is favourable for flooding for the straightforward reason that the improved resistant land for streets, roads, and arrangements keeps runoff confined in the urban developed area following heavy rainfall for enough time until flooding occurs. On the other hand, flood prevention measures in already developed areas and those that are still in the planning stages need more consideration. It may be possible to make existing developed land cover, such as buildings that are already located in flood hazard zones, flood-proof to reduce the amount of damage that floods cause to properties. By avoiding floodplains and/or incorporating necessary drainage measures to construct flood-proof facilities, newly developed areas may be able to make provisions for flooding during the initial design and construction of structures (Daramola et al., 2022). These preparations may take place during the design and construction phases.

2.8 Multistakeholder Perspectives in Flood Management

Flood management is a complex challenge that requires the involvement and cooperation of multiple stakeholders, each with unique roles, perspectives, and expertise. Understanding and integrating these diverse viewpoints is crucial for effective flood risk reduction.

2.8.1 Identification and Roles of Different Stakeholders

Stakeholders play different roles in flood management. In Nigeria, the roles of Federal, State, and Local governments are distinct yet interconnected, each playing a crucial part in flood management. Understanding these roles is essential for stakeholders involved in flood management, including policymakers, emergency responders, urban planners, and community leaders.

2.8.1.1 Government Agencies:

Government bodies at various levels (local, state, and national) are typically responsible for policy formulation, land use planning, and emergency response. These agencies provide regulatory frameworks and resources necessary for flood risk management (Kundzewicz et al., 2018). For example, the U.S. Federal Emergency Management Agency (FEMA) plays a critical role in floodplain management and disaster response (FEMA, 2019).

2.8.1.2 Community Members:

Local communities are often the most affected by flooding and thus have vital insights into local conditions and vulnerabilities. Community involvement is essential for the successful implementation of flood management strategies, as local knowledge can enhance the effectiveness of these measures (Alexander et al., 2016). Community based flood risk management (CBFRM) approaches, such as those implemented in parts of Southeast Asia, have shown the benefits of engaging local populations in planning and decision-making (Chan et al., 2019).

2.8.1.3 Businesses and Industry:

Businesses, particularly those in construction, insurance, and real estate, have a significant stake in flood risk management. These sectors can contribute to resilience by adopting and promoting flood-resistant designs and practices (Surminski et al., 2015). Insurance companies, for example, can provide incentives for risk-reducing behaviors through premium adjustments and innovative insurance products (Surminski & Hudson, 2017).

2.8.1.4 Nongovernmental Organizations (NGOs):

NGOs often play a crucial role in advocacy, education, and the implementation of community-based projects. They can bridge gaps between government agencies and local communities, ensuring that vulnerable populations are represented in flood management processes (Sayers et al., 2013). The role of NGOs in disaster risk reduction has been highlighted in various global frameworks, including the Sendai Framework for Disaster Risk Reduction (UNISDR, 2015).

2.8.2 Stakeholder Engagement in Flood Risk Management

Effective flood risk management requires a participatory approach where stakeholders are actively involved in the planning and decision-making processes. This engagement ensures that the diverse needs and perspectives of all parties are considered, leading to more sustainable and acceptable solutions (Reed, 2008).

2.8.2.1 Collaborative Planning:

Collaborative planning involves stakeholders working together to develop flood risk management plans. This approach promotes shared understanding and ownership of the strategies developed. In the Netherlands, the Room for the River program exemplifies successful collaborative planning, where stakeholders, including government agencies, local communities, and environmental groups, work together to create innovative flood management solutions (Warner et al., 2018).

2.8.2.2 Public Participation:

Public participation is essential for enhancing the legitimacy and effectiveness of flood management policies. Techniques such as public meetings, workshops, and participatory mapping allow community members to contribute their knowledge and preferences to the planning process (PahlWostl et al., 2007). Involving the public early and throughout the process can build trust and ensure that the measures adopted are socially acceptable (Reed, 2008).

2.8.3 Case Studies of Successful Multi-Stakeholder Collaborations

2.8.3.1 Thames Estuary 2100 Project, UK:

The Thames Estuary 2100 project is a comprehensive flood risk management plan developed through extensive stakeholder engagement, including local authorities, businesses, and residents. The project aims to protect London from tidal flooding through adaptive management strategies that account for future uncertainties such as climate change (Environment Agency, 2012).

2.8.3.2 Flood Resilience Program in Gorakhpur, India:

In Gorakhpur, a city prone to flooding, a multistakeholder approach involving local government, communities, and NGOs has been implemented to enhance urban flood resilience. The program focuses on building community capacity, improving drainage systems, and integrating climate adaptation into urban planning (Shaw et al., 2016).

By incorporating the perspectives and expertise of various stakeholders, flood risk management strategies can become more comprehensive, resilient, and sustainable. Effective engagement ensures that the measures adopted are well-informed, widely supported, and capable of addressing the multifaceted nature of flood risks.

2.9: Development of Initial Conceptual Framework

A conceptual framework is an essential aspect of research as it gives a clear picture of the research processes in terms of suggested goals, constructs, and concepts to be investigated, and variables under inquiry (Berman & Smyth, 2015). The researcher's integration of a literature review on how to explain the occurrence is described in the conceptual framework. It elegantly depicts the necessary actions mostly during an investigation and is based on the author's prior knowledge of other researchers' perspectives and observations concerning research. It illustrates, either visually or in narrative form, the essential objects to be researched — the key aspects, constructs, or variables – and the sensed relationships that exist among them (Miles & Huberman, 1994). It means the phenomenon under a study, where researchers can explain the primary concepts pertinent to the study, as well as how the ideas are connected, and the contexts under which the notions and interconnections are stated to be true, according to Yin (2003b).

Though weather patterns are the primary causes of flooding, changes in land cover can have an impact on the incidence and frequency of floods by altering river flow responsiveness to rainfall. Land use and land cover are not a constant phenomenon, rather they are dynamic. Their changing features and effects are determined by many factors. The framework adopted for this study seeks to focus on these factors that portray land use and cover as dynamic tools or signals towards the establishment of the relationship between land use, land cover, and incessant flooding in the study area.

In trying to establish a link between flooding, land use, and land cover, a logical route could be an examination of the factors that cause the ever-changing nature of the last two phenomena (land use and land cover). As a result, conducting such research would necessitate a conceptualization of what can cause floods in the study area, as well as the known drivers of land use and land cover. This could also mean a comparison of the situation before now and an inquiry into what must have changed in the study area that can cause flooding. To ascertain land change, land use map changes from 1986, 2001, and 2020 were mapped.

The Intergovernmental Panel on Climate Change, (2007) in its report agreed that the World's climate is changing and during the next few decades, global environmental changes are expected to have major impacts on ecological, social, and economic aspects of human society. The ecological impacts of climate change include shifts in vegetation types and associated impacts on biodiversity (National Assessment Synthesis Team [NAST] 2001; Elliott & Baker 2004); decline in water quantity and quality (Gutowski et al. 2008; Milly et al. 2008); change in forest density and agricultural production (Adams et al. 1990; Smith et al. 2007); expansion of arid land (Woodhouse and Overpeck 1998; Karl et al. 2009); effects on aquatic species and ecosystems (Environmental Protection Agency [EPA] 2007, 2008); and stresses from pests, diseases, and wildfire (Alig et al. 2004; Gan 2004). Therefore, an understanding of the anthropogenic causes of land-use change like socioeconomic and political factors is necessary to manage ecological functions effectively on regional and global scales.

Based on history, changes in LULC and modifications by man to gain the fundamental resources for his survival have been a long-standing tradition, but the rate of LULC change has risen dramatically because of the human population growth and high socio-economic demands. Hence, Ellis, (2001) noted that land-use changes have led to significant changes in ecosystems and environmental processes at local, regional, and global scales, such as biodiversity loss, global warming, and flooding. According to Liang, Li, and Wang, (2012), studies focused on land use and land cover changes have been on since the 1970s because the phenomenon has a direct relationship with many of the world's basic features and processes, which includes 'the productivity of the land, ecosystems, and biodiversity, the biogeochemical and carbon cycles, water and energy cycles, and climate variability and change' (p. 763). In particular, the mitigation potential of land use activities, including those related to forests and agriculture, has been recognized as essential in meeting climate targets under the Paris Agreement, making land use a vital component of many international policy debates (Winkler,2021). The unprecedented urbanization recently has inevitably intensified the changes in land use morphology. However, current studies on land use primarily analyze a single morphology, ignoring the relationships between different land use morphologies (Ma, 2022). The study of land use and land cover changes (Henceforth, LULCC) is targeted at an understanding of the causes and direct effects of human and non-human use of land and the natural and artificial cover on land.

Although land that is managed sustainably has the potential to help mitigate the effects of global warming, changes in land use are currently one of the most significant drivers of climate change. Alterations in land use are a significant contributor to emissions of greenhouse gases like carbon dioxide, nitrous oxide, and methane and are responsible for an estimated 23 percent of the world's total greenhouse gas emissions (Mushtaq et al., 2022). As shown in Fig 2.1, studies by Fernandes et al., (2020); Hurtt et al., (2020); Sleeter, (2018), Bradshaw et al., (2007); Depicker et al., (2021); Tanyas et al., (2022) have established the link between climate change and land use\cover. Change in land use contributes to climate change and this has been studied with suggestions to practice better land management to mitigate global climate change issues.

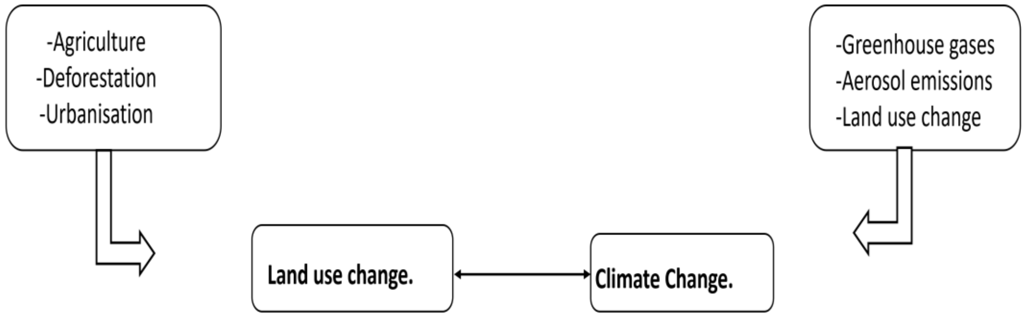


Figure 2. 7: Developing Conceptual model showing a link between land use change and climate change.

Mango et al., (2011) show that Change in land use affects flood frequency and flood area of a river. Wan and Yang (2007) also established that anthropogenic land-use change is one of the major drivers of an increased frequency of flooding incidents. Flooding which is the most frequently occurring natural disaster is also affected by Global climate change impacts such as heavy rainfall and ice melts and this is a global challenge. According to the World Health Organisation, between 80-90% of all documented disasters from natural hazards during the past 10 years have resulted from floods, droughts, tropical cyclones, heat waves, and severe storms. Floods are also increasing in frequency and intensity, and the frequency and intensity of extreme precipitation are expected to continue to increase due to climate change. Therefore, one common impact that land use and climate change have is on flooding. As shown in Fig 2.2, flooding disasters affect people in numerous ways including destruction of properties, loss of life, and source of livelihood (WHO, 2019). Arnall et al., (2013), examined how and why people's livelihoods change because of resettlement and concluded that the ability to secure a viable livelihood was a key determinant of whether resettles remained in their new locations or returned to the river valleys despite the risks posed by floods. Mahmoud et al. (2023), and Luo et al. (2022) brought to light the impacts of flooding on people's livelihoods. Both studies agreed that natural hazards like flooding affect the livelihood and social life of people in communities by disrupting the process of growth and development.

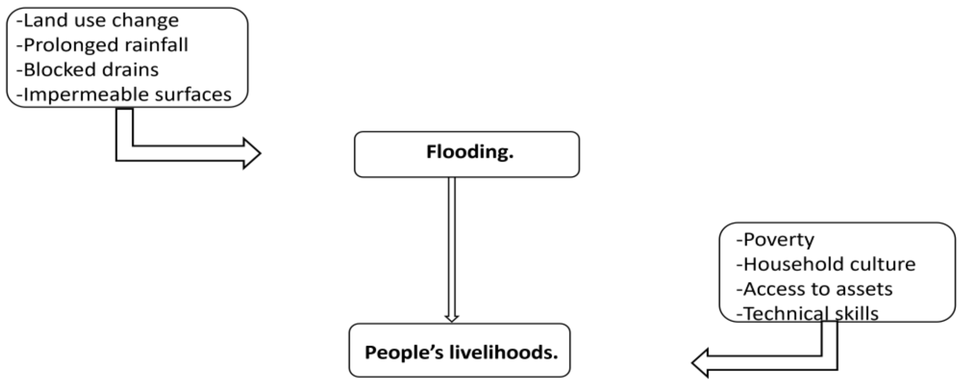


Figure 2. 8: Developing conceptual framework showing how flooding impacts people's livelihoods.

From Fig 2.8 and 2.9, an initial conceptual model that shows the link between climate change, change in land use and land cover, flooding, and people's livelihoods is illustrated in Fig 2.3 below and explains how each component affects the other. From these findings, it is deduced that climate change affects land use/cover, which affects flooding, and flooding, in turn, affects the livelihoods of people.

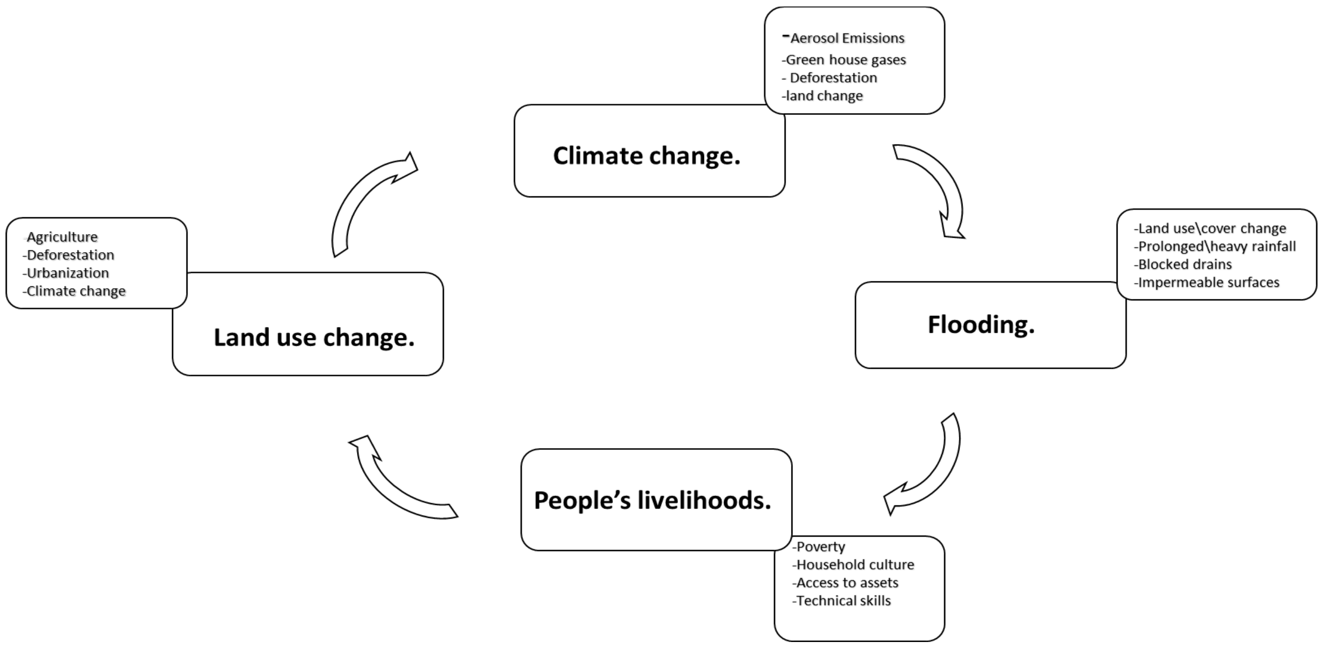


Figure 2. 9: Initial Conceptual mode showing links between land use change, climate change, flooding, and people's livelihoods.

Although changing climate can also affect land use, alterations to land use frequently result in changes to land cover, which are, in turn, strongly associated with climatic shifts. For example, tropical forests are essential not only for their ability to sequester carbon but also for the "ecosystem services" they provide, which include things like assisting the soil in maintaining its moisture content, maintaining a humid environment, and limiting the amount of sunlight that can penetrate the canopy. The transformation of tropical forests into agricultural land affects the climate of a region because it interferes with the natural processes that keep the climate stable. Alterations in the plant cover affect the energy balance at the surface of the Earth, which can either result in warmer or cooler surface temperatures.

2.10: Synthesis and Summary

In the preceding section, researchers have collectively acknowledged the profound impact of changes in land use and land cover (LULC) on various environmental aspects such as watershed runoff, microclimatic resources, land degradation processes, landscape biodiversity, soil erosion, and sediment load, both at the local level and in downstream areas. These changes have wide-ranging effects on local communities.

The influence of land use changes on flood risk is a significant focus in flood management discussions. Studies have demonstrated the relationship between land use changes, such as deforestation, Urbanisation, and agricultural practices, and their potential to increase flood occurrence and intensity, heightening community vulnerability (Ramesh, 2013). Alterations in land use have disrupted runoff generation processes and flooding patterns in river basins, reducing rainwater infiltration and increasing surface runoff (Bronstert et al., 2001; Ghosh and Dutta, 2011; Beckers et al., 2013).

The removal of vegetative cover and expansion of impervious surfaces have notably contributed to increased surface runoff, elevating urban flood risk (Li et al., 2019; Shang and Wilson, 2009). Urban development-induced changes, including vegetation removal and soil degradation, amplify runoff to streams, leading to increased peak discharge and frequency of floods (Miller and Hess, 2017).

The global concern over land use/land cover change stems from its diverse impacts on weather, climate, erosion, biodiversity, and socio-economic factors (Lambin et al., 2003). Land use changes affect various processes, influencing flooding and its consequences on communities and ecosystems (Abubakar et al., 2021; Ndabula et al., 2013).

GIS and remote sensing are essential tools for assessing land cover changes and monitoring urban growth, aiding in effective planning and natural resource management (Kushwaha, 1990; Alberti et al., 2004). However, challenges persist due to the lack of high-quality data on land use changes, hindering project planning and execution (Loveland et al., 2002).

In Nigeria, the use of GIS has been instrumental in analyzing land use changes and flood dynamics, particularly in areas like Epie Creek. However, research gaps exist, highlighting the need for more focused studies (Izinyon, 2011). Land-use policies, such as those outlined in the Land Use Act of 1978, aim to regulate land use and ownership but face challenges in implementation, leading to unplanned constructions in flood-prone areas.

Effective land use planning is crucial for flood risk reduction, incorporating principles like managing growth and endorsing flood-resistant designs (Wilson, 2009). However, challenges remain in evaluating the comprehensive impacts of zoning policies, particularly in developing nations like Nigeria (Echendu, 2020).

Understanding the benefits of efficient land use systems is essential for informing policymaking and advocacy efforts in flood-prone regions like the Niger Delta, where current housing standards are inadequate to withstand persistent flooding. Collaboration among stakeholders is vital for successful flood management strategies, particularly in developing nations facing challenges such as informal settlements and uncertain land ownership (Wilson, 2009).

CHAPTER THREE: THE CASE STUDY

3.1: Introduction

The previous chapter looked at existing works of literature and the gaps in the literature on land use land cover change and flooding. This chapter gives a comprehensive explanation of the single case study area which is Epie Creek and looks at how land use has changed and how these changes affect flooding. It discusses the history, geography, and physical settings of Epie Creek. Historical flooding, policies, and flood management strategies along Epie Creek are discussed.

Nigeria, officially the Federal Republic of Nigeria is a country in Western Africa. It is situated between the Sahel to the north and the Gulf of Guinea to the south in the Atlantic Ocean with its Federal Capital Territory Abuja. Nigeria borders Niger in the north, Chad in the northeast

Cameroon to the East and Benin to the West. It covers an area of 923, 769 square kilometres, with a population of over 230 million. Nigeria is made up of 36 states and each state has its state capital. Lagos State is the largest city in Nigeria. Yenagoa is the capital of Bayelsa State, which was created in 1996 from the old Rivers State, Nigeria in 1996. Bayelsa State is made up of eight local Government Areas, including Yenagoa the State capital which is the study location as shown in Figure 3.1 below. It is the cultural and political headquarters of the Atissa Kingdom, the seat of the Ebenibe Ancient traditional stool of the Atissa people. Surrounding Yenagoa town are 16 settlements with an estimated area extent of 7857 hectares (falling generally within the 5km radius for the development of the Yenagoa Capital City). This surrounding territory and the city are homogenous in terms of ethnic and cultural characteristics and together formed the old Epie-Atissa Kingdom (Aprioku 2013).

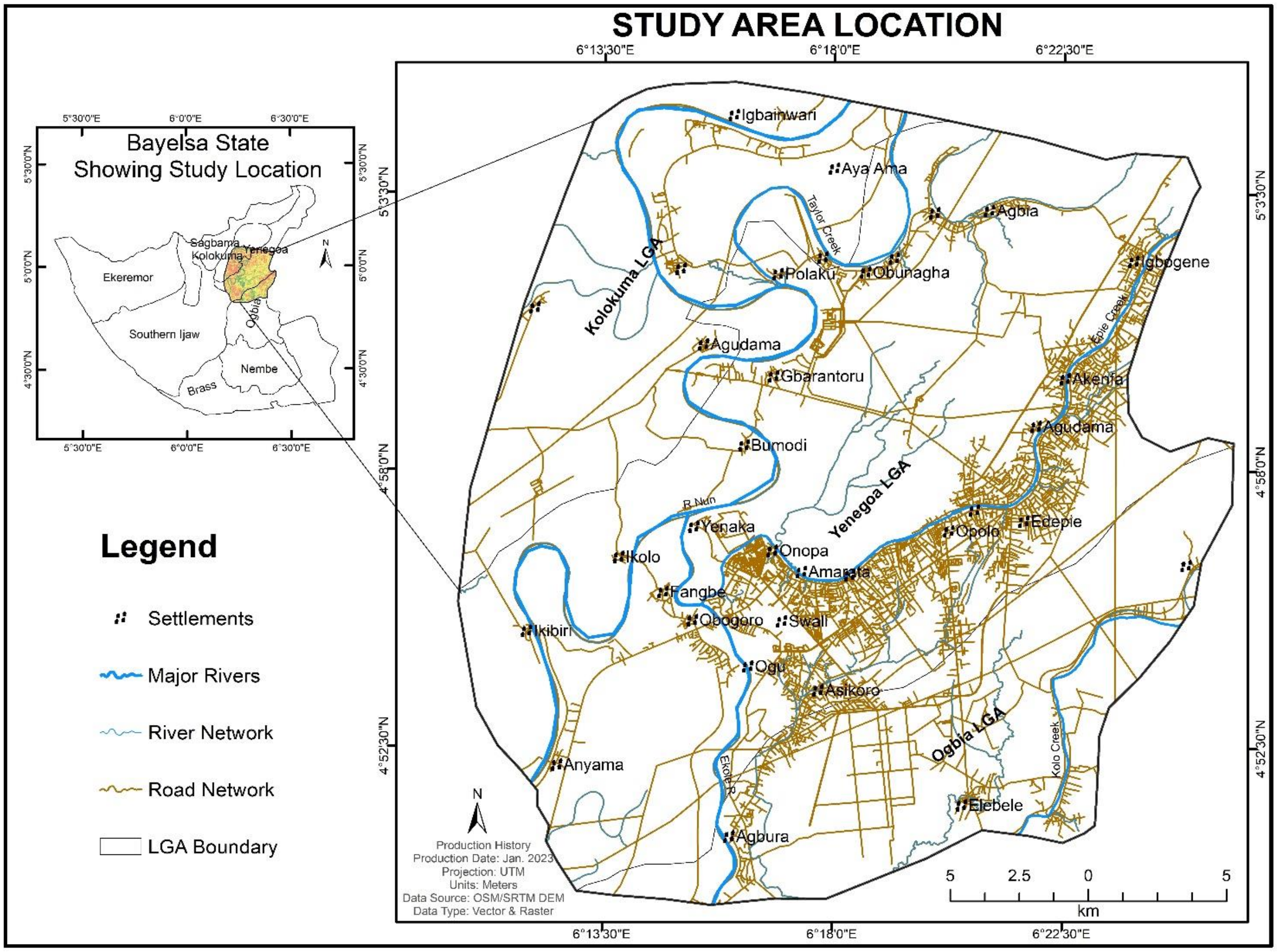


Figure 3. 1: Map of Bayelsa State showing the eight Local Government Areas (LGAs) and the capital Yenagoa (Source: Author)

3.2: History of Epie-Atissa People

The Epie and Atissa are two nations residing along Epie Creek, northeast of Yenagoa, Bayelsa State, Nigeria (Bayelsa State Government). Collectively, they are referred to as the Epie-Atissa, but they remain distinct nations. The Epie encompasses villages stretching from Igbogene to Amarata, including Igbogene, Yenegwe, Akenfa, Agudama Epie, Akenpai, Edepie, Okutukutu, Opolo, Biogbolo, Yenizue Gene, Kpansia, Yenizue Epie, Okaka, Ekeki, Azikoro, and Amarata.

On the other hand, the Atissa have villages from Onopa to Ikolo to Ogu to Agbura, namely Onopa, Ovom, Yenagoa, Bebelebiri, Yenaka, Ikolo, Famgbe, Obogoro, Akaba, Ogu, Swali, and Agbura. They both speak the Epie language.

In the 1970s, the Epie language had approximately 12,000 speakers spanning from Igbogene to Amarata, but over the last 30 years, the number of living speakers has significantly dwindled. Despite the absence of current statistics, the Epie language is not exempt from the global trend affecting many of the world's smaller languages. The decline is attributed to a lack of education and promotion of the Epie language (Wikipedia).

Westernization also plays a crucial role in the language's decline. Traditional chiefs and council elders are now predominantly young individuals, some in their 20s, who have become disconnected from their cultural heritage, hindering its transmission to younger generations. Many cultural aspects of the Epie-Atissa people have vanished due to the prioritization of Western ideals over traditional culture. Notably, the Epie-Atissa kingdom serves as a business hub in Bayelsa state, with the largest public local market located at Swali in the Atissa clan, proving to be a valuable resource for the Niger Delta region of Nigeria.

Yenagoa is at the forefront of cultural conflicts, positioned within a cultural borderland. As a precautionary measure, Yenagoa with a landmass of 1698km^2 is strategically located at the convergence of two rivers, namely the Ekole and Epie Creeks, around which it was originally established. The town's population was a mere 4,185 in 1953, but it experienced significant growth to 7,015 in 1963, 23,000 in the 1991 National Census, and a substantial increase to 253,664 by 2006, as reported by the National Population Commission (NPC) in 2007. Following the establishment of Yenagoa as the capital of Bayelsa State in 1996, there was a significant surge in population. Approximately 30,000 individuals relocated to Bayelsa State, primarily to the Yenagoa Metropolis, during the period from 1996 to 2000 (Yenagoa Master Plan). This was also the report of the Guardian of 21 October 2018 which referred to Yenagoa as ‘an old town but a new city’. It further stated that when the state was created in 1996 the area that comprises the present metropolis was a rural backwater with a population of barely a few thousand people who were mostly natives of the small local villages. These are the same communities that now house well over three hundred thousand inhabitants.

With the rise in urban population, there is a constant struggle for space and residence among less privileged groups within cities. In Yenagoa, many communities have a considerable portion of their residents living in informal settlements that emerged beyond the oversight of authorities responsible for land use and construction regulation. Established and formally endorsed land delivery systems for housing have faltered, leaving the disadvantaged, and impoverished with limited or no access to land for housing through these channels (Aprioku, 2013).

In Yenagoa, one potential avenue is the acquisition of land from communities adjacent to regulated informal settlements, a process often facilitated through strong political or official connections. Most settlements in Yenagoa lack planning and remain concealed from authorities; encroachment is typically disregarded unless the land is needed by the owners or those in positions of authority. The inhabitants of these unplanned informal settlements are fully aware of existing laws but choose non-compliance to secure resources that would otherwise be elusive, as highlighted by Aprioku (2011), Rakodi and Leduka (2009), and Ikedi (2008). Private markets provide urban housing for low-income families, often involving individual developers. Most rent out a portion of their property, saving money. Poor-quality houses are in the city core and periphery, with old, low-quality materials and limited amenities. The Bayelsa State Government provides high-quality housing in the city centre (Aprioku, 2012). An example is the Azikoro and Okaka Housing Estates.

3.3: Geography and Physical Setting

Yenagoa is in a low-lying coastal region that is characterised by rivers, creeks, and mangrove swamps. The mangrove forests provide homes for various plants and animals. It is also dominated by marshy areas and tropical vegetation. Mbiama/River and Nun River in Aguda West Local Government Area of River State at the North, Ikoli Creek at the South, Epie Creek at the West, and Kolo Creek at the East border of Yenagoa. This seaside area makes it exceptionally defenseless against environmental change and makes it vulnerable to flooding. It is composed of mainland stores of Miocene and residue in this way existing in the outcropping of Benin arrangement.

Yenagoa experiences a tropical climate, characterized by elevated temperatures, humidity, and heavy rainfall. The region typically has two main seasons: a wet season from April to October and a dry season from November to March. It experiences heavy downpours in the wet season. As such there is a weighty deluge that causes a rise in ocean level and consistently with precipitation length of 40mm in January to 472mm in September and a sum of over 2300mm per annum. It has a mean temperature of 26.70C. Yenagoa has four (4) biological zones; the coastline forests, freshwater swamps, mangrove forests, and tropical rainforest. The vegetation in this area is dominated by woody species, either with a dense or sparse growth form. This has been meddled by anthropogenic exercises like cultivating, shrubbery consuming, numbering, and fast advancement around there. Because of these impacts, the vegetation of the investigation region has been seen as primarily of optional sort of vegetation with patches of trees infield. Nonetheless, because of farming, mechanical, business, and private reasons just as for other public or government exercises like schools, banks, arenas, entertainment focuses, parks, and so forth (Odionkhere & Efe, 2020).

The Niger Delta region, including Yenagoa, is rich in natural resources such as oil and gas, which have significant economic importance for Nigeria. However, the exploitation of these resources and other anthropogenic activities have also led to environmental challenges such as pollution and deforestation.

3.3.1: Major River Systems

Nigeria has several major rivers that play a significant role in its Geography. The longest River in Nigeria and Africa, the River Niger runs through five countries and empties into the Gulf of Guinea. The main tributary of the river Niger is River Benue which originates from Cameroon and joins the Niger at Lokoja, also called the confluence town. Other important rivers in Nigeria are the River Osun, Kaduna, Ogun, Yobe River, Cross River, Calabar River, etc.

The Yenagoa terrain is scarred by a network of tributaries, creeks, and rivers, depositing their load into the Atlantic Ocean. There are 10 channels from which the waters of the river Niger are emptied into the Atlantic Ocean and 8 of these rivers run through Bayelsa State. Epie Creek flows southward from its source, eventually reaching the Nun River through Ekole Creek. The Nun River, in turn, is a tributary of the river Niger. Thus, the waters of Epie Creek as illustrated in Figure 3.2 indirectly connect to the mighty Niger River through this network of watercourses (Izonfuo and Bariweni 2001).

Figure 3. 2: Map of Epie Creek showing connection with Ekole Creek and River Nun (Google photo)

The Epie Creek on the north has a total of about 59 tributaries along its 30km length feeding off it. The tributaries include Akenfa Creek, Agudama Creek, Edepie Creek, and Okutukutu Creek which runs southwards and joins up with the Ogbuko and Alagada creeks at Amarata (Brisibe and Pepple, 2018).

These bodies of water in combination with the characteristic heavy rainfall in the region cause annual flooding and subsequent erosion. The major drainage outflow channels within the Yenagoa Capital City are Ekole Creek, Epie Creek, Kolo Creek, and Azikoro Creek. The Epie Creek serves as both an inflow and outflow channel based on the season. It runs south-westward and has 59 other connecting creeks and rivulets running off it, all of which empty into the Capital City Territory. Other subsidiary creeks within the Capital city include Igbogene Creek, Akenfa Creek, Agudama Creek, Edepie Creek, Amarata Creeks 1 and 11, OnopaCreek, Otuasega Creek, and Elebele Creek amongst others (Brisibe and Brown, 2020). The annual rainfall in Yenagoa Capital

Territory is estimated to be about 2,845mm, with two peaks in July and October, respectively, at which time flooding is expected to occur (Brisibe and Brown, 2020).

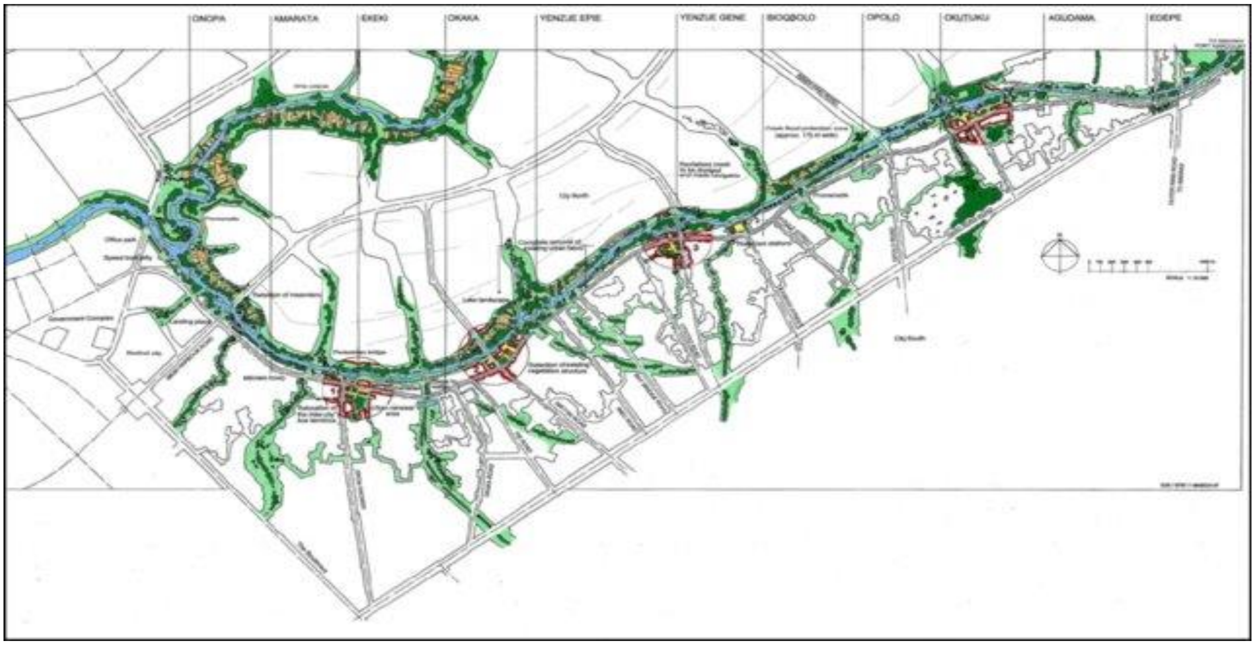


Figure 3. 3: Map showing Epie Creek and its tributaries in the study area (Courtesy: Albert Speer & Partners)

The banks of Epie Creek were previously fertile farmland that was mostly utilised for cultivating seasonal crops, including yams, plantains, and coco-yams, as well as traditional crops like peppers and local spices. Nevertheless, the channel currently serves as the primary outlet for wastewater from the growing metropolis. Urban planners who have examined the requirements of the new city have unanimously advised that it should be excavated, deepened, and transformed into a permanent maritime route. The nature and origin of the surroundings of Epie Creek have undergone irreversible changes due to the intrusion of property developers into the once seasonal flood plain along its banks. However, due to the lack of dredging or deepening, the areas near the riverbanks are now experiencing the most severe damage during the flood. According to Barrister Esuene Kikile, a former commissioner of Information and current official of the Nigerian Content Development and Monitoring Board (NCDMB), the areas adjacent to the stream where we used to fish, play, and cultivate our families' crops during my childhood have now become residential backyards.

3.3.2: Rainfall Distribution and Climatic Characteristics

The Epie Creek Region experiences a tropical climate with two seasons, the wet and dry seasons. The wet season starts around April till October and is characterised by frequent and high rainfall accompanied by lightning and thunderstorms. This season supports lush vegetation and agricultural activities. There is usually a break in rainfall in the month of August referred to as the 'August break.'

The dry season on the other hand begins in November and lasts till March. There is minimal rainfall during this time. Clear, sunny skies and high humidity characterise this season, especially in December and early January when the area experience harmattan. Harmattan is brought on by the northeasterly trade wind which blows from the Sahara over Africa into the Gulf of Guinea. The Harmattan wind is cold, dry, and dusty (Minka & Ayo, 2014).

Epie Creek region experiences elevated temperatures throughout the year due to its proximity to the equator, with daily average temperatures between 25°C to 32°C. Temperature does not vary much in both the dry and wet season.

3.3.3: Hydrology and Drainage Systems

As explained in section 3.3.2 above, the location and climatic characteristics of Epie communities affect the hydrology and drainage systems of the area. The Niger Delta region of Nigeria is influenced by its low-lying topography, abundant waterways, and tropical climate. The river systems play a crucial role in the hydrology of the region, providing drainage pathways for surface water runoff and supporting various aquatic ecosystems while the mangrove swamps and wetlands serve as important buffers against flooding, as mangroves can absorb and store large volumes of water.

Yenagoa is prone to flooding during the wet season when the drainage systems get overwhelmed and water levels rise quickly. Urbanisation and land development have also hindered the flow of water and contributed to increased flood risk by altering natural drainage patterns and reducing the permeability of the soil. According to Ebakpa & Brisibe, (2019), rural-urban migration has not only over-stretched social and physical facilities, free flow of traffic, and access to open space, but has led to the development and spread of shantytowns, uncontrolled settlements, and a general deterioration of the environmental quality. The findings of the study suggest that houses in the area were erected without consideration for construction requirements. The analysis reveals that only about 2% of the residences have a distance exceeding three meters between them, whereas the remaining 98% are situated at less than three meters from one another. These findings indicate that the region is densely populated with residential dwellings that are within five or fewer meters from the utility line (See Figure 3.4).

Figure 3. 4: Houses built with little or no space between them (Ebakpo and Brisibe, 2019).

Figure 3. 5: Densely populated residential dwellings (The Nation).

Only 9% of the houses are situated more than five meters from the utility line, while the remaining 91% are constructed within 5 meters of the utility line. (Figure 3.5). This means that property owners in the region do not adhere to the government-approved minimum setback of three meters between dwellings and a minimum building line (setback) of five meters from the utility line. In addition, the findings indicate that 2% of the residences in the region were constructed before the establishment of Bayelsa State in 1996. 18% were built between 1996 and 2000, 19% between 2001 and 2005, 23% between 2006 and 2010, and 21% between 2011 and 2013. The remaining 17% were constructed from 2016 onwards. These findings indicate that a mere 2% of the houses in the region were constructed before the establishment of the state, but an overwhelming majority of 98% were built after 1996. It suggests that most residences in the region are in a state of disrepair, not due to their age but rather due to substandard architecture, shoddy construction, and insufficient amenities.

One such important amenity is the lack or absence of proper drainages. Settlements are built without a plan or consideration for drainage. Some areas in the city of Yenagoa have a system of drainage channels, culverts, and canals designed to manage stormwater runoff and alleviate flooding but most of these are not maintained or functional as they are now filled with wastes or sand (Figure 3.6). Inadequate or poorly maintained drainages lead to flooding problems in some areas. Efforts to improve drainage infrastructure and mitigate flood risk are ongoing, but challenges remain due to limited resources and rapid Urbanisation. Another factor that contributes to the clogging of Epie Creek is the indiscriminate dumping of waste by residents.

Figure 3. 6: Waste dumped in Okutukutu canal.

The hydrology and drainage systems of Yenagoa are intricately linked to environmental issues such as water pollution and habitat degradation. Runoff from urban areas, industrial activities, and agricultural practices can introduce pollutants into waterways, affecting water quality and ecosystem health as most of the wastewater channeled to river sources is not treated. Runoff from rainwater that carries nutrients from organic waste, untreated waste, and fertilized fields into Epie Creek has enhanced the growth of water hyacinths that clog the creek and displace native plants and animals (Honlah et al., 2019), as shown in (Figure 3.7). Managing water resources effectively and improving drainage infrastructure is essential for enhancing resilience to flooding and safeguarding the environment and public health in the city and surrounding areas.

Figure 3. 7: Water Hyacinth Invasion along Epie Creek (Source: www.environewsnigeria.com)

In Yenagoa, most markets are located close to surface water. Most of the wastes generated from market activities often end up in the water bodies. This waste tends to affect water quality parameters including microbial, general physiochemistry, and heavy metals (Ben-Eledo et al., 2017). Ezenagu, (2000) identified overcrowding as a major environmental problem in the cities of developing countries like Yenagoa because with a high population comes a high generation of waste. Waste is dumped in the creek, by roadsides, in canals, or at designated points. According to the author, the congestion of both buildings and people leads to slums and poor sanitary conditions (Figure 3.8).

Figure 3. 8: Indiscriminate dumping of waste along Epie Creek.

3.4. Historical Records of Flooding

Undoubtedly, the frequency of flooding in recent decades has reached an unparalleled level. Approximately seventy million individuals worldwide are annually subjected to flooding, while over 800 million reside in regions susceptible to floods (Peduzzi et al., 2009). The occurrence of flooding in Nigeria has had a catastrophic impact, posing significant dangers to individuals, crucial infrastructure, and economic operations amounting to billions of US dollars (NEMA, 2013). The hazard associated with climate change and inadequate urban design has caught the attention of government entities at various levels, local communities, humanitarian organisations, and academic institutions (Nkwunonwo et al., 2015).

In Nigeria, floods have occurred in the past 40 years, resulting in significant effects and means of addressing its challenges are critical issues (Obeta, 2014). The country has experienced devastating floods which affected millions of people and caused fiscal losses amounting to billions of US dollars (NEMA, 2013). These hazards were linked to poor urban planning, poor waste disposal, and climate change, especially in increased frequency and intensity of rainfall (Adeloye & Rustum, 2011; Action Aid, 2006; Cline, 2007).

Yenagoa has experienced three major devastating flood events in 2012, 2018, and 2022, and other minor ones in the last two decades (Umar et al., 2022). The Epie Creek region lies astride the confluence of two rivers: the Ekole and Epie Creeks, around which it was founded. In Bayelsa State, 87 communities are at a high risk of flooding due to the presence of numerous distributaries of the Niger-Benue systems in the state. Additionally, the Orashi River, although not directly connected to the Niger-Benue systems, also overflows its banks, and drains part of Bayelsa where it intersects with Kolo Creek. This leads to flooding in areas such as Yenagoa, Opuama, Ovom, Opolo, Biogbolo Akaba, Otueke, Azikoro, Yenezue, Ekeke, Amarata, Onopa, and the surrounding regions (Amangabara & Obenade, 2015).

The population of the town was only 4185 in 1953. It increased to 7015 in 1963, 23,000 in the 1991 National Census, and by 2006, Yenagoa's population was 253,664 (National Population Commission (NPC), 2007). As the urban population increased, poorer groups struggled for place and space within cities. Most communities in Yenagoa City have a substantial proportion of their population in informal settlements, which developed outside of the control of the authorities charged with the regulation of land uses and building construction (Ebakpa & Brisibe, 2019). Most settlements are unplanned and, therefore, hidden from the view of those in authority; encroachment is ignored unless or until the land is required by the owners or by those in Authority. Those in these unplanned informal settlements do so in full knowledge of existing laws; but this non-compliance is a means of obtaining resources they would have otherwise not been able to get (Aprioku 2011, Rakodi & Leduka 2009, Ikedi 2008). An increase in population also means more forest areas are cleared for buildings and construction, more surfaces are paved, and runoff increases. There is also the issue of the absence of drains in most areas of Yenagoa metropolis while the few available are not properly maintained.

3.4.1: The 2012 flood

According to Aprioku and George (2013), the rainy season of 2012 in Nigeria was notably severe compared to previous years. The Nigerian authorities implemented emergency measures to manage the initial surge of excess runoff, with water reservoirs reaching capacity and the necessity to release water from dams to alleviate pressure, affecting areas in Nigeria as well as neighboring Cameroon and Niger. Consequently, this led to severe damage to riverbanks and infrastructure, significant loss of property and livestock, and the occurrence of flash floods in numerous regions. By September 29, 2012, the floods had impacted 134,371 individuals, displacing 64,473, causing injuries to 202, and resulting in 148 fatalities. By the end of October, the floods had affected over 7.7 million people, with more than 2.1 million registered as Internally Displaced Persons (IDPs). The toll included 363 reported deaths and damage to nearly 600,000 houses. The devastation extended across 32 out of Nigeria's 36 states (Office for the Coordination of Humanitarian Affairs [OCHA], 2012).

The flooding severely disrupted socio-economic activities as vital transportation arteries such as roads and bridges connecting towns and cities were either submerged or washed away. Notably, the wooden bridge spanning Epie Creek at Okutukutu and the Tombia-Amassoma road were both severed by floods in 2012 (see Figure 3.10). This infrastructural damage constrained the mobility of people, goods, and services, precipitating a significant inflation in the prices of essential commodities and services.

Figure 3. 9: Pictures showing stranded commuters at the Tombia-Amassoma Road.

The flood that swept through Nigeria in 2012 took the nation by surprise. As reported by the National Emergency Management Agency (NEMA), the flood of 2012 had a profound impact on Nigeria, affecting 30 out of its 36 states and leaving approximately 7 million people grappling with its aftermath. The calamity destroyed 597,476 houses and displaced 2.3 million individuals. Regrettably, it also claimed the lives of 363 people. Beyond human casualties, the flood wreaked havoc on farmlands and other sources of livelihood, while also adversely affecting wildlife and biodiversity. Furthermore, Nigeria's crude oil production witnessed a significant decline, with an estimated reduction of about 500,000 barrels per day attributed to the extensive flooding (Amangabara & Obenade, 2015).

3.4.2: The 2018 flood

There were reports of flooding along Epie Creek in 2018, but the damage done, and the impact of the flooding were not as severe when compared to the flooding of 2012. It was noted in 2018 that there was flooding which also affected the socio-economic activities of residents for some weeks. One reason why this flood was not categorised as a monster flood could be because it had less impact and receded quickly like with the regular flooding that happens along the plains of Epie Creek. However, school and commercial activities were still affected.

Figure 3. 10: Picture of flooded residential homes.

3.4.3: The 2022 flood

A decade after the 2012 flood, a more devastating flood occurred in Nigeria in 2022 and the Epie Creek region was affected. The torrential downpour caused water reservoirs and dams to exceed their capacity, forcing dams to be opened to release excess water from the Lagdo dam in Cameroon resulting in fatalities and property damage to all communities downstream (Figure 3.11). According to (BBC; The Guardian), the causes of the 2022 floods were attributed to heavy rainfall, the impacts of climate change, and the release of water from the Lagdo Dam in neighbouring Cameroon, which commenced on September 13, 2022. The flooding which affected Nigeria, Niger, Chad, and the surrounding region commenced in the early summer of 2022 and subsided by October. Despite Nigeria's usual seasonal flooding patterns, these floods were the most devastating floods since the 2012 floods (Maclean, 2022).

The Nigerian federal government through NEMA reported that a total of 603 individuals lost their lives and around 2.5 million people were forced to leave their residences due to the floods in the country in 2022. According to the Ministry of Humanitarian Affairs, Disaster Management and Social Development, a total of 82,053 buildings were destroyed and 332,327 hectares of land were entirely drowned. Additional data indicates that there were 2,407 injuries, 121,318 partially destroyed dwellings, and 108,392 partially affected farms.

Figure 3. 11 Excess water released from Lagdo dam in Cameroon (Punch, 2022).

Other elements contributing to flooding include the improper disposal of waste in water bodies (David, 2004), the construction of structures on floodplains, and the inadequate upkeep of drainage systems (Ajayi, 2012). Deforestation, urbanisation, and blocked canals are all factors that lead to flooding. (Bufebo and Elias, 2020; to Nuissl & Siedentop, 2020). Flooding can also occur due to excessive rainfall that surpasses the soil's ability for absorption (Tramblay et al., 2021). Additional factors contributing to floods encompass climate change, abundant precipitation, elevation in sea level, and population growth (MacLeod et al., 2021).

3.5: Impacts of flooding on activities along Epie Creek

Increased flooding incidences have been reported in Nigeria and Epie Creek which is in Yenagoa has been one of the most severely affected cities (Brisibe & Pepple, 2018; Obinna et al. 2018). The Federal Government declared the floods of 2012 which affected 19 states of the federation in 2012 and 32 states out of 36 states in 2012 including Bayelsa State, a national disaster because the National Emergency Management Agency (NEMA) felt that the states involved could not sort out the problem without support from the federal government.

The 2012 and 2022 floods began with an abrupt flow that persisted for several days. The floods were unusual because they were not accompanied by lightning and thunder or intense downpours. The Ekole and Epie Creeks were unable to hold the water coming from the Nun River and that of the marshes behind the dike along the Mbiama/Yenagoa road. The roadways in the towns turned into fast-moving streams of water. The force of these streams had become too great for houses to withstand, and more than 2,000 houses were inundated by floods and 413 houses were damaged, including 164 houses that were extensively damaged (Aprioku & George, 2013).

Those whose homes were submerged or damaged sought shelter from their relatives, friends, and the community, while others with nowhere to go sought refuge in churches, schools, and the Sports Stadium. There was loss of life and livestock, damage to properties, and buildings, and obstruction of transportation in most areas due to washed-off roads. Many households suffered major losses. Given that this was the period when Primary and Secondary Schools were in session, students could not go to school due to flooded classrooms and roads. This resulted in the adjustment of the academic calendar to make up for time lost during the flooding. There was also the risk of drowning, especially for those who had to use canoes for transportation across the river and could not swim.

Food items like garri (Cassava flakes), beans, rice, plantain, and other essentials like drugs, and sachet water became expensive as these were scarce and the Mbiama\Yenagoa road which is the major road through which goods are brought into the city was also flooded. Food crops that were not harvested early enough before the flood all perished, and livestock farmers had great losses. Severely affected also were the fish farmers, most of whom lost their fish to the floods as the floods inundated ponds. Drinking water was also contaminated.

People were exposed to diseases like malaria, typhoid, and cholera from mosquito bites and unclean water. Stagnant water was polluted and there were reports of dead bodies floating at the cemetery. Water from soakaway pits also contaminates flood water, resulting in an offensive smell as shown in Fig 3.12 below.

Figure 3. 12: Flood water contamination from soakaway pits.

There was exposure to snake bites and other reptiles. Children were most affected by illnesses after the floods. Besides all these, there was also the psychological impact resulting in anxiety, depression, and post-traumatic stress (Lowe et al. 2013).

Transportation and power were also affected as most major and minor roads were fully or partially submerged or cut off, forcing people to stay indoors or sort out another route. Transformers were also submerged so the power grid had to be shut down to prevent electrocution.

The impacts of flooding are becoming more severe. Impacts are increasing with rapid urbanisation, climate change, and other anthropogenic factors. Urban flooding has had significant detrimental impacts on various parts of urban life, particularly on citizens, the economy, and the environment (School Today, 2010).

3.6: Structural and Non-Structural Measures of Flood Management

The fast increase in population and urbanisation in the country has significantly heightened the risk of flooding, posing severe threats to human lives and properties. Lack of flood management measures and policies is a major setback towards flood management which is a significant obstacle to its management. This results in a substantial lack of knowledge on how to enhance the current initiatives aimed at tackling the issues of flooding in Nigeria (Nkwunonwo, 2016).

Flood control measures include many techniques and actions designed to lessen the effects of flooding and lower the danger of floods. These steps could be either structural, such as implementing community-wide flood preparedness measures like early warning systems, evacuation plans, and public education campaigns or non-structural like Constructing flood defences and elevating structures which can all mitigate the adverse impacts of flooding. Communities can improve their resilience to flooding and reduce negative effects on lives, property, and the environment by using a mix of these methods. Key measures include:

1. Floodplain zoning involves assigning floodplain regions for land uses, limiting growth in high-risk zones, and encouraging resilient land uses that can endure flooding.
2. Constructing flood defences: This involves erecting physical barriers, including levees, floodwalls, embankments, and storm surge barriers, to shield settlements from floodwaters.
3. Natural flood management: This involves utilising nature-based solutions, including wetland restoration, green infrastructure such as rain gardens and vegetated swales, and protecting natural floodplains to absorb and decelerate floodwaters.

4. Early warning systems: This involves setting up efficient monitoring networks, weather forecasting systems, and communication channels to give timely alerts to vulnerable communities and aid with evacuation procedures.
5. International collaboration involves collaborating with neighbouring nations, sharing best practices, and participating in regional initiatives to mitigate transboundary flood risk and promote sustainable water management.
6. Flood forecasting and modelling involve using sophisticated hydrological models, GIS technology, and remote sensing data to predict floods, evaluate flood risk, and guide decision-making.
7. Community engagement and education involve increasing knowledge of flood risk, offering emergency preparedness and response training, and promoting community resilience through participatory methods and stakeholder participation.
8. Providing cost-effective flood insurance choices to property owners to minimise financial damages and encourage the use of risk reduction strategies.
9. Emergency response and recovery involve creating thorough plans, setting up evacuation routes and shelters, and assisting in post-flood rehabilitation, which includes debris clearance and infrastructure repair.
10. Land use planning involves implementing laws and regulations to direct development away from flood-prone regions, encourage sustainable urban design, and guarantee robust infrastructure.

    Communities can improve their resilience to flooding and reduce negative consequences for lives, property, and the environment by using a mix of these methods. Efficient land-use policies are also crucial.

3.7: Policies of Flood Management

Policies, laws, and legislatures are essential tools in dealing with flooding issues. In Nigeria, there is the National Erosion and Flood Control Policy that integrates the management of flooding and coastal erosion and involves multiple stakeholders at various levels of government and specialized agencies with various roles as shown below in Figure 3.13.

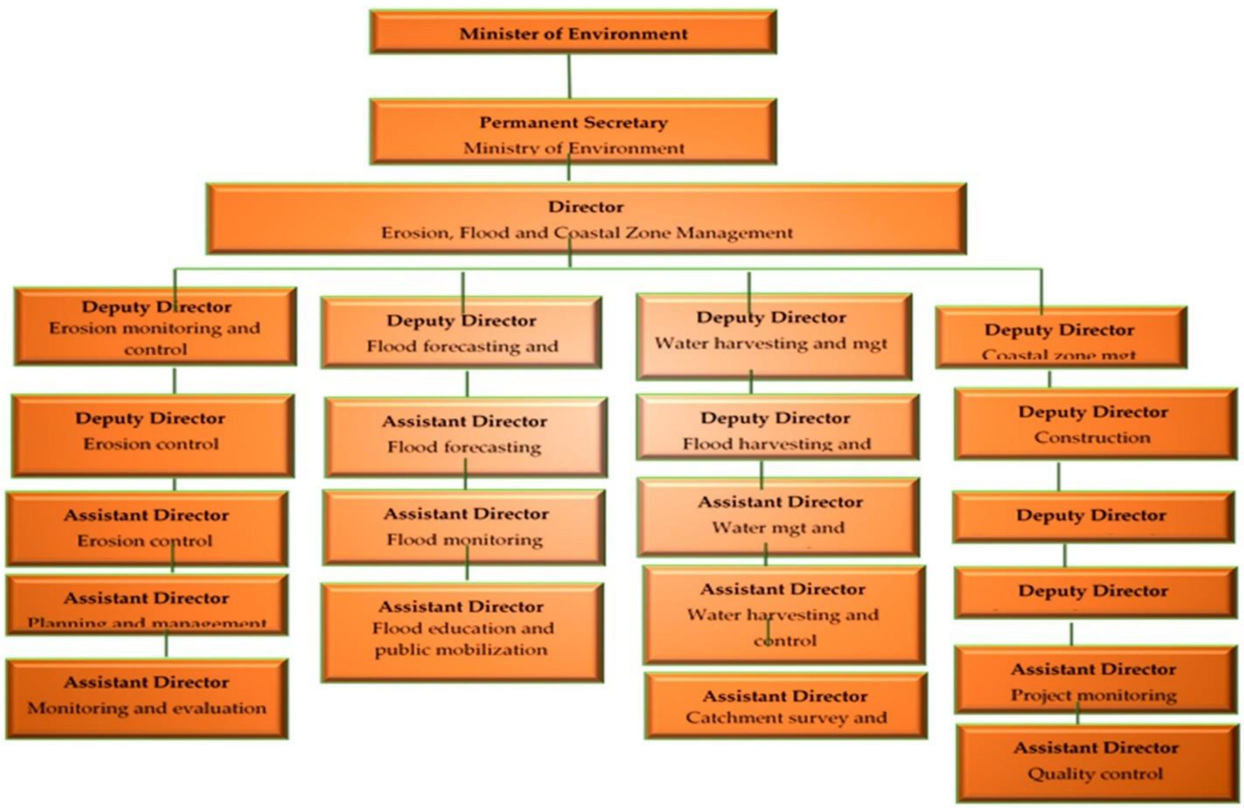


Figure 3.13. Institutional Structure of Flood Governance in Nigeria (Danhassan et al., 2023).

The Erosion, Flood, and Coastal Management Department of Nigeria's Federal Ministry of Environment is structured into four divisions, each with distinct responsibilities. These divisions include coastal zone management, focusing on flood and erosion control along the national coastline; flood forecasting, monitoring, and control, which anticipates and manages flood events; erosion control and monitoring, tasked with inland erosion management nationwide; and water management and harvesting, which oversees water transfer between basins and implements measures to prevent flash floods through water harvesting from micro-catchments (CGIAR, 2022).

Under the purview of the department, policies and programs are coordinated and formulated to address flood forecasting, prevention, and control, with an emphasis on minimizing flood and coastal degradation (CGIAR, 2022). This entails executing measures to mitigate flood and coastal degradation, raising awareness, and promoting practices that mitigate these hazards. The department also develops integrated biotechnological measures for managing flood hazards and contributes to national policy formulation on flood management, including flood forecast, prediction, early warning, and vulnerability analysis (Vanguard 2005).

At the national level, the Federal Ministry of Environment takes the lead in developing national planning policies and legislation to address these environmental challenges (Chioma et al., 2019). This ministry plays a crucial role in formulating strategies and regulations to mitigate the impacts of climate change, floods, and coastal erosion across the country.

Additionally, other key institutions such as the Federal Ministry of Water Resources, the Nigerian Hydrological Service Agency (NIHSA), and the National Emergency Management Agency (NEMA) are actively involved in flood-related matters (Isife & Ugwuanyi, 2012). Both NIHSA and NEMA collaborate to coordinate flood prediction at the National level and issue early warnings to communities at risk (Mashi et al., 2019), ensuring timely preparedness and response measures as shown in Figure 3.14 Below.

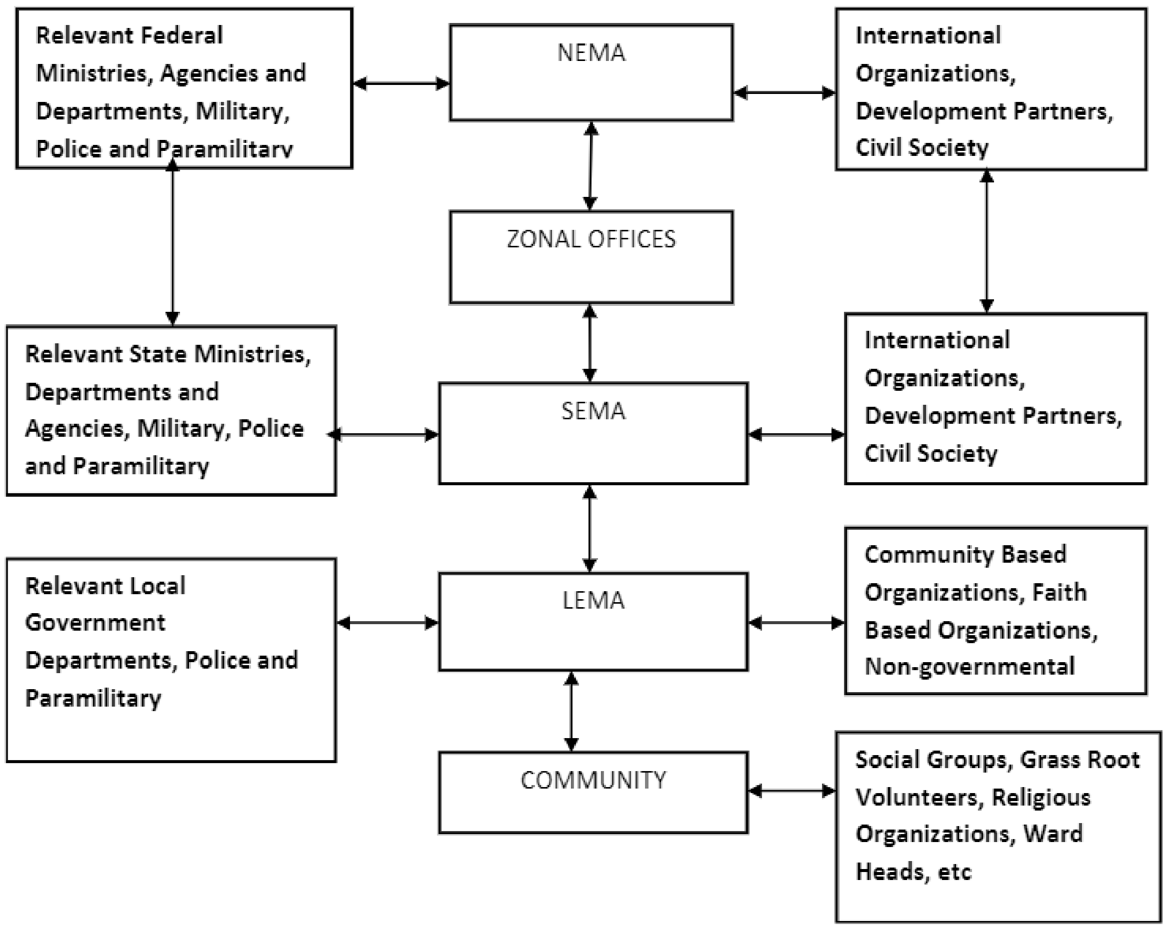


Figure 3.14. Institutional Structure of Emergency Management in Nigeria (NEMA, 2011).

While the national government sets overarching policies and legislations, funding and resources, research and support, the responsibility for handling disasters and emergencies often falls on local and state governments (Omofonmwan & Osa, 2008). The State and local governments are tasked with implementing disaster management plans, coordinating response efforts, and helping affected communities through the State Emergency Management Agency (SEMA) and Local Emergency Management Agency (LEMA). However, in cases where disasters overwhelm the capacity of State and Local Governments, the Federal Government steps in to provide supplemental assistance (Ite et al., 2016). Below in Table 3.1 is the summary of Disaster Risk Reduction (DRR) and the expected outcomes.

Table 3. 1. Summary of DRR Strategies and the expected outcomes (Danhassan et al., 2023).

Sector	Strategy	Expected Outcome
All form of disaster	National Disaster Response Plan (NDRP)	Major disasters and emergencies are addressed effectively, efficiently, and in a systematic manner
All form of disasters including flood	National Disaster Management Framework (NDMF)	Preparation, prevention, mitigation, response, and recovery from disasters should be ensured at all government levels.
Flood	National Flood Preparedness Plan (NFPP)	State participation in disaster relief, including coordination of humanitarian actors and resources
Environment, soil and flood	National Environmental (soil erosion and flood control) Regulations, 2011	Prevent floods and erosion, protect human life and the environment.

According to (Danhassan et al., 2023), the environmental policy framework in Nigeria has evolved, with efforts dating back to the colonial era. The enactment of colonial bylaws and the 1958 Health Act marked early attempts at environmental protection. Subsequent milestones include the publication of the National Policy on Environment in 1989, which was revised in 1999, alongside the establishment of the Federal Ministry of Environment to address environmental challenges comprehensively. Additionally, the development of The National Agenda 21 in 1999 underscored the importance of sustainable development practices.

Furthermore, recognizing the urgency of addressing erosion, flood control, and coastal zone management, Nigeria developed the National Policy on Erosion, Flood Control, and Coastal Zone Management in 2005 (Emodi & Boo, 2015). This policy aims to ensure coordinated and systematic measures for managing and controlling erosion and flood hazards, safeguarding both the environment and human populations.

Overall, Nigeria's environmental governance framework encompasses a range of policies and institutions aimed at promoting sustainable development, managing environmental risks, and enhancing resilience to climate-related challenges.

3.8: Challenges of Flood Management Policies.

Addressing the increasing flood events experienced recently in Nigeria is of high importance and requires a holistic approach from a policy and government perspective. Findings of the study by (Danhassan et al., 2023) concluded that '*there is no single flood policy in Nigeria. Due to this, there is no focus and no defined objectives for flood governance, prevention, control, and management, and no imperative for the government to seek both short-term and long-term flood solutions. There is no synergy and coordination among institutions for flood governance in the country, floods and climate-related hazards are given less priority.'*

There is no stand-alone flood policy but there are other related policies and existing legislation governing land use in Nigeria such as the Land Use Act of 2004. This act outlines directives for both state and local governments to adhere to when formulating land use plans and zoning regulations. Additionally, it allocates funds for initiatives aimed at mitigating floods. The responsible authorities overseeing the implementation of these policy tools in the specified area include the Federal government, State government, and local governments. The purpose of these acts and policies is to prevent the misuse of land (Ezebube et al., 2023). They were created to ensure compliance and effective administration of land use for the collective welfare of the population. Consistent adherence to the Act contributes significantly to flood mitigation. The modified Nigerian Land Use Act of 2004 was intended to facilitate compliance with zoning regulations through measures such as Floodplain easements and other Legal Easements, including Coastal Zone management compliance. The 2004 Act addresses various issues, such as the transfer of land ownership to state governors, the control and management of land advisory bodies, the designation of urban areas, and the applicable law for interim land management. While each of these acts aims to safeguard communities from flooding and other natural disasters, they have unfortunately given rise to contentious personalities within the political leadership of the state and have blurred the delineation of roles between local governments and states in land administration.

The problem however in a country like Nigeria is the ability to implement many of these plans. This has led to people building on flood plains and waterways hitherto not designed for residential buildings. The effects are what is seen in the recurring flooding in many urban cities in Nigeria. Land-use policies and new construction regulations are significant instruments for reducing the danger of flooding in cities (Jha et al., 2012). Once rapid Urbanisation compromises natural runoff and storage space, increases impermeable cover, limits soil infiltration, and contributes to urban slums in flood-prone places with no infrastructure or social networks to buffer the impact of natural risks, flood risk intensifies (Kryspin-Watson et al., 2017). This case applies to the Epie communities.

The May 2011 official gazette of the Federal Republic of Nigeria includes a segment devoted to National Environmental Regulations, featuring a subsection on Flood and Soil Erosion Control. The flood control regulations within this section address issues related to human-induced actions, specifically those concerning construction on floodplains and other high-risk flood areas. On page 8 of the International Journal of Architectural Engineering Technology in 2020, the regulations are outlined as follows:

1. The regulations prohibit the siting of facilities and major structures in identified high-risk flood areas. However, if buildings are proposed in such areas vulnerable to flood hazards, special building and zoning permits are mandated.

2. Certain locations are designated as special flood hazard areas, where intrusive developments such as dredging, reclamation, sand filling, excavating, and mining are prohibited.

Additionally, the flood control regulations specify that:

- Infrastructural development and construction involving water diversions should not redirect drainage systems into any adjoining or downstream settlement or built-up area. Moreover, all infrastructural development must incorporate appropriate flood control measures such as surface and sub-surface drainage facilities, dams, flood walls, and the planting of trees, shrubs, and grasses.

- The action of greening is emphasized to discourage the creation of impervious layers using concrete as groundcovers over large areas. This anthropogenic action hinders the natural seepage of water into the groundwater table, leading to increased surface runoff and subsequent flooding.

- Any form of water diversion or encroachment into an existing stream channel necessitates obtaining a permit.

In contrast to all the regulations outlined above, major structures have been cited in high-risk flood areas like the flood plains of Epie Creek without special building and zoning permits. Reclamation and construction of canals that redirect water to built-up areas are common without any form of flood control measure.

Enforcement of these regulations in states designated as high-risk flood zones could significantly mitigate anthropogenic actions exacerbating flooding. However, the implementation and enforcement of these control and mitigation measures are delegated to the individual states of the Federation on a case-specific basis. This devolution of responsibility is evident in regulation number 4, which stipulates that applicants must comply with zoning and building regulations of states and local governments where development is to take place. This approach acknowledges the flexibility for state governments to enact laws and bylaws based on their geographical peculiarities, absolving the Federal Government of the direct responsibility for ensuring the implementation of these regulations and placing the onus on the states. According to Brisibe (2020), the issue lies not in the existence of these regulations, acts, or laws, but rather in the fact that they are only formally established (de jure) and not actively embraced as operational regulations (de facto). Consequently, the primary challenge arises from the lack of widespread adoption and implementation of these regulations by most State authorities. As a result, many states have yet to incorporate these regulations into their practices, let alone execute them.

3.9: Application of the SENDAI Framework to Epie Creek Area.

The Sendai Framework for Disaster Risk Reduction (SFDRR), which was established in 2015, promotes Worldwide policies on Disaster Risk Reduction. It offers an integrated approach to mitigating disaster risk, minimising the consequences of disasters on communities and nations, and enhance our understanding of the intricate nature of disaster risk in the modern era. Although the framework is powerful, its adoption at the local level is still limited (Busayo et al., 2020). By applying various fundamental principles and techniques from the Sendai Framework, we can improve resilience and minimise the negative impacts of floods along the Epie Creek area, in Nigeria.

1. Understanding Risks: By using a strong risk assessment technique tailored to the Epie Creek area, we can effectively identify communities, infrastructure, and ecosystems that are in danger. Through the integration of scientific data, local knowledge, and historical information, authorities can establish efficient early warning systems to promptly notify communities and officials about imminent floods, facilitating timely evacuation and preparedness steps.

2. Enhancing Governance and Coordination: It is crucial to improve the coordination among different stakeholders, such as government agencies, local communities, non-governmental organisations, and the business sector, to effectively manage flood risks. Creating multi-sectoral

committees or task forces specifically focused on reducing flood risks can promote cooperation, mobilise resources, and enable the execution of comprehensive flood management strategies.

3. Building Resilient Infrastructure: Investing in resilient infrastructure and implementing land-use planning policies can effectively reduce the impact of floods on communities located along Epie Creek. This encompasses the implementation of flood mitigation measures, such as the erection of levees and embankments, together with the establishment of green infrastructure, such as wetlands and green areas, to assimilate surplus water and diminish the likelihood of flooding.

4. Strengthening Community Engagement and Capacity Building: It is crucial to empower local communities with information, skills, and resources to effectively plan for and respond to floods to enhance their resilience. Residents along Epie Creek Region see flooding as a normal occurrence that is beginning to have impacts that exceed the normal. The locals are not aware of the impacts of their activities on the environment and Ecosystems. Implementing community-based efforts, such as flood awareness campaigns, training programs on disaster response and first aid, and the building of community emergency shelters, can enhance the ability of locals to deal with flood events.

5. Integrating disaster risk reduction into development planning: Integrating flood reduction and planned development is crucial for ensuring sustainable flood risk management along Epie Creek. This involves incorporating flood risk reduction considerations into development policies, plans, and programs. This entails incorporating flood risk assessments into land-use planning, infrastructure development, and environmental conservation endeavours to guarantee that development operations do not worsen susceptibility to floods.

6. Promoting Ecosystem-based Approaches: Adopting ecosystem-based approaches to flood risk reduction that harness the natural functions of ecosystems to protect against floods. This includes restoring mangroves, wetlands, and other natural habitats in the Epie Creek area, which can help absorb floodwaters, stabilize shorelines, and provide habitat for biodiversity.

7. Enhancing Community Resilience: Strengthen community resilience to floods through capacity-building initiatives, community-based disaster risk management programs, and participatory decision-making processes. This includes providing training on disaster preparedness and response, establishing community emergency response teams, and supporting livelihood diversification and income-generating activities to reduce dependency on flood-prone areas.

8. Incorporating Climate Change Adaptation: Integrate climate change adaptation considerations into flood risk reduction efforts in the Epie Creek area. This involves assessing future climate scenarios, identifying climate-related risks and vulnerabilities, and implementing adaptation measures that enhance the resilience of communities and ecosystems to changing climate conditions.

By applying the Sendai Framework principles to the Epie Creek area, stakeholders can work together to reduce the risk of floods and build a more resilient community that is better prepared to cope with and recover from flood disasters. This would result in a decrease in the severity of floods and safeguard the lives, livelihoods, and infrastructure in the area.

3.10: Summary

This chapter provided a comprehensive analysis of the case study area, Epie Creek. It commenced with an exploration of the historical background and geographical context of Epie Creek, including an examination of its major rivers and drainage systems. Moreover, it conducted a detailed analysis of major flood events, identified contributing factors, and evaluated their impacts. Additionally, the chapter examined various measures of flood management, pertinent policies, and challenges associated with land use policies. The application of the SENDAI framework to the case study area was also discussed here. Subsequently, the following chapter will elucidate the methodology used in this research.

CHAPTER FOUR: RESEARCH METHODOLOGY

4.1: Introduction

In the preceding chapter, the single case study was introduced. Factors of Land use and land cover and impacts of flooding were examined. This chapter gives a comprehensive explanation of the investigative procedure, including a complete discussion of the methods used to obtain and assess information. It also includes validation for the techniques and methodology employed by the investigator. This chapter presents an overview of the primary investigation decisions made during this investigation. These decisions encompass the philosophical foundations, ontology, epistemology, axiological considerations, and methodologies chosen based on the nature of the research. It also delineates the four primary phases of the research process.

The initial stage centred on a comprehensive examination of pertinent literature concerning land changes and flooding in themes, shedding light on the study's context. The second phase involved the collection and analysis of qualitative data to delve into the phenomena under scrutiny. The third phase marked an integration point, involving the development of appropriate qualitative instruments using variables identified in the second phase and existing literature. Finally, the last phase encompassed the collection and analysis of qualitative data, used for the development of the flood risk reduction framework.

This chapter provides the rationale behind the selection of data collection methods and analysis techniques, as they were deemed the most suitable means to address the research questions outlined in Chapter One.

4.2: The Research Process

The research process, as described by Arthur and Hancock (2009), facilitates the systematic execution of a research study in alignment with a well-structured plan. It involves a sequence of steps that researchers must undertake to attain the study's objectives. Figure 4.1 displays a graphic depiction of the research methodology utilised in this study.

The process was started with a background study aimed at identifying the research problem that this study would address. Subsequently, a comprehensive literature review was conducted to gain a theoretical grasp of the research area, with a focus on partially achieving all five defined objectives.

The data collection phase unfolded in three distinct steps: through literature review, GIS data capture, and administration of in-depth interviews. Subsequently, data analysis was performed in three main stages, encompassing the analysis of the literature review, in-depth interviews, and the analysis of the GIS data. The analysis of in-depth interview findings proved instrumental in achieving all five research objectives, while the analysis of GIS data findings specifically contributed to the accomplishment of the first and second objectives, which involved characterizing the pattern of spatial variation in land use from 1987 to 2022 along Epie Creek, flood and flood risk data for objective two on vulnerability of flooding. The empirical findings from the literature review served as the foundation for the conceptual framework from which a flood risk reduction framework was developed after integration with the analysis from GIS and Interviews.

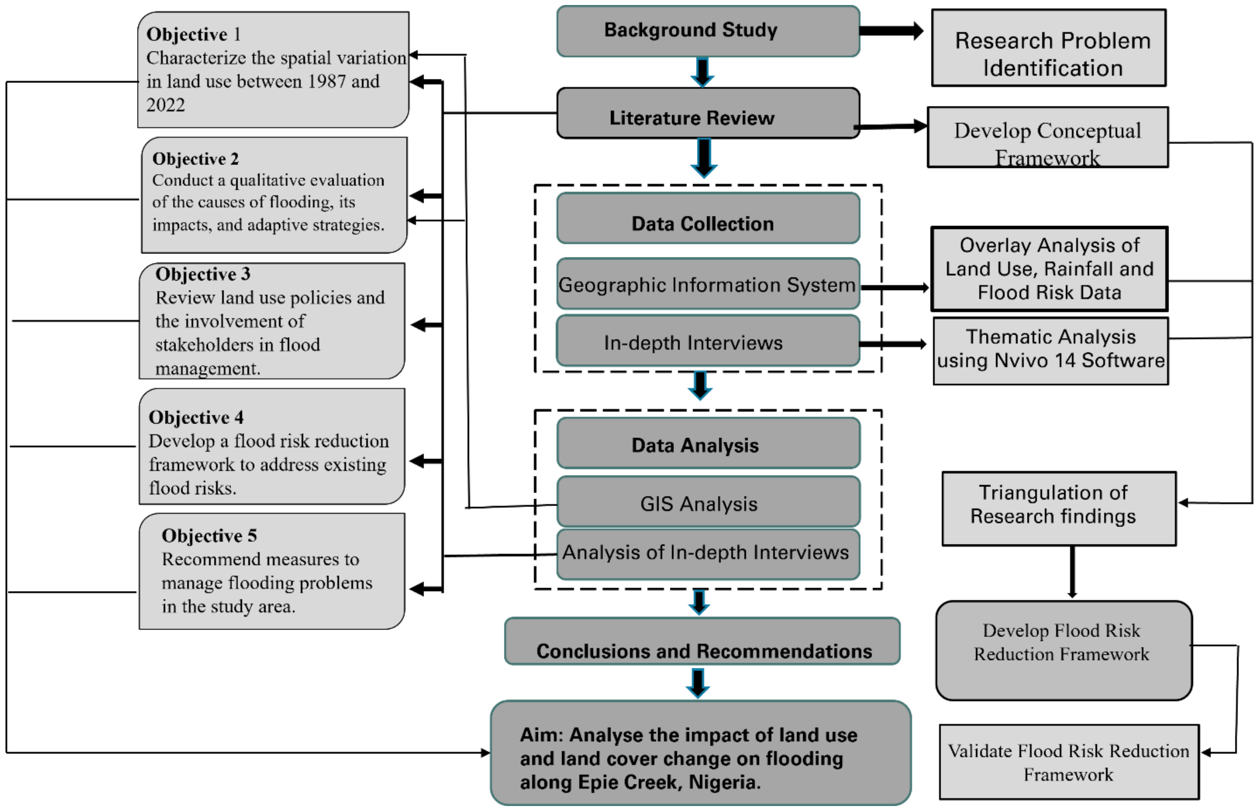


Figure 4. 1: The Research Process

After identifying the research problem, the researcher must acquaint themselves with the research area and develop a comprehensive theoretical foundation by examining the existing body of literature. In its simplest form, a literature review can be described as an exploration of what previous scholars have published on a specific research domain (Mudavanhu, 2017). The primary purpose of conducting a literature review is to enable any researcher to grasp the current state of knowledge in their research area before formulating the argument or rationale for their proposed study (Arshed & Danson, 2015). As outlined by Rudestam and Newton (2007), a literature review primarily extracts and synthesizes various findings, issues, key points, and research methodologies that have emerged through a critical analysis of prior works. In general, two main categories of literature reviews can be identified: traditional or narrative reviews and systematic literature reviews (Arshed & Danson, 2015). Furthermore, as elaborated by these authors, narrative or traditional literature reviews aim to critically evaluate the relevant literature within a particular research field, while systematic literature reviews employ a more rigorous approach to examining literature, following a well-defined and systematic methodology.

Given that traditional or narrative literature reviews provide a comprehensive and expanded comprehension of a subject matter, especially suitable for topics requiring an extensive exploration of the literature (Rozas & Klein, 2010), the present study employed an extensive traditional literature review. Through this literature review, the research delved deeply into Investigating the effects of alterations in land use on floods, as well as examining the consequences of flooding and flood management.

The key themes highlighted in the literature review were utilised to construct the semi-structured open-ended questions, as depicted in Figure 4.2.

Table 4.1 Table showing key issues of literature.

The key issues highlighted from the literature were utilised to construct semi-structured open-ended questions.	Areas covered by semi-structured interviews	Open-ended questions	Some literature References
Land use and land cover change	Urbanisation, Deforestation, climate change, Agriculture,	What land changes are most common in the study area? What causes or triggers these changes? Have there been changes in the number of built houses?	Karina et al (2021) Adelekan (2010) Brisibe and Brown, (2020) Mmom, (2008)
Flooding and flood risks	Flood risks, Vulnerability to flooding, flooding,	What land use is most affected by flooding?	Braimah et al, (2014)

	causes and management	How has flooding affected activities in the study area? Why do people live in flood-prone areas?	Bang et al., (2019) Taiye (2014)
Government Policies	Land use policies, role of stakeholders in land and flood management	What measures have been put in place to tackle flooding problems? Are these measures effective? What challenges do stakeholders face in land and flood management?	Jha et al., (2012) Ezebube et al., (2023). Mulligan et al., (2016)
Negative impacts of flooding	Environmental impacts, Economic impacts,	What are the impacts of flooding on people's livelihoods? How has flooding impacted on prices of commodities? Have there been changes in rainfall?	Ezemonye and Emeribe, (2011) Saru, (2012) Hirschboeck et al (2000), Kodoatie and Syarief, (2006)

4.3: Research Methodological Design

Research methods encompass the diverse processes, procedures, and tools used to obtain information and analyse it in many ways. According to Collins and Hussey (2009), research methodology refers to the comprehensive approach used throughout the entire research investigation. Typically, a researcher employs methodologies to gather and analyse data to achieve research goals and tackle research inquiries (Creswell, 2012). A research technique is a crucial procedure that allows a researcher to oversee the process to accomplish the intended aim and objectives. Nevertheless, numerous novice researchers mistakenly equate research methodology with research design. The research design refers to the whole framework of the research endeavor. When constructing a house, it is essential to have a clear understanding of the specific type of house you intend to build. Without this knowledge, you will be unable to proceed with any construction activities. A research design is essential for conducting a research study; it is a prerequisite for proceeding with the research. The primary distinction between research techniques and research design lies in the fact that research design encompasses the comprehensive framework of the research study, while research methods encompass the diverse processes, procedures, and tools employed to gather and analyse data. The selection of a research methodology is contingent upon the nature of the research problem and the chosen study design.

Multiple methodological designs are present in the literature. Creswell (2014) proposed a study design framework comprising three layers, along with the nesting model developed by Kagioglou et al. (2000). The first step in this framework is determining the philosophical stance, then the research approach and research technique.

Creswell's study design framework and the nesting model in research present challenges such as the complexity of aligning multiple paradigms, which can lead to difficulties in maintaining coherence across diverse methodological approaches (Creswell & Plano Clark, 2018). Researchers might struggle with balancing the rigor and flexibility needed to integrate quantitative and qualitative methods effectively (Tashakkori & Teddlie, 2010). Additionally, ensuring that nested models adequately address all research questions without compromising depth or breadth of analysis can be particularly challenging, often requiring advanced planning and methodological expertise (Bryman, 2016). The research onion model, developed by Saunders et al. (2016) was chosen for this study because The Saunders Research Onion provides a structured framework that guides researchers through the complex layers of qualitative study design, ensuring comprehensive consideration of philosophical, methodological, and procedural aspects. This approach helps in systematically addressing the impacts of land use and land cover change on flooding by facilitating clear articulation of research objectives, selection of appropriate qualitative methods, and rigorous data analysis techniques (Saunders et al. 2019). Moreover, the model's step-by-step progression enhances the coherence and transparency of the research process, which is crucial for exploring multifaceted environmental phenomena such as flooding. The research onion, as shown in Figure 4.2 below, consists of six layers and offers a systematic approach for researchers to choose the appropriate research method accurately and efficiently by following a series of logical processes. The text offers a comprehensive explanation of the various steps involved in developing a successful research technique. These steps are metaphorically depicted as layers of an onion (Melnikovas, 2018). The Research Onion model's strengths stem from its versatility in accommodating various research procedures applicable in diverse settings (Bryman, 2012).

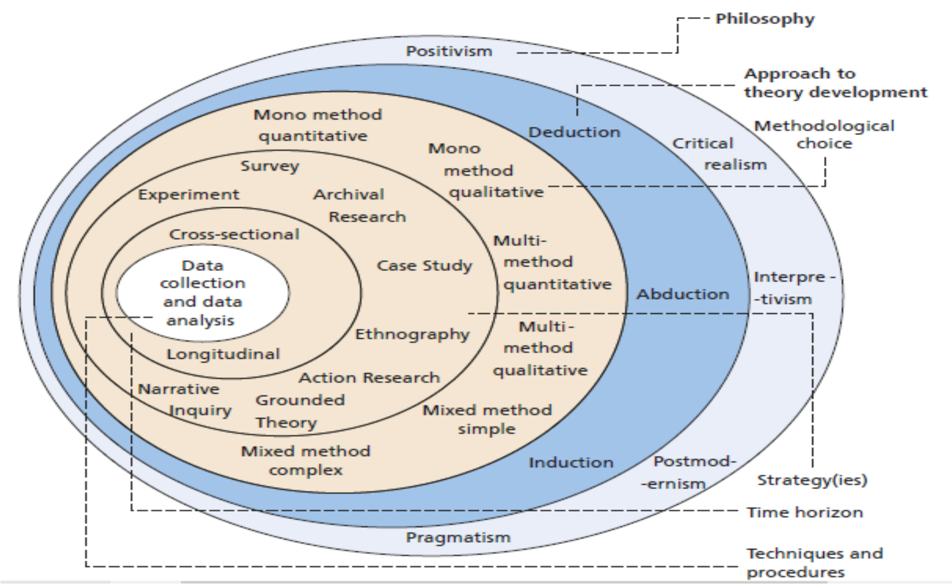


Figure 4. 2: Saunders Research Onion Model

This study employed the Saunders' research onion model. There are six distinct levels to the Saunders research onion, which has a metaphorical onion-like shape. The research philosophy serves as the initial foundation, the research approach as the subsequent layer, and the methodological option in the third layer., the research strategy is in the fourth layer, the time zone is in the fifth layer and the sixth layer includes data collection and analysis. To build a successful research methodology, the researcher must systematically progress through these steps. Therefore, the next section explores the methodological design of this study, following the many levels of the research onion.

4.4: Research Philosophy

The research philosophy is the foundational layer of the research onion and holds the utmost significance in the research process. According to Chege and Otieno (2020), the topic under investigation heavily influences the choice of a research philosophy for a study. According to Saunders et al. (2019), research philosophy refers to a collection of beliefs and assumptions about how knowledge is created in a particular research field. Therefore, it is crucial to possess a comprehensive comprehension of the fundamental philosophical presumptions within the discipline, and researchers ought to align their study with a specific paradigm (Doyle et al., 2009; Bazeley, 2004). Nevertheless, this work is challenging due to the presence of multiple diverse paradigms. Paradigms are differentiated by a collection of concepts that encompass three fundamental perspectives: ontology (the nature of reality), epistemology (how knowledge is acquired and what is known), and methodology (the research process) (Creswell, 2013; Doyle, Brady, & Byrne, 2009).

These foundational principles inevitably influence how the researcher comprehends the research problem, employs research methodologies, and interprets the research findings.

4.4.1: Ontology

(Guba and Lincoln, 1994) define ontology as a cognitive framework that encompasses one's understanding of the fundamental nature of reality and the limits of knowledge regarding reality. This pertains to the researcher's perspective on the actuality of the research being conducted. Two primary viewpoints on reality are recognised in the literature. The fundamental principle is that there exists a singular and autonomous reality that can be objectively apprehended. The second point is that reality is dynamic and evolving, indicating that there are various realities that social interactions have shaped. These perspectives represent objective and subjective viewpoints on the problem of reality, respectively.

To categorize ontology into two primary perspectives, we can distinguish between realism and idealism. As articulated by Hays and Singh (2012), realism is characterized by the belief that the external world contains inherent, universally applicable truths about reality that can be discerned. In contrast, idealism posits that there are no predetermined truths intrinsic to the external world, but rather, the reality is shaped by the specific contexts in which individuals are situated. Consequently, in idealism, the nature of reality can vary across various locations and evolve.

In the context of our present research, the identification of the impacts of land use change on flooding is intricately linked to the diverse viewpoints and perceptions of the individuals engaged in these activities. Therefore, adopting a realist perspective may not be the most appropriate approach. This study is oriented toward an idealistic ontological standpoint because it recognizes the significance of human interactions and actions. Furthermore, by developing a framework for flood risk reduction from the findings of multi-stakeholders, an idealistic ontology aligns more effectively.

4.4.2: Epistemology

The understanding of the nature of reality determines and enforces the understanding of knowledge (Morgan, 2007; Guba and Lincoln, 1994). It concerns the generation and acquisition of 'legitimate' knowledge and raises inquiries about how humans acquire knowledge. It refers to the philosophical premise of the connection between the researcher (investigator) and the research phenomena (the examined subject). The researcher's ontological and epistemological assumptions directly impact their beliefs about how knowledge is acquired or formed, which refers to the methodological assumption.

Epistemology concerns itself with assumptions regarding the validity, acceptability, and legitimacy of knowledge and how that knowledge can be conveyed to others (Burrell & Morgan, 2017). There are two contrasting extremes within epistemological assumptions. One extreme asserts that knowledge is grounded in observation and evidence, promoting objectivity. The other extreme posits that knowledge is rooted in people's opinions, thus emphasising subjectivity (Saunders et al., 2009). Given that the present study focuses on the perspectives of individuals involved in the study of land use change and flooding, highlighting subjectivity in its epistemological stance is appropriate which is in line with interpretivism because the research questions within the interpretivist paradigm typically focus on understanding the subjective meanings, experiences, and social contexts of individuals or groups. These questions often aim to explore how people interpret and make sense of their worlds, seeking to uncover the underlying reasons, motivations, and perspectives behind their actions and interactions. Interpretive research questions are usually open-ended and exploratory, emphasizing depth and richness of understanding rather than generalizability.

4.4.3: Axiology

Axiology, on the other hand, pertains to the set of values and ethical considerations woven throughout the research process. It involves a critical examination of how researchers manage their values and ethics, as well as those of the research participants (Saunders et al., 2019). Axiology assumptions are related to the value concerns of the study. As Lewthwaite and Nind (2016) point out, a study can either be value-laden, where choices regarding what and how to study are influenced by human values and experiences, or value-free, where these choices are guided by objective criteria (Easterby-Smith et al., 2018). Given that the study involves inviting people with diverse views and values to contribute to the research, it adopts a value-laden stance.

Building on these philosophical assumptions, various philosophies are associated with each assumption, primarily positivism, interpretivism, and pragmatism (Zefeiti & Mohamad, 2015).

4.4.4: Positivism

Positivism is rooted in the ontological assumption that the external world holds universal truths about reality, often referred to as "realism." This aligns with an epistemological assumption that reality should be measured objectively rather than subjectively (Easterby-Smith et al., 2018). Positivists also adhere to the axiological assumption of value freedom, which dictates that researchers should remain independent of what and how they study. Consequently, researchers should refrain from interfering with the research environment and introducing biases into the study's results. In summary, positivism relates to the philosophical stance that emphasizes a true reality, explored through observable facts while maintaining independence from the research environment (Saunders et al., 2019).

4.4.5: Interpretivism

In contrast, interpretivism emerged as a critique of positivism. Interpretivism primarily aligns with the ontological assumption that there is no pre-established truth in the external world, a perspective referred to as "idealism" (Dudovskiy, 2022). Epistemologically, interpretivists argue that reality is understood through subjective measures, considering people's opinions and perceptions. Thus, interpretivism asserts that human beings are not detached from the knowledge under investigation (Saunders et al., 2019). Furthermore, it allows researchers to engage closely with the research context, making the researcher an integral part of the study, in contrast to positivist studies. This approach results in a value-laden axiological stance (Easterby-Smith et al., 2018). Interpretivism pertains to the socially constructed and subjective nature of reality, with the researcher's interpretations playing a significant role as an active participant in the study (Saunders et al., 2019).

4.4.6: Pragmatism

Pragmatism serves as a research paradigm that permits researchers to adapt elements of both positivism and interpretivism, choosing what works best for a particular study (Melnikovas, 2018). It provides a flexible philosophical framework for research, often associated with mixed-methods research (Kaushik & Walsh, 2019). Pragmatists acknowledge the existence of a predetermined truth in the world while also acknowledging that it is subject to personal bias. In terms of epistemology, pragmatism adopts a more flexible approach, encompassing both objective and subjective viewpoints. This implies that research outcomes in pragmatism may vary in terms of objectivity and subjectivity (Saunders et al., 2019). Axiologically, pragmatist studies are characterised by researcher reflexivity, meaning the study is initiated and sustained by the researcher's doubts and beliefs.

4.4.7: Philosophical Stance

Interpretivism was chosen as the most suitable research philosophy because it is primarily associated with the belief that there is no pre-existing truth in the external world, a perspective known as "idealism" (Dudovskiy, 2022). From an epistemological standpoint, interpretivists argue that reality is comprehended through subjective measures, considering individuals' opinions and perceptions. Consequently, interpretivism posits that individuals cannot be detached from the knowledge examined (Saunders et al., 2019). Moreover, it enables researchers to closely engage with the research context, positioning the researcher as an integral part of the study. This orientation results in a value-laden axiological stance (Easterby-Smith et al., 2018).

The study aims to find out how changes in land use and land cover affect flooding, what policies are in place, and the role of stakeholders in managing flooding. As a result, it relies on subjective measurements based on respondents' opinions. The research aims to explore and understand the meanings and interpretations that people assign to their experiences. An interpretivism philosophy also typically manifests in the adoption of a qualitative methodology, relying on data collection methods such as interviews, observations, and textual analysis. Therefore, interpretivism is the most suitable research philosophy for this study.

4.5: Research Approach

The second layer in Saunder's research onion model pertains to the challenge researchers face when selecting a research approach for their scientific investigations. According to Saunders et al. (2019), this choice is often a subject of debate, leading researchers to grapple with the task of determining the most appropriate approach for their studies. They propose three primary research approaches for theory development: inductive, deductive, and abductive.

The inductive approach, colloquially referred to as the "bottom-up" method, commences with data collection to explore a phenomenon, allowing a theory to emerge from the observations made (Soiferman, 2010). Inductive reasoning involves moving from specific observations to the broader development of theories.

Conversely, the deductive approach, informally known as the "top-down" method, starts with a theory and subsequently involves empirical observation to evaluate the theory (Park et al., 2020). This approach progresses from the general to the specific.

The abductive approach, on the other hand, combines elements of both inductive and deductive approaches. In this method, researchers collect data to explore a phenomenon, with the goal of either constructing a new theory or modifying an existing one. The resulting theory is then subjected to further testing through additional data collection (Saunders et al., 2019). The abductive approach has primarily emerged to address the limitations of the other two methods.

In the context of the current study, the research initially considered pre-established theories, models, and knowledge related to land use change and flooding. Subsequently, these theories and knowledge were refined or adjusted based on additional data collected within the Epie Creek context. Consequently, the study incorporated aspects of both inductive and deductive approaches. Thus, the abductive approach was determined to be the most suitable research method for this study as abductive reasoning allows researchers to consider the broader context and multiple interpretations of data, which aligns with the interpretivism emphasis on context and the subjective nature of human experience

4.6: Choice of Research Methodology

The selection of research methodology represents the third layer in the research onion model, encompassing the decision between qualitative, quantitative, or mixed methods for a research study. A quantitative approach primarily deals with factual and numerical data, employing mathematical operations to analyse study findings (Walliman, 2011). Kumar (2019) further reinforces this by asserting that the quantitative approach adheres to a structured procedure for assessing the extent of a phenomenon based on precise, high-quality data collected from a broad sample and presenting them analytically and collectively. The quantitative approach is best suited for research questions beginning with 'what,' 'where,' 'who,' 'how much,' and 'how many' (Apuke, 2017).

On the other hand, a qualitative approach involves an in-depth exploration of the subject area by analyzing respondents' experiences, attitudes, and behaviours (Fellows & Liu, 2015). Yin (2011) shares the same perspective, emphasizing that the qualitative approach can represent the views and perspectives of specific groups of people. Qualitative research deals with non-numerical data, making it more appropriate for research questions starting with 'how' and 'why' (Yin, 2011). In the mixed research approach, both qualitative and quantitative methods are employed, mitigating the shortcomings of each (Doyle et al., 2009). This approach offers a more comprehensive view of the research study, combining the advantages of both methods (Schoonenboom & Johnson, 2017).

The present study aims to investigate the impact of land use and land cover changes on flooding along Epie Creek by analysing land changes and flooding situations using GIS and Semi-Structure interviews. The qualitative method aligns with interpretivism. Also, the philosophical stance influences how data is collected and analysed. The interpretivists prefer unstructured to semi-structured data collection and thematic analysis. Therefore, the qualitative research approach was chosen as the most suitable for this study to capture the insights, knowledge, and experiences of the individuals involved.

4.7: Research Strategy

Research strategy encompasses the overall approach used by a researcher to select the primary and secondary data collection methods required to address the research question (Melnikovas, 2018). It encompasses the way a researcher addresses research questions, as highlighted by Denzin and Lincoln (2011) and Saunder (2016). The selection of a research strategy is influenced by the nature of the research questions and objectives, aligning with the researcher's outlined approach and philosophy (Saunder, 2016). Saunders et al. (2019) have suggested a range of research methodologies, such as experiments, surveys, case studies, archival research, ethnography, action research, grounded theory, and narrative inquiry, to guide research projects. This investigation employed the survey research strategy and single-case study methodology.

4.7.1: Survey

As indicated by Mathiyazhagan and Nandan (2010), a survey can be described as a systematic data collection procedure conducted on a population or a sample using various methods. The survey method allows researchers to employ a range of data collection techniques, including questionnaires, interviews, and focus group discussions, which can incorporate both quantitative and qualitative aspects (Singleton & Straits, 2009). While surveys are typically associated with quantitative data, there is also a qualitative dimension aimed at understanding variations within a given population (Jansen, 2010). Fink (2002) has recommended the qualitative survey method for exploring the meanings and experiences of individuals within a population concerning a specific subject.

Given the study's objective of reviewing land use policies and stakeholders' engagement in flood management within the Epie Creek context, semi-structured interviews were used to capture the experiences and opinions of those involved. Hence, the qualitative survey strategy is an appropriate choice.

4.7.2: Case Study

According to Robson (2002), a case study is a research approach that involves studying a current event in its real-life context, using various information. Case studies contribute to knowledge across diverse situations involving individuals, communities, organizations, and groups, often guided by specific criteria (Yin, 2003, 2018). They are suitable for obtaining a comprehensive understanding of the research context and processes (Tham et al., 1991). Despite the strategy's qualitative nature, it allows for the use of diverse evidence sources, such as interviews and observations, providing a comprehensive comprehension of the study problem.

In a case study conducted on the impact of land change on flooding along Epie Creek in Yenagoa, a single case study was employed, incorporating a single data source from Yenagoa to address various research questions with rigor (Tashakkori & Teddlie, 2010b; Onwuegbuzie et al., 2009). The study explored land changes and their impacts on flooding along Epie Creek, Yenagoa, Nigeria. It was exploratory due to the lack of existing research on land changes and flooding in Nigeria, specifically focusing on flood-prone areas. The study also included descriptive and explanatory elements, reviewing land use policies, and using a conceptual framework developed from qualitative research findings to explain land use changes and flooding interrelationships.

The case study approach was chosen for its utility in exploring social phenomena in a specific context and studying unique phenomena within their settings (Yin, 2018; Denscombe, 2014). Epie Creek is in the Niger Delta region which is an area that is of great economic importance and environmental significance due to its oil and gas reserves, revenue generation, biodiversity, and ecosystem services yet characterised by environmental pollution, degradation, and security concerns. It is therefore a microcosm that allows the researcher to study the broader phenomena on a smaller scale. The researcher's favorable access to stakeholders in government ministries and parastatals, NGOs, and local communities facilitated the acquisition of necessary information for the study.

A single case design involves an in-depth study of a specific case, often chosen for its critical, extreme, or unique characteristics. This approach is deemed safer for developing high-quality theories, as it can lead to a more robust theoretical framework. A single case study of Epie Creek was done given the typical nature of the flooding problem which is applicable in other states like Delta, Rivers, and other sub-Saharan African countries like Ghana that experience perennial flooding. The researcher needs a deep understanding of the topic under investigation. Selecting a vital case that represents a typical assessment of an existing theory or assertion is a common rationale for choosing a single case. This design is also suitable when deviating from norms or studying unique circumstances, routine daily activities, or situations where data are challenging to obtain as in the case of Epie Creek and areas with similar climate and topography.

4.8: Time Horizon

This constitutes the fifth layer within the research onion model, and it pertains to the time frame of the research. Once the appropriate research philosophy, research approach, research choice, and research strategy have been selected for the study, a crucial decision must be made regarding whether the investigation will focus on a specific moment in time or span across multiple time points (Iovino & Tsitsianis, 2020).

In this context, according to Saunders et al. (2019), two primary time horizons can be discerned: cross-sectional and longitudinal. A cross-sectional timeframe provides a snapshot perspective of the study, where the phenomenon is examined at a particular instant. These types of studies concentrate on the current or past situation, without delving into potential trends or historical developments (Bryman & Bell, 2011).

On the other hand, longitudinal studies involve data collection over an extended period, enabling the analysis of changes that occur during that specific period (Caruana et al., 2015). This timeframe is especially valuable when investigating the evolution and progression of a phenomenon over time.

As outlined by Saunders et al. (2019), case studies (short-term) and surveys align with the cross-sectional time frame, while ethnography, long-term case studies, action research, and archival research are aligned with the longitudinal time frame. Consequently, given that this study is examining the current state of flooding issues as impacted by land use and land cover changes, the choice of a cross-sectional time horizon was deemed appropriate.

4.9: Data Collection Techniques

Data-gathering methods typically offer a systematic approach to collecting information to address the research question (Kabir, 2016). There are two primary categories of data: primary data and secondary data. Primary data entails information collected directly from firsthand experiences, which remains unaltered (Salkind, 2010). Various methods for collecting primary data include interviews, questionnaires, document examination, observations, and focus group discussions. Secondary data primarily encompasses information gathered from various pre-existing sources, such as journal papers, books, online articles, records, and so on (Kabir, 2016). In research studies, the review of literature typically relies on these secondary data sources. As such, the present study employed a variety of data collection techniques to achieve the research objectives, as illustrated in Table 4.2

Table 4.2 Data Collection Techniques.

Data Collection tool	Purpose
Literature Review	Traditional literature review: Identifying the link between land use changes and flooding, its impacts and management.
Geographic Information System	GIS: Establish land use changes and rainfall variability between 1986 and 2022 along Epie Creek, Yenagoa.
In-depth Interviews	Semi-structured interviews: Identifying land use changes, causes, and impacts of flooding impacts along Epie Creek.

As presented in Fig.4.2 the findings from both primary and secondary data collected from the literature review, semi-structured interviews, and GIS data were analysed and integrated to develop a flood risk reduction framework, with the discussion of findings presented in chapter five. The literature evaluation served the purpose of identifying deficiencies in current research and formulating the research inquiries and conceptual framework. Information was gathered using semi-structured interviews on people's opinions and experiences while GIS was used to visualize and analyse land use and land cover change patterns and rainfall.

4.10: Methods of Data Collection

The study employs varying methods and materials for varied factors, all aimed at addressing the central challenge which is flooding. Therefore, the process has been segmented into multiple stages, which are determined by the methodologies utilised and the data employed. These can be classified into the following primary categories: Literature review, Remote Sensing and GIS Methods, and Semi-Structured Interviews as presented in Figure 4.3 below.

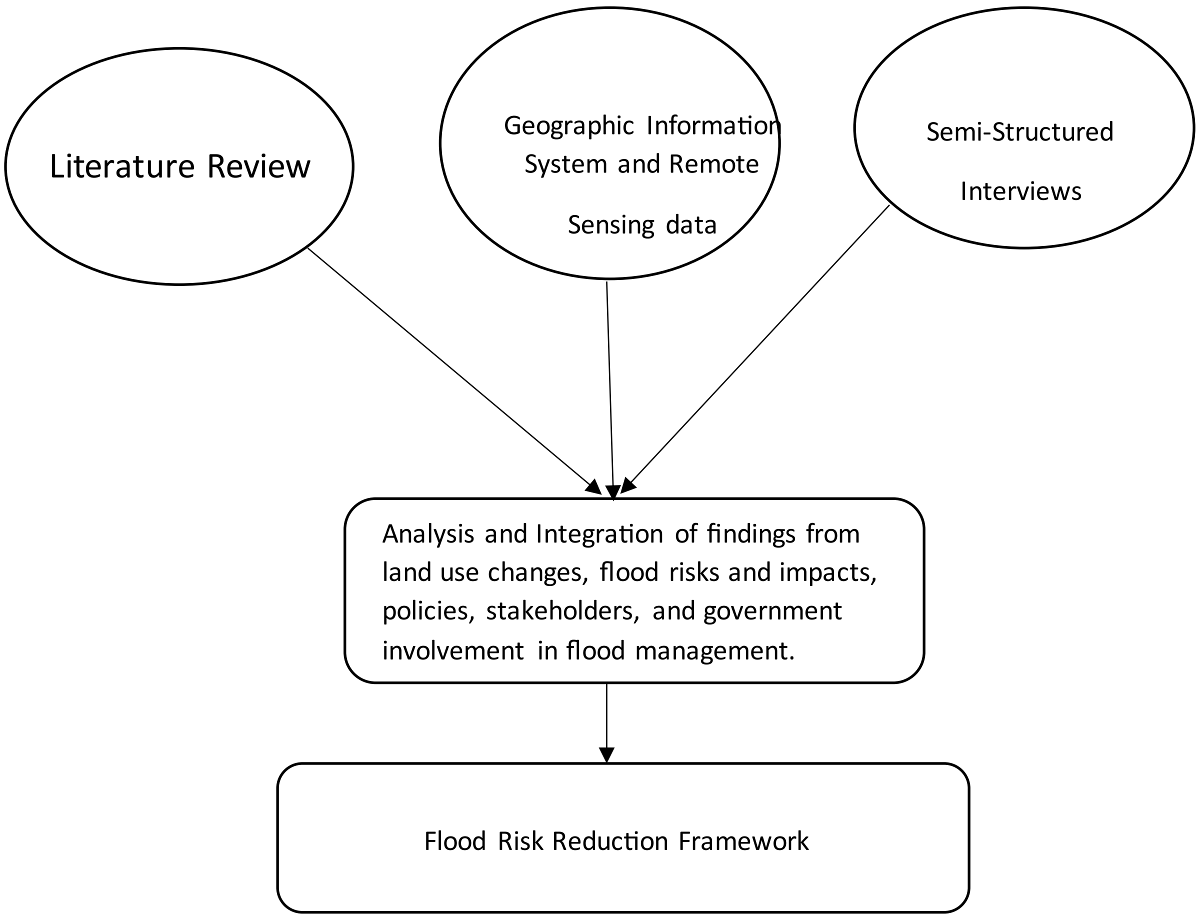


Figure 4. 3: The Research Technique.

4.10.1: Use of GIS

The integration of remote sensing and GIS techniques was utilised to demarcate the land use and land cover (LULC) alterations in Epie Creek and its surrounding areas. The analysis of land use and land cover change (LULC) involved several steps, including data gathering, data preprocessing, supervised classification, accuracy assessment, and change detection analysis (Boori et al., 2015; Rahman & Saha, 2008). The USGS-Earth Explorer supplied the remote sensing data. The remote sensing data underwent pre-processing using ArcGIS 10.2 to facilitate the interpretation of the images and data management. The Landsat images (TM, ETM+, and OLI) were analysed to discover changes during the specified study period of 1986, 2001, and 2020 in the designated study region. The Anderson (1971) Classification Scheme (Level I) was utilised for this objective. The study region has a considerable expanse, which renders this plan appropriate for this investigation. Refer to Table 4.3 for further details. The chosen algorithm for this task was Maximum Likelihood, which operates under the assumption that the calculated probabilities are uniform across all classes and that the histograms of the input bands follow a normal distribution. This approach was employed to achieve a more accurate result. This approach considers the average, spread, and range of brightness values for each class provided as a training set. The ground-truth observations were utilised to confirm the Land Use and Land Cover (LULC) classification and evaluate the precision of the categorised image. The accurate locations were obtained using the Global Positioning System (GPS). The accuracy of the land use and land cover changes was referenced using GPS ground truth point data after using the supervised classification method in ArcGIS software. Secondary data from the United States Geological Survey (USGS) archives was utilised, namely Landsat imageries from three distinct time intervals: (1986 Landsat 45), (2001 Landsat 7 ETM+), and (2020 Landsat 8 OLI). Land use and land cover information were derived from the processed data collection.

Flood risk data was also collected to examine the general condition of the study area.

The key variables for mapping flood risk assessment are as follows, Drainage Density, Distance to River, Distance to Roads, Slope, Elevation, Rainfall and Land Use Land Cover which the methodology for the latter two (Rainfall and Land Use Land Cover) have already been outlined above.

The spatial analyst and the hydrology tools in the ArcToolbox will be deployed to analyze for above parameters using the acquired SRTM data. Each of these parameters or variables was assigned weights and ranks as shown in tables 4.3 and 4.4 below.

Table 4.3: Flood Risk Variables and Assigned Weights

S/N	**Variable or Parameter**	**Weight**
1	Land Use Land Cover	10%
2	Drainage Density	15%
3	Distance to Roads	5%
4	Distance to River	20%
5	Slope	10%
6	Rainfall	25%
7	Elevation	15%

Table 4.4: Risk Ranking

Risk Intensity	**Risk Rank**
Very High Risk	5
High Risk	4
Moderate Risk	3
Low Risk	2
Very Low Risk	1

Based on the above each of the 7 variables was reclassified using the reclass tool by assigning the above ranks (rank 5-1). Finally, the weighted sum was calculated using the weighted sum tool under the spatial analyst tool in the ArcToolbox, where weights are assigned as depicted in table 4.4 above. It is worthy of note, that at this point; the assigned weights are based on the degree of influence of a particular parameter or variable. Normally, rainfall and distance to the river has more influence on flooding typically for tropical regions like this study area; thereby been assigned the highest weights followed by elevation, drainage density, etc.

In addition, a portion of the secondary data utilised consisted of time-series rainfall data for 3-time intervals 1990-2000; 2000-2010, and 2010-2020) from the archives of the Climatic Research Unit (CRU-TS) high-resolution grided time series datasets. The CRU-TS project is principally funded by the UK's Natural Environmental Research Council (NERC), its collaborative Centre: the UK's National Centre for Atmospheric Scientific (NCAS), and the US Department of Energy. CRU is globally recognized as one of the world's leading institutions concerned with the study of natural and anthropogenic climate change. The datasets were used for variability assessment of rainfall for the period of the study in time series over space, Harris I, Osborn TJ, Jones P & Lister D., (2020). Table 4.3 below presents the data types and sources for land use and rainfall data.

Table 4.5 Data Types and Sources (Author 2023).

Data Type	Source	Year	Resolution	Purpose
Rainfall	Climatic Research Unit (CRU-TS)	1987, 2002 & 2022	30x30m	Annual Average Rainfall

	https://crudata.uea.ac.uk/cru/data/hrg/cru_ts_4.06/			
Landsat 4-5 (Path/Row)	www.earthexplorer.usgs.gov	1987	30x30m	LULC & LST
Landsat 7 ETM+ (Path/Row)	www.earthexplorer.usgs.gov	2002	30x30m	LULC & LST
Landsat 8 OLI (Path/Row)	www.earthexplorer.usgs.gov	2022	30x30m	LULC & LST
SRTM DEM	www.earthexplorer.usgs.gov	2014	30x30m	Flood Risk Mapping
GPS Coordinate	Field Work	2022	-	Ground Truth Data for Change Detection

The LULC maps that were created underwent statistical analysis to determine the changes in land use and land cover within the research area, as will be discussed in the following chapter. Table 4.6 presents the different land use types in the research area.

Table 4.6 Classification Scheme (Anderson et al.,1971)

Land Use/Land Cover	Description
Built-Up	All areas are designated for residential, commercial, and industrial use, including villages, settlements, and transportation infrastructures.
Waterbody	Permanent open water, rivers, lakes, canals, ponds, reservoirs.
Vegetation	Trees, vegetated lands, forests
Agriculture	Farmlands, Plantations
Bare land	The mentioned areas include grasslands, cultivated lands, areas with soil and sand, infillings, and landfills for solid waste disposal.

4.10.2: Analysis of Rainfall Data

The study utilised ArcGIS software as a fundamental analytical tool to examine the rainfall data. The CRU-TS high-resolution gridded time series datasets in NetCDF formats were converted to raster layers using the Multidimensional tool in the Arc Toolbox.

The raster layers were analysed in the GIS environment to calculate the average yearly rainfall within the study period for the study area. The Arc Toolbox utilised the Inverse Distance Weighting (IDW) algorithm as the chosen approach for key interpolation. The Inverse Distance Weighting (IDW) method offers the benefit of being easily definable and, as a result, provides a straightforward interpretation of findings. This is because nearby points have a greater influence on a point's interpolation than do farther-away ones. This principle is known as spatial autocorrelation or Tobler's First Law of Geography. Burrough and McDonnell (1998).

4.10.3: Semi-Structured Interviews

An interview typically entails a dialogue between two individuals: the interviewer, who aims to gather specific information, and the interviewee, who responds. The qualitative interview guide created was adaptable and underwent a continuous redesign, as described by Herbert & Rubin (1995).

A pilot study which serves as a crucial phase in the research process, aiming to assess the feasibility of an approach intended for broader application was first conducted after the interview guide was developed. According to Bell and Waters (2014, cited in Saunders, 2016), it is emphasized that 'regardless of time constraints, it is essential to conduct a trial run of the questionnaire' to ensure the effectiveness of the questions. In March 2022, before conducting interviews, a pilot study was carried out, involving discussions with four experts from government ministries and parastatals, NGOs, and community leaders over the phone due to travel restrictions. Access to participants was facilitated through personal contacts, resulting in four semi-structured interviews. Field notes, audio recordings, and subsequent transcriptions were collected, transcribed, and analysed.

The insights gained from the pilot study played a pivotal role in shaping the main research. The four pilot studies were conducted over the phone to evaluate the suitability of the interview questions. These studies provided valuable insights that led to several improvements in the interview process:

1. Refinement of Questions:

- The pilot study revealed the need to clarify the concept of land use policies. Initially, some participants perceived these policies as informal rather than formal. Consequently, questions were simplified and broken down into smaller parts to enhance understanding.

- For instance, the initial question, "How changes in land use affected flooding in the study area?" was found to be more effective when divided into three distinct questions:

  - What land use changes have occurred and are currently happening?
  - What are the causes of these land use changes?
  - What impacts have these changes had on flooding?

2. Interview Process Optimization:

- To minimize interruptions, interviews were scheduled during less busy times for each participant. This consideration aimed to ensure a smoother, uninterrupted interview process.

3. Technical Assessments:

- The quality of the internet network and the clarity and audibility of the recordings were assessed. This step ensured that the technical aspects of the interviews were reliable.

4. Question Review:

- All questions were meticulously reviewed and checked to eliminate leading questions and biases, ensuring the interview process was as objective as possible.

Overall, the pilot study was instrumental in refining the interview questions and process, making them more effective and ensuring high-quality data collection.

As part of the interview process, purposive sampling was employed to identify and engage experts in the fields of environment, works, lands, urban planning, NGOs, and local communities for qualitative interviews. Purposive sampling involves inviting individuals possessing the necessary expertise to participate in interviews (Etikan et al., 2016). The selection of these experts was based on their substantial knowledge and experience in land use changes and flooding along Epie Creek.

Upon identification, the selected experts received a consent letter, and subsequent semi-structured interviews were conducted with them. The scheduling of interviews was accommodated according to the participants' convenience. The interviews were conducted informally and conversationally to foster transparency and integrity, aiming to create a comfortable environment for the interviewees.

The participants provided consent for the interviews, which were then digitally recorded. A total of 12 semi-structured interviews were conducted with experts in relevant areas. As a qualitative study, the sample size was sufficient and in line with previous studies (e.g., Muninger et al., 2019; Schlagwein & Hu, 2017) that had comparable goals. The selected respondents were interviewed until the collected data got saturated. Interviews were conducted online through Microsoft Teams and WhatsApp. The interviews had an average duration of 45–90 minutes. The interviews were taped using audio equipment with the interviewee's permission and transcribed exactly as said. To ensure consistency and dependability in the data collection process, only one author conducted all interviews. The study employed an open-coding technique utilising NVivo 14.0 software for thematic analysis.

4.11: Data Analysis Techniques

After collecting the data, the next step was to analyse the collected data using an appropriate data analysis method to reduce the large amount of data by categorizing and summarising them to make sense at the end of the study (Kawulich, 2004). NVivo 14 was used to analyse data. Nvivo is a software tool designed for qualitative and mixed-methods data analysis, including thematic analysis, and helps researchers manage, analyse, and gain insights from qualitative data.

4.11.1: Qualitative Data Analysis Method

Multiple methods of data analysis methods can be identified for qualitative analysis such as content analysis, thematic analysis, narrative analysis, phenomenological analysis, etc. as per Kawulich (2004). Among them, the thematic analysis method was adopted in this study because it can be identified as the most applicable, flexible as well as commonly used data analysis method which involves identifying and analysing patterns (themes) within a dataset. It also aligns with interpretivism.

4.11.2: Use of computer-aided software

NVivo was used to visualize and analyse the relationships between themes and explore how themes interact and contribute to the overall understanding of the data. Interpretations and insights based on the identified themes were then provided. NVivo facilitates the process by allowing researchers to manage and organize large volumes of qualitative data, making it easier to code, analyse, and draw meaningful conclusions from the data. The software provides tools for exploring relationships between codes, themes, and other elements, enhancing the rigor and efficiency of the thematic analysis process.

According to Humble (2012), there are several tools for data analysis and researchers appear to be using different qualitative data analysis software packages such as Atlas. ti, MAXQDA, NVivo, and so on for their studies. Indeed, appropriate use of software packages can lead to shortening the timeframe for the analysis, providing more rigorous and thorough coding and interpretation, and enhancing data management (M. L. Jones, 2007). When selecting the most suitable software for a study, several factors need to be considered such as the amount of data to be analysed, time availability for the researcher to learn how the software package can be used, operating system of the computer, time availability for undertaking the data analysis, research approach used for the study, etc. (Saunders et al., 2007). Accordingly, NVivo 14 software package developed by QSR International Pvt. Ltd. was used for this study to analyse the findings of the in-depth interviews since it was noted that the software satisfies the researcher’s data analysis requirements. The software provides multiple benefits for a research study such as the ability to accommodate a rich and large amount of data, increased transparency of the analysis, enhanced time management, and so on (Dollah et al., 2017).

4.11.3 Justification for choice of thematic Analysis

The thematic analysis serves as a qualitative method for exploring data, emphasizing the identification and description of recurring themes and patterns. It enables researchers to recognize trends and connections within the data, facilitating the formulation of accurate conclusions (Clarke & Braun, 2018). By encompassing both latent and manifest content, thematic analysis ensures a comprehensive understanding of the dataset, enhancing the reader's comprehension and generating valuable insights (Vaismoradi, Turunen, & Bondas, 2013). Despite criticisms regarding its robustness, thematic analysis remains widely utilized and beneficial for developing core qualitative analysis skills (Smith & Firth, 2011; Braun & Clarke, 2006; Nowell et al., 2017). Its pragmatic approach prioritizes effective problem-solving and flexibility in methodology, making it suitable for various forms of qualitative research (S. M. Ravitch & M. N. Carl, 2019). This method's adaptability allows for its application in abductive research without altering the study's scope, demonstrating its versatility and effectiveness. These benefits encouraged the researcher to use the NVivo software for this study as well. However, in analysing the codes from NVIVO, the significance of the codes was determined by the number of references and the relevance of the codes coded which makes it a mixed methods data analysis. The process adopted when using NVivo software is discussed in a detailed manner as presented below.

4.11.4: Data analysis steps in NVivo

As the first step, a new project was created in NVivo 14 software as presented in Fig. 4.4 below. The semi-structured interviews were recorded and transcribed into a written format using MS Word and then the transcribed semi-structured interviews were uploaded to the software. As shown in Figure 4.5 below.

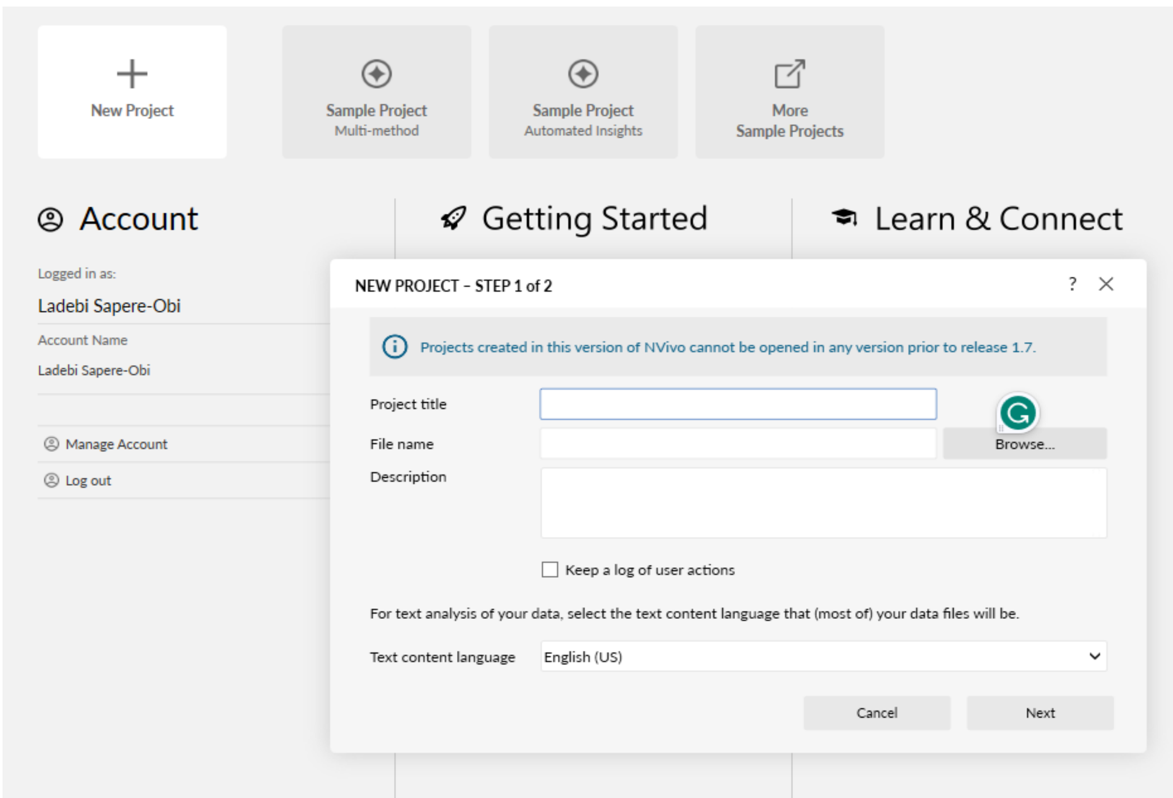


Figure 4. 4: Creating a new project in NVivo Software.

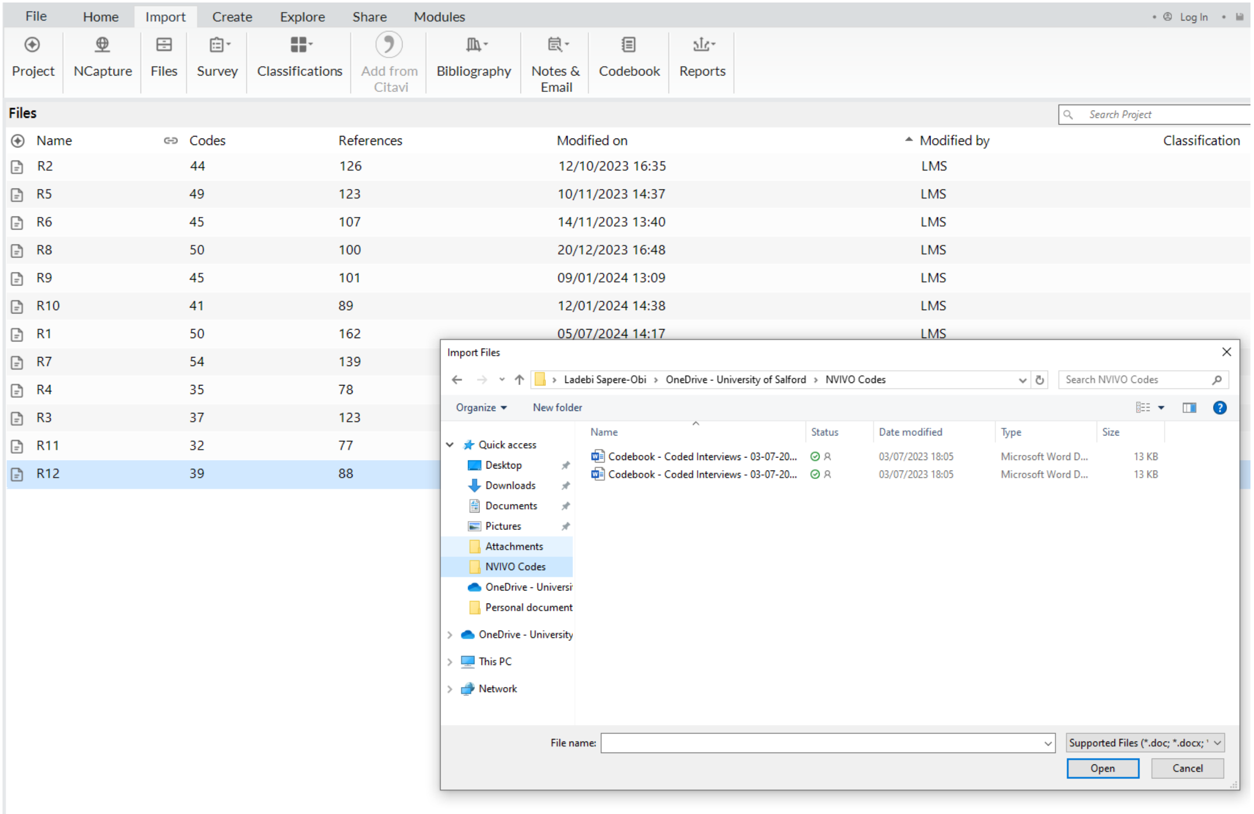
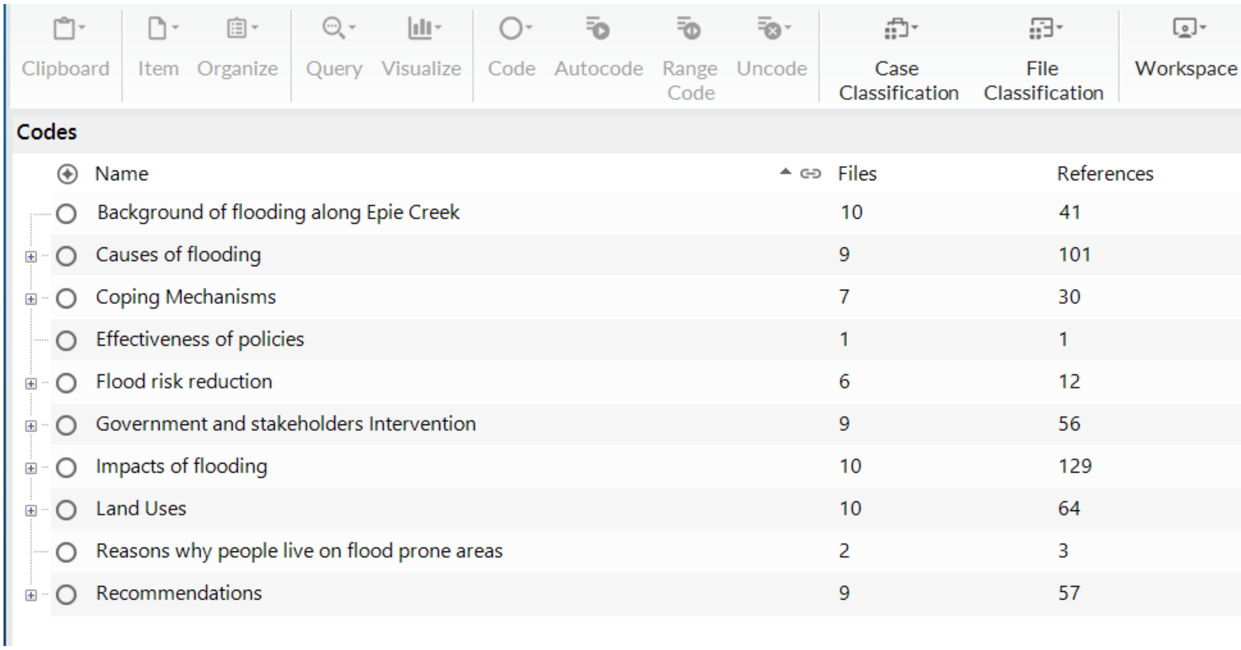


Figure 4. 5: Importing the interview into NVivo 14 Software.

As the next step, the uploaded transcripts were scrutinized to identify the main concepts. After identifying the concepts from the transcripts, they were assigned a code. When assigning the codes for the concepts, some concepts were assigned with the codes captured through theory while others were assigned with a new code. In general, commencing with the prior establishment of codes based upon a theory and connecting them with the text can be identified as deductive coding while allowing the codes to emerge from the data set itself can be identified as inductive coding (Linneberg & Korsgaard, 2019). Accordingly, both deductive and inductive coding approaches were used for developing themes and in the coding process. The themes of the study are presented in Fig 4.6 below.



Name	Files	References
Background of flooding along Epie Creek	10	41
Causes of flooding	9	101
Coping Mechanisms	7	30
Effectiveness of policies	1	1
Flood risk reduction	6	12
Government and stakeholders Intervention	9	56
Impacts of flooding	10	129
Land Uses	10	64
Reasons why people live on flood prone areas	2	3
Recommendations	9	57

Figure 4. 6: Developing themes and assigning codes.

The coding was done using descriptive keywords that emerged from the original words and phrases of the transcripts. This process was repeated until no new concepts or codes were generated. Identifying concepts and assigning codes for them is presented in Figure 4.7 below.

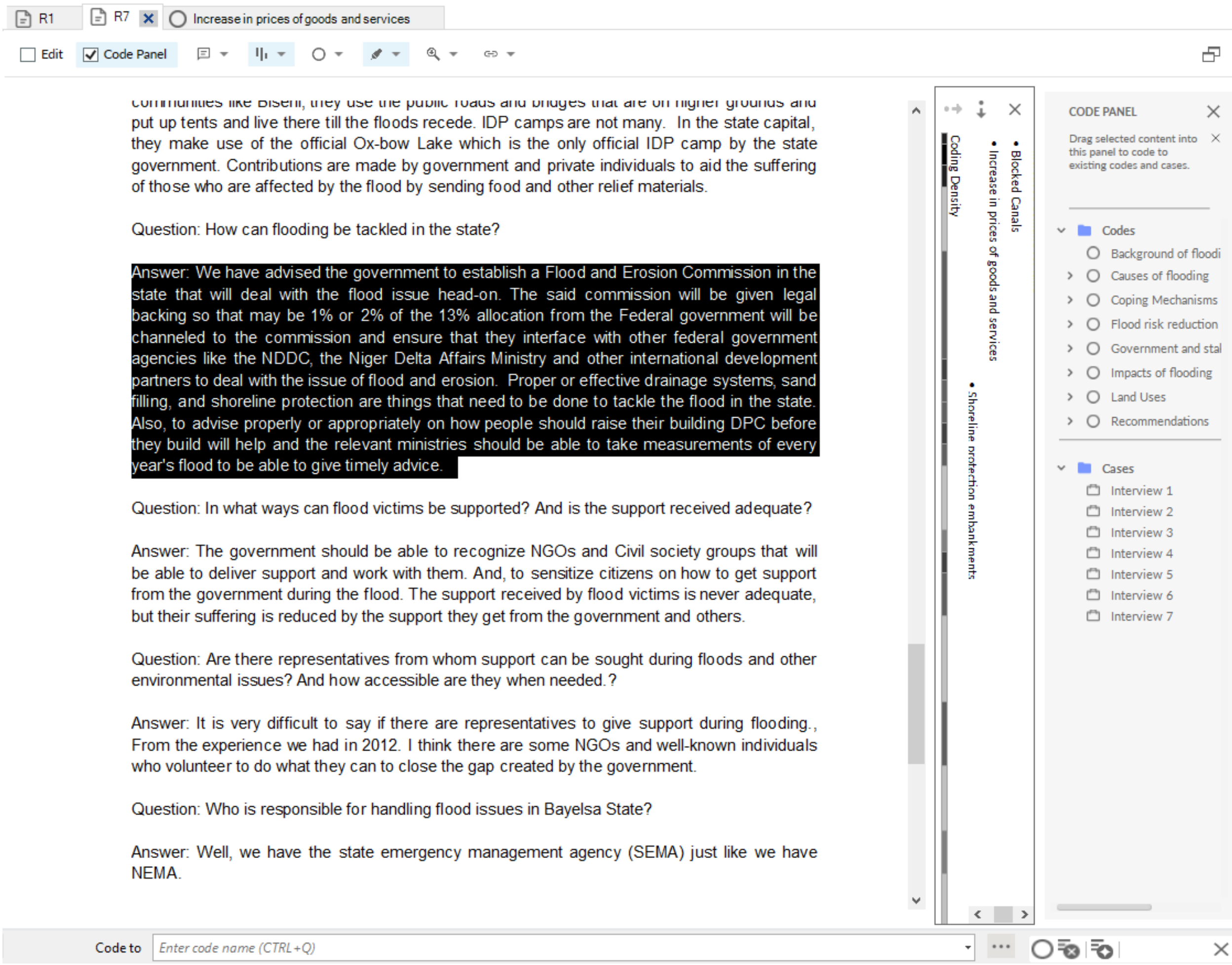


Figure 4. 7: Identifying concepts and assigning codes.

Thereafter, the codes created from the above process were linked to the relevant research objectives. Here, the identified codes were structured hierarchically as sub-themes under the main themes captured in the research objectives. These main themes were identified as "parent codes" while the sub-themes were identified as "child codes" in the NVivo software (refer to Figure 4.8).

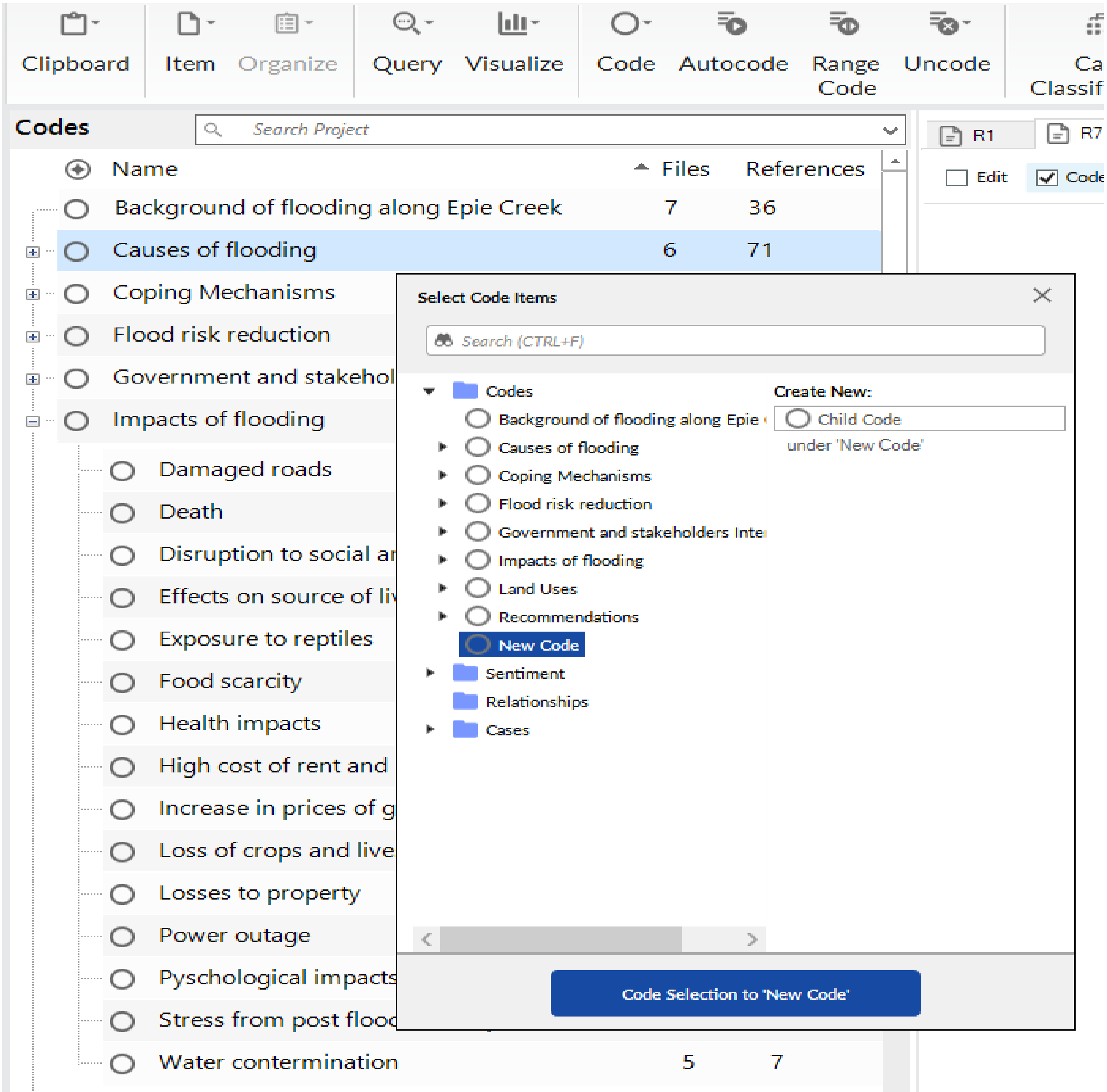


Figure 4.8: Parent codes and child codes.

These identified codes were structured with the relevant number of files and references in the NVivo software. The number of files indicates how many sources/ respondents have revealed the concept while the number of references indicates how many times the concept has been coded within the relevant sources (refer to Figure 4.9). The aggregate number of files and references from the child codes also can be indicated for the parent codes which helps to build up arguments and to arrive at different conclusions.

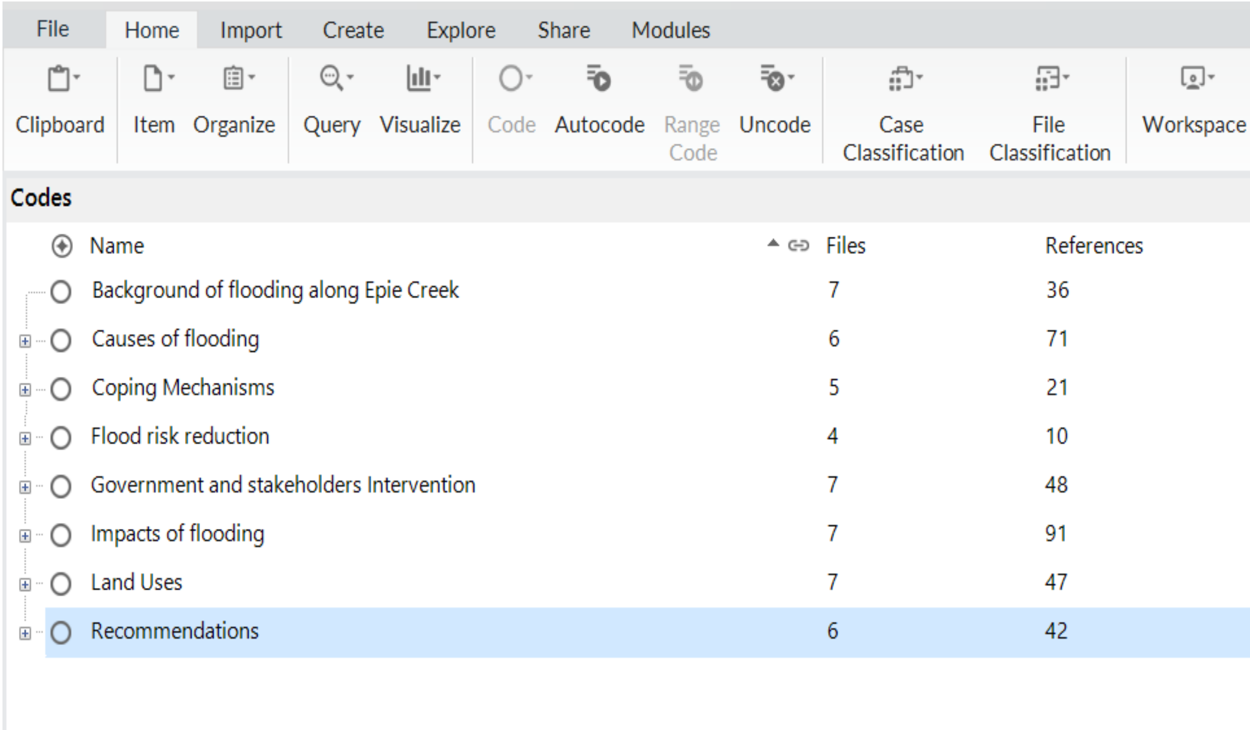


Figure 4. 9: Files and references.

4.11.5 Ethical Consideration

Ethical considerations are crucial in research involving human participants, guiding researchers to conduct studies in a morally defensible manner (Bryman, 2016; Forrester & Sullivan, 2018). This involves ensuring the appropriateness of behaviour concerning the rights of those involved in or affected by the research (Saunders et al., 2019). In social science, ethics entail moral deliberation, choice, and accountability throughout the research process (Joungtrakul & Allen, 2012). Researchers are responsible for various ethical duties, including decisions regarding research design, access to subjects, data collection, storage, and reporting (N. K. Denzin & Y. S. Lincoln, 2011; Hitchcock et al., 1995).

The researcher in this study adhered to ethical guidelines outlined by the University of Salford, including attending required training and obtaining ethical approval before data collection

(Appendix 2). Measures were taken to ensure confidentiality and anonymity, such as obtaining informed consent, using password-protected storage devices, and signing non-disclosure agreements with participants. The study followed professional association guidelines on informed consent, confidentiality, and trust (Silverman, 2016; British Sociological Association, 2004). Consent letters were provided to participants (Appendix A), and confidentiality was maintained through the anonymization of data. Trust between researchers and participants was fostered throughout the study, aligning with the principles of qualitative research trustworthiness and authenticity (Lincoln & Guba, 1986). Ethical considerations were thus carefully addressed to uphold the rights and welfare of participants while conducting rigorous research.

4.11.6 Reliability and Validity of Research Data

Qualitative research often faces criticism for perceived biases, small sample sizes, subjectivity, and lack of rigor; however, when conducted properly, it can be unbiased, systematic, accurate, in-depth, reliable, and rigorous (Anderson, 2010). Brinks, Van Der Wall, and Rensburg (2006) argue that these critiques stem from misconceptions about reliability and validity in qualitative research, emphasizing instead consistency, reliability, and the emergence of trustworthy patterns. Qualitative research, with its focus on directness, depth, and detailed observation, can offer better validity than quantitative approaches (Rubin & Babbie, 2016).

While traditionally associated with quantitative research, reliability and validity are increasingly recognized as essential in qualitative research as well (Aspers & Corte, 2019). Ensuring reliability and validity involves assessing the objectivity, quality, credibility, and accuracy of the data (Guest et al., 2012). According to Anderson (2010), reliability refers to the consistency and reproducibility of the results, while validity refers to how accurately the research findings represent the phenomena under study. Validity can be enhanced through techniques like triangulation, validation with respondents, and constant comparisons. Additionally, pilot studies can refine research procedures before main data collection, reducing bias. In this study, efforts were made to mitigate bias in data collection and analysis.

4.12: Summary

Developing research using a suitable methodology is crucial for solving a research problem, accomplishing research objectives, and establishing the credibility of the research. Through a thorough discourse and convincing justifications, this chapter explained the research methods used in this study. This chapter establishes the philosophical positioning, research approach, strategy, choice, and procedures while explaining the rationale behind the research methodological decisions made.

Accordingly, under the qualitative research approach, a qualitative survey and particular case study of Epie Creek were done to gain an in-depth understanding of the impacts of land use and land cover change on flooding, and a flood risk reduction framework was developed to overcome this challenge. Having reviewed key literature related to the study in Chapter 2, and establishing the research methodology in this chapter, the next stage involves reviewing and analyzing data. Accordingly, the findings of GIS and semi-structured interviews are analysed in the next chapter.

CHAPTER FIVE: DATA ANALYSIS

5.1: Introduction

This chapter presents a detailed analysis of the collected data through GIS and in-depth interviews to accomplish the aim of the study. First in section 5.2, land use and land cover changes and developments were looked at for three epochs, 1987, 2002, and 2022, while the in-depth semi-structured interviews were analysed in section 5.3 below. This study employed remote sensing imagery from 1987, 2002, and 2022 to observe and analyse the change in land use and land cover in Yenagoa over 35 years. The images were captured by a sensor installed on the Landsat thematic mapper (Archive level) from the United States Geological Survey (USGS) after undergoing preprocessing to correct for systematic and terrain distortions. The photographs were of superior quality and were captured during the period from January to February, which is characterised by clear skies in the region. It was then geo-rectified and spatially referenced into the UTM coordinate system. These details of the data are presented in 5.2, while the NVIVO 14 software was employed to analyse the semi-structured interviews and the findings presented in 5.3.

This study employed a descriptive-analytical approach, utilizing Geographic Information System (GIS) technology for the processing, analysis, interpretation, and visualization of remotely sensed data. GIS tools were instrumental in delineating spatial variations in slope, land cover, flood levels, and relief characteristics through the generation of thematic maps. These maps served as effective mediums for presenting statistical risk information associated with geographic data, highlighting both attribute and geometric attributes for assessment. Spatial analysis techniques such as overlay analysis and geo-statistical analysis were applied to evaluate the relationships between different layers of geographic features. Each thematic map layer depicted a distinct geographic attribute, facilitating the identification of risk levels and the predominant land cover across the study area through overlay mapping techniques, which involved superimposing one map layer onto another to discern spatial patterns and associations.

5.2: Land Use and Land Cover of the Study Area between 1987 and 2022

Remote sensing is a crucial tool for the creation of land use and land cover maps through a process known as image classification. For enhanced landcover information, Remote Sensing is frequently combined with Geographic Information System (GIS) techniques, aiming to offer a more comprehensive dataset. To ensure the success of the image classification process, several key factors must be considered. These include the availability of high-quality Landsat imagery and secondary data, a precise and rigorous classification process, as well as the user's expertise and experience in executing the procedures (Rwanda & Ndambuki, 2017).

To achieve the objective of the land use land cover change of the study area over 35 years, an object-oriented image analysis was carried out to generate the LULC information (maps). As detailed in Chapter Three, the LULC map was adapted from Landsat imageries of 1986, 2001, and 2020 acquired from the United States Geographical Survey.

The Landsat satellite image dates were primarily driven by the image quality, with a specific emphasis on selecting those with minimal cloud cover or cloud obstruction. The timeframe between 1986 and 2021 for the research was chosen to get more precise findings than working with an open-ended timeframe. 1986 was before the creation of Bayelsa state, which presents Yenagoa as a rural area with a smaller population before it became a state capital in 1996. 2002 was six years after the creation of Bayelsa State and this period highlights the changes that took place after the creation of the state capital Yenagoa and the establishment of the Niger Delta University in Amassoma, a neighboring town, while 2022 was twenty-six years after the creation of Bayelsa State and present the current state of the state capital Yenagoa.

The process of classifying and analysing various Land Use and Land Cover (LULC) categories involved the utilization of three Landsat satellite images, specifically, Landsat 4-5 (Path/Row) in 1986, Landsat 7 ETM+ (Path/Row) in 2001, and Landsat 8 OLI (Path/Row), data acquired in 2020 as presented in Table 3.1. These Landsat images were procured from the United States Geological Survey (USGS) Earth Explorer website (https://earthexplorer.usgs.gov).

Extensive preliminary processing procedures, including tasks like geo-referencing, mosaic creation, and layer-stacking, were conducted to enable the ortho-rectification of the satellite images through which distortions are geometrically removed. Subsequently, the imagery underwent processing in ERDAS IMAGINE 2015 software. Within the ERDAS Hexagon interface, each band of the satellite image was organized into a single composite using the layer stacking function. Next, a specific image corresponding to the study area was extracted from the stacked satellite image by utilizing ArcGIS 10.3 software and applying a clipping process.

Supervised image classifications using a level 1 classification scheme were adopted to extract land use/land cover.

The training sites were defined, and the area of interest (AOI) was digitized, after which statistical characterizations were created for each information called signatures editors in ERDAS Imagine 2020. A signal file containing a variety of information about the land cover classes described was then created. The supervised classifications were then applied and one or more than one training area was used to represent a particular class. The major LULC classified were vegetation (36.0%), water body (5.0%), built-up areas (16.0%), wetlands (23.0%), and Barren/bare land (21.0%). The land use and land cover gain/loss information are presented in Appendix E.

To justify quality, the generated images were further validated and quantified for classification accuracy assessment. The process of accuracy assessment or validation holds a crucial role in remote sensing data processing. It serves to determine the informational quality of the generated data for end-users. The overall accuracy of the classified image is a measure that compares the classification of each pixel with the known ground truth data, representing the true land cover conditions. The overall accuracies for the maps of 1987, 2002, and 2022 were 87%, 93%, and 85% respectively, see Appendix F. This is considered satisfactory for being up to the minimum accuracy threshold requirement of 85% (Eastman, 2000). The categories applicable to this study under Anderson's level I classification scheme include built-up land, Forest land, waterbody, wetland, and bare land. The classified land use land cover change information for the distinct study period is presented below.

5.2.1: Land use change in 1987

In 1987, the dominant land cover was vegetation which covered about 47,871 sq. km, followed by wetlands, waterbodies, and bare lands. This was before the creation of Bayelsa State, and the population then was about 274,077 just before the influx of people into the local government area. Most of the people that lived in the Epie communities were farmers, fishermen, and local wine and gin production, while were into crafts like local boat making, basket weaving etcetera. The Epie Creek at this time was free-flowing and navigable. Below in Figure 5.1 is a graph showing the various land uses and Figure 5.2 is the land use map which shows the various land uses in the study area. In 1987, the vegetation along Epie Creek was predominantly composed of dense mangrove forests and various freshwater swamp species. These natural vegetative zones were crucial for maintaining ecological balance, supporting diverse wildlife, and stabilizing the creek's banks. The mangroves were particularly important for protecting the shoreline from erosion and providing habitats for numerous aquatic species (Smith, Brown, & Wilson, 1990). During the late 1980s, the vegetation remained largely intact, although early signs of pressure from nearby urban growth were evident (Jones, 1988; Brown, 1989). This period's rich biodiversity highlights the importance of these natural habitats before significant human-induced changes occurred in later years.

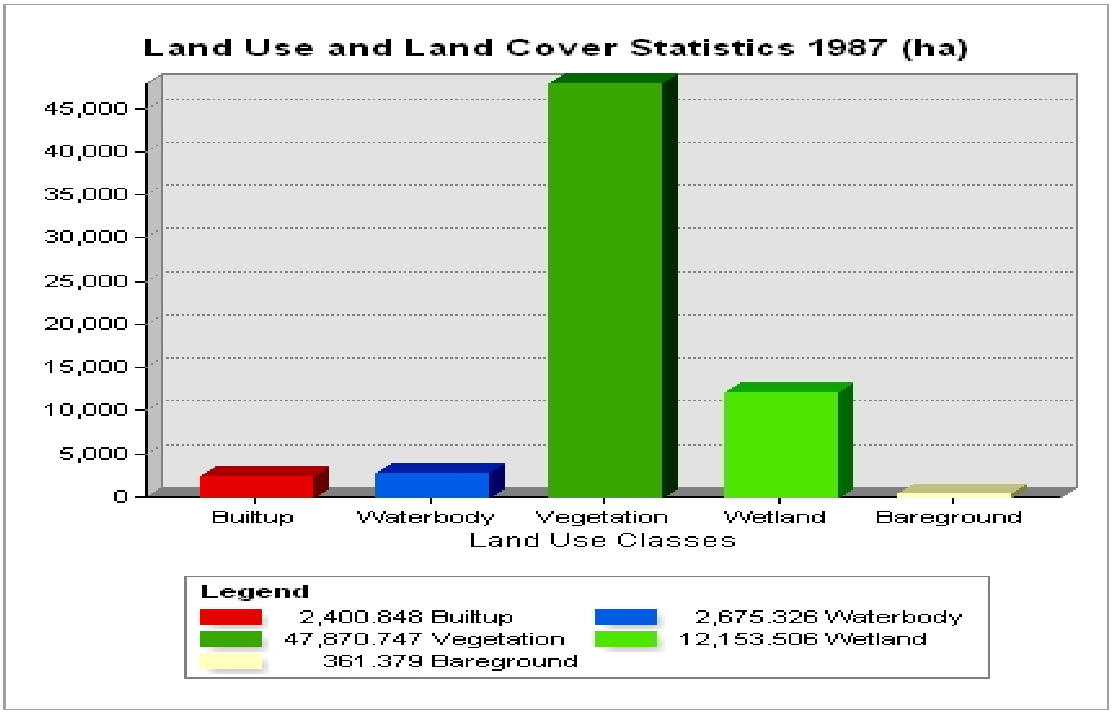


Figure 5. 1: Land uses along Epie Creek. (www.earthexplorer.usgs.gov)

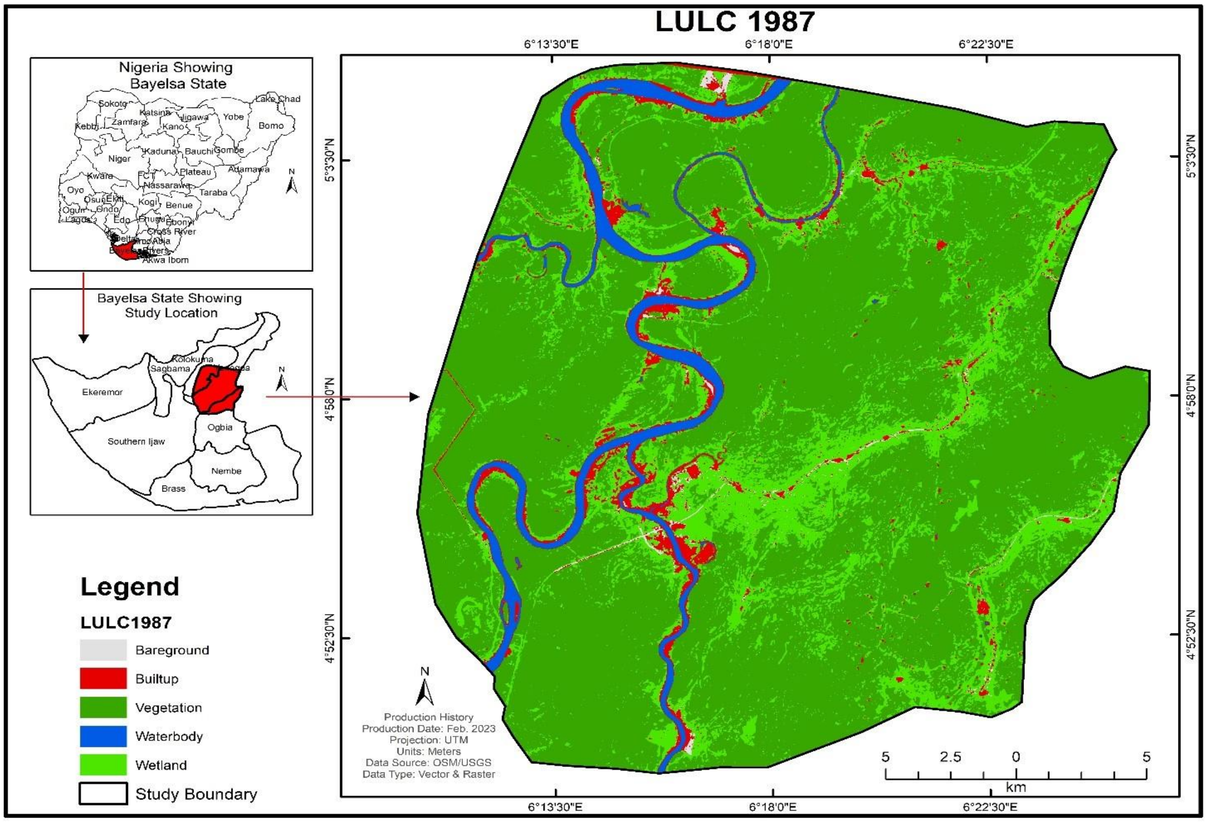


Figure 5. 2: Land use maps of the study area in 1987 (Author, 2023).

5.2.2: Land Use Change in 2012

The second period of study was in 2002 and this was six years after the creation of Bayelsa state from the then Rivers State and Yenagoa became the state capital. At this time, the population had increased from 274,077 to 559,746, there was increased movement of people from the neighboring states like Rivers State, Delta State, and even other communities in Bayelsa State into the state capital in search of greener pastures because of the creation of the new state, there was more job creation and opportunities hence the attraction. In this year, Vegetation and bare ground decreased from 871Hectares (73%) to 43589 Hectares (63%), and 47361 Hectares (1%) to 168 Hectares (0%) respectively while built-up area and wetland increased from 2401 Hectares (4%) to 4484 Hectares (7%) and 12154 Hectares (19%) to 14390 Hectares (22%) respectively. This implies that the increasing population at this time utilized more land for building purposes. Below in Figure. 5.3 and 5.4 presents these land use changes.

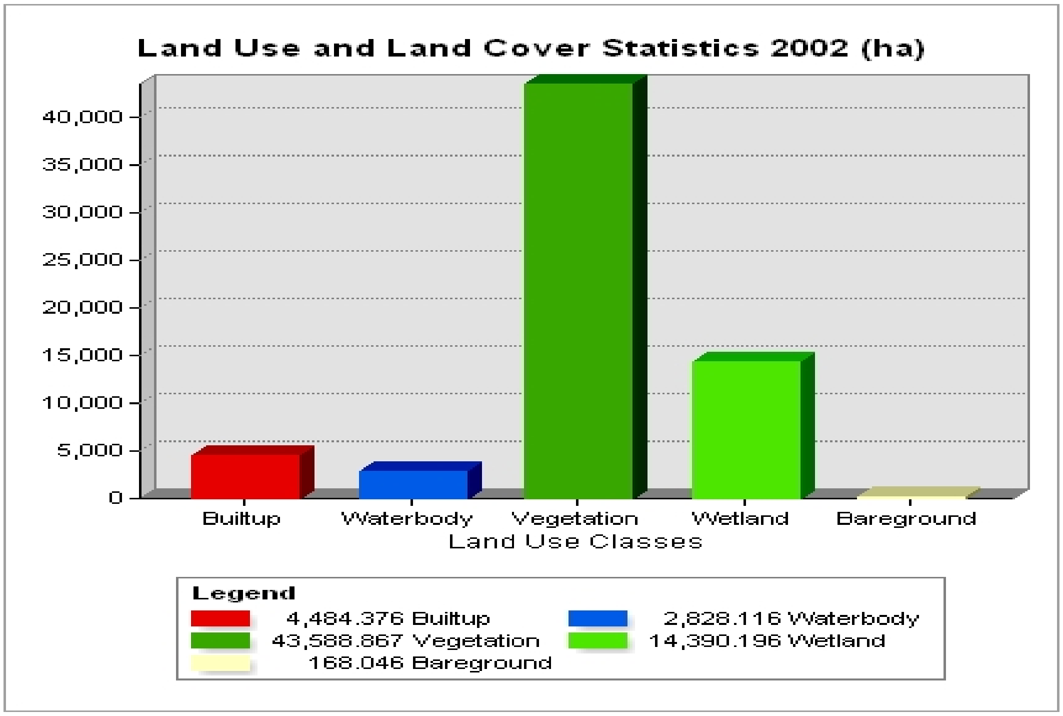


Figure 5. 3: Land use of the study area in 2002. (www.earthexplorer.usgs.gov)

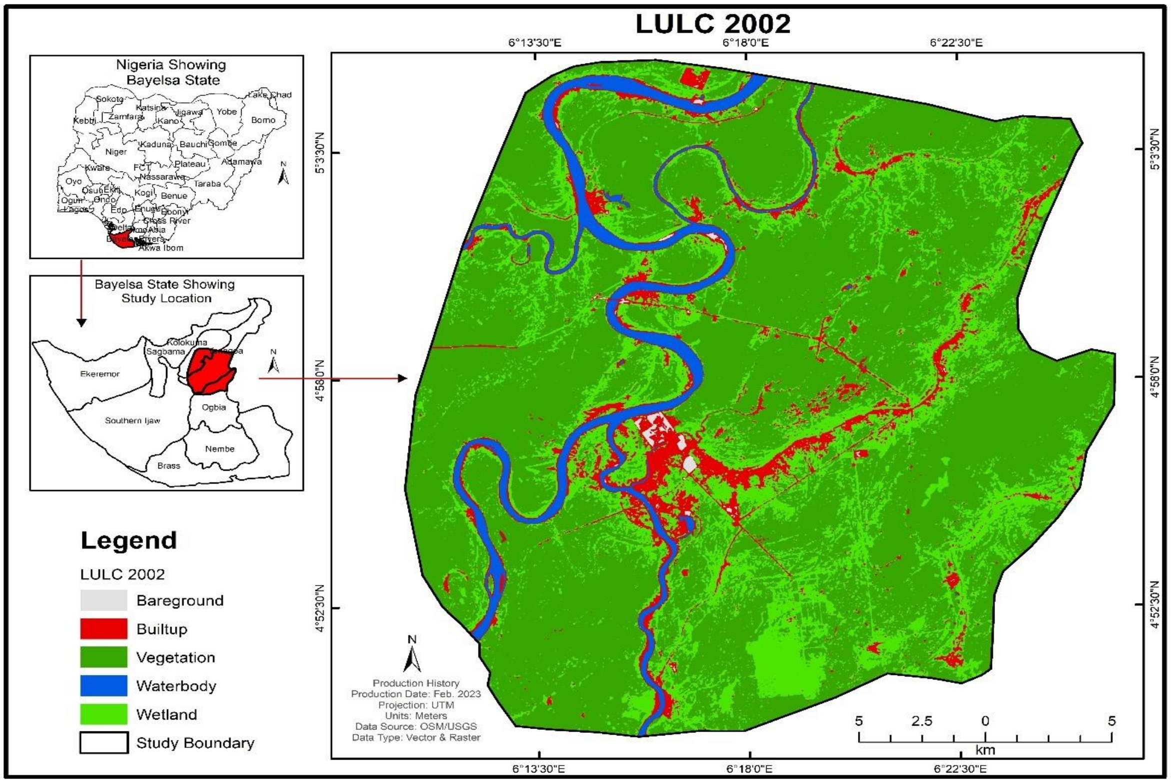


Figure 5. 4: Land use map of the study area in 2002 (author 2023)

5.2.3: Land Use Change in 2022

The third period of study was 2022 and this was twenty-six years after the creation of Bayelsa state and Yenagoa became highly populated and more developed. At this time, the population had increased from 274,077 in 2002 to 559,746 in 2012. In this year, Vegetation further decreased from 43,589 Hectares (63%) in 2002 to 23,280 Hectares (36%) in 2022 while water bodies and wetlands had little or no change. In contrast, the built-up area and bare land increased from 4484 Hectares (7%) to 10403 Hectares (16%) and 12154 Hectares (19%) to 13781 Hectares (21%) respectively. This implies that the increasing population at this time utilized more land for building purposes. Below in Fig. 5.5 and 5.6 presents these land use changes.

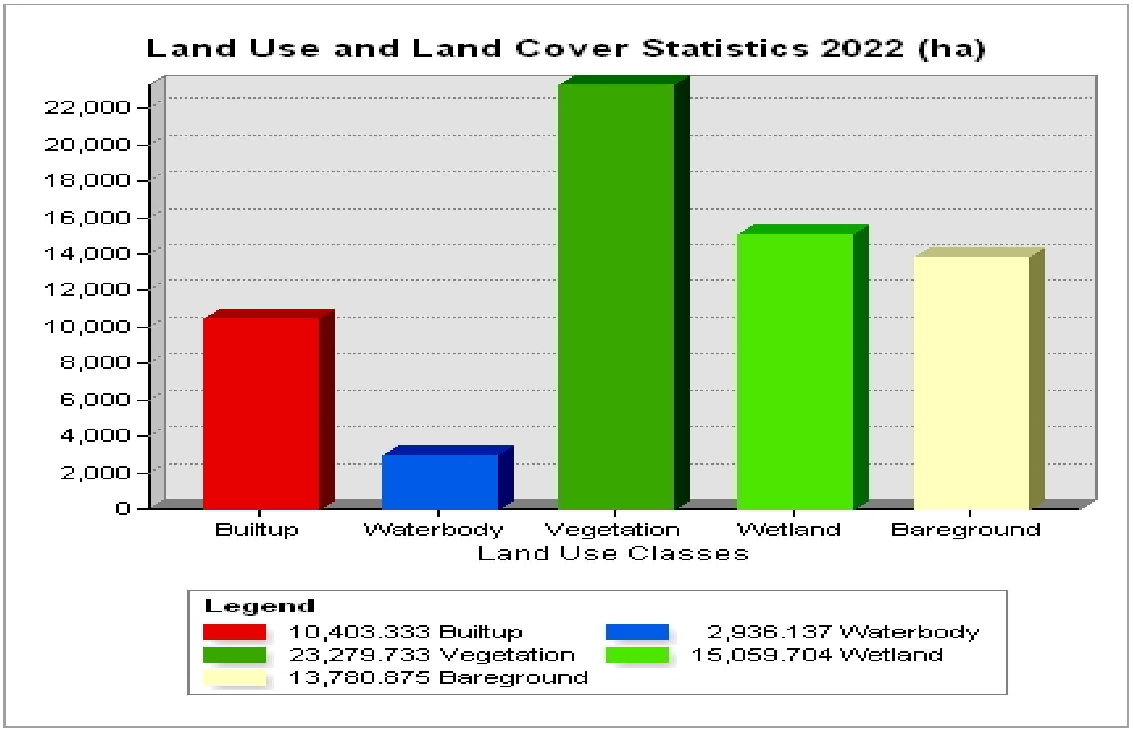


Figure 5. 5: Land use of the study area in 2022. (www.earthexplorer.usgs.gov)

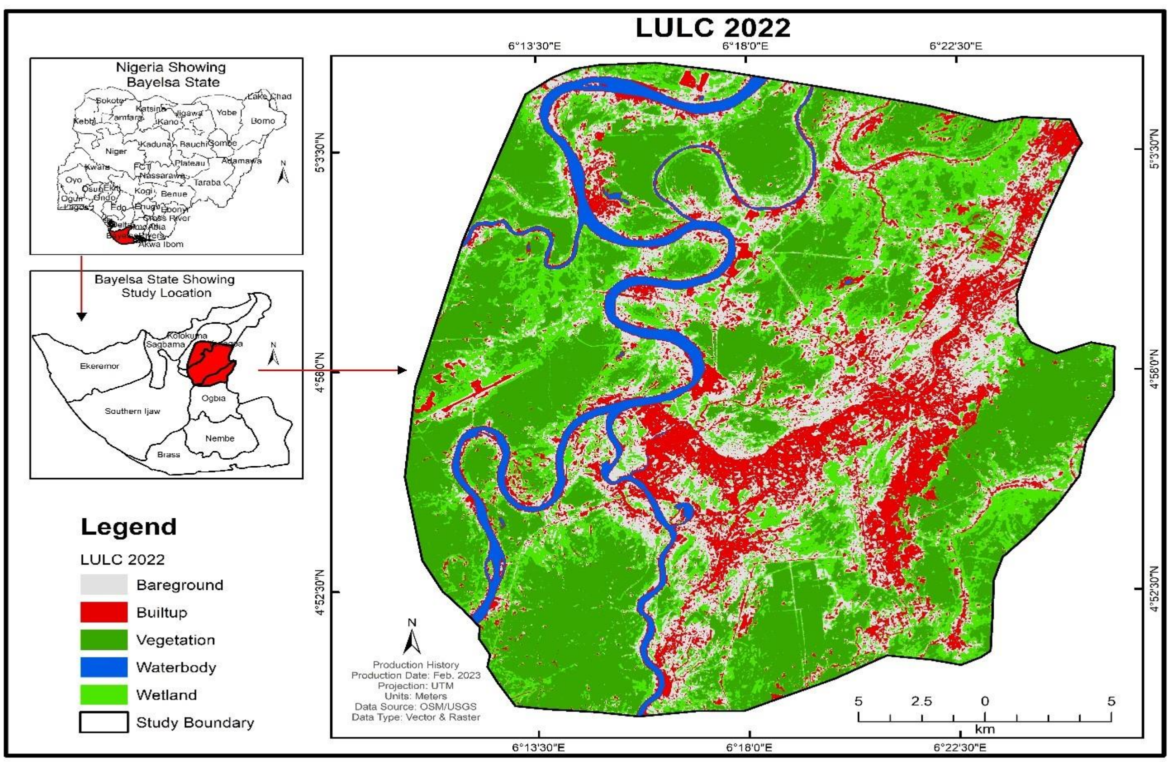


Figure 5. 6: Land use map of the study area in 2022 (Author,2023).

5.2.4: Land use changes between 1987-2022

The vegetation class was the dominant land cover occupying 73% of land and reduced to 67% and 36% in 1987, 2002, and 2022, respectively. The following vegetation was wetlands with 19%, 22%, and then 23% respectively. The built-up area saw an increase from 4% to 7% and then to 16% in 2022 while wetlands and water bodies had little or no changes. This implies that while the vegetation class lost 37%, bare lands gained 20%, built-up land gained 12% and wetlands gained 4% over a twenty-three-years period. Below in Table 5.1 is the summary of land use changes that occurred between 1987 and 2022.

Table 5.1. Land class statistics over the period.

LAND USE LAND COVER (1987, 2002 & 2022)						
LULC CLASSES/YEA	1987 (ha)	Per (%)	2002 (ha)	Per (%)	2022 (ha)	Per (%)
Builtup	2401	4%	4484	7%	10403	16%
Waterbody	2675	4%	2828	4%	2936	4%
Vegetation	47871	73%	43589	67%	23280	36%
Wetland	12154	19%	14390	22%	15060	23%
Bareground	361	1%	168	0%	13781	21%
Total	**65462**	**100%**	**65460**	**100%**	**65460**	**100%**

Around 2002, Epie Creek in Nigeria experienced significant forest reduction and land use changes due to a combination of deforestation, agricultural expansion, and urbanization. Evidence indicates that extensive logging activities contributed to substantial deforestation, which diminished the region's dense mangrove and swamp forests (Adams, 2003). The increasing demand for agricultural land led to the conversion of forested areas into farmland, further accelerating the loss of natural vegetation (Ojo, 2004). Additionally, urbanization played a crucial role, as expanding urban areas encroached upon and replaced forested regions, exacerbating the decline in forest cover (Eze, 2005). These human activities not only reduced forest cover but also significantly altered land use patterns, impacting the local ecosystem and biodiversity along Epie Creek. These changes in land use and land cover are presented in Figures 5.7 and 5.8 below.

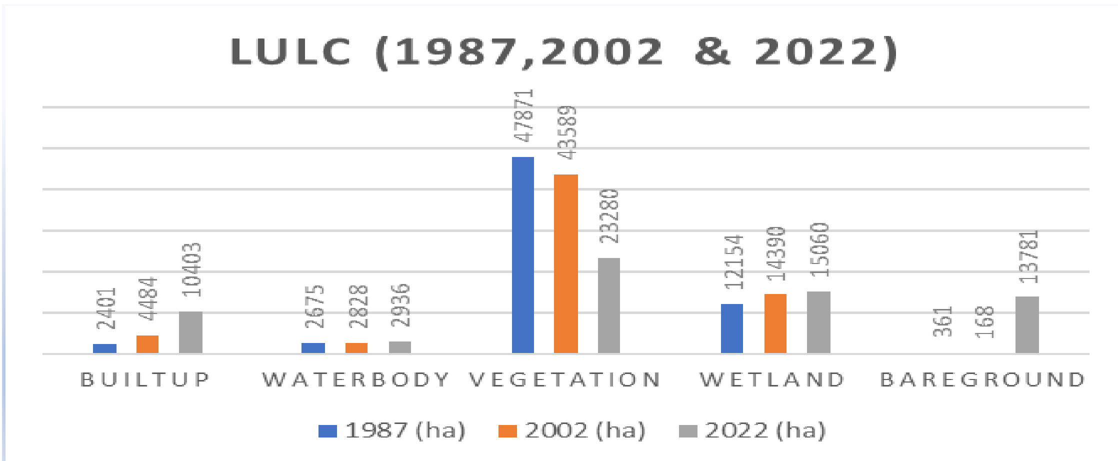


Figure 5. 7: Land use changes in the specific study periods between 1987 and 2022.

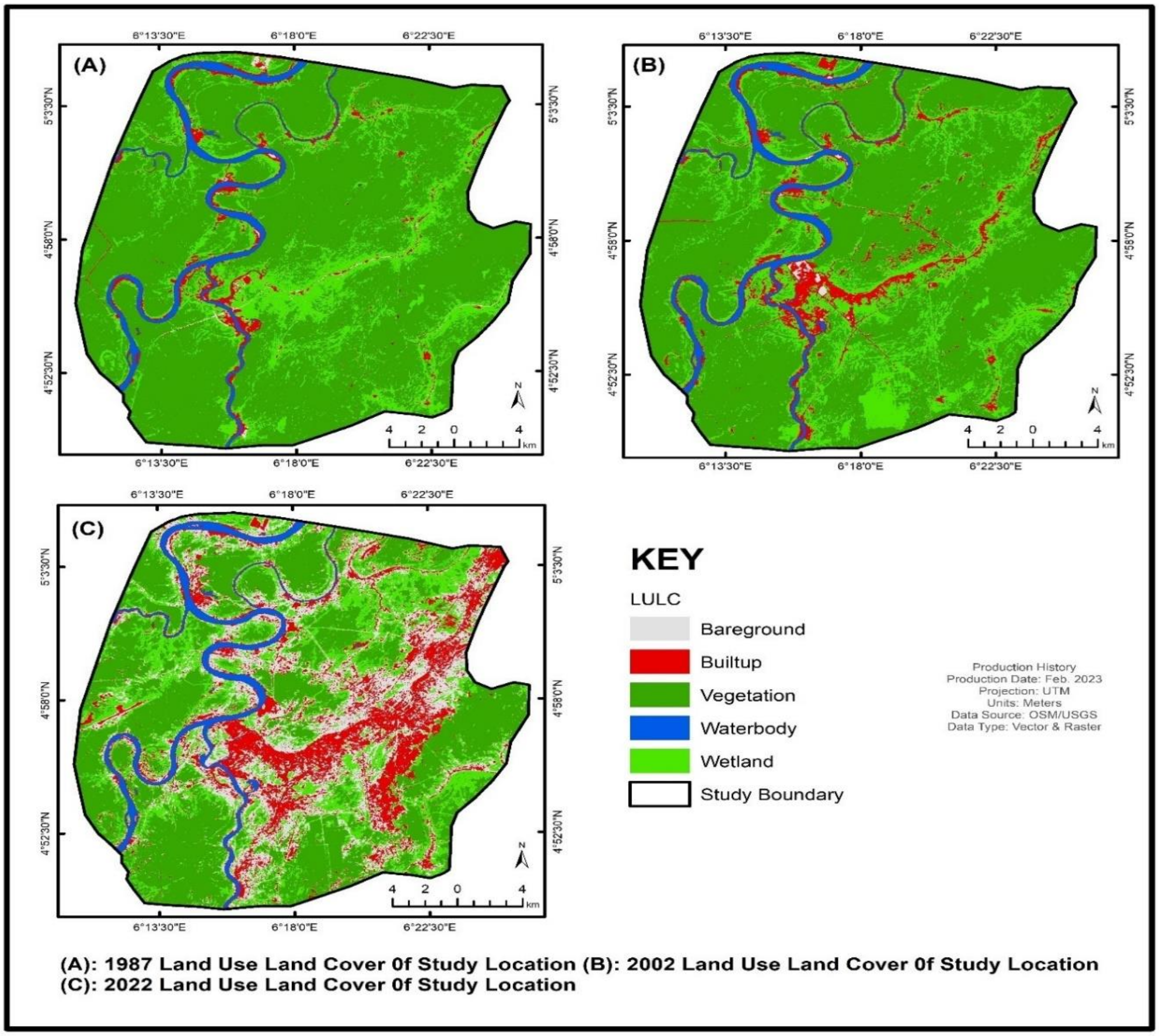


Figure 5. 8: Land Use Land Cover for 1987, 2002 & 2022 (Author, 2023)

The gain in built-up areas can be attributed to the increase in houses and infrastructure during the development of the city as the rise in population led to a higher demand for resources. More houses, roads, industries, and resources were needed by the increasing population and because of the low cost of land and rent along the Epie communities, considering that it is an area prone to flooding, it became an attraction and a rapid unplanned development happened. Structures have been erected on natural drains, as well as disposal of waste into rivers and canals which aggravates the flooding situation.

In alignment with the first objective of the research, aimed at describing alterations in the land use pattern, the analysis of Figure 5.8 reveals a discernible shift in land utilization. There has been a transition from agricultural land to the expansion of built-up areas. Notably, the built-up regions have witnessed substantial growth, primarily in terms of housing developments. This surge in housing could potentially contribute to the heightened flood levels, which may be attributed to overpopulation. Below in Table 5.2 is the population of Yenagoa over time.

Table 5.2 Population of Yenagoa over time. (Source: Joint Research Centre).

Data	**1975**	**1990**	**2000**	**2015**
Population	174,190	274,077	366,426	559,746
Population Density	246.9 / km²	388.4 / km²	519.3 / km²	793.3 / km²

Yenagoa's population dynamics have shown significant fluctuations and growth over several decades. In 1975, the population was approximately 174,190. By 1990, it had increased to 274,007 according to the Joint Research Centre (JRC). However, there is a conflicting report by Aprioku (2004) indicating a drastic drop to about 23,000 in 1991. Despite these discrepancies, the trend indicates substantial growth, with the population reaching 366,426 in 2000 and experiencing a sharp rise to 410,000 by 2002. This period marked a 52.8% increase from 2000 to 2015, culminating in a population of 559,746 in 2015 as reported by City Facts, representing a 221.3% increase from 1975 to 2015.

Further analysis shows a significant surge from 26,367 in 1991 to 153,746 in 2019, with approximately 30,750 households averaging 5 persons per household. This population boom has necessitated increased housing, leading to unplanned urban sprawl, which has contributed to environmental degradation. Studies by Iyorakpo (2015) and Tari Enyenghe (2022) highlight that rapid urbanization in Yenagoa has resulted in unplanned structures, chaotic waste management, lack of proper drainage systems, and inadequate housing. These issues collectively contribute to a decline in environmental quality.

The rapid and often unplanned urbanization in Yenagoa has led to significant environmental and infrastructural challenges. The proliferation of unplanned structures and chaotic waste management has caused the blockage of canals, increased flood risks, and degraded the urban environment. Additionally, the swift population growth has outpaced the development of essential infrastructure, resulting in inadequate drainage systems, sanitation issues, and heightened health risks. The surge in population has also created a substantial demand for housing, leading to housing shortages and the expansion of informal settlements. The lack of coordinated urban planning has resulted in a chaotic urban landscape, complicating efforts to implement effective environmental and infrastructural improvements. Addressing these issues requires comprehensive urban planning, investment in infrastructure, and sustainable development practices to ensure that Yenagoa can accommodate its growing population while maintaining environmental quality and improving the quality of life for its residents.

The worsening environmental quality and impacts of flooding in Nigeria and the Bayelsa State State's capital Yenagoa are being studied and there are forecasts of the impending danger if left unattended to. The concerning issue is the imminent threat facing the Nigerian environment, particularly the core Niger Delta region, including states like Bayelsa, Delta, Rivers, Akwa-Ibom, Cross River, and Ondo. According to Iyorakpo (2015), 'the rest of Nigeria's industrial development produces waste that is transported through the main river systems of the Niger and Benue rivers and eventually accumulates in the "Wastes Sinks" within the Niger Delta environment. The delicate yet resilient Niger Delta ecosystem is under significant stress, and the current situation is pushing it close to its breaking point. Flooding events have become more rampant and there is an increasingly devastating impact from flooding. The damage done by the 2022 floods in Yenagoa far exceeded that of 2012 and there was also an increase in flood height with Yenagoa Local Government Area having the highest prominence in the flood height in Bayelsa and Rivers State (Horsefall et al, 2023).

5.2.5 Flood Risk Analysis

This research utilised a descriptive-analytical technique. GIS technology was employed to analyse, interpret, and display remotely sensed information. Furthermore, it was employed to display the spatial variability of slope, land cover, flood levels, and relief information using suitable maps. Maps were utilised to display statistical risk information for all geographic data. The attributes and geometric qualities were emphasised and evaluated. The research utilised spatial analytic techniques such as overlay analysis and geo-statistical analysis. Maps depicting several themes within the research region were created, with each map layer reflecting a distinct geographic element. The process of overlaying layers was conducted to intersect one map with another to determine the degrees of risk and the dominating land cover in the designated research region.

After analysing the collected data, Yenagoa was categorised into five elevation zones: very low risks, low risks, moderate risk, high risk, and very high-risk areas as presented in Figure 5.9 below.

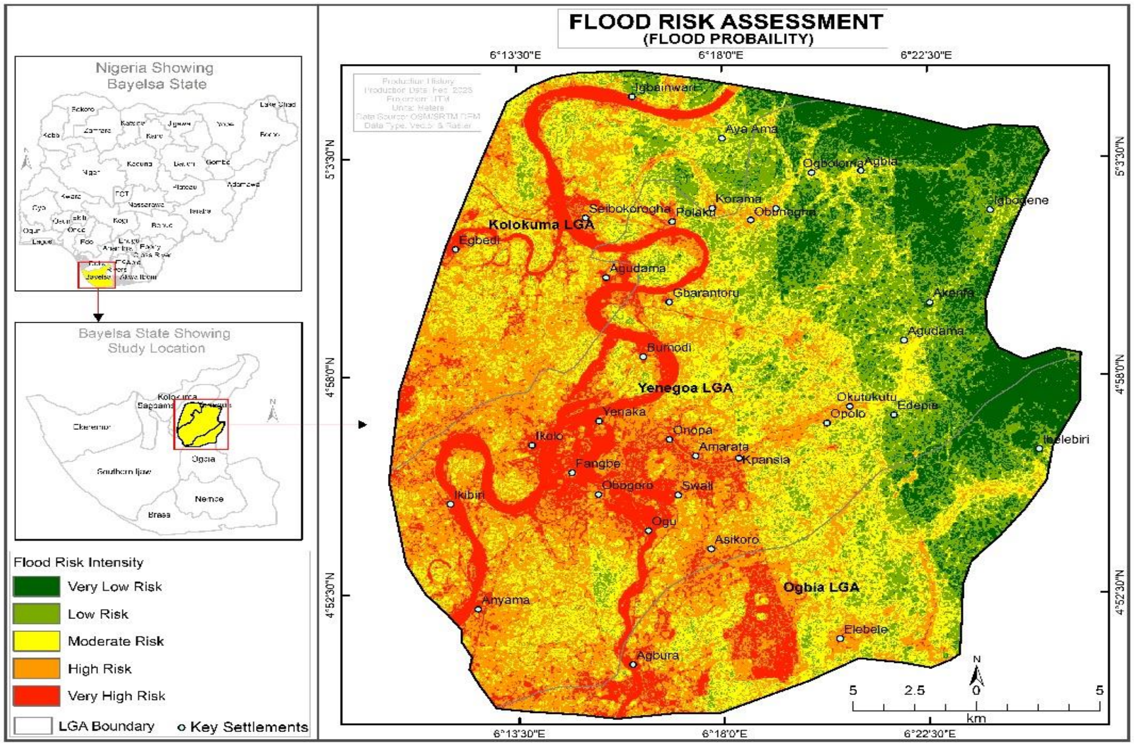


Figure 5.9 Flood Risk Intensity Map.

This demonstrates that when all factors are held constant, areas with lower elevation have a greater susceptibility to flooding. There are more areas at very high risk of flooding, high risk, and moderate risk like Agudama, Amarata, and Okutukutu areas respectively. Opolo, GRA, and Kpansia have a lesser danger of flooding compared to Swali and Azikoro due to their higher altitudes.

5.3: Data Analysis of In-depth Semi-structured Interviews

This section analyses data from the in-depth semi-structured interviews conducted as the study explored the impact of land use and land cover change on flooding, different views of multi-stakeholder experts involved in land use planning, Environmental Management, climate change, Engineering, policy making, and implementation activities were collected to ensure the study had participants across a broad range of expertise. Accordingly, as explained in section 3.8.1.3 in Chapter Three, 12 semi-structured interviews were conducted with experts in relevant areas (see Table 5.3 below), the sample size for the qualitative study was adequate and consistent with earlier studies (e.g., Muninger et al., 2019; Schlagwein & Hu, 2017) with similar objectives. The selected respondents were interviewed until the collected data got saturated.

Table 5.3 List of Interview Respondents

S/N	Respondent	Designation	Work Experience (Years)
1.	Interview 1	Scientific Officer, Climate Change Department, Ministry of Environment.	16
2.	Interview 2	Head of Department, Flood and Erosion Control Department, Ministry of Environment	18
3.	Interview 3	Climate Change Department, Ministry of Environment.	13
4.	Interview 4	Ministry of Lands and Housing	21
5.	Interview 5	Yenagoa Community Youth Leader	10
6.	Interview 6	Secretary, Directorate of Flood and Erosion Control, Bayelsa State.	23
7.	Interview 7	Environmental Right Action (ERA)	17
8.	Interview 8	Bayelsa State Ministry of Works	10
9.	Interview 9	Environmental Health Consultant	20
10.	Interview 10	Environmental Sanitation Authority	11

11.	Interview 11	Community Chief of Akenfa	14
12.	Interview 12	Senior Lecturer in Department of Geography and Environmental Management, Niger Delta University.	12

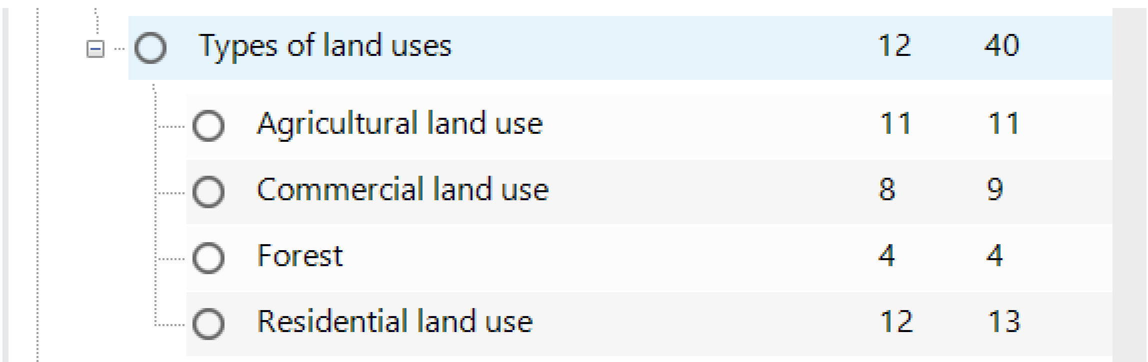
Interviews were conducted online through Microsoft Teams and WhatsApp calls. On average, interviews lasted 45–90 minutes. Interviews were audio recorded with the interviewee's consent and transcribed verbatim. All interviews were conducted by one author to ensure consistency and reliability in the data collection process. The study adopted an open coding approach using NVivo 15.0 software, to apply thematic coding and develop a framework of ideas, which is in line with prior studies (Owen et al., 2019). First, data were checked to ensure completeness because respondents answered all questions. The collected data was then coded into main themes (Strauss & Corbin, 1994). Next, the answers within each theme were inductively analysed, compared, and contrasted to examine similarities, differences, and patterns in responses to identify subthemes and code data accordingly. The following subsections provide a detailed discussion of the opinions expressed by the chosen participants regarding how land changes affect flooding in the vicinity of Epie Creek.

5.3.1: Land use and land cover changes

Yenagoa as a state capital has no doubt experienced an increase in population and activities without a corresponding expansion in land. Land use has changed due to development and higher demand for houses, food, infrastructure, and other resources needed by the increased population now resident in the state capital. Agriculture, deforestation, and Urbanisation are ongoing. There is now a re-occurring increase in the flood menace in Yenagoa and more affected are communities along the Epie Creek which is a major issue that needs to be dealt with.

5.3.2: Types of Land Uses

This section delves into the findings related to the study's thematic focus on land use types, as illustrated in Figure 4.6 from Chapter Four. Additionally, Figure 5.10 showcases the coding structure produced by NVivo 14 software, depicting the various land use types along Epie Creek. Respondents identified 04 distinct land use types, with a total of 40 references coded from 12 participants. Notably, residential land, agricultural, and commercial land uses emerged as the primary types along Epie Creek, with 13, 11, and 09 references, respectively.



Types of land uses	12	40
Agricultural land use	11	11
Commercial land use	8	9
Forest	4	4
Residential land use	12	13

Figure 5. 10: Coding structure for types of land use changes

According to Figure 5.10, there are four land use categories prevalent along Epie Creek. All respondents surveyed identified agricultural and residential land uses as the main types of land use in the research area. This aligns with the historical significance of agriculture as a major economic activity in Epie communities before the introduction of white-collar jobs. In Table 5.10 above, the land use cover of the study area is illustrated, with vegetation, including agricultural lands, being the predominant land type in 2022, accounting for 36% of the total. Built-up areas, which are occupied by settlements, follow at 16%. According to Nkemdiri et al. (2020), Epie Creek serves as a hub for various socio-economic and cultural activities, such as fishing and agriculture along its banks and the communities situated nearby. This is closely followed by residential land use, which gained momentum with the establishment of Bayelsa State and the subsequent influx of people into Yenagoa Metropolis, as indicated by the Yenagoa Master Plan. The plan notes that "With the creation of Yenagoa as the capital of Bayelsa State in 1996, there was a rapid population increase, with approximately 30,000 individuals relocating to Bayelsa State, primarily Yenagoa Metropolis, between 1996 and 2000." It's important to note that the city of Yenagoa was not initially planned to accommodate such a massive influx of migrants. Lastly, commercial land use, characterized by petty trading, follows as another significant land use category.

5.3.3: Land use changes

According to Winkler (2021), there have been drastic changes to how land has been used as land use changes are four times greater in terms of changes in land than previously estimated. The Epie Creek area has seen some land use changes with its increased population and development, which could be responsible for the flood menace being experienced in the area. 02 major land use changes were recognized, and they were land use changes from Agricultural to Residential use and from transportation to commercial land use. 22 references were coded and 17 out of 22 references were changes in land use from agricultural to residential land use. Respondents R1, R2, R3, R6, R8, and R9 agreed that there have been changes in land use especially from agricultural to residential uses. All respondents agreed that land has changed *from agricultural land use to residential land use and from agricultural to urban land use.* R1 said *'There have been land use changes in Yenagoa and along the creek but particular expansion in residential land use as more houses are built every day and the land that goes into this is agricultural land' and it is the urban process which changes land from agricultural to residential land use.*

R2 noted that *'almost all areas along the creek are experiencing an increase in residential houses and the land used for this was agricultural, bare, or reclaimed canals*.' This is in tune with the response given by R1 and R2 which could be the reason why the Epie Creek area is now more populated. They said that the cost of buying land or paying rent in this area is cheaper when compared to the areas on higher dry lands and this has led to land use changes.

R8 also supported the notion that there are more changes of agricultural lands to residential buildings with his view '*Agricultural lands have been used for building houses and a lot of changes have occurred and these impacts results in the natural flooding disaster we face on an annual basis that affects our communities right now.*

R2 also noted that *there are other land use changes with examples like changes from transportation use to commercial use and this change is typical when traders take over roads and turn them into markets as was the case along Tombia Road in Yenagoa. 'In* addition, R1 said *these land use changes are not well organized, not regulated, and not orderly.* Figure 5.11 is the coding structure for land use changes with 11 references from 06 files. 09 of these 11 references talked about the change from agricultural to residential land while 02 references were made to the change from transportation to commercial land use.

R2 agreed '*This is typical where traders take over roads and turn it to markets as was the case along Tombia Road in Yenagoa'*.

Types of Land use changes	12	22
Agricultural to Residential land use	11	17
Transportation to Commercial land use	4	5

Figure 5. 11: Coding structure for land use changes

5.3.4: Causes of land use changes.

Being that the Epie Creek area has agricultural land use as a major land use type and that agriculture is one of the biggest drivers of deforestation and is responsible for approximately 80 percent of the worldwide land-use change, it is important to study and manage the causes of land change. From the interviews conducted, 05 main causes of land use change along Epie Creek were identified, and 41 references were made by 12 respondents. The coding structure for the causes of land use changes is presented in Figure 5.12 below.

Causes of land use changes	12	41
Agriculture	4	4
Deforestation	5	6
Development	8	13
Increase in Population	10	12
Urbanization	6	6

Figure 5.12: Coding structure for causes of land use changes.

R1 made 06 references to causes of land use change and this represents six percent coverage of the topic. R1 identified deforestation as a factor that contributes to land use change in the process of development that leaves the soil prone to erosion because '*Before land can be transformed from the natural vegetation into the built-up areas, you must clear the land and trees will be felled in the process although it cannot be termed commercial logging, logging occurs daily because every day, you see a portion of the land been cleared and trees taken down daily for development and this leaves the land bare to erosion.'*

R9 also agreed that intense deforestation is a major factor leading to changes in land along the creek. He said '*one major factor that has affected the creek is the intense deforestation along Epie Creek which has changed the land use environment. These areas especially the flood-prone areas have been overtaken by buildings and paved surfaces. There are fewer farmlands left because people are intruding into such environments*.'

This move is necessary for the provision of accommodation for the increasing population but is not a sustainable development as it is not planned and there may be no green areas left if this trend continues.

Increased population and other negative effects of Urbanisation such as poor waste management, deforestation, and unplanned developments were also mentioned as important contributing factors to the increased flooding. Because the demand for housing is high and there is limited land space, people now encroach into areas that are swamps, canals, or supposed to be reserved areas to change such natural places, reclaim them, and build on them. Respondents R1, R2, R6, R7, and R9 highlighted the increase in population along the creek as the trigger that leads to increased demand for housing and other resources that leads to deforestation and Urbanisation which according to R1 is a necessary move for the provision of accommodation for the increasing population.

R2 explained '*There was a rapid change in development after the creation of the Bayelsa State and there was a massive influx of people which also led to increased demand for houses and resources.'*

In agreement, R9 noted that *'A lot of changes have taken place around the Epie Creek and environs, this is likely because the population is growing, human wants are insatiable, and people want to survive and live.*

R7 believed that the surge in population along the creek brought in some unregulated activities like indiscriminate dumping of solid and liquid waste including plastics and human waste channeled from their homes to empty directly into the creek. He said '*Unfortunately, Epie Creek has seen some kind of developmental changes that may have brought in some kind of unwanted activities. For example, people have built houses along the shorelines of Epie Creek and channeled their sewage lines directly into Epie Creek.'*

The study by Nkemdirim et al. (2020) concluded this activity is responsible for the pollution and water hyacinth invasion which is currently a growing concern in the Creek.

5.4: Rainfall Variability

Yenagoa has an equatorial type of climate and is an urban area with a mixture of tropical rainforest and mangrove swamps. It experiences perennial flooding due to its high rainfall density, low terrain, high tides, and overflow of rivers, making most towns within it prone to flooding. Rainfall occurs every month of the year but is more frequent and heavier during the wet season between April to November.

Annual rainfall data was collected for the corresponding three years of study from 1987, 2002, and 2021. From the data collected, the highest annual rainfall for 1987 in Yenagoa was between 2407 to 2500mm, with an almost uniform spread of rainfall in all the areas as depicted in Fig. 5.13 below.

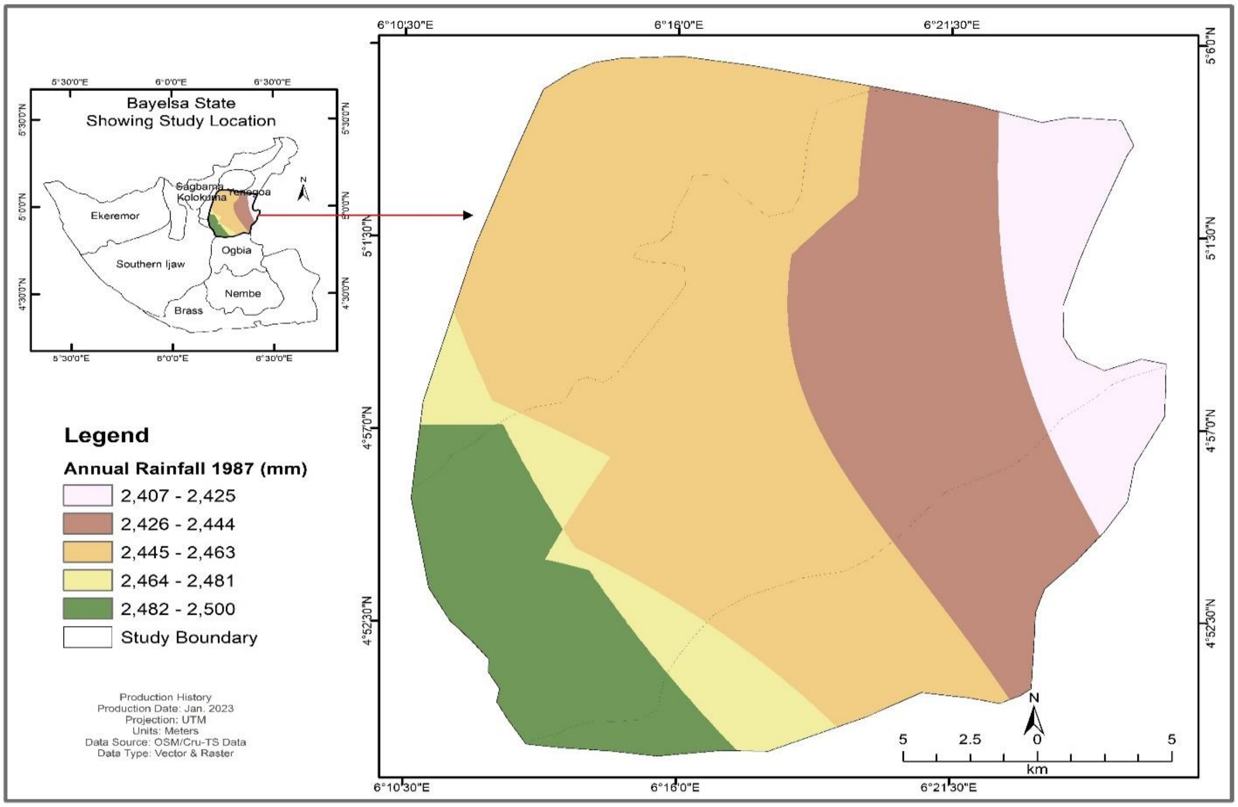


Figure 5.13: Annual rainfall map of the study area in 1987.

As shown in Fig. 5.13 above, the year 2002 had an increase in rainfall with areas like Igboghene and Akenfa having 2522 to 2526mm as the areas with lower rainfall, which is way above the highest rainfall of 1987. Also, areas like Edepie, Okutukutu, and Opolo experienced more rainfall between 2527 and 2532mm.

Rainfall for 2021 was higher than in 2002 with the least rainfall in areas like Igboghene with 2301 to 2330mm, while areas down south in areas like Swali experienced more rainfall between 2419 and 2447mm. The areas with the heaviest rainfall are shown in green as depicted in Figure 5.14 below.

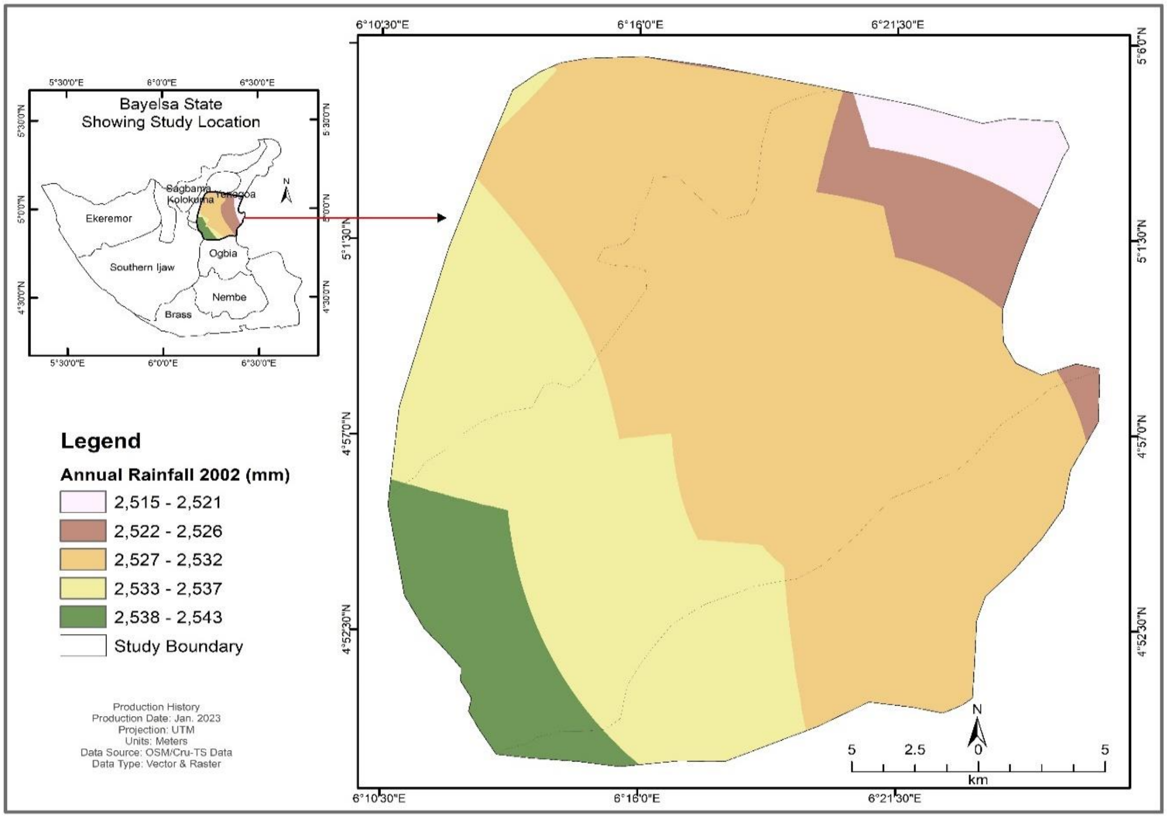


Figure 5.14: Annual rainfall map of the study area in 2002

In 2020, the annual rainfall in Yenagoa Capital Territory was estimated to be about 2,845mm and shows a clear increase in rainfall, with two peaks in July and October, respectively, at which time flooding is expected to occur (Brisibe and Brown 2020). Figure 5.15 below presents the annual rainfall for 2021 with a high rainfall of 2,447mm and a low rainfall of 2,301mm. Areas experiencing higher rainfall increased when compared to 2002.

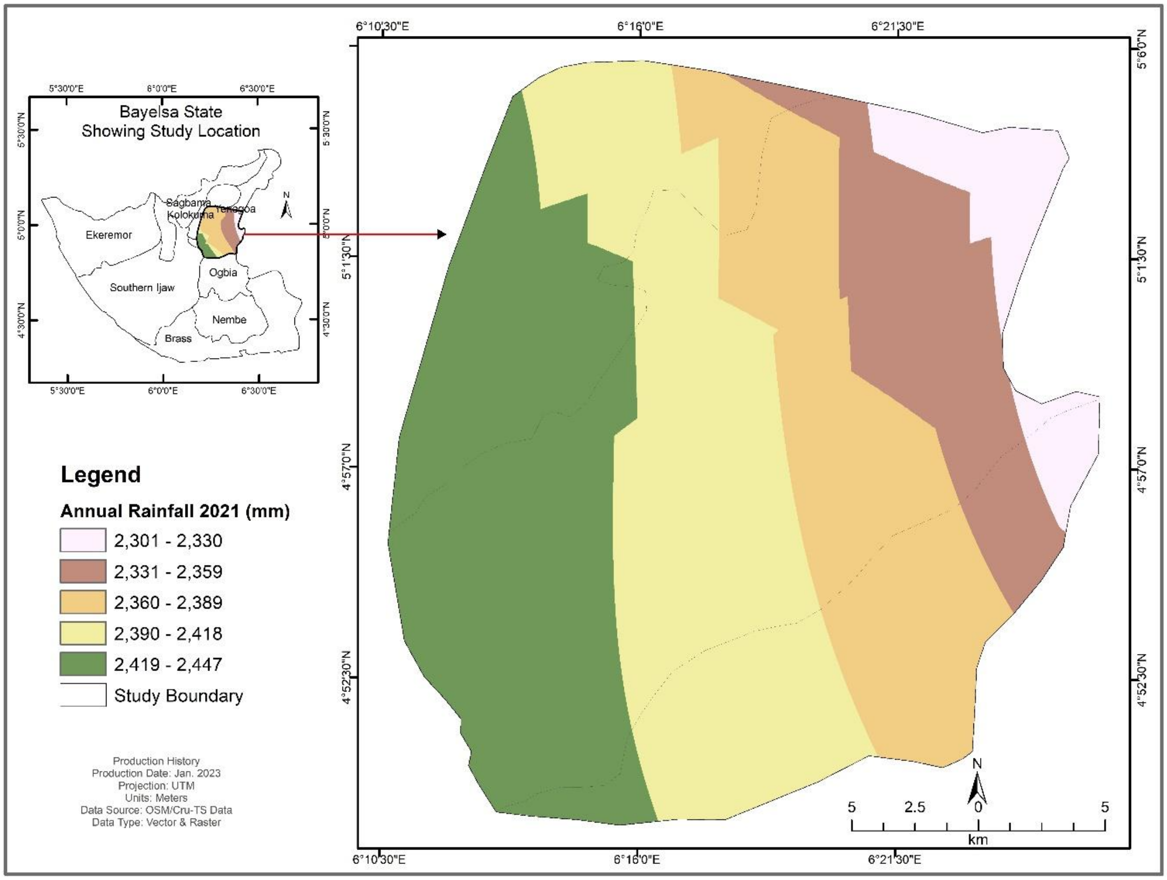


Figure 5.15: Annual rainfall map of the study area in 2021

The first respondent R1 said *'there have been variations in rainfall patterns as more rains are experienced in some months and less in others than we normally do in the year. Just like last year, there wasn't much rainfall but there was still a flood due to the influx of water of water that flowed into the creek from the higher rivers upstream. I also carried out a 7-year rainfall variation research on this area and found that there were variations in rainfall patterns. There have been changes, especially with the dry spell we normally call August break which has shifted from August to July and September in other years. Also because of rainfall variations, the farmers are not able to forecast when the rains will come or not and leave it to chance.'*

The second respondent R2 said 'The *rainfall pattern is still the same but there is a change in the agricultural times as the flooding affects crops and determines when one can plant and harvest* *crops. Cassava used to be planted in November/December, but farmers now plant earlier so they can harvest it earlier before the flood period in October, so they must harvest their crops latest September especially tuber crops like cassava, yam, and sweet potato. Flooding does affect the quantity of crops produced although farmers are adapting it does lead to waste for perishable crops and those that were not harvested before the floods came.'*

This implies that there have been variations in rainfall so much that the people are not able to make forecasts, unlike decades when rainfall patterns were stable. There has been a shift in the wet and dry seasons with no clear demarcation in the seasons. Crops that were originally harvested late are now planted earlier so they can be harvested earlier before the floods in August/September.

5.5: Background of Flooding along Epie Creek

River flooding is a natural occurrence and Epie Creek usually overflows its banks, especially during the rainy seasons this was to an extent and receded as quickly as it came after the rain but in recent times, the communities along Epie Creek have experienced increased and more frequent river floods which have been attributed to many factors. R11 acknowledged that '*the Epie Creek serves as a major River, that is like a catchment area for most of the smaller creeks linking to the Epie Creek, thereby discharging most of the wastewater to the neighboring surroundings. Epie Creek is very important, it flows down to dispose of its water into the river nun river via the Orashi River that is connected to the Epie Creek and Mbiama axis'*

R12 observed that '*for or several years now starting from 2012 Bayelsa State in particular and a large size of the Niger Delta has been experiencing unusual levels of the flood, higher than the return levels for 50 years or even 100 years and the causes are due to some factors'*

R5 recounted '*There were devastating floods experienced in 2012, 2018, and 2022, and another one was expected in 2023 but there was no flooding.'*

Figure 5.16 below shows the reference for the background of flooding along Epie Creek with 43 references.

Background of flooding along Epie Creek

Name	In Folder	References	Coverage
R1	Files	14	17.65%
R10	Files	1	2.78%
R11	Files	1	3.24%
R12	Files	1	2.77%
R2	Files	1	2.78%
R3	Files	6	3.79%
R4	Files	5	10.82%
R5	Files	3	5.60%
R6	Files	3	7.46%
R7	Files	4	10.63%
R8	Files	1	4.36%
R9	Files	3	7.16%

Figure 5.16: Reference for the background of flooding along Epie Creek.

R1 noted that '*all the communities along the creek have back swamps. When you move inland from the countryside, on the levees of the creek, you will see certain marsh areas called swamp zones that are supposed to contain water and supply the Epie Creek. There are deep swamps located in most of the communities located around Opolo quarters to Igboghene, if you are coming from Igboghene down to the Opolo area, you will notice there are bridges, these are where the canals that connect the buffer zones to the Epie Creek are located. These are the pathways through which water moves into the canals. There are several studies on the roles these canals and back swamps play in the area and how they have been impacted and transformed by man.* R1 mentioned that '*some of the swamps have been reclaimed and converted to residential houses and other kinds of construction activities taking place so they can no longer link the Epie Creek and so any rainfall* *events can cause flash floods in the area'.* The reason is that '*changing land from the natural vegetation to urban areas intensified the flooding in the area as the area is naturally vulnerable to flood'* because as explained by Aprioku et al, (2013) the Epie Creek in Yenagoa is located on a lowland that is about 3-8km above sea level. Because '*naturally the elevation of the area above sea level is very low so the urban process intensifies the flood situation.' R1 concluded that 'Urbanisation is not what causes the floods as the area is already prone to flooding, but it intensifies the flooding because it inhibits the movement of water in some areas as well as increases run-off in other areas.'*

R2 recognized also that the flooding situation was already there but had worsened due to overpopulation in the area due to cheap rent and cost of land which attracted so many people to build there. *'Most people live in flood-prone areas because rent is affordable, others have bought land at cheaper rates and built houses.'*

R3 also pointed out that '*The state initially had a population of no more than 50,000 residents, with approximately 10,000 residing in the state capital, Yenagoa*.'

This implies that the Epie Creek area is heavily populated so as more houses are built in the area, the more water will be displaced so the increase in houses built has displaced water, causing it to overflow.

R4 believes the release of water from upland rivers contributes to the problem at hand. R4 referred to the Lagdo dam in Cameroon and cited it as the main factor in flooding along Epie Creek. R1 said '*If the Lagdo dam is opened, we will experience flooding'*.

R5 attributes the problem of land use change and flooding to an increase in population and the activities of people in the area. R4 explained that '*the communities along Epie Creek were occupied by just a few persons and most places there were used as burial grounds until the surge* *in population and the need for more accommodations when people started building everywhere and encroaching into the flood plains.'*

R6 commented on the attraction of the Epie Creek area and confirmed that the area was occupied by a small number of people which changed because '*people were attracted to this area and are still buying land there to build because of the cheap cost of land as the flood plains are cheap to buy, then they raise it by sand filling and building. In comparison with land on the upland dry areas in Yenagoa which is more expensive, as little as 200,000 to 300,000 naira can get you land so people prefer to buy their land cheaply than paying rent to someone else. They believe that even if the floods come, it will just be for some months after which they can continue living in their homes.'* R4 noted '*recently there has been an increase in flood level as the years go by, the flood level of 2022 was way higher than that of 2020 while that of 2020 was higher than 2012. This was not so when Yenagoa was just a local government area with few people around. There were normal river floods, but this quickly went away.'*

5.5.1: Causes of flooding along Epie Creek

According to the data coded and presented in 5.17 below, 09 significant causes of flooding along Epie Creek were evident and 116 references were coded to the causes of flooding. Among them, land changes, poor waste management, absence of adequate drainages and blocked canals, and climate change were prominently identified by respondents and had the highest references of 37, 20, 15, and 10, respectively. Other causes identified were heavy rainfall (10), silted creek and depositions (08), excess water from Lagdo dam (08), increased demand for land (06), and the geographical location of the study area with 02 references.

Causes of flooding	12	116
Absence of or Blocked Canals	10	15
Climate change	5	10
Excess water from Lagdo dam	5	8
Geographical location	2	2
Heavy rainfall	7	10
Increased demand for land	5	6
Land changes	11	37
Agriculture	2	3
Deforestation	9	13
Urbanization	7	14
Poor waste Management	9	20
Silted Creek and Depositions	4	8

Figure 5.17: Coding structure for causes of flooding along Epie Creek.

5.5.2: Land changes

Land use change refers to the transformation of land from its natural state or previous use to another use. Land use changes from vegetation to built-up areas as shown in Figure 5.1 were evident in the study area and were mainly caused by developments, urbanisation, agriculture, and deforestation. 11 respondents made 37 references to changes in land use as a contributory cause of flooding along the Creek.

R2 noted that 'land use or cover changes contribute to worsening the flood situation in the area, although the area is naturally susceptible to floods.'

R6 was of the view that '*the increase in buildings causing obstructions, paved surfaces contributing to increased runoff and other developments like road constructions and oil company activities change the use of the land and contributes to flooding.'*

R8 identified '*deforestation and agricultural activities that expose the soil surface and leave it prone to erosion which is washed into the creek and deposited in it*.'

R10 also cited '*unplanned development including making pavements in our surroundings have all caused an increase in runoff which naturally would have been absorbed by the soil as a contributing factor to flooding*.'

A: Urbanisation

Urbanisation which is the urban shift of population from rural to urban areas is responsible for most of the modern problems facing humanity and always involves the conversion of land use from non-urban to urban uses.

From the coded data presented in Figure 5.17 earlier, Urbanisation was referred to 12 times by 05 respondents as a major contributor to flooding along Epie Creek. R1 said '*Urbanisation is not what causes the floods as the area is already prone to flooding, but Urbanisation intensifies the flooding because, with an increase in population, more houses have been built which inhibits the movement of water in some areas as well as increases run-off in other areas due to surfaces have been paved*.'

R3 explained further that '*this is happening because we have occupied space, we have now displaced the water, but water will always find its way. Without a doubt, the buildings in Epie-Creek, the change of land use, and the loss of the natural use of the land have cost havoc. It has worsened the flooding*.' Also*, there is a lack of oversight in how land is sold. In some areas, land is sold without consideration for land access, leading people to purchase land and create roads without proper planning*. R3 referred to '*our ancestors who displayed more wisdom in* *concentrating development in areas with abundant land. They organized construction into well-designed clusters and utilized vertical space for buildings. This approach ensures that some land can be preserved for important natural features like forests and water bodies.'*

R6 also agreed that '*Flooding has increased drastically in the state capital in recent times because of the Urbanisation activities going on'*. R6 discussed more on the absence of drainages and the blockage of the few available ones that are no longer functional due to waste or silts in them. R6 explained that '*buildings around most of the areas do not have drainages, these buildings obstruct water flow and human activities such as disposing of waste also contributes to blockages, so the flood level has changed drastically. It is the reason why the flood level keeps rising because of an increase in Urbanisation with no outlet for water.'*

R8 identified a high concentration of people and human activities like construction, deforestation, housing, agriculture, waste management, and others as the factors causing increased flooding.

B: Deforestation

Deforestation which is the removal of trees is another type of land-use change that occurs and can cause global problems including flooding. From Figure 5.17 presented earlier 08 respondents made 12 references to deforestation as one of the other causes of flooding along Epie Creek. R1 explained that '*before land can be transformed from the natural vegetation into the built-up areas, you must clear the land and trees will be felled in the process although it cannot be termed commercial logging, logging occurs daily.* R2 also agreed to the statement that *deforestation is not done on a large scale but there is clearing of trees while developing an area or for the need for wood for construction, building, or even firewood.*

R3 further explained that *the Niger Delta region has witnessed extensive deforestation, with forests being cleared for building and areas like the Epie-Creek no longer have forests. These forests have* *been depleted, and loggers are now moving into the interior regions. Rules restricting construction in certain places have been disregarded, and all the natural parks in Bayelsa have been filled with buildings. Violations of these laws are commonplace. Additionally, in contrast to what R1 and R2 think, there is an alarming level of logging taking place in Bayelsa state and there is now severe land loss, and that is because the trees that have been removed whose roots used to hold the land together are no longer there so when the water comes up with force, it can easily wash off the soil.* R5 in support of R3 said there were no major trees along Epie Creek anymore, in fact, we don't even have them because trees have been cut down to meet demand. When there are no trees or shrubs to slow down runoffs, the runoff will be swift and increased, causing flooding.

R6 also agreed that there is deforestation going on along the Creek but not on a commercial scale. R7 attributes '*the logging activities around Epie Creek to development because the city is expanding, and people are selling off their lands. People who buy these lands will have to clear the bushes and cut down trees to build their houses because of development. Unguided development.' The indiscriminate logging activities are a disservice to the state, in fact, in all the local government areas in Bayelsa State, there is logging going on, so Epie Creek is no exception.*

Agricultural expansion, wood extraction for fuel wood, poles, roads, and building construction provide access to forests and are associated with deforestation. The development of roads exposes the inner regions of the forest to exploitative activities. Additionally, other forms of infrastructure, such as dams, markets, schools, hospitals, and operations like pipe-laying and seismic activities, are intricately linked with deforestation (Ekwugha et al,2020).

C: Agriculture

From the response of respondents on the cause of flooding, 02 respondents made 03 references to Agriculture as a factor that affects flooding in this area but with the level of responses, agriculture plays a very minor role in contributing to erosion.

R2 agreed that '*Agriculture exposes the soil surface and erosion washes loose soil into the creek which gradually builds up and has made the creek shallow and limited the quantity of water it can accommodate.'*

5.5.3: Poor waste management

As per the views of the respondents, the cause of flooding along Epie Creek was linked to poor waste management. R1 noted that the '*disposal of waste, both organic and domestic waste into the creek by residents who connect their sewage (septic tanks) directly into the creek. This waste occupies the creeks and promotes eutrophication and excessive growth of hyacinths and other plants* which have slowed water movement and caused siltation. R1 also linked massive waste disposal into the creek from markets. R1 said that *There is a market and a slaughter located close to the Epie Creek at the Tombia junction area at Etegwe where a whole lot of activities that are affecting the regime of the river happen, they use the creek for waste disposal.* This act alone can cause the river to overflow because of the weight of the load that is thrown into the Creek.

'R3 additionally endorsed the assertion regarding inadequate waste handling and emphasized that *'as a society, people in the Epie Creek area struggle to foster a culture of effective waste management. Furthermore, the government has not sufficiently educated the populace on this matter. Consequently, waste management practices are severely lacking Despite efforts to educate and raise awareness among the public, without a well-organized system for waste collection and* *disposal, people will still have no suitable means to manage their waste, leading to the likelihood of them disposing of it wherever they can once it's removed from their homes.'*

R3 also noted '*that there are no dedicated waste bins or proper waste collection points in the area so when people see gutters and canals around them, they easily use them as dumping sites. Any place where they can conveniently dump their waste, they utilize it.'*

R5 attributed the reason for improper waste disposal to the absence of proper waste dump sites and illiteracy and explained that '*waste collected is still dumped where it gets back into water sources. This can be attributed to a lack of education. People are not properly educated about the importance of our canals and creeks, because if they are properly educated, they will know that the creek is also a living being, so you cannot put wastes into it.'*

R8 '*mentioned the population of the city increases daily and so does the rate of waste generated. The rate at which debris and waste products are disposed of into the creek contributes to flooding.'*

R9 noted that *'the slaughterhouses along the Amassoma-Tombia Road and people selling in Tombia market dispose of about 70% of waste generated from the market into the creek causing blockage and drying up of the creek and other river channels.'*

R6 referred to the impact of the quantity of waste that goes into the creek which can act as load and displace water thereby causing an overflow.

5.5.4: Absence of Drainages or Blocked Canals

Yenagoa City faces a deficiency in established waste collection sites and effective waste management, leading to the indiscriminate disposal of waste in low-lying areas, particularly rivers, drains, and canals. This practice has a cumulative impact, rendering the drainage systems nonoperational. In the study area, respondents mentioned blocked canals on four occasions as a significant contributor to flooding.

R1 explained that '*moving inland away from the flood plains along Epie Creek, there are buffer zones about 500km away from the levees of the flood plains which are the back swamps so the transformation of land through the construction of roads on open spaces and residential buildings have really obstructed the pathway of the canals connecting the buffer zones into the creek and so at the slightest provocation of the rainfall event, you see flash floods occur*.' R2 also in agreement said, '*most of the canals have been sold and reclaimed for housing activities and this is the cause of very severe and high flooding in the area as natural drains are blocked.'* R2 reiterated a situation during fieldwork when it was discovered that a *house built on a natural drain was obstructing the flow of water and causing flooding in the surrounding areas. The right thing to do was to demolish that structure so there could be a free flow of water but someone in a top position in the government told us that there are some sacred cows you don't touch no matter where they are found and this is just one out of many of such cases where the right thing will not be done because of top politicians and influential people in power or favoritism where they consider that this person is my brother or sister so they do not want to offend them.'*

The observations from R3, R5, and R12 shed light on a pervasive issue plaguing the Epie Creek area: the obstruction of drainage systems due to human activities and urban development. These reports highlight the detrimental practices of street cleaners disposing of debris into canals and gutters, exacerbating blockages that impede water flow and contribute to flooding incidents. Moreover, the encroachment of buildings and the accumulation of waste have blocked major canals meant for water transportation, further exacerbating the flooding risks faced by the community. R6 delves into the root cause of these challenges, emphasizing the unplanned nature of urban development in the region. The absence of proper drainage infrastructure and the disregard for water flow considerations have led to widespread blockages, intensifying the vulnerability of the area to flooding events.

The findings presented in these reports resonate with broader research conducted in the region. Braihma et al. (2014) found that a staggering 82% of respondents identified the lack of drainage systems as a significant concern, reflecting the inadequacy of infrastructure to manage water flow effectively. Similarly, Brisibe and Brown (2020) documented the prevalence of blocked drainage systems along roads in the study area, further corroborating the challenges highlighted by the reports. The absence of proper drainage infrastructure, coupled with the encroachment of buildings and the accumulation of waste, underscores the urgent need for comprehensive interventions to address the root causes of flooding in the Epie Creek area.

In essence, the collective evidence presented by R3, R5, R6, Braihma et al. (2014), and Brisibe and Brown (2020) paints a concerning picture of the drainage challenges facing the Epie Creek community. These findings underscore the critical importance of addressing human-induced blockages and implementing sustainable urban planning practices to mitigate flooding risks effectively. Without concerted efforts to address these issues, the community will remain vulnerable to recurrent flooding events, with severe implications for public safety, infrastructure integrity, and socio-economic well-being.

5.5.5: Climate change

Many factors contribute to rainfall but Climate Change as a global challenge makes rainfall more likely and the study area has experienced more rainfall over the years. Climate change impacts can be felt far away from the source and so the activities happening somewhere else could cause adverse effects at another place.

Climate Change as a cause of flooding along Epie Creek from the data coded in Figure 5.17, had 10 references from 05 respondents. The respondents talked about rainfall patterns, how this contributes to flooding, and how it affects farmers and crop production as most people in the Epie Creek areas are farmers. R1 agreed that '*there have been variations in rainfall patterns as more rains were experienced in some months and less in others than we normally have in the year and because of these rainfall variations, the farmers are not able to forecast when the rains will come or not, so they leave it to chance. R1 carried out a 7-year rainfall variation research on this area and found that there were variations in rainfall patterns. There have been changes, especially with the dry spell we normally call August break which has shifted from August to July or September in other years.*

R1 noted *last year, there was not much rainfall but there was still flooding due to the influx of water from higher rivers upstream as there was more rainfall in the North.*

R2 thinks the *'rainfall pattern is still the same but there is a change in the agricultural structure as the flooding affects crops and determines when one can plant and harvest crops. Cassava used to be planted in November or December, but farmers now plant earlier so they can harvest it earlier before the flood period in October or November, so they must harvest their crops latest August or September especially tuber crops like cassava, yam, sweet potato*.' This flooding as highlighted by R1 earlier is not caused by rainfall in the Epie Creek area but by water from rivers upstream and the release of water from dams in neighbouring countries.

R6 explained that *before the creation of Bayelsa State, there was not much rainfall and the seasons were clear, and one can easily say when it was dry or wet season.* But over the years*, 'there is no defined rainy or dry season anymore because it rains continuously in the dry season and becomes dry in the rainy season. There is now an extended period of rainfall during the wet season. The change in the pattern of rainfall affects agriculture and has changed the planting seasons because* *unlike before, we normally plant crops in December and it can be there for one year even during the wet and dry seasons but recently, if you plant cassava for instance in December, you cannot keep it for more than eight months so you should be thinking of harvesting in August before the onset of flood any time from September. So, this has affected the planting and harvesting time of crops.'*

R9 believed that the weather is becoming more erratic, one can hardly predict the weather these days due to climate change while R8 climate change has impacted the amount of rain not just in Nigeria but globally as we now have more intense rainfall, longer duration of rain fall or droughts in some areas.

5.5.6: Heavy rainfall

Due to climate changes, there have been changes in the intensity and frequency of rainfall. 06 respondents made 04 references to heavy rainfall as a contributing factor to flooding. Most respondents admitted the area was characterized by heavy rainfall but there have been some changes in the seasons.

R 7 explained '*There have been heavy rains when it was not the rainy season and flash floods. It is difficult to ascertain if rainfall is the cause of massive flooding in the area because as of 2012 when we had that monster flood the rains didn't fall much but to the surprise of many the flood came heavily. We had a long August break last year from July into August but when the flood came it was astronomical.'*

R8 mentioned that *'the rains that come annually usually start from March April, May, and June down to August and October but to my greatest surprise even now it's still raining in December.*

So, this year we had more rain than last year, but the flood didn't come. So, I will say the rain does not increase the water bodies on earth.'

R9 and R10 believe that the heavy rainfall contributes to increased flooding due to the intensity and frequency of rainfall. R10 said '*there have been changes to the intensity of rainfall. The change is that sometimes it falls more sometimes and other times it falls less. For example, in 2022 we did not experience rainfall the way we have this 2023 but we had the worst flood in 2022. Also, the seasons of rainfall seem not to be clear anymore as we have rainfall in the dry season now and there is a shift in the usual 'August break' from August to late July or early September.'*

This implies that there are heavy rainfalls in the area that lead to flash floods that resolve quickly but the seasons are no longer clear as there is now a shift so there is rainfall even during the dry season.

5.5.7: Silted Creek and Depositions

The Epie Creek gets its flow from Rivers upstream like River Niger and River Benue which flows into the Orashi River. This leaves Epie Creek with a lot of deposition as it is on the lower course of the river. The Epie Creek is heavily silted and covered by water hyacinths. The creek was navigable until after the massive deposition of waste (both organic and domestic) by the high population living along the creeks due to Urbanisation.

04 respondents made 08 references to Epie Creek as approaching its old age or lower course. R1 noted that '*most areas in Epie creek have become very shallow due to siltation and there is less flow of water as the flow of water is weakened during the dry season as the force of the flow of water is less\reduced and with this reduction in flow, deposition is bound to happen. The silt has reduced the depth of the creek, and this means less space for water so water spills over to the*

adjacent lands. Silt deposition affects both the depth and width of the creek due to blockage of canals connecting buffer zones and the creek.'

R2 said the creek is just taking a natural course as it has reached its old age, citing that the Epie Creek was navigable many years ago but is getting to its old age so just as we were taught in Geography, it is no longer flowing as fast as it used to and is now silted with debris, sand, waste, and others. It becomes shallow and loses its course and that is why it overflows with water.

R5 explained '*how the River Nun accepts water from river Niger and that River Nun services the Epie Creek and the Orashi River. The silts that come from these rivers are deposited in Epie Creek due to its elevation and slow speed of water flow. Because the Creek is heavily silted, and human activities have increased along this creek, more debris and waste is deposited in the creek, and this limits the quantity of water that the Creek can accommodate.'*

R8 also agreed to the above statement and that '*once the volume of waste can no longer be sustained by the creek, it overflows into the hinterlands and that could be because of lack of dredging, lack of desilting activities on the river channel over time due to government neglect and due to individual nonchalant attitude towards the environment*.

5.5.8: Excess water from Lagdo Dam

Lagdo dam as explained earlier is a dam in Northern Cameroon on the Benue River, in the Niger Basin. Construction of this dam started in August 1977, but it was completed in 1982 to supply electricity to the Northern part of Cameroon that stores water in its dam and then releases this stored water at 200 cubic meters per second for about seven days, resulting in flooding along all frontline states along its course for days or weeks which flows down to Nigeria through Rivers Niger, River Benue, and its tributaries down to the delta in southern Nigeria where Yenagoa is located.

From the interviews done, 06 references were made by 04 respondents attributing the excess water released from the Lagdo dam as the cause of the increased flooding situation along Epie Creek. Respondents R5, R7, R8, and R9 all acknowledged the role of water released from the dam in contributing to flooding downstream and along Epie Creek.

R5 reiterated that there had been no massive flooding for years. He said '*Never in my lifetime until 2012, was there a massive flood as that of 2012 never! Epie Creek experienced flooding but was still able to hold the water and it lasted only for days. Furthermore, there was the release of water from the Lagdo dam this year 2023 but flooding was not severe because it was done systematically. If they can follow this pattern every year, I do not think we will experience massive flooding. The highest we will have been a flash flood which would last only for a few days.'*

R7 referred to the massive floodings experienced as 'monster floods like that of 1969, 2012, 2017, 2018, 2019, and the very last one of 2022 which has been the highest. R7 said that most *parts of Bayelsa State were flooded. I don't know how the 1969 flood happened but those we experienced from 2012 upwards are caused or attributed to the release of water from the Lagdo Dam and some parts of Northern Nigeria.'*

R8 further explained '*that Lagdo dam releases its water to the downstream plains and Bayelsa State is at the tail end of the downstream of the Delta so when water is released from the dam it flows through some states in Nigeria that are along the plain of the Delta and increases the water volume in these areas thereby affecting the residents of the Niger Delta. Coupled with the fact that our river channels are now too shallow to accommodate most of the water, it overflows and destroys properties*.'

5.5.9: Increased demand for land

Respondents R5 and R10 agreed strongly that increased demand for land due to the increase in population is what led to deforestation and other land changes that are contributing to increased flooding in the area now. R7 referred to the year 2000 or 2005 as the time when the demand for demand for land began to increase. This time corresponds with the time when the Niger Delta University in Amassoma, a town close to Yenagoa was established and was a huge attraction for students and other people in search of jobs and better living.

R6 highlighted the increase in population as one of the factors affecting flooding because, '*before the creation of Bayelsa State when the buildings and human inhabitants were few, there were no drainages but because the buildings were few and not too close to each other, flood incidents within the area was very low because the water could flow on their own an easily flow out but now that the population has increased, those natural channels are blocked now by houses.*'

5.5.10: Geographical location

The geographical location of Epie Creek on the delta in southern Nigeria makes it prone to soil/silt deposition and flooding. Most respondents did not refer to the geographical location as a contributory factor because it is assumed that this factor is already a constant with which flooding was normal before the area began to experience massive floods.

5.6: Negative Impacts of Flooding

Floods have some positive impacts such as the renewal of wetlands and fostering the well-being of ecologically significant areas. This, in turn, supports the replenishment of nutrients in the soil. These are some of the positive impacts of flooding, but the negative effects far exceed the positive effects, and the following negative impacts were identified by respondents as presented in Figure 5.18. 12 respondents made 144 references. Details of each impact are presented below.

Impacts of flooding	12	144
Affects biodiversity	3	3
Change in planting seasons	2	3
Damaged roads	6	7
Death	7	7
Disruption to social and economic activitie	10	27
Effects on source of livelihood	7	11
Exposure to reptiles	5	5
Food scarcity	2	2
Health impacts	9	10
Increase in prices of goods and services	12	20
Loss of crops and livestock	7	14
Losses to property	6	7
Power outage	4	4
Pyschological impacts	4	5
Stress from post flood clean up	4	6
Variations in cost of rent and land	4	4
Water contermination	7	9

Figure 5.18: Coding structure for Impacts of flooding along Epie Creek

5.6.1: Disruption to Socio-Economic Activities

Respondents from the study identified disruption to socio-economic activities as a major negative impact of flooding in the study area. Making 27 references to it, 10 respondents R1, R2, R3, R6, R7, R8, R9, R10, R11, and R12 agreed that flooding affected almost all activities along Epie communities for months during flooding.

R1 explained that during flooding, '*all activities are normally affected by flooding Economic activities are severely affected especially petty traders, those that hawk, their products for sale. There are no farming activities including fish farming, and most banks and schools are closed.'*

R3 recounted *'the loss of jobs and livelihood and that people cannot go about their normal activities during flooding. Even government officials are affected, some ministries are closed, school activities are also affected, students and teachers cannot go to school, and academic activities are put on hold until the floods recede*.'

R6 also agreed that '*most activities and businesses shut down during flooding and there is disruption to the educational system as schools are also closed all through the flooding period. Residential buildings are also partially or fully submerged in most areas, so people suffer from improvising, adapting, or relocating temporarily to camps for internally displaced persons. Transportation is affected so movements are also restricted, and recreational activities and the real estate market are all negatively impacted*.'

R8 identifie*d 'market traders and palm oil producers are also greatly affected in addition to the closure of schools and adjustments in the educational calendar of Bayelsa State considering the stay-at-home period during flooding.'*

R9 said '*Even fishing activities were affected by the flood and there was a massive loss to those that had fishponds that were submerged*.'

5.6.2: Increase in prices of goods and services.

Yenagoa City has experienced increases in the cost of goods and services, rent, and petroleum products**.** These changes can be attributed to several factors. For instance, increases in the cost of land and rent are due to higher demand for land and the location of the land while other goods or services have increased due to increases in the cost of production and transportation.

All 12 respondents identified increases in prices of goods and services as an impact caused by flooding in the area. 20 references were also made as presented below.

R1 believes that '*the value of land in Bayelsa state and most cities in Nigeria rely heavily on whether the area is free of flooding or prone to flooding. Even rent is determined by the location of the house, whether it is on a flood plain or not as those in dry flood-free areas are way more expensive while those in flood-prone areas are cheaper to buy or rent.'*

The difference in cost of goods and services is on the high side because Bayelsa state is a consumer state that is heavily dependent on the neighbouring states for a lot of items including food items and so with the floods, connecting roads were cut off and most of them were submerged. Prices of goods were doubled during flooding in 2022. The floods of 2012, 2018, and 2022 were major ones that saw the rise in prices of goods and services.

R2 explained *'There was also an increase in the prices of goods and the cost of food items as some traders could not restock due to roads being cut off. Rice that was sold for 2,500 was sold for 5,500 while a custard of garri that was 500 was sold for 2000 naira'*.

R4 attributes the inflated cost of goods and services during flooding to the excessive cost of transportation.

R5 reiterated how *'during last year's flooding, people bought sachet water bags at the rate of 400 naira, instead of 200 naira as it doubled its price. Fuel was also sold at the rate of 800 naira per litter as against 450 naira because there was no way to bring in petroleum products due to roads being cut off. So, we can say it affects the cost of living and the cost of goods and services.'*

R6 also agreed that *'the cost and prices of goods and services increase because most crops and goods become scarce due to difficulty in transportation or destruction during flooding'*.

Whether an area is prone to flooding or not also determines the cost of land and rent in Yenagoa now. The cost of rent in areas that are free from floods is higher than those places that are always flooded.

R7 highlighted a situation where prices of goods are increased due to scarcity from panic buying.

5.6.3: Loss of crops and livestock

Crops and livestock that are cultivated and reared on land are directly affected during floods.

R1 believes '*flooding affects agricultural productivity, and it is what has contributed to the soaring prices of foodstuff and refers to farmers who lose their crops like cassava to floods especially when they are not yet matured or when they were not able to harvest before the floods. It affects those who planted late most as people who planted early may be able to harvest quickly before the water submerges them.'*

According to R3, '*Farming is the most affected activity as farmers hurriedly harvest their farm produce prematurely before the floods to avoid total waste to their crops. There is also food insecurity during flooding. There is no provision for insurance for the peasant farmers even when they lose their crops and resources during flooding.'*

R5 noted that '*when floods are expected, farmers harvest their crops, both the mature and the pre-mature ones. These harvested products would be ridiculously cheap. This is so because these farmers want to get even if there is little gain from their farm produce than leaving it to rot away. But after that time, the products become scarce.'*

R6 believes that '*the flooding caused food wastage and loss during the 2022 flood, there were lots of losses as many people were not able to harvest their crops before the floods came while even those that sold it, sold it cheap just to get it off*.'

R8, R12, and R10 agreed that during flooding, agriculture is reduced to zero because farmers cannot do any farm work as farmlands and biological species are submerged.

5.6.4: Impact on Livelihood

Floods lead to the submersion of buildings, flooding of roads, and restricted movement, causing a pause in normal activities and adversely affecting people's livelihoods. Respondents mentioned this impact on livelihood four times.

R1 specifically linked this consequence to '*the disruption of power during floods, explaining that submerged transformers result in power outages, thereby affecting small businesses that rely on electricity to operate their businesses.'*

R2 and R6 both alluded to the hindrance caused by flooding, preventing workers from commuting to their workplaces and traders from accessing their shops. This disruption significantly impacts their income sources, as individuals are compelled to stay at home.

Moreover, R5 detailed '*the repercussions of flooding on agricultural activities, highlighting alterations in the timing of planting and harvesting. This leads to wastage, as crops harvested hastily lack processing or preservation means, resulting in their deterioration. Additionally, farmers incur losses when unable to harvest crops before the onset of floods.'*

R7 looked at the long-term impact of businesses being closed for months due to flooding in business places as every form of business is affected. Market traders cannot go to the market, Palm oil producers cannot produce oil. He also mentioned that '*the consequences of this monster flood are enormous and affect every sphere of our daily lives. Workers are not left out because they can't go to work when their houses are flooded, and this leads to a loss of manpower and affects the income of people and livelihood*.'

5.6.5: Health Impacts

During flooding, stagnant water becomes breeding grounds for mosquitoes that can spread malaria parasites. People are constrained during flooding, especially when their houses are partially submerged in water, they dispose of urine, feces, and all other household wastes directly into flood waters. It was also reported by R5 that '*in the last 2022 floods, corpses that were not properly buried were seen floating during the flood. Flood water becomes contaminated with offensive odour during flooding.'*

R2, R4, R5, R8, and R9 all attested to an increase in the spread of disease during and after flood events from drinking bad water, using contaminated water, poor hygiene, and bites from mosquitoes.

R3, R11, and R3 elucidated that there is a sanitation hazard during floods, as cholera tends to surge due to the contamination of water by people urinating and disposing of faeces in the floodwater. This viewpoint was concurred by R1, R4, and R5, who highlighted various illnesses such as malaria, typhoid, and other waterborne diseases that can easily propagate in such conditions.

5.6.6: Water contamination

During flooding, water becomes contaminated and requires proper treatment after the floods before water becomes drinkable again.

Respondent R1 identified bad odour from water during floods. R3 and R4 both agreed that when the flood goes down, households would need to flush their borehole systems for at least a week and treat the water to prevent further illnesses because these systems have been contaminated by the flood waters, so people depend on bottled or sachet water.

R5, R7, and R8 noted that There's also no access to clean water for drinking and doing other necessary things during flooding as the water becomes toxic.

5.6.7: Damaged roads

In the event of flooding, most roads become submerged, with some completely severed by rapidly flowing floodwaters. This creates significant challenges for people's mobility, as even vehicles are susceptible to being swept away by the powerful currents of the floodwater. R2 and R5 provided insights into the repercussions of flooded roads, elucidating how it hampers movement, contributes to heightened transportation expenses, and leads to an increase in the cost of goods.

R2 further clarified that the city of Yenagoa relies on neighbouring communities for the supply of essential commodities, including food. Consequently, when the roads are inundated by floods, the city becomes isolated, impeding the inflow and outflow of goods.

R6, R&, R8, and R9 explained Transportation during this period is down because roads and infrastructure become flooded and damaged in most cases. Temporary bridges are not exempted. An example mentioned by R7 was the wooden bridge constructed across the Epie Creek at Okutukutu which gets flooded and washed away every year.

5.6.8: Death

Death of persons during flooding from drowning was reported in the literature. From the interviews conducted, 06 respondents made 07 references to the death of residents along Epie Creek from drowning. And snake bites.

R1 said people living along the creeks are exposed to reptiles and last year 2022, there were reports of snake bites that led to the death of a child.

R4 in addition said Sometimes people die because they do not know how to swim. For example, in last year's 2022 flooding, a woman died in Agudama by drowning while another incident happened where a woman mistakenly put her leg in a ditch while packing her loads and was washed away as people could not rescue her.

R7 who referred to *'the devastating floods as the monster flood, said it is an which is an exceptionally high flood and comes with a lot of problems. It leads to the death of lives and livestock.'*

R9 and R12 were of the view that '*flooding causes death when people are affected without warning or drown in flood waters.'*

5.6.9: Stress from Post-Flood Clean up.

One aspect of flooding that is overlooked after flood events is the aftereffects of flooding. 06 references were made to stress as the impact of flooding by 04 respondents.

R4 referred to the suffering and stress of post-flood cleanup after some houses had been covered by water, mud, and debris for months.

R9 referred to the stress of moving from one place to another as some people end up moving to more than one place as they must move again when the place moved to becomes flooded too.

R10 was of the view that flooding causes stress, suffering, and hardship in terms of finances as money will be spent on relocation, moving belongings to keep them safe, or repairing destroyed buildings and replacing spoilt items. According to R7, those who have built houses in flood areas normally relocate during the flood season. So, when the flood recedes, they go back, clean their houses, and continue to live there.

5.6:10 Losses to property

Damages to people's properties are one impact of flooding that cannot be overlooked. According to Oguntola, (2022), about 82,035 houses were damaged, and 332,327 hectares of land had also been affected by flooding in 2012. According to the Guardian (2022), As of October 2022, over 200,000 homes were completely or partially destroyed by the floods.

R2 explained that '*household items and properties are destroyed with devastating impacts on the people. The most affected were people who had houses made from mud as these were all washed away, while others were partially or submerged in flood water*.'

R3 noted the increase in theft during flooding when people leave their homes and R10 stated that 'the impacts of flooding are enormous as it causes a lot of destruction to infrastructure and properties.'

R6 and R11 agreed the impacts of flooding are enormous as it causes a lot of destruction to infrastructure and properties. Large household items like furniture, electronics, and other heavy items are at a higher risk of being damaged during flooding.

In contrast to these views, R1 explained that '*few people derive some benefits from the floods such as fishing and canoe transportation businesses but the negative impacts, especially loss of property and suffering far exceed the little benefits.'*

5.6.11: Exposure to reptiles

Accompanying the floods are reptiles like snakes, crocodiles, and monitor lizards that have been displaced from their natural habitats by floodwaters. This poses a risk to humans, as there is an increased likelihood of being bitten by these animals, and such bites can be fatal if not promptly treated.

Three respondents R1, R4, and R5 referred to people been exposed to dangerous reptiles like snakes, crocodiles, and monitor lizards and R1 further explained that *last year 2022, 'there were reports of snake bites that led to the death of a child.'*

R8 also agreed that reptiles are more rampant during flooding.

5.6.12: Psychological impacts

From the interviews done, only 03 respondents referred to the psychological impacts of flooding on people. 04 references were made and R3 said '*being a refugee, sleeping in government camps that are not well-organized, or staying away from one's home or family may cause psychological impacts like depression.'*

According to R7 '*people affected by floods live with fear in their hearts because they must relocate again every August or September whenever the floods come. That thought alone is very painful and worrisome.'*

5.7: Land Use Policies, Government and Stakeholders Intervention.

The interviews conducted revealed that out of the 12 respondents, 62 references were made regarding Government and stakeholder intervention in flood Management. Figure 5.19 below illustrates the coding structure for Government agencies in flood management, flood management strategies, and challenges**.**

5.6.1 Government and Stakeholders Intervention During Flooding.

From the data collected, the following table presents the codes for Government and Stakeholders Intervention during flooding and will also be referred to when analysing data on Government agencies in flood Management, flood Management, and the challenges of flood management from respondents.

Government and Stakeholders Intervention	12	62
Clearing drains	5	8
Construct effective drainages	3	4
Document yearly flood data	3	3
Establishment of regulatory body	2	2
Insurance and Empowerment	2	2
Land use planning	3	3
Provision of IDP camps	7	8
Raise building DPCs	2	2
Relief materials	8	15
Sensitisation and awareness creation	6	8
Shoreline protection embankments	5	5

Figure 5.19: Coding structure for Government and stakeholder intervention in flood Management.

On the intervention of the government during flooding, respondent R2 said '*The prevailing sentiment suggests that the government perceives flooding primarily as a natural disaster. In response, governmental efforts predominantly focus on establishing camps to accommodate Internally Displaced Persons (IDPs) affected by flooding, particularly those who lack alternative shelter options.'* However, a significant challenge arises from the reluctance of many affected individuals to relocate, as they are deeply attached to their homeland and hesitant to leave despite the risks posed by recurring floods. Thus, while the government's provision of IDP camps addresses immediate humanitarian needs, it underscores the necessity for comprehensive strategies that address both short-term emergency responses and long-term solutions, considering the complex social, cultural, and economic factors influencing relocation decisions in flood-affected areas.

R1, R2, and R4 explained that '*efforts were made to clear drains initially during flooding because the ministry is only mobilized during the flood crisis when people are already suffering from the* *flooding which is when they go out to clear the drains and canals. Camps for Internally Displaced people are built on uplands to accommodate flood victims during flooding. Relief materials have also been given out over the years to flood victims.*

However, R4 reiterates that '*the materials meant for distribution during such flood time is not distributed but stored in warehouses till after the floods, then some of these items are repackaged and sold for personal gain'.* This agreed with R5 who also explained that '*The government offers aid to flood victims; however, regrettably, this assistance often fails to reach them or proves inadequate. It is typically when non-governmental organizations (NGOs) step in that flood victims receive substantial support. NGOs take direct action to provide aid to flood victims, bypassing government channels, as they are cognizant of the misconduct that occurs in this domain*.'

On the effectiveness of government intervention, R6 explained that '*the assistance provided by the government to the affected population is deemed insufficient, with significant room for improvement, particularly concerning the quality of support and the equitable distribution of relief items.'* R9 observed that *the 'extent of government intervention is contingent upon available funds, leading to inconsistencies in the provision of aid. For instance, in the preceding year of 2022, logistical challenges emerged as access to affected communities was impeded by damaged roads, necessitating the costly and cumbersome use of barges to transport relief materials.'* This logistical constraint not only exacerbated the already dire situation but also underscored the need for more robust and adaptable disaster response mechanisms capable of overcoming such logistical hurdles efficiently and cost-effectively.

R7 mentioned several challenges hinders the effectiveness of policies aimed at mitigating flooding along the Epie Creek area. '*Foremost among these challenges is the dense population residing along the Creek, leading to overcrowding primarily characterized by the proliferation of informal settlements lacking proper urban planning. Additionally, a pervasive lack of awareness* *exacerbates the situation, as many residents remain uninformed about the detrimental consequences of their actions, such as indiscriminate waste disposal into drains and creeks, construction on floodplains, and the encroachment upon wetlands.'*

This act contributes to blockages and impediments to the natural flow of water, thereby exacerbating the risk of flooding.

The bodies responsible for flood management in Bayelsa state are the National Emergency Management Agency, State Emergency Management Agency, Niger Delta Development Commission, and NGOs who support people during flooding. The responsibility of the Ministry of Environment is to desilt the canals and clear all blockages while the Capital City Development Committee is charged with removing illegal structures especially those obstructing free flow of water.

On flood management, R8 said '*Most flood management plans in the state have not been effective because of lack of funding and political will'*.

R12 said '*the effectiveness of flood management plans in the region is hampered by inadequate funding*.' In agreement, R1, R11, and R5 explained that despite the pressing need for robust flood mitigation measures, the limited financial resources allocated to such initiatives have undermined their implementation and efficacy. Consequently, the absence of sufficient funding has resulted in the inability to undertake critical infrastructure projects, implement flood control measures, and adequately support emergency response efforts. Addressing these funding challenges is essential to bolstering the resilience of communities along Epie Creek and mitigating the adverse impacts of recurrent flooding events.

For the impact of flooding to be reduced in Bayelsa State, we need to have flood control structures (shoreline protection embankments) that equally help to protect the shoreline from erosion and flooding as almost all the communities are affected.

5.8: Links in the study

According to the study's findings, changes in land use from vegetative to residential, agricultural, commercial, and transportation purposes were identified as being associated with both climate change and human activities in the study area. The primary drivers of land use changes included population growth, development, and Urbanisation, all of which contribute significantly to alterations in land utilization. Urbanisation plays a substantial role in exacerbating flooding, with factors such as poor waste management, deforestation, canal blockages, silted creeks, obstructed drains, increased land demand, and the discharge of excess water from the Lagdo Dam all contributing to the deteriorating flood situation in the city.

The consequences of flooding in this region have widespread impacts, affecting the prices of goods and services, socio-economic activities, livelihoods, health, rental costs, and water quality, and causing damage to roads, buildings, and infrastructure. The repercussions also extend to losses in crops and livestock, property damage, power outages, and psychological impacts stemming from stress and trauma as depicted in Figure 5.20 below.

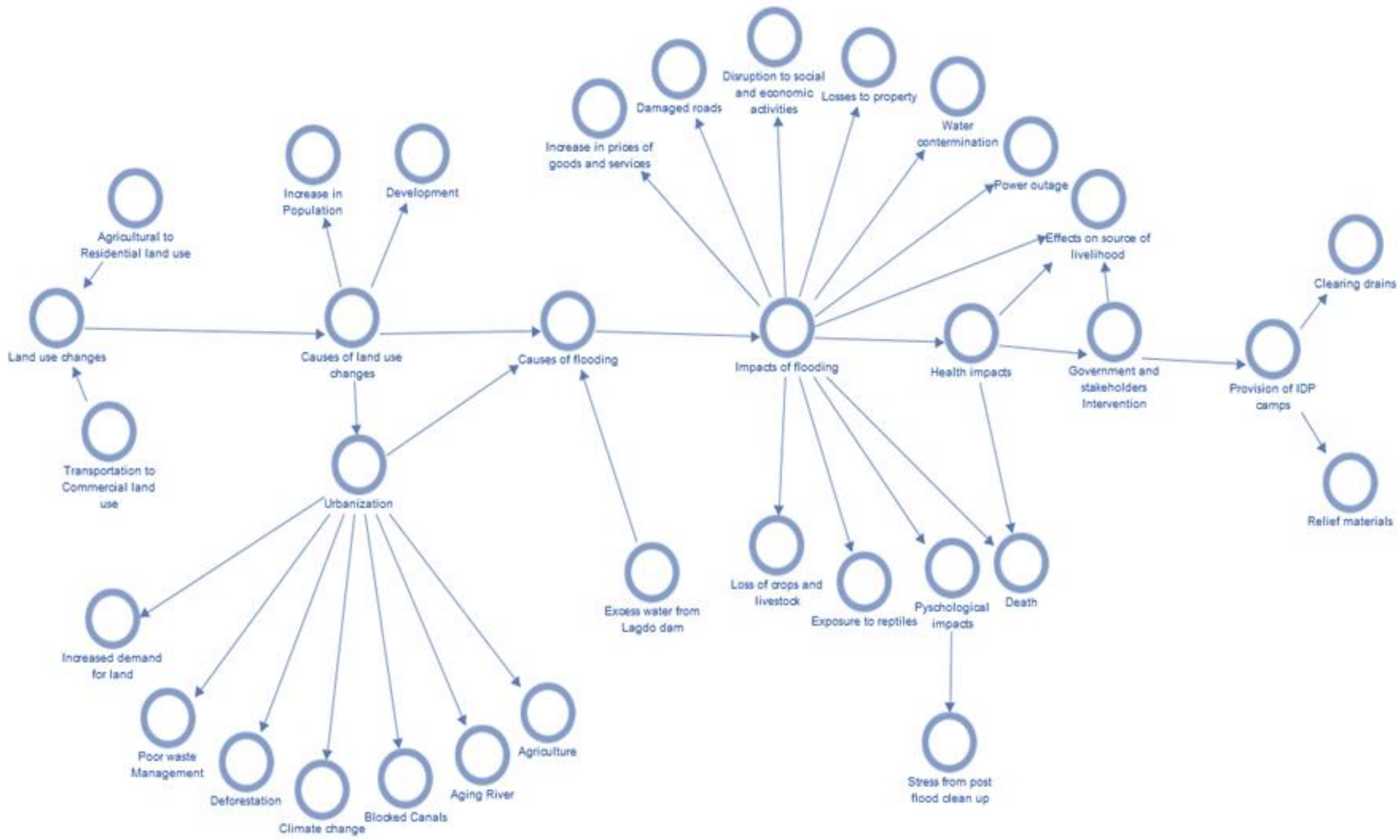


Figure 5.20: Cognitive map showing links in the study.

The government, stakeholders, and non-governmental organizations (NGOs) take steps to assist flood victims through the establishment of camps for internally displaced persons, the clearing of drains to enhance water flow, and the provision of relief materials to help ameliorate the sufferings of the people affected. However, according to respondents, the assistance provided to flood victims is deemed insufficient, prompting a call for more extensive efforts.

Figure 5.21 below depicts the hierarchy of the study and their corresponding responses with the size of the boxes indicating the level of response received. The impacts of flooding and the causes of flooding received the highest responses followed by land use and land cover changes and recommendations. Policies, Government, and Stakeholders Intervention were next in the response rank, followed by adaptive measures with the least responses from flood risk reduction. The respondents' perception highlights their familiarity with certain areas, while also underscoring the need for increased awareness and efforts in addressing policy-related issues and flood risk reduction in less clear-cut domains.

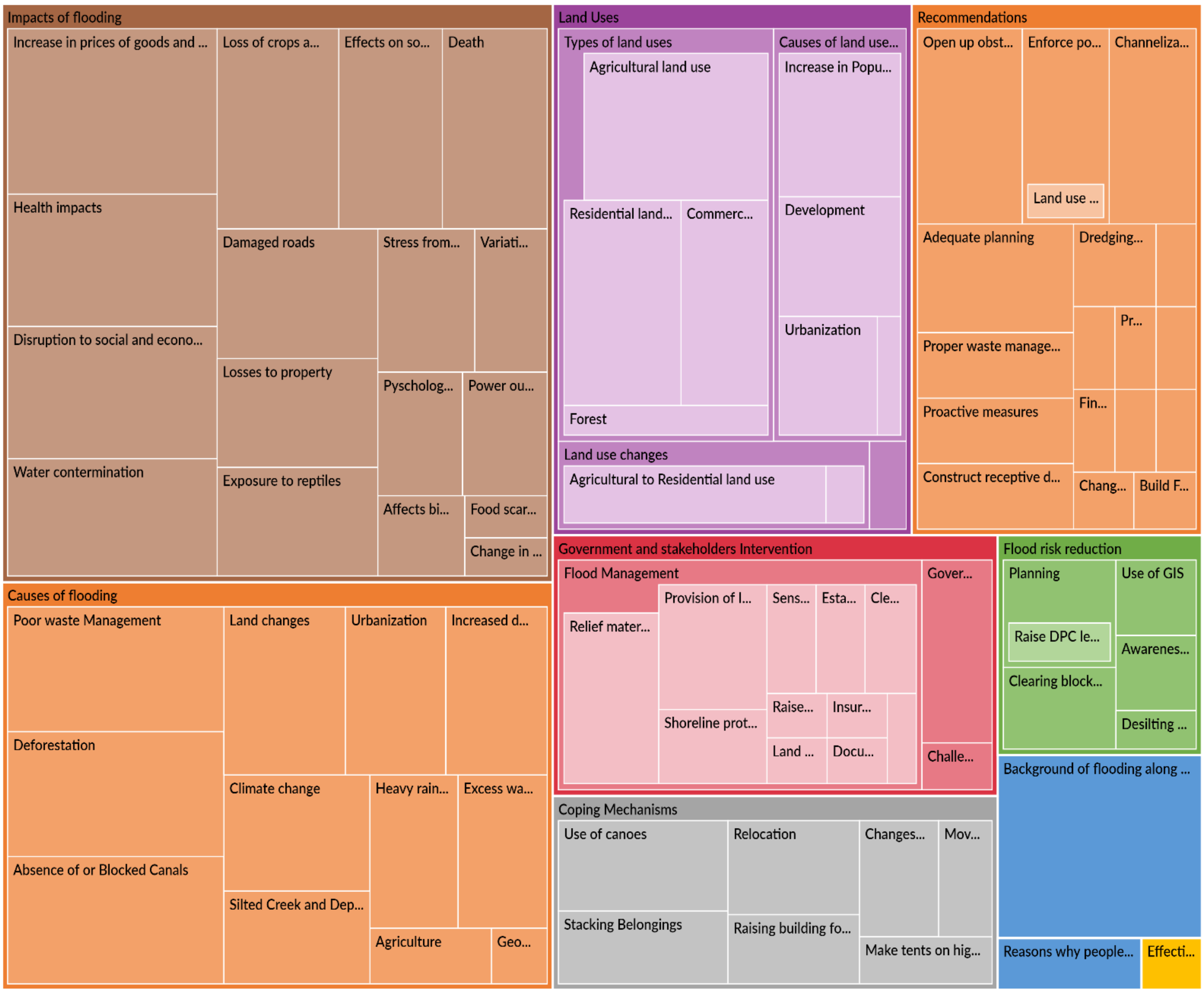


Figure 5.21: Hierarchy map of the study

Figure 5.22 below shows the number of coding references with distinct colors for different themes achieved using the hierarchy chart from the explore tool bar of Nvivo to look at the responses received. The first inner circle indicates the themes while the second circle depicts the codes, and the third circle represents the child codes. The number of sections represents the number of references coded. The variables central to this study are depicted, with a primary focus on the discussion of flooding's impacts. Flooding's consequences were a prominent theme with 129 references, as all ten participants emphasized its effects on both people and the environment. Out of the 129 responses gathered from these 10 participants, the most frequently cited impact was the disruption of social and economic activities and the increase in the prices of goods and services with 24 references, as well as 14 references to the loss of crops and livestock as significant impacts. Furthermore, the causes of flooding received substantial attention, with participants identifying a range of factors contributing to it. Notably, poor waste management was mentioned 19 times, while Urbanisation was referenced 12 times, indicating their heightened importance in the discussions.

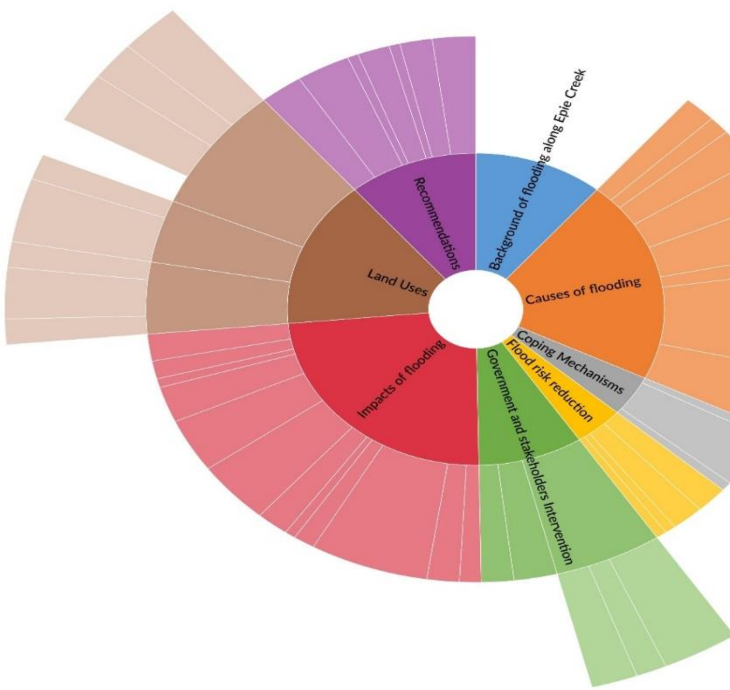


Figure 5.22: Hierarchy map of the study

5.9: Summary

Data analysis is vital for understanding the impact of land use and land cover (LULC) changes on flooding along Epie Creek in Nigeria. By utilizing various analytical tools and techniques, researchers can measure the extent of LULC changes over time and examine their relationship with flooding events. This process involves analyzing satellite imagery, historical flood records, and other geographical data to identify patterns and trends. The insights obtained from this analysis help pinpoint key factors contributing to increased flood risks, such as deforestation, urbanization, and agricultural expansion. Furthermore, data analysis aids in developing predictive models to forecast future flood scenarios based on projected LULC changes, thus supporting effective flood management and mitigation strategies. The findings of the study are discussed in the next chapter.

CHAPTER SIX: RESEARCH FINDINGS AND DISCUSSION

6.1: Introduction

This chapter discussed the findings and captured the essence of this research, emphasizing the impacts of land use and land cover change on flooding. The findings of the interviews, GIS, and Literature reviews are discussed. Thematic analysis was utilised to examine the interview data, as it is the most prevalent method of analysing qualitative data. This technique focuses on identifying, analysing, and interpreting patterns found in the data (Braun and Clarke, 2006). The primary themes that were explored and incorporated into the research results were land use and land cover change, flooding and vulnerability, policies, and stakeholders' engagement. A flood risk development framework is developed to mitigate flooding problems by identifying land use and land cover changes along Epie Creek. The framework's validation and recommended measures of flood mitigation are also presented here. To fulfil the study's objectives, it is essential to reinforce the results obtained in Chapter 5. The discussion of the findings will align with the themes. Consequently, the findings from the literature review are employed to strengthen and unify the outcomes of the empirical investigation presented in this chapter.

6.2: Interview Findings from Land Changes

The semi-structured interview of twelve experts was collected and analysed thematically into land use and land cover changes, flood and rainfall variability, policies, and stakeholders' intervention. Data for land use and land cover changes were collected in section 4.10.3, and analysed in 5.3. The following findings were made:

6.2.1 Changes in the Natural Landscape

Before this research, there was noticeable uncontrolled migration to the Epie Creek area, reflecting a broader trend seen in other regions, such as Manila in the Philippines and Amassoma in Bayelsa State, Nigeria. This migration has significantly impacted local ecosystems, with insufficient attention from authorities exacerbating existing issues. The research revealed significant deforestation and unplanned development in the back swamps of Epie Creek, leading to increased runoff and displacement of water, worsening the flooding problem in the area. This aligns with Lawrence and Vandecar (2014) and Winkler (2021), who note that deforestation has significant climatic and environmental consequences, including increased flooding and changes in local hydrological cycles. Understanding these underlying causes and their proportions is essential for authorities to develop effective support strategies and foster sustainable community collaboration in environmental conservation and development.

6.2.2 Urban Sprawl

Urbanization in Yenagoa city, especially along Epie Creek, has increased dramatically from 1987 to 2022. Indicators include high population density, expanded built-up areas, and diverse economic activities. GIS land use data shows a significant transformation from 1987 to 2020, with agricultural and bare lands being converted into built-up areas, increasing from 4% to 16% by 2022. This rapid urbanization, driven by the city's designation as the state capital in 1996 and the establishment of Niger Delta University in 2000, has led to increased housing and resource demand. These findings support observations by Nuissl and Siedentop (2020), who identified urbanization as a critical factor in land use change, and Tijani et al. (2018), who noted the environmental toll of urban sprawl, including soil degradation and increased runoff.

To ensure sustainability, authorities need comprehensive urban planning strategies, such as zoning regulations, green infrastructure investments, and sustainable building practices. Collaboration between government agencies, local communities, and stakeholders is crucial to balance urban development and environmental preservation (Din & Mak, 2021). Such strategies are necessary to mitigate the adverse impacts of urban sprawl documented by Ramesh (2013) and Miller and Hess (2017).

6.2.3 Climate change impacts

Climate change has significantly influenced land use and land cover in the study area, altering precipitation patterns and increasing extreme weather events. Respondents noted more rainfall in some months and less in others, disrupting traditional farming schedules. Farmers must now adjust planting seasons and focus on faster-maturing crops like tomatoes, okra, peppers, and pumpkins. This adaptive strategy is consistent with findings by Xiao-Peng et al. (2018) and Tesser (2005), who documented similar adjustments in agricultural practices due to climate variability.

The conceptual framework initially proposed, linking land use change to climate change, has evolved. Urbanization, high population, and rapid development emerged as significant contributors to land use changes, with greenhouse gases, land use changes, and aerosol emissions identified as climate change drivers (Turner, 2007; Foley et al., 2005). This has resulted in greater than-expected inundation levels, highlighting the urgent need for effective land management and climate adaptation strategies. These findings are supported by Verburg et al. (2000) and Winkler et al. (2021), who emphasized the importance of adaptive land management in response to climate impacts.

6.3: Findings from Flooding and Rainfall Variability

The vulnerability findings reveal critical insights into the susceptibility of communities to environmental hazards. Through comprehensive analysis, patterns of exposure, sensitivity, and adaptive capacity emerge, shedding light on areas most at risk. These findings serve as a foundation for informed decision-making, enabling the implementation of targeted interventions to mitigate vulnerabilities. Understanding the multifaceted nature of vulnerability enhances resilience and fosters sustainable development. By addressing underlying vulnerabilities, communities can better withstand and recover from the impacts of natural disasters and other threats. From the study, the following findings were made.

6.3.1 Urban and River Flooding

The findings reveal that areas along Epie Creek and communities in Yenagoa experience increasing flood events, with varying impacts depending on location and drainage infrastructure. This aligns with the literature which emphasizes that urbanization and inadequate infrastructure exacerbate flood risks. For example, poor waste management, which clogs drainage systems, is a significant contributor to urban flooding (Olawumi et al., 2015). This is consistent with the respondents' attribution of increased flooding intensity to poor waste management and blockage of drains due to high population density and urbanization. Similarly, studies have shown that changes in land cover from vegetation to paved surfaces increase runoff and contribute to flash floods during heavy rainfall (Li et al., 2019).

Moreover, the finding that the 2022 flood was more severe than the 2012 flood highlights the increasing intensity and magnitude of flood events, a trend also observed in global flood data

(Rentschler et al., 2022). This can be attributed to both climatic factors and human activities, which have been documented to influence flood frequency and severity (Jonkman, 2005; Hirschboeck et al., 2000).

6.3.2 Hydrological changes

The research confirms that hydrological processes are significantly affected by rainfall patterns and external factors such as the release of water from dams. The massive floodings of 2012 and 2022 were exacerbated by the release of water from the Lagdo Dam in Cameroon, underscoring the need for international water management agreements (Aprioku, 2012). This finding is consistent with the literature that highlights the role of human interventions, such as dam operations, in influencing flood events (Gebeyehu, 1989).

Furthermore, the findings align with studies showing that heavy and prolonged rainfall events lead to saturated soils and increased runoff, which exacerbate flooding (Hirschboeck et al., 2000). This is particularly pertinent in regions with inadequate drainage infrastructure, which cannot cope with sudden increases in water volume (Braimah et al., 2014).

6.3.3 Socio-economic and ecosystem impacts

The socio-economic and ecosystem impacts of flooding are profound and multifaceted. Flood events in Yenagoa disrupt social and economic activities, halt schooling, and cause displacement and health issues, including stress and waterborne diseases. These findings echo the literature, which documents the extensive economic and social disruptions caused by floods (Echendu, 2020; Wilson, 2009). The increased health costs and infrastructure damage observed are also consistent with global reports on flood impacts (Shang & Wilson, 2009).

Additionally, the impact on terrestrial and aquatic ecosystems, such as altered species distribution and disrupted habitats, is well-documented in the literature (Flotemersch et al., 2019). This aligns with the study's findings on the ecological consequences of flooding, emphasizing the broad and interlinked impacts of flood events on both human and natural systems.

6.4: Findings from Review of Land Use Policies and Stakeholder Engagement

From the review of literature in section 2.4 and data analysis 5.6, several land use management policies in Nigeria are applicable in Epie Creek the study area. The policies, details, and findings are presented in Table 6.1

Table 6.1 Findings of Land Use Policies

Policies	Details	Findings
Nigerian Urban and Regional Planning Act CAP 138	The Nigerian Urban and Regional Planning Act CAP 138 is a legal framework aimed at promoting sustainable development, optimizing land use, enhancing infrastructure, and protecting the environment, guiding the formulation and implementation of policies for balanced urban growth.	Research on non-compliance with the Nigerian Urban and Regional Planning Act CAP 138 highlights challenges in urban development, including unregulated expansion, illegal construction, and inadequate infrastructure. Studies by Olujimi (2019) and Oloyede et al. (2020) emphasize the prevalence of non-compliance and its adverse effects on sustainable development and environmental conservation efforts in Nigeria. These findings underscore the importance of effective enforcement mechanisms and

		policy reforms to address urban planning challenges and promote sustainable urban growth.
Laws of the Federation of Nigeria, 2004	The "Laws of the Federation of Nigeria, 2004" is a compilation of all laws enacted by the National Assembly of Nigeria up to the year 2004. It serves as a comprehensive repository of legislation, covering various aspects of governance, justice, administration, and socio-economic development in Nigeria. The compilation includes statutes, acts, regulations, and subsidiary legislation enacted by the federal government, providing a legal framework for governance and regulation across different sectors.	
Land Use Act CAP L5	findings regarding the application of the "Laws of the Federation of Nigeria, 2004" may reveal challenges such as inconsistent enforcement across different regions, limited public awareness of legal rights and responsibilities, bureaucratic delays in accessing justice, and gaps in implementation due to resource constraints	findings regarding the application of the "Laws of the Federation of Nigeria, 2004" may reveal challenges such as inconsistent enforcement across different regions, limited public awareness of legal rights and responsibilities, bureaucratic delays in accessing justice, and gaps in implementation due to resource constraints Okonjo (2018) and Adebayo et al.

		(2020) may shed light on these issues
Environmental Impact Assessment Act CAP E12	The Environmental Impact Assessment (EIA) Act, CAP E12, is a significant piece of legislation in Nigeria that governs the environmental impact assessment process for proposed projects and activities.	Inadequate Enforcement: One major challenge is the lack of effective enforcement mechanisms to ensure compliance with EIA regulations. Regulatory agencies may struggle to monitor and enforce adherence to environmental standards due to limited resources, capacity constraints, and corruption within regulatory bodies.
National Housing Policy of 1991, 2012	The National Housing Policy of 1991, updated in 2012, outlines Nigeria's strategic framework for addressing housing challenges. It aims to provide affordable and adequate housing for all citizens, promote sustainable urban development, and improve living standards.	Nigeria faces a significant housing deficit, with millions lacking decent, affordable housing, especially in urban areas. Informal settlements are prevalent, with inadequate housing, lack of basic services, and tenure insecurity. Affordable housing remains a challenge, with high construction costs and limited government support.
Urban Development Policy of 2012	The Urban Development Policy of 2012 in Nigeria aims to guide sustainable urban growth, improve urban infrastructure, and enhance the quality of life for urban residents.	challenges associated with the implementation of the policy persist. These challenges include inadequate funding for urban development projects,

	Key components of the policy include provisions for integrated urban planning, land use management, infrastructure development, and slum upgrading.	limited capacity and resources within urban planning agencies, ineffective coordination among government ministries and agencies, rapid urbanization leading to informal settlements and urban sprawl, and weak enforcement of urban development regulations.
National Building Code of 2006	The National Building Code of 2006 in Nigeria serves as a comprehensive set of guidelines and standards aimed at ensuring safety, durability, and sustainability in the construction of buildings across the country. While the code provides a framework for improved building safety, resilience, and quality of construction	limited awareness and enforcement of the code's provisions, especially in rural and informal urban areas, inadequate capacity and resources within regulatory agencies for monitoring and enforcement, and factors such as corruption and bureaucratic delays that hinder compliance.
Bayelsa State Housing and Property Development Authority Law of 1998.	The Bayelsa State Housing and Property Development Authority Law of 1998 may vary depending on research focus and objectives. Positive findings may include increased access to affordable housing, improved urban infrastructure, and enhanced regulatory mechanisms for property transactions.	challenges in the implementation of the law may also be identified, such as inadequate funding for housing projects, bureaucratic bottlenecks in land acquisition and development processes, and limited capacity within the BHDA to effectively carry out its mandate.

Over the past decades, Nigeria has witnessed the enactment of several land policies aimed at addressing various aspects of land tenure, management, and development. The Land Use Act of

1978, which remains a fundamental legal framework, sought to unify land tenure systems and facilitate access to land for individuals and government purposes. However, challenges in its implementation, including limited land allocation and disputes over land rights, have persisted. Subsequent policies, such as the Nigerian Urban and Regional Planning Act CAP 138, the Environmental Impact Assessment Act CAP E12, and the National Housing Policy of 1991 and its 2012 update, have addressed issues related to urban development, environmental protection, and housing provision, albeit with challenges in enforcement, funding, and public participation.

In more recent years, the Urban Development Policy of 2012 aimed to guide sustainable urban growth and infrastructure development, while the National Building Code of 2006 set standards for building construction and safety. However, challenges remain in implementing these policies effectively, including inadequate funding, weak enforcement mechanisms, and limited public awareness. Additionally, the Bayelsa State Housing and Property Development Authority Law of 1998 focused on housing and property development within the state, contributing to efforts to address housing challenges and promote urban development initiatives in Bayelsa State, Nigeria. Overall, while these land policies have provided a framework for addressing land-related issues in Nigeria, ongoing efforts are needed to overcome implementation challenges and achieve their intended objectives of promoting sustainable land management and development, especially in urban areas like Yenagoa.

6.4.1 Legal and Regulatory Challenges

The findings indicate that despite the existence of comprehensive land use policies in Nigeria, such as the Land Use Act of 1978 and the National Urban Development Policy of 2012, implementation and enforcement remain major challenges. These policies aim to regulate land tenure, prevent speculative land practices, and promote sustainable urban development (Oluwasegun & Ayoade, 2017; Oni, 2016). However, the unauthorized building on floodplains, sand filling of swamps for construction, and inadequate waste management persist in the study area, exacerbating flood risks (Critchley et al., 2023).

Literature supports that weak enforcement mechanisms, corruption, and lack of accountability undermine the effectiveness of these policies (Azadi, 2020; Kryspin-Watson et al., 2017). For instance, despite legal provisions, unplanned settlements continue to encroach on flood-prone areas due to informal land acquisition practices facilitated by local leaders and sometimes state officials (Adekola et al., 2020). This situation highlights a critical gap between policy intent and on-the-ground realities, which perpetuates environmental degradation and increases vulnerability to climate change impacts (Lawry et al., 2023).

6.4.2 Stakeholder Engagement and Participation.

The study finds minimal community engagement and stakeholder participation in the land use planning process, which limits the effectiveness of policies in addressing local needs and challenges (Kryspin-Watson et al., 2017). This lack of inclusivity in decision-making processes reinforces social injustices and exacerbates poverty and inequality (Ouikotan et al., 2017). In contrast, effective policies, such as those outlined in the Environmental Impact Assessment (EIA) Act of 1992, emphasize participatory planning to mitigate adverse environmental impacts of development projects (Osinowo et al., 2019).

Literature underscores that inclusive governance and meaningful stakeholder engagement are essential for sustainable land use management (UNISDR, 2009). For instance, successful policy implementation requires active involvement from local communities, NGOs, private sectors, and government agencies to ensure that diverse perspectives are considered in decision-making processes (Kryspin-Watson et al., 2017).

6.4.3 Adapting to changing conditions

The study highlights the inflexibility of existing land use policies in adapting to evolving social, economic, and environmental conditions (Kryspin-Watson et al., 2017). This rigidity undermines the resilience of policies in accommodating rapid urbanization, population growth, and technological advancements (Egbinola et al., 2017). Effective policies, such as those integrating climate change adaptation strategies, are crucial to mitigate risks associated with changing environmental conditions (Jha et al., 2012).

Literature suggests that adaptable land use planning frameworks, like those seen in developed nations, incorporate zoning regulations and building codes tailored to local flood risks (Hudson & Botzen, 2019). However, in Nigeria, the lack of such adaptive policies contributes to continued vulnerability to floods and other natural hazards (Mulligan et al., 2016).

6.5: Flood Risk Reduction Framework (FRRF)

From the literature reviewed, it was revealed that land use land cover changes significantly affect the severity of flooding. The initial conceptual model in 2.7 highlighted the concepts of the study and established the relationship between land use, land cover change, and flooding, as well as the impact of climate change on people's livelihoods. It was expected that the impacts of human activities would be gradual and possibly reduce with current drain clearing but this was not the case as there was a rapid increase in the effect, intensity, and frequency of flood which takes us back to the need for an effective framework.

According to Oladimeji & Owho (2022), The geographical positioning of Yenagoa within the Niger Delta region, characterized by abundant rainfall and a network of creeks and streams, renders it highly vulnerable to flooding, particularly rapid urban flash floods triggered by heavy rainfall and the seasonal rise of the Epie and Ekole Creeks. Consequently, any significant flood event poses a substantial threat to both property and the economy, impacting both governmental infrastructure and the livelihoods of citizens. The city's rapid population growth and expanding socioeconomic activities further exacerbate the risk of flooding due to inadequate urban development controls. Thus, there is an urgent imperative to evaluate Yenagoa's flood risk profile and develop policies aimed at mitigating these risks in alignment with the Sendai Declaration. One effective approach to achieve this objective is through flood mapping, enabling the identification of vulnerable areas and exposed elements within Yenagoa susceptible to flood hazards.

Based on the study's findings on changes in the landscape (wetlands), urban sprawl, and other environmental impacts, the conceptual model was subsequently elaborated to encompass the comprehensive findings of the investigation by incorporating flood management.

The conceptual framework highlights the essential concepts and how they can be tackled from the land use and flooding perspectives. A flood risk reduction strategy was subsequently established. Explanations for land use and land cover change involve several beginning causes, which can either be exogenous or endogenous (Lambin & Meyfroidt, 2010) or a combination of both (Le Plain de Waroux et al., 2018) as illustrated below in Figure 6.1. Then the

The big box encompasses all the internal factors; causes, impacts, and likely solutions to land use, land cover, and flooding respectively. The factors highlighted in green are responsible for alterations in land use and land cover, whereas the factors in blue are responsible for the increasing floods. The yellow elements encompass all the variables that are involved in explaining the land and flood systems, whether they are initial factors or factors that mediate the process. The arrows linking the items represent the explicit relationships between the variables that have been examined in the study.

The SENDAI framework which outlines seven targets to guide nations in mitigating disaster risk and building resilience at local, national, and international levels can be applied to the Epie Creek area. With its focus on understanding risk, strengthening governance, investing in resilience, and enhancing disaster preparedness. By applying various fundamental principles and techniques from the Sendai Framework, we can improve resilience and minimise the negative impacts of floods along the Epie Creek area in Nigeria.

Several primary causal factors in land-use land cover change explicitly attribute urbanisation (due to overpopulation) and heightened resource demand as the primary determinants of land changes. Additionally, excess water from the Lagdo dam, obstructed drainage systems, and alterations in land surfaces, such as an increase in paved areas, significantly contribute to the escalation of flooding.

The recommendations for land use management and flood risk management are presented in the green and blue boxes, respectively. The yellow box contains recommendations that pertain to both land and flood management.

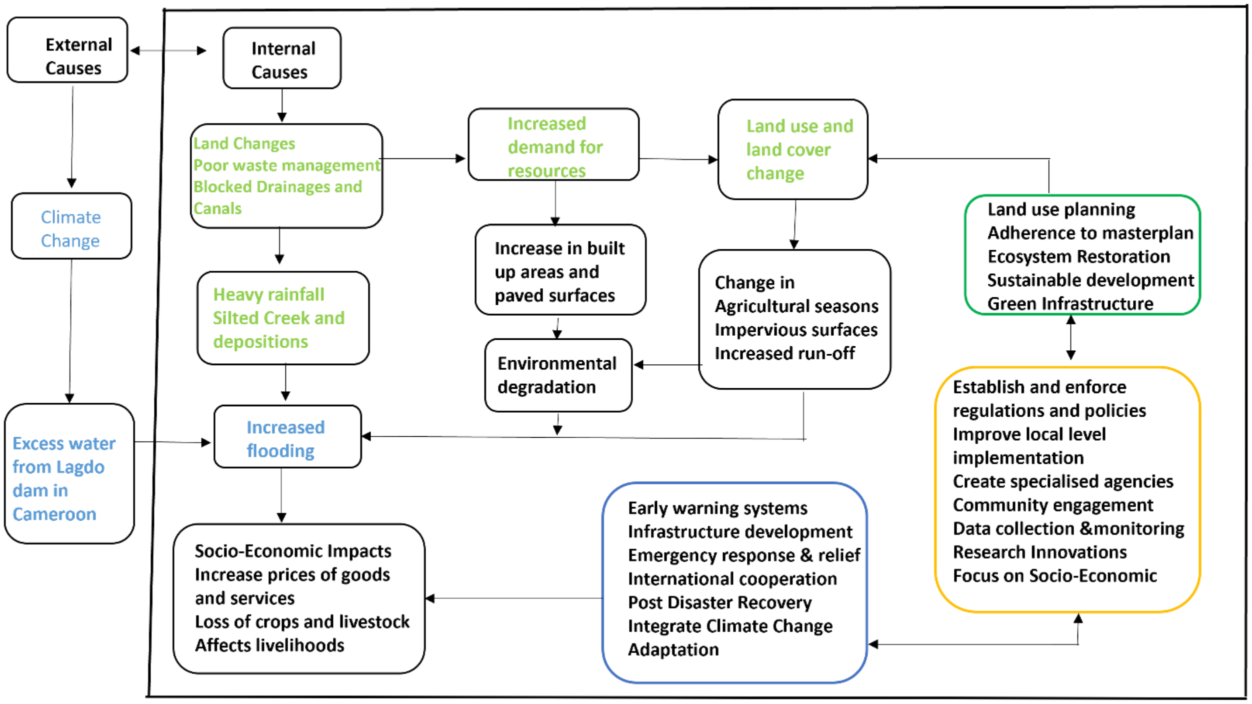


Figure 6. 2: Flood Risk Reduction Framework

6.5.1: Validation of Flood Risk Reduction Framework

Rykiel (1996) stated that the validation process is crucial in confirming that any guideline or proposed framework is suitable for its intended usage. Assessing the validity and reliability of research is crucial to guarantee the high quality of the data collected and produced. Saunders et al. (2009) highlighted that decreasing the likelihood of inaccurate responses underscores the significance of reliability and validity in research methodology. Morse et al. (2002) contended that some verification tactics can attain reliability and validity in research, even with variations in the reliability and validity procedures of qualitative methods.
A focus group discussion with of six specialists was done to validate the flood risk reduction framework as presented in Table 6.2 below. Six expert respondents were assigned codes P1-P6 for anonymity. The validation questionnaire is presented in Appendix G.

Table 6.2 List of respondents for framework validation

S/N	Respondent Code	Designation	Years of Experience
1.	P1	Environmental Health Consultant (NGO).	16
2.	P2	Head of Department, Directorate of Flood and Erosion Control.	18
3.	P3	Head of Department, Flood and Erosion Control, Ministry of Environment.	13
4.	P4	Ministry of Lands and Housing	21
5.	P5	Yenagoa Community Chief	23
6.	P6	Senior Staff, Ministry of Works.	10

The discussion lasted for two hours. The purpose of utilising a focus group for framework validation is to guarantee the effective use of the implementation. This involves evaluating the quality aspects such as simplicity, completeness, flexibility, comprehensibility, acceptance, utility, and implementation capability. The quality factors utilised in this research study are derived from those established by Moody and Shanks (2003) and Moody (2003) and are presented below.

The validation process aimed primarily to confirm the presence of key issues and gaps outlined in the study, validate the appropriateness of the research methods employed, and validate the integrative framework and Capability Maturity Model that were developed. The session commenced with an overview of the study, its aims and objectives, a brief overview of relevant literature, the research methodology, data collection procedures, conceptual framework, and the final proposed framework. Following the presentation, participants provided the following feedback:

1. Consensus on the significance and relevance of the research: Interviewees concurred that the research and development of the integrative framework were warranted, given the relevance of the topic within the case study area, Epie Creek.

2. Recognition of prevalent flooding and land use issues addressed in the thesis: These issues primarily encompassed Urbanisation and unplanned developments.

3. Appreciation for the integrative nature of the framework, which delineates key stages with potential applications.

Participants were then provided with a set of questions on a five-point Likert scale to gauge their knowledge and opinions regarding the accuracy and validity of the Flood Risk Reduction (FRR) Framework (Boone & Boone, 2012). The Likert scale ranged from "strongly disagree" (1) to "strongly agree" (5), facilitating the collection of precise information and facts about the framework. Participants were encouraged to respond honestly, ensuring their answers accurately reflected their viewpoints.

6.5.2 Framework Validation

The results of the validation process demonstrate the suitability and reliability of the FRR framework within the study's context. Table 6.1 and Figure 6.1 present the outcomes of the focus group session involving six experts from diverse backgrounds including the environmental sector, government, NGOs, research, policymaker, and community.

Table 6.3: Flood Risk Reduction Framework Validation.

FRR Framework Questions	**Strongly Disagree**	**Agree**	**Not Sure**	**Agree**	**Strongly Agree**
1. Do you think the framework is straightforward for evaluating the				√√	√√√√

impacts of land changes on floods? (Simplicity)					
2. Do you think the framework has adequately accounted for all the factors in assessing flood risk reduction? (Completeness)				√√√	√√√
3. Do you think the framework is flexible enough to adapt to any change in flood management? (Flexibility)				√√	√√√√
4. Do you think the framework content and structure are easy to understand? (Understandability)					√√√√√√
5. Do you think that local authorities will accept the framework? (Acceptability)			√	√√√	√√
6. Do you think that the framework components are useful for flood risk reduction? (Usefulness)				√√√	√√√
7. Do you consider that the framework can be adopted and implemented in your working environment? (Implementation Ability)				√	√√√√√

6.5.3 Results of the Flood Reduction Framework Validation

The evaluation of the Flood Risk Reduction framework (FRRF) across various quality factors yielded positive insights:

1. Framework Simplicity: Strong agreement among participants (4 strongly agreed, 2 agreed) that the framework is simple for assessing flood resilience.

2. Framework Completeness: Most participants agreed or strongly agreed (3 strongly agreed, 3 agreed) that the framework encompasses all necessary factors for assessing resilience.

3. Framework Flexibility: Majority agreement (4 strongly agreed, 2 agreed) that the framework is flexible enough to adapt to changes.

4. Framework Understandability: 100% agreement (6 strongly agreed), that the framework content and structure are easy to understand.

5. Framework Acceptability: Agreement from most participants (3 agreed, 2 strongly agreed, 1 was not sure) that local authorities would accept the framework.

6. Framework Usefulness: Strong agreement (3 strongly agreed, 3 agreed) that the framework is useful for future flood mitigation and management in Yenagoa, the Niger Delta Region, and other States with similar climatic factors.

7. Framework Implementation Ability: Most participants (1 agreed, 5 strongly agreed) believe the framework can be implemented in their organizations.

In conclusion, the FRR framework demonstrates simplicity, completeness, flexibility, understandability, acceptability, usefulness, and implementation feasibility for reducing flood risks.

6.6: Recommendations of the study

Based on the research findings, several recommendations emerge to address the pressing issues identified in the Epie Creek area:

1. Address Uncontrolled Migration and Urban Sprawl:

Authorities should implement measures to manage uncontrolled migration and urban sprawl in the Epie Creek area. This could involve zoning regulations to control urban expansion and prevent encroachment on environmentally sensitive areas. Additionally, efforts should be made to provide alternative opportunities for livelihoods and housing outside of flood-prone zones to reduce population pressure on vulnerable areas.

2. Enhance Environmental Conservation and Sustainable Development:

Collaborative efforts between authorities and local communities are essential to promote environmental conservation and sustainable development practices. This includes initiatives to restore deforested areas, protect wetlands, and improve waste management systems. Community-based conservation programs can empower residents to actively participate in environmental stewardship and mitigate the adverse impacts of urbanization on local ecosystems.

3. Strengthen Urban Planning and Infrastructure Development:

Authorities should prioritize comprehensive urban planning strategies to manage the rapid expansion of built-up areas and infrastructure development in Yenagoa city. This involves investing in green infrastructure, such as rainwater harvesting systems and permeable pavements, to mitigate the impacts of increased runoff and flooding. Zoning regulations should be enforced to prevent construction in flood-prone areas and preserve natural drainage channels.

4. Improve Flood Preparedness and Disaster Response:

Given the increasing frequency and intensity of flooding events, there is a need to enhance flood preparedness and disaster response mechanisms. This includes developing early warning systems, conducting public awareness campaigns on flood risk, and establishing emergency evacuation plans for vulnerable communities. Additionally, international agreements and coordination are essential to address transboundary issues, such as water releases from dams, and mitigate their impacts on downstream communities.

5. Strengthen Policy Implementation and Stakeholder Engagement:

Efforts should be made to strengthen the implementation of existing land use and flood management policies in the Epie Creek area. This requires enhancing enforcement mechanisms, addressing corruption and accountability issues, and fostering greater stakeholder engagement and participation in decision-making processes. Authorities should prioritize inclusivity and transparency in policy development to ensure that the needs and concerns of all stakeholders are adequately addressed.

6. Promote Adaptive Governance and Policy Flexibility:

Finally, there is a need for adaptive governance structures and flexible policy frameworks that can respond to changing social, economic, and environmental conditions. Policymakers should regularly review and update land use policies to accommodate population growth, economic development, and technological innovation while safeguarding the environment and promoting sustainable development goals. This entails fostering a culture of innovation, learning, and collaboration among government agencies, civil society organizations, and local communities to navigate the complex challenges posed by urbanization, climate change, and environmental degradation.

6.7: Summary

The analysis of data in Chapter 5 established the land use changes, causes, and impacts of flooding, and how land use changes contribute to flooding. This chapter discussed the research findings. The results of the study show that urban sprawl, changes in landscape, and climatic factors cause urban flooding, hydrological impacts, socio-economic impacts, and ecosystem impacts. There is a need for legal regulations, adaptation to changing conditions, stakeholder engagement, and participation. Such an understanding will advance theoretical knowledge development on the framework for land use and flood management. The recommendations of the study were also presented in this chapter.

CHAPTER SEVEN: CONCLUSIONS AND RECOMMENDATION

7.1: Introduction

This chapter presents the conclusions derived from the empirical findings of the study. This thesis is structured into seven chapters. In Chapter 1, the research background and topic were introduced, emphasising the research problem, the research gap, and the study's aims and objectives. Chapter 2 featured a critical literature review and introduced the initial conceptual framework. The single-case study (Epie Creek) was introduced in Chapter 3, and the research process and methodology were outlined in Chapter 4. Chapter 5 presents the results of the study from GIS and qualitative interviews. The main findings from these analyses were synthesised in Chapter 6, leading to the development and discussion of the final framework. This concluding chapter offers a comprehensive summary of the study, revisiting the research aim and objectives and presenting key findings. It emphasises both theoretical and practical contributions, acknowledges study limitations, and proposes potential future research areas.

7.2: Achievement of the Research Aims and Objectives

Land changes and their contribution to increasing flooding events and flood height are the focus of the study. Flood issues have been widely studied, focusing on causes, risk assessments, and flood management. This study was undertaken to address the gap between the increasing number of flood events and the need for more holistic flood management that incorporates the government and other stakeholders in the process. The study therefore developed a flood risk reduction framework to mitigate increasing flooding and flood impacts. This was achieved through the five objectives that were set, and the following sub-section shows how the objectives were achieved.

7.2.1: Objective One

From Section 1.4 of the study in Chapter 1, the first objective is ‘to examine land use and land cover variations between 1987 and 2022 to answer the research question, ‘What are the land use and land cover variations in land use and land cover from 1987 to 2022’? Using Geographic Information Sensing, land use change data was mapped and triangulated with a semi-structured interview of twelve experts and a review of the literature to arrive at the findings of the study. Data for land use and land cover changes were collected and analysed, and the findings were presented in Section 6.2.1.

The variations in land use and land cover were from vegetation to built-up areas, which implies a change in land use from agricultural and forest use to residential uses. This was due to the high demand for housing, land, and other resources brought on by the high population influx after the creation of Bayelsa State. People reclaimed swamps and built on canals after landfilling.

There was also an increase in the change of bare lands to paved surfaces, and a lot of houses were built on the flood plains due to the low cost of purchasing land in such places as compared to buying land in upper areas. These settlements on floodplains were the most vulnerable and worst affected by flooding.

The changes in land use and land cover along Epie Creek were due to urbanisation, deforestation, high population, and rapid development, which brought about unplanned development without the corresponding infrastructure in place. These, in conjunction with poor waste management, blocked drains, and the silted creek, worsen flooding along Epie Creek.

7.2.2: Objective Two

The second objective is to 'conduct a qualitative evaluation of the causes of flooding, its impacts, and adaptive strategies.' This objective aims to answer the research question, 'What are the causes of worsening flood events in the Epie communities, what are their impacts, and how have the communities coped?'

Communities along Epie Creek, in Yenagoa, and its environs have experienced devastating flood events, with increasing negative impacts with the passing years. A comparison of the 2012 and 2022 floods saw an increase in flood height, more losses, and a greater extent of damage in 2022. This increase in flooding has been attributed to a lot of factors, but from the findings of the study, the flood situation along Epie Creek is aggravated by multiple factors, both internal and external. The internal factors are inadequate or blocked drains, indiscriminate dumping of waste in drains, canals, and rivers, and river siltation from depositions. The external factors, on the other hand, are climate change and the release of excess water from Lagdo dam in Cameroon, which floods all the coastal cities along its course through the river Niger, with its contribution to severe flooding noticed most in 2012 and 2022.

The increasing flood impacts caused suffering and hardship, disruption to socio-economic activities, damages to properties and infrastructure, and an increase in health issues like malaria, typhoid fever, cholera, etc. It also led to the closure of schools and restructuring of the school calendar to make up for lost time, adjustments in planting seasons to mitigate flood impacts on crops, and an increase in the prices of goods and services.

Flooding also affects the cost of land and the cost of rent along Epie Creek and environs, such that places that are prone to flooding are way cheaper to buy or rent compared to those areas that are on highlands. Other impacts of flooding include the death of livestock and poultry birds and the displacement of microorganisms and other biodiversity from their habitats. Flooding can also lead to death when people drown or are involved in accidents during flooding.

Besides changing the planting time and crops and adjusting the school's academic calendar, the residents of Epie Creek adapt to flooding and flood risks in many ways. During flooding incidences, most people relocate to higher grounds where they live with relatives, friends, or in IDP camps, then return to their houses after the floods. Others, especially those with nowhere to go, continue to live in the flooded houses, using adaptive measures to help them live in the flooded houses or surroundings. These measures included the use of canoes for transportation, the use of bags of sand and cement to block water from flowing into houses or compounds, and the use of wood to make footbridges for access to their homes. Also, platforms are raised in flooded houses where people stay, sleep, and keep their belongings away from the flood water.

7.2.3: Objective Three

The third objective was 'to review land use policies and stakeholders' involvement in flood management' to answer the research question, what policies guide the people, and what have the government and stakeholders done to mitigate flooding? In Bayelsa State and along Epie Creek, there are some existing laws, such as the Bayelsa State Housing and Property Development Authority Law of 1998. Other policies and regulations are at the national level and include the Nigerian Urban and Regional Planning Act (CAP 138), the Land Use Act, CAP L5, and the Urban Development Policy of 2012.

While some people are aware of the land use and flooding policies, most residents do not know much about these policies, so lands are bought and houses are built at will without consideration of these policies, especially on flood plains along Epie Creek. The government lacks the political will to implement or enforce these policies most of the time. The policies on flooding that are meant to protect the river plains from development, if effective, would have prevented a lot of flooding issues. Also, if the three-meter rule was adhered to and proper infrastructure like adequate drainage free from waste and debris were in place, the frequency and intensity of flooding along the creek would be minimal.

In response to flood management, very few activities are carried out before flooding incidences. The government and stakeholders only come in to lend a helping hand during the flood crisis, which is a challenging time to render help as there are a lot of limitations such as hindrances to transportation, inflated costs of goods and services, and scarcity of basic amenities like portable drinking water. There is also the issue of corruption where certain top officials or dignitaries are exempted from these regulations and policies, such that if a structure is erected on a natural drainage, it could be demolished if it belongs to just anyone, but if it belongs to a top politician or official, the regulations or policies are overlooked.

In recent years, the flood impacts of 2012 and 2022 have prompted both the government and stakeholders to deliberate on what can be done to mitigate the recurrent flooding issues, and measures have been taken by the Bayelsa state government and the Niger Delta Development Commission (NDDC) to clear up silted and blocked major drains and canals in the state to aid the free flow of water. There is also a plan to get a mutual agreement with the Cameroon government on a regulated release of the water from the Lagdo dam.

7.2.4: Objective Four

The fourth objective is to ‘develop a flood risk reduction framework’ that will help in the mitigation of flood risks. This was done in Chapter 6, Section 6.6. It involved the study and understanding of flood risks, considering risk assessments by assessing vulnerability and evaluating the economic, social, and environmental impacts of flooding, including disruption to services, loss of lives and property, and environmental degradation. The framework incorporates flood risk mitigation strategies, stakeholder engagement, monitoring and evaluation, policy and governance, and community education.

7.2.5: Objective Five

The fifth objective is to ‘recommend measures to address land use and flooding issues’ to reduce the frequency and severity of flooding and land misuse. This was achieved in Section 6.6 of Chapter 6. Among the recommendations made, priority should be given to proper town planning, affecting the use of the Yenagoa masterplan. Attention should be given to waste management and the free flow of water in canals, drainages, and Epie Creek. Policies should be enforced and binding on all. Also, stakeholders should be engaged in planning processes, and the residents should be enlightened about the activities of man and how they impact the environment.

7.3: Summary of Research

The study focuses on land changes and their contribution to increasing flooding events and flood height in Epie Creek, serving as a single case study. It aims to bridge the gap between the escalating flood events and the necessity for a comprehensive flood management approach involving governmental bodies and stakeholders.

A qualitative evaluation was conducted to discern the causes behind the aggravation of flood events in the Epie communities, emphasising the adverse effects of these occurrences. Internal factors such as insufficient or obstructed drains, indiscriminate waste disposal, and river siltation were identified as contributors to heightened flooding, losses, and damages in 2022. External factors, including climate change and the discharge of surplus water from the Lagdo dam in Cameroon, further exacerbated the situation.

The escalating flood impacts resulted in various hardships, socio-economic disruptions, property and infrastructure damages, health issues, school closures, and alterations in planting seasons to mitigate flood repercussions. Additionally, flooding influenced land costs and rents, leading to increased expenses for residents.

Based on the findings from the study conducted in the Epie Creek area, several recommendations are proposed to address the critical issues identified, integrating insights from both land changes and flooding vulnerabilities with a review of existing land use policies. Firstly, to address uncontrolled migration and urban sprawl, it is essential to implement robust zoning regulations. These regulations should strategically manage urban expansion, particularly in flood-prone zones, while providing viable alternatives for livelihoods and housing outside these vulnerable areas (Musakwa & Niekerk, 2013; Lawry et al., 2023). This approach not only mitigates environmental impacts but also reduces population pressure on sensitive ecosystems, aligning with sustainable development goals (Kryspin-Watson et al., 2017). Additionally, enhancing environmental conservation and sustainable development requires collaborative efforts between authorities and local communities. Initiatives should focus on restoring deforested areas, preserving wetlands, and improving waste management systems (Oluwasegun & Ayoade, 2017; Azadi, 2020). By fostering community-based conservation programs, residents can actively participate in safeguarding local ecosystems, thus mitigating the adverse effects of rapid urbanization (Din & Mak, 2021).

Moreover, strengthening urban planning and infrastructure development is crucial. This involves investing in green infrastructure, such as rainwater harvesting systems and permeable pavements, to manage increased runoff and mitigate flooding risks (Turner, 2007; Hudson & Botzen, 2019). Enforcing zoning regulations to restrict construction in flood-prone areas and preserving natural drainage channels are essential components of effective urban planning strategies (Verburg et al., 2000). Additionally, improving flood preparedness and disaster response mechanisms is imperative. This includes developing early warning systems, raising public awareness about flood risks, and establishing emergency evacuation plans (Jha et al., 2012; Egbinola & Adepoju, 2017). International cooperation is essential to address transboundary issues and mitigate the impacts of upstream water releases on downstream communities (Foley et al., 2005). Furthermore, enhancing policy implementation and stakeholder engagement is critical for effective flood management. This requires strengthening enforcement mechanisms, combating corruption, and promoting accountability in governance (Adekola et al., 2020). Ensuring inclusive and transparent policy development processes that incorporate the perspectives of all stakeholders will enhance policy effectiveness and promote social equity (Oni, 2016). Finally, promoting adaptive governance and flexible policy frameworks is essential. Policymakers should regularly review and update land use policies to accommodate evolving socio-economic and environmental conditions (Ologunorisa, 2009). This adaptive approach fosters resilience to climate change impacts and supports sustainable development goals (Kryspin-Watson et al., 2017).

In conclusion, integrating these recommendations is crucial for addressing the complex challenges of urbanization, land use change, and flood vulnerability in the Epie Creek area. By implementing effective zoning regulations, enhancing environmental conservation efforts, strengthening urban planning strategies, improving flood preparedness, ensuring robust policy implementation, and promoting adaptive governance, stakeholders can mitigate the adverse impacts of urban development on natural ecosystems and enhance community resilience to flooding events. These measures highlight the importance of holistic and proactive approaches in managing urban growth and safeguarding environmental sustainability in rapidly developing regions like Yenagoa City.

While Nigeria has developed comprehensive land use policies aimed at promoting sustainable development and mitigating environmental risks, significant challenges persist in their implementation, stakeholder engagement, and adaptability to changing conditions. Addressing these challenges requires strengthening enforcement mechanisms, enhancing stakeholder participation, and improving the adaptive capacity of policies to ensure resilient and sustainable land use management practices. Future research and policy efforts should focus on bridging the gap between policy formulation and effective implementation to achieve meaningful environmental and social outcomes in Nigeria's urban and rural landscapes.

7.4: Research Contributions to Theory and Knowledge

This study provides multiple contributions to both theoretical understanding and practical application. Combining two distinct bodies of knowledge-flooding and agricultural livelihoods presents a significant opportunity to enhance our understanding of the complex interactions between natural hazards and human activities. Historically, research on flooding and agricultural livelihoods has evolved independently, with scholars focusing primarily on either the physical processes of floods or the socioeconomic dynamics of agricultural systems. However, bringing these domains together can yield valuable insights into the vulnerability of agricultural communities to flood events and the implications for livelihood sustainability.

By integrating insights from flood science with agricultural livelihood research, scholars can explore the multifaceted impacts of flooding on agricultural production, food security, and rural livelihoods. Understanding how floods disrupt agricultural activities, damage crops and infrastructure, and displace farming communities is essential for devising effective disaster risk reduction strategies and adaptive measures. Moreover, examining the adaptive capacities and coping mechanisms employed by farmers in flood-prone areas can inform the development of resilience-building interventions that bolster agricultural livelihoods in the face of climate-related hazards.

Furthermore, the convergence of flooding and agricultural livelihood research can foster interdisciplinary collaboration and knowledge exchange between natural and social scientists, practitioners, and policymakers. By bridging disciplinary boundaries and integrating diverse perspectives, researchers can develop holistic frameworks and methodologies for assessing the complex interactions between floods and agricultural systems. Such collaborative efforts can contribute to the co-production of knowledge that is contextually relevant, actionable, and inclusive of local knowledge and priorities. Ultimately, integrating insights from flooding and agricultural livelihoods can inform evidence-based policy and practice aimed at enhancing the resilience and sustainability of rural communities in flood-prone regions.

7.5: Research Contribution to Practice

Combining the bodies of knowledge surrounding flooding and agricultural livelihoods holds significant practical implications for disaster management, agricultural development, and rural community resilience. By integrating insights from both domains, practitioners gain a more comprehensive understanding of the complex interactions between floods and agricultural systems, enabling them to develop more effective strategies for disaster preparedness, response, and recovery. For instance, understanding the specific vulnerabilities of agricultural communities to flood events can inform the design of early warning systems tailored to the needs of farmers, enabling timely evacuation and asset protection. Additionally, integrating flood risk assessments into agricultural planning and land use management can help identify suitable adaptation measures, such as flood-resistant cropping practices or the creation of buffer zones, to minimize the impact of flooding on agricultural production and livelihoods.

Methodologically, this research utilized a qualitative approach, integrating literature reviews, interviews, and Geographic Information Systems (GIS) analysis. By employing this multifaceted methodology, the study aimed to bridge existing knowledge gaps and tackle issues related to land use, land cover change impacts, and the escalating incidence of flooding. Engaging experts as research participants enabled a nuanced exploration of the subject matter, leveraging their insights and expertise to gain deeper insights into the complex interplay between land use dynamics and flooding phenomena. Through a combination of qualitative data collection methods, including in-depth interviews and spatial analysis using GIS, the research sought to provide a comprehensive understanding of the factors driving land use changes and their implications for flood risk management, ultimately contributing to informed decision-making and sustainable land use planning initiatives. Furthermore, this research has also influenced policy and practice. The empirical data analysis demonstrated how the problems and impacts mentioned earlier were experienced by the impacted individuals in practice. This research contributes by developing a flood risk reduction framework as a viable instrument for flood risk management, emphasising its value as an alternative to hard technical approaches. Therefore, it provides clearer distinctions in effectively using policies, land management, and planning to enhance land use and flood risk management. It is better to focus help for floodplain communities on building flood resilience rather than just restoring damage after a disaster. Investing in making properties resistant to future flood events is more effective. This demonstrates a comprehensive and forward-thinking strategy for managing flood risks, which the study has proven to be more effective than the current reactive method after a disaster. Implementing these suggestions will enhance policy and the regulatory structure, thereby decreasing the vulnerability of properties located on floodplains.

7.6: Delimitations of the Study

The present study contains several contextual and methodological constraints, highlighting the necessity for more research in this field. The study is focused on the Epie settlements inside the Yenagoa local government region; hence, most of the data pertains to Yenagoa rather than communities specifically along the Epie Creek. Although limited, this study illuminates a research topic that has received little attention.

There is a lack of government data on floods and drainage for Epie Creek and Yenagoa, which are essential for understanding the patterns, causes, and impacts of flooding events. Without comprehensive data on past flood events, including their frequency, duration, and magnitude, researchers may struggle to analyse flood dynamics accurately and develop effective flood mitigation strategies. The researcher utilised the qualitative method using semi-structured interviews to collect data on this.

Another significant advantage of the qualitative phase is the data obtained from experts directly engaged in areas such as the environment, land use, planning, government, NGOs, etc. This supplied significant data and firsthand information regarding land usage, land cover changes, and flooding. The researcher was unable to analyse non-verbal cues and body language due to the absence of face-to-face interviews caused by the COVID-19 pandemic and travel limitations during the Covid 19 Pandemic. This was addressed by conducting online and telephone interviews, all done by the researcher to maintain uniformity.

7.7: Recommendations for Future Research

Future studies on land use change and flooding should focus on the following areas to enhance understanding and mitigation strategies:

Longitudinal Studies: Perform longitudinal studies to monitor alterations in land use and land cover over prolonged durations, facilitating a more thorough examination of patterns and their influence on flood dynamics.

Community-based research: This involves engaging local communities in participatory research to obtain insights into their perceptions, experiences, and adaptive strategies regarding land use change and flooding.

Interdisciplinary Studies: Encourage cooperation across many fields such as hydrology, ecology, urban planning, sociology, and economics to thoroughly evaluate the intricate relationships among land use change, flooding, and socio-economic aspects.
Policy Analysis: Evaluate the effectiveness of current land use planning and flood control strategies in reducing flood hazards caused by changes in land use. Identify chances for creating new policies and integrating them across various industries.

There is no physically viable working document or data bank on drainage or flooding in the state government archives. This makes it difficult for continuity as events are not properly documented and handed over to the next government. Conducting research is also limited by this factor.

7.8: Summary

This chapter provided a summary of the main goals of the research, how they were accomplished, and highlighted major suggestions based on the research results. The study also emphasised the consequences of the research, such as its contribution to knowledge and practical application. One significant contribution is the inclusion of actual data in the existing knowledge on the impact of land use and land cover change on flooding, thereby addressing a previously noted study gap. The flood risk reduction framework could improve land use management and reduce flood risk by promoting opportunities for improving land use governance, proper planning, stakeholder involvement, and enforcing regulations and policies. The study, despite its limitations, aims to benefit the government, stakeholders, and the research community.

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Appendix A: Ethical Approval Document

Ethics Application: Panel Decision

This message was sent with Low importance

Flag for follow up.

E

ethics

To: Ladebi Sapere-Obi

Thu 24/06/2021 15:15

The Ethics Panel has reviewed your application: The impact of landuse land cover change on flooding along Epie Creek, Niger Delta Region of Nigeria.
Application ID: 1960

The decision is: Application Approved.

If the Chair has provided comments, these are as follows:

Please add data protection checklist

Please use the Ethics Application Tool to review your application.

Reply Forward

Appendix B: Participant Information

Research Title: Impact of Land Use and Landcover Change on Flooding Along Epie Creek, Nigeria: A Multi-Stakeholder Approach.

1. You are being invited to participate in a research study. I am Ladebi Sapere-Obi, a Post Graduate Student in the School of Science, Engineering, and Management, University of Salford, UK. I am presently collecting data for my research on the impacts of land use and land cover change on flooding along Epie Creek, Nigeria: A multi-Stakeholders Approach.
2. Before you decide whether to participate, you need to understand why the research is being done and what it will involve. Please take time to read the following information carefully and feel free to ask us if you would like more information or if there is anything that you do not understand. We would like to stress that you do not have to accept this invitation and should only agree to take part if you want to.
3. What is the purpose of the study? The underlying motivation for this study is the need to tackle the flooding problems in the study area. Residents of Epie Creek experience flooding from Epie Creek annually, in addition to this are flash floods from heavy and prolonged rainfalls which are experienced regularly given the climate of the area. This has resulted in the loss of lives, properties, and disruption of day-to-day activities in the area. Buildings, roads, bridges, and farmlands are submerged, and power supply and source portable water are cut off to avoid electrocution as most transformers are submerged and water contaminated, respectively. Children cannot go to school because the roads and schools are flooded, and farmers lose their farm produce as they either harvest prematurely or risk decay in cases of tuber crops. Most residents affected are forced to move out and return after the floods or adapt to the situation, using canoes to get to their homes or constructing footbridges above the flood level to their doorsteps. Wood or metal is also used to make

suspensions above water to keep furniture and other items above water to keep it dry and safe. This is the scene that plays out yearly and the level of flood is on the rise.

4. Why have I been chosen to take part? The study aims to examine the impact of land use land cover change on flooding along Epie Creek and you have been chosen to take part based on your office, position, and years of experience in the Environmental sector.
5. Do I have to take part? Your participation is entirely voluntary, and you are free to withdraw at any time without giving any reason, and without your rights being affected. In addition, should you not wish to answer any question or questions, you are free to decline.
6. What will happen if I take part? This study will require that you complete an online interview along with any additional comments you want to make. Data for the survey will be collected using the online survey engine hosted by the university server.
7. Expenses and/or payment? No expense or payment is involved in this study.
8. Are there any risks in taking part? There is no risk associated with participating or being involved.
9. Are there any benefits to taking part? There is no direct benefit but the information and findings from the study will be used to develop a flood risk reduction framework and proffer some measures to help with flooding problems in the study area.
10. What if I am unhappy or if there is a problem? If you have any concerns about this study, you should speak to the researcher at any time (details below), who will do his/her best to answer your questions.
11. Will my participation be kept confidential? All information that is collected during the research will be kept strictly confidential, names and any other information you provide will be kept strictly. Only the researcher and his supervisor will have access to the data. The results of this research will be used for academic purposes only.

12. What will happen to the results of the study? The result of this research would be purely for educational use, specifically the researcher's PhD thesis and any publication related to it. After the thesis is accepted or the research will be otherwise ended, all the data will be securely destroyed.

13. What will happen if I want to stop taking part? Since the answers will be collected anonymously and the collected data is not connected to the participants, there is no way to remove your data after you have finished your answers and sent them to the server. However, you can stop answering the questionnaire at any point and not send the answers you have. You can also choose the questions you want to answer and ignore the questions you do not want to answer. If you want to participate, the next page will contain the final consent information. After giving your consent, you will be redirected to the actual Interview.

Thank you.

The Research Student: Ladebi Martha Sapere-Obi

Tel: 07459547955

Email: l.m.sapere-obi@edu.salford.ac.uk

The Research Supervisor: Prof. Bingu Ingirige

Email: m.j.b.ingirige@salford.ac.uk

However, if you remain unhappy and wish to complain formally, you can do this by contacting the Research Governance Officer at S&T-ResearchEthics@salford.ac.uk When contacting the Research Governance Officer, please provide the study title above for identification, the researcher's name above, and the details of the complaint you wish to make.

Appendix C: Participants Consent Form

Participants Consent Form

☐ I confirm that I have read and understood the participant information section for this study. I have had the opportunity to consider the information, ask questions by email and calls, and have had these answered satisfactorily.

2. I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason, and without my rights being affected in addition, should I not wish to answer any question or questions, I am free to decline.

3. I understand that since the answers will be collected anonymously and the collected data is not connected to my contact information, there is no way to remove my data after I have finished my answers and sent them to the server. However, I can stop answering the questionnaire at any point and not send the answers I have given at that point.

4. I understand and agree that once I submit my data it will become anonymised, and I will therefore no longer be able to withdraw my data.

5. I understand that my responses will be kept strictly confidential, and I permit the researcher to have access to my anonymised responses. I understand that my name will not be linked with the research material, and my company or I will not be identified or identifiable in the report or reports that result from the research.

☐ YES, I confirm to take part in this questionnaire study only.

☐ No, I do not consent to take part in this questionnaire study.

Name of participant:
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Signature: ……………………………………………………………………………………….

Date: ………………………………………………………………………………….

INTERVIEW QUESTIONS ON IMPACT OF LAND USE CHANGE AND FLOODING ON PEOPLE'S LIVELIHOODS ALONG EPIE CREEK, NIGERIA.

The aim of this interview is to collect data for academic research which is studying the impact of change in land use and flooding on people's livelihoods along Epie Creek in Yenagoa, Nigeria.

A: Interview information

Name of

Interviewer……………………………………………………………………………………..

Date of Interview ………………………………………..…………………………………

Venue of Interview …………………………………………………………………………….

Time ……………………………………………………………………………………….

Duration………………………………………………………………………………………

B: Interview respondent and other relevant information

Name of respondent (optional)……………………………………………………………….

Where do you live? …………………..……………………………………………………

How long have you lived here? ………..…………………………………………………

Occupation…………………………………..………………………………………………

Sex ………………………………………………………………………………………….

Level of education …………………………………………………………………………….

C: Land use changes and its impacts on flooding.

i. What land use changes have you noticed on agricultural lands or practices along Epie Creek and environs over the last 10 years?
ii. What changes have you experienced in the built-up areas along Epie Creek and environs and how does this affect flooding?
iii. Can you explain in detail how the water body have been changed or impacted along this route?
iv. Are logging activities (deforestation) common in this area and how does this affect the environment?

v. What changes have been made to bare lands (Grassland, cultivated areas, sand lands, infillings, and solid waste landfills) and what impacts do they have?
vi. How have the wetlands been affected by human activities?
vii. Which areas are well known for specific land use changes with great impacts?
viii. What other human activities or practices worsened flooding issues?
ix. What periods did these land use changes take place?
x. Besides flooding, what other impacts have changes in various land uses had in the study area?
xi. Have there been changes in rainfall patterns? if yes, what changes?
xii. What land use changes have contributed most to flooding in the study area?
xiii. What land use change have contributed least to flooding in the study area?
xiv. Why do people choose to live in flooded and flood-prone areas despite the dangers?

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D: Role of Government and Stakeholders in Flood Mitigation

i. In what ways can these people be supported?
ii. Are there representatives from whom support can be sought during flooding and other environmental issues and how accessible are they when needed?
iii. How are the ministries or parastatals responsible for handling flooding issues in the state tackling flooding issues?
iv. What temporary or permanent measures have the government put in place to tackle recurrent flooding problems?
v. Are these measures effective in reducing flood risks?
vi. What more do you think can be done to help mitigate flooding problems?
vii. Were there plans by the state government to relocate people living in flood prone areas?

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E: Flood vulnerability and adaptation

i. How prone is your residence to flooding?
ii. Have you been affected by flooding and how did you cope?
iii. What hazards are the people exposed to during flooding?
iv. How have the people adapted to flooding?
v. What are some of the activities that are affected by flooding in your area?
vi. In what ways have people affected by flooding adapted?
vii. If given an option of relocation, what will your response be and why?

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F: Flood Risks and People's Livelihoods

i. How does flooding affect your income or source of livelihood?

ii. What changes in prices of goods, foodstuff and services have you observed during the flood crisis and why?

iii. In a hierarchy, what activities are mostly affected by floods along Epie Creek?

iv. In what way does flooding affect housing and rent?

v. Explain how floods affect the planting and harvesting of crops.

vi. How are the costs of goods and services affected during flooding?

vii. How have farmers been coping with recurring floods and what changes have they put in place to mitigate this problem?

viii. Have they made changes to seed or plant types?

ix. What changes have been made to planting or harvesting seasons to help mitigate flooding impacts?

x. Have farmers experienced prolonged dry periods?

xi. Have farmers experienced salt intrusion from the river?

xii. Do farmers cultivate selected crops due to flooding challenges?

xiii. What impacts does flooding have on crop harvests and livestock rearing?

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Appendix E: Land Use Land Cover Class Gain/Loss Information

CLASS LOSS/GAIN (1987-2002)

CLASS CHANGE 1987-2002	AREA CHANGE OVER TIME (ha)
Bareground - Bareground	9
Bareground - Builtup	253
Bareground - Vegetation	2
Bareground - Waterbody	3
Bareground - Wetland	94
Builtup - Bareground	8
Builtup - Builtup	1426
Builtup - Vegetation	140
Builtup - Waterbody	228
Builtup - Wetland	597
Vegetation - Bareground	56
Vegetation - Builtup	946
Vegetation - Vegetation	40712
Vegetation - Waterbody	83
Vegetation - Wetland	6064
Waterbody - Bareground	17
Waterbody - Builtup	163
Waterbody - Vegetation	1
Waterbody - Waterbody	2484
Waterbody - Wetland	11
Wetland - Bareground	77
Wetland - Builtup	1695
Wetland - Vegetation	2725
Wetland - Waterbody	31
Wetland - Wetland	7621

CLASS LOSS/GAIN (2002-2022)

CLASS CHANGE 2002-2022	AREA CHANGE OVER TIME (ha)
Bareground - Bareground	30
Bareground - Builtup	132
Bareground - Vegetation	0
Bareground - Waterbody	3
Bareground - Wetland	3
Builtup - Bareground	1257
Builtup - Builtup	2568
Builtup - Vegetation	51
Builtup - Waterbody	296
Builtup - Wetland	312
Vegetation - Bareground	7122
Vegetation - Builtup	4523
Vegetation - Vegetation	21380
Vegetation - Waterbody	50
Vegetation - Wetland	10497
Waterbody - Bareground	86
Waterbody - Builtup	209
Waterbody - Vegetation	1
Waterbody - Waterbody	2516
Waterbody - Wetland	17
Wetland - Bareground	5283
Wetland - Builtup	2969
Wetland - Vegetation	1840
Wetland - Waterbody	70
Wetland - Wetland	4224

CLASS LOSS/GAIN (1987-2022)

CLASS CHANGE 1987-2022	AREA CHANGE OVER TIME (ha)
Bareground - Bareground	109
Bareground - Builtup	234
Bareground - Vegetation	0
Bareground - Waterbody	3
Bareground - Wetland	15
Builtup - Bareground	704
Builtup - Builtup	1061
Builtup - Vegetation	55
Builtup - Waterbody	304
Builtup - Wetland	275
Vegetation - Bareground	8439
Vegetation - Builtup	5513
Vegetation - Vegetation	22202
Vegetation - Waterbody	236
Vegetation - Wetland	11466
Waterbody - Bareground	128
Waterbody - Builtup	239
Waterbody - Vegetation	1
Waterbody - Waterbody	2279
Waterbody - Wetland	29
Wetland - Bareground	4397
Wetland - Builtup	3355
Wetland - Vegetation	1014
Wetland - Waterbody	115
Wetland - Wetland	3269

Appendix F: Generated Accuracy Assessment Results from the Land Use Land Cover Analysis for the Study Period

		CONFUSION MATRIX (1987)						
LULC CLASS	Builtup	Waterbody	Vegetation	Wetland	Bareground	Total	U_Accuracy	Kappa
Builtup	17	3	0	0	0	20	0.85	0
Waterbody	0	20	0	0	0	20	1	0
Vegetation	0	0	19	1	0	20	0.95	0
Wetland	2	0	5	13	0	20	0.65	0
Bareground	0	0	2	0	18	20	0.9	0
Total	19	23	26	14	18	100	0	0
P_Accuracy	0.894737	0.869565	0.730769	0.928571	1	0	0.87	0
Kappa	0	0	0	0	0	0	0	0.8375
		CONFUSION MATRIX (2002)						
LULC CLASS	Builtup	Waterbody	Vegetation	Wetland	Bareground	Total	U_Accuracy	Kappa
Builtup	17	0	3	0	0	20	0.85	0
Waterbody	0	20	0	0	0	20	1	0
Vegetation	0	0	20	0	0	20	1	0
Wetland	0	0	4	16	0	20	0.8	0
Bareground	0	0	0	0	20	20	1	0
Total	17	20	27	16	20	100	0	0
P_Accuracy	1	1	0.740741	1	1	0	0.93	0
Kappa	0	0	0	0	0	0	0	0.9125
		CONFUSION MATRIX (2022)						
LULC CLASS	Builtup	Waterbody	Vegetation	Wetland	Bareground	Total	U_Accuracy	Kappa
Builtup	17	1	2	0	0	20	0.85	0
Waterbody	0	20	0	0	0	20	1	0
Vegetation	0	0	20	0	0	20	1	0
Wetland	0	0	8	12	0	20	0.6	0
Bareground	0	0	4	0	16	20	0.8	0
Total	17	21	34	12	16	100	0	0
P_Accuracy	1	0.952381	0.588235	1	1	0	0.85	0
Kappa	0	0	0	0	0	0	0	0.8125

Appendix G: Framework Validation Questionnaire

Dear participant,

I am Ladebi, a PhD student at the School of the Built Environment, University of Salford.

Manchester-UK. I am conducting a study on the impacts of land use and land cover change on flooding along Epie Creek, Nigeria: A multi-stakeholder approach. The findings of the study have led to the development of the attached "flood risk reduction framework. The framework if implemented could help in the reduction of flooding along Epie Creek and similar Environments.

You have been selected to participate in the framework validation because of your work experience and knowledge of land use and flooding issues. I believe that your experience and perspectives will help in VALIDATING THE ATTACHED FLOOD RISK REDUCTION FRAMEWORK. Also, feel free to provide any suggestions or contributions regarding any area that needs to be improved or modified within this proposed framework.

I wish to assure you that ethical issues related to the research philosophy have been considered by the researcher and the University of Salford.

Thank you,

Yours Sincerely,

Ladebi Sapere-Obi

Contact:
l.m.sapere-obi@edu.salford.ac.uk

The Questionnaire

1. Do you think the framework is straightforward for evaluating the impacts of land changes on floods? (Simplicity).
2. Do you think the framework has adequately accounted for all the factors in assessing flood risk reduction? (Completeness)
3. Do you think the framework is flexible enough to adapt to any change in flood management? (Flexibility)
4. Do you think the framework content and structure are easy to understand? (Understandability)
5. Do you think that local authorities will accept the framework? (Acceptability)
6. Do you think that the framework components are useful for flood risk reduction? (Usefulness)
7. Do you consider that the framework can be adopted and implemented in your working environment? (Implementation Ability)

Appendix H: Research Work

Published Work

Ushurhe, O., Famous, O., Gunn, E. O., & Ladebi, S. O. M. (2024). Lead, Zinc, and Iron Pollutants Load Assessment in Selected Rivers in Southern Nigeria: Implications for Domestic Uses. *Journal of Water Resource and Protection*, *16*(01), 58–82. https://doi.org/10.4236/jwarp.2024.161005

Unpublished Research

On-street Parking and Road Traffic Congestion in Port Harcourt Metropolis (2018). University of Port Harcourt, Nigeria.

Impacts of Petroleum Products on Prices of Goods and Services in Amassoma, Nigeria (2007). B.SC Research, Niger Delta University, Wilberforce Island. Nigeria.

Conference

Impact of land use and land cover change on flooding along Epie Creek, Nigeria (2023). Abstract presentation in SPARC 2023

Impact of land use and land cover change on flooding along Epie Creek, Nigeria (2023). Poster presentation in SPARC 2023