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IMPACT OF FLOODING AND BANK EROSION ON LIVELIHOODS AT THE LOWER PRA BASIN.

BY

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DECLARATION

I, Ebenezer Asiedu, hereby declare that this thesis is the result of my independent work under strict supervision and neither me nor anybody else has submitted it elsewhere, either in part or in full for the award of another degree

Where other materials have been used, they have been duly acknowledged in the work.

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DEDICATION

"Thee will I praise with all my heart,

And tell mankind how good thou art,

How marvelous thy works of grace;

Thy name I will in songs record,

And joy and glory in my Lord,

Extolled above all thanks and praise" MHB 80 (Stanza 1).

I dedicate this work to the almighty God, my mother, Family members and loved ones who contributed immensely to the completion of this thesis. May God bless them and grant them their heart desires more especially my mother.

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ABSTRACT

River flooding and bank erosion pose serious environmental and socio-economic threats, thus impacting the livelihoods of people in diverse ways. Understanding the vulnerability of people to these hazards will help come up with proactive adaptation and mitigation measures. This study looked at the impact of flooding and bank erosion on livelihoods at the lower Pra basin. Using a mixed-method strategy, 200 questionnaires were administered with Topographical maps, and Satellite imageries being used. Also, key informants were interviewed to collect data and information. The study revealed that the river bankline of the Lower Pra basin has changed from 16.17516km² to 66.8808km² from 1974 to 2018 due to the river eroding the banks and anthropogenic activities. The study also revealed that the Residents continue to be highly vulnerable to these hazards due to the type of structures they live in, their livelihood activities and the inability of government agencies such as the NADMO and District planners in dealing with the hazards. The livelihoods of people living in the lower basin continue to be threatened because of the individual vulnerabilities to flooding and bank erosion. Residents were highly impacted in the physical and socio-economic aspects of their livelihoods such as the destruction of farmlands and household properties, economic activities and health related issues. To overcome the impacts of flooding and bank erosion, the study recommends that residents who live along the Pra river should be relocated. Also, there should be riverbank defense, desilting of the river channel, planning of education and sensitization programs to reduce their impact to both flooding and bank erosion at the Lower Pra basin. The study gives the trustworthiness of the sustainable livelihood framework that if the communities and institutions in the country wholly function properly with the available capital to support the household, it will reduce the people's vulnerability and the impacts to these hazards thereby improving and maintaining good livelihood outcomes.

LIST OF ABBREVIATIONS

GIS- Geographic Information System

RS- Remote Sensing

CERSGIS- Center for Remote Sensing and Geographic Information system

DFID- Department for International Development

NADMO- National Disaster Management Organization

WHO- World Health Organization

UNDP- United Nation Development Program

EPA- Environmental Protection Agency

ISDR- International Strategy for Disaster Reduction

DRR- Disaster Risk Reduction

CIAT- International Center for Tropical Agriculture

EM-DAT- Emergency Event Database

NIDM- National Institute of Disaster Management

UNDRR- United Nation Office for Disaster Risk Reduction

WRI- Water Resource Institute

USGS- United State Geological Survey

CREW- Community Resilience through Early Warnings

EWS- Early Warning Systems

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CHAPTER ONE

INTRODUCTION

1.0 Background of the Study

Rivers play a critical role in providing water for industrial and domestic purposes. These rivers are subjected to continuous change through erosional and depositional processes leading to displacement of its bed and the bankline. Notwithstanding these river processes, natural and human-impacted land-use changes continue to impact river catchment with negative reverberation on the river and the livelihood of the people along the basins (Ayivor & Gordon, 2012). As a result of these land-use changes, there is widespread flooding, riverbank erosion, sedimentation, pollution and livelihood impacts that affect people living along river basins (Hill, 1999).

Flooding and bank erosion are common issues in many parts of the world, but the scope and its impacts differ in their socio-economic and livelihood problems. Riverbank erosion is one of the most worrisome environmental hazards nowadays (Chatterjee, 2013). Although floods and bank erosion are natural occurrences, they become a reason for genuine concern when they surpass the adaptive limits, which create a lot of social, economic, and environmental impacts affecting communities. (Abhas et al., 2011: Rahman, 2010). The geometry, gradient and topology in basins cause erosion in river banks and flooding, which creates many problems such as land loss and dislocation of residents affecting their livelihoods (Ali, 2000).

River flood hazard is a natural phenomenon, but the outcome of damages and losses are as a result of human activities. Land use and landcover changes reduce the permeability of the soil, overloads drainage and increases surface runoff and increase the risk of flooding and bank erosion (Abhas et al., 2011).

Normal river floods are seen as a blessing because they bring financial and ecological benefits. This flood happens by producing arable and fertile terrains thereby increasing agricultural production but high magnitude floods are very disastrous, causing widespread crop damage, loss of livestock and properties, withering life and livelihood (Few, 2003). The degree of the flood depends on several factors such as the intensity and duration of rainfall, ground conditions, drainage characteristics, siltation of the river, erosion of banks and settlements of people in the floodplain and on the river bank (Jha *et al.*, 2012).

Riverbank erosion is seen as a disaster and ranks as topmost concern which leads to losses in all aspects of their livelihood (Shamsuddoha & Chowdhury, 2007). Excess water from upstream, sudden flood, siltation on the bed of the river, unintended intercession are the significant reasons for riverbank erosion. Bank erosion hazard usually causes displacement of resettlement of inhabitants who live near the river bank. This disaster causes people to lose their lives, houses, livelihood and assets, increasing their vulnerability to their settlement in such area (Das, 2017).

According to Bertrand (2013), river channel changes bring about significant damage to infrastructures, loss of fertile land and stream quality. The physical, socio-economic and ecological problem resulting from bank erosion requires the need to understand the processes associated with it and appropriate measure to curtail it. Kusimi (2014) indicated that the geometry of the river drives bank erosion, discharge and bank materials and these driving forces lead to significant erosion of sediments into river basins. According to Rahman (2010), bank erosion and flooding in Bangladesh cause a lot of unemployment, displacement, and poverty every year, and they are responsible for the unstable conditions in Bangladesh. Bank erosion is pushing a lot of people to migrate and resettle in areas which make them more vulnerable.

Globally, flood hazard and bank erosion have a lot of serious challenges causing a lot of economic damages and loss of lives. For example, in 2005 and 2009 flooding in Cumbria and the far-reaching flooding crosswise over England in summer 2007, brought about the death toll and significant effects on the well-being and prosperity of individuals living and working in the territories to an aggregated expense of more than £3.2 billion. Also, between 1980 and 2008, Bangladesh experienced 219 floods and bank erosion hazard, costing them over US $16 billion in total damage to lives and properties (United Nation Development Program [UNDP], 2010).

In recent years, Africa has increasingly experienced severe flooding. More than one million individuals were affected in more than 20 nations, and more than 500 lives were lost. Over 12 million individuals were dislodged, especially in Uganda, Ethiopia, Sudan, Burkina Faso, Togo, Mali and Niger (Theron, 2007). It was discovered that rainfall influenced almost 50% of the African nations, conveying the all-out death to more than 350,000 with countless occupants dislodged (Agence France-Presse, 2007).

Ghana is very prone to flooding within our basins and also during the rainy season. Ghana recorded 19 significant flood events between 1968 and 2015 nationwide, causing about 415 causalities with a lot of people displaced. This cost the country about US$ 108, 200,000 in economic losses (Emergency Event Database [EM-DAT], 2015). Within this same time, the Northern part of Ghana experienced the most remarkable flood incidence in the nation's record of which 350,000 people were affected with 49 casualties estimated at about US$ 130,000 (Environmental Protection Agency [EPA], 2012).

Flooding is a serious issue in drainage basins worldwide. This cutoff of rivers from their natural floodplain causes a lot of disasters because houses and industrial sites have been constructed in this area naturally liable to flooding, thereby leading to a lot of destruction. River basin undergoes

a lot of floods, causing a lot of damages to crops and properties, and these are as a result of human influence (Wohl, 2000). Ghana's flooding situation continues to worsen due to torrential rains and human activities. Several families close to the banks of the white and black Volta rivers have been relocated because of the impact of flooding on the area. In totality, 31903 people (5,317 households) have been affected in the Northern and Upper East Regions of Ghana (IFRC, 2018).

Residents along the Pra basin engage in a lot of farming, mining, and fishing activities (GSS, 2010). Their anthropogenic activities expose the river to bank erosion and river flooding. Improper land use along the basin exposes residents to flooding, causing a lot of displacement of people and destruction of farmlands. Areas like Shama and Twifo Praso at the Lower Pra basin have been experiencing a lot of flood incidents as a result of the river overflowing its banks, exposing them to a lot of socio-economic and livelihood problems. Also, the Water Resource Commission has identified that there is weak institutional capacity in terms of human, financial, logistics, and data which tend to increase resident's vulnerability to flooding in the area (Water Resource Commission, 2012).

These hazards put a lot of pressure on the livelihoods of residents. Livelihood has become a very utile concept when considering the impacts of hazards or disaster because it helps depict how socio-economic unit changes with existing resources or assets and how to cope with such anxiety (Devereux, 1999). The impacts of flood and bank erosion on livelihood are considered critical issues, especially in rural areas where livelihoods depend on agriculture. Assessing the livelihood and socio-economic impact in disaster management of hazards and disasters helps in the recovery and reconstruction of the affected inhabitants and sectors (Baki, 2014).

Geographic Information Systems (GIS) and Remote Sensing (RS) are vital tools for detecting variations along floodplains and riverbank erosion. Forecasts can be made on change detection

outcomes and trend analysis. Morphological changes of rivers have to be from historical maps, and satellite images to promote appreciable archival stability of rivers and the responsiveness of the river to human activities change at the riparian region (Alam et' al 2007).

Based on the anthropogenic activities at the lower basin, it was much helpful to study river processes at the lower Pra river and how to mitigate any future hazard with the right human intervention to theses river processes and to the people settling at the riparian zone of the river.

Therefore, in managing flood risk and bank erosion hazards at the lower Pra basin, knowledge about these hazards was investigated to help design essential measures to help prevent damages. It was therefore very relevant to understand the resident's vulnerability to these hazards to take critical steps to mitigate their impact on their livelihood to these hazards.

1.1 Problem Statement

Globally, people face difficulties regarding livelihoods during and after floods and bank erosion. Lack of defence mechanisms have made settlers along river basins highly vulnerable to the floods and bank erosion (Few, 2003). Improper land use has also increased the risk of flooding and bank erosion with urban development; reducing the permeability of soils and increasing surface runoff. The effect of flooding and bank erosion is a very devastating hazard to the level that geographers are examining the role of flood on humanity and its supporting ecosystem globally.

Globally, 55% and more of all fatalities are accounted for by flood hazard with nearly 2.5 billion people affected (EM-DAT 2015). It was estimated that the average annual population that is affected by river floods is around 21 million people worldwide and is likely to rise to 54 million by 2030 (World Resources Institute [WRI] 2016)

In Africa, a flood is a common occurrence, despite the various interventions to fight it (World Meteorologist Organization, 2012). East Africa experienced flooding in Kenya, Ethiopia, Uganda, Rwanda, Somalia, Djibouti, and Burundi affecting millions of people. The flood incidents claimed about 500 lives with hundreds of thousands of people displaced in these areas (Gebre, 2018). Also, West Africa experiences torrential downpour of rains leading to flooding every year, which tends to result in death, destruction of properties and crops, and the outbreak of diseases. For instance, Nigeria recorded 363 deaths in October 2018 with 2 Million people displaced and 618000 houses destroyed as a result of torrential rains leading to flooding incidence (Ighobor, 2019).

Several flood incidents have occurred in Ghana, which caused a lot of calamities to properties like houses, farmlands and displacing people. For instance, in March 2013, severe rainstorm and overbank erosion in the Northern region displayed about 25,000 people spoiling their residence and farms which lead them to a lot of food insecurity in the area (Musa et, al, 2013). An assessment report produced by NADMO in 2018 indicated the overwhelming impact of the floods in the northern part of Ghana. Some 23 communities in 2 districts (13 communities in Bawku West District and 11 communities in Talensi Districts) with a total of 3,556 households (21,336) were affected in the Upper East region, whilst in the Northern region 202 communities in 9 districts, thus 10,567 people, were also affected leading to a total of 31,903 people (5,317 households) affected in both regions (IFRC, 2018). According to the assessment report by the National Disaster Management Organization (NADMO) as a result of flooding in the Northern regions, about 11,959.6 Hectares of farm lands were affected, posing food insecurity and livelihood risk to the affected communities in these regions.

Channel migrating from its original bank causes a lot of catastrophic local or regional changes in a river channel (Thakur et al., 2012). The comprehensive effect of such changes becomes a socio-

economic and livelihood risk for residents of the floodplain of rivers. Also, the frequency of flooding and bank erosion over the years results in loss of life, properties, damage, and environmental problems. People at risk have also been increasing every day in developing countries due to various factors like poverty, making them more vulnerable to these hazards (Living with risk, 2006).

These and more are the key issues facing bank erosion and flood hazard management in the world, and settlers along the lower basin of the Pra River are not excluded. And concerning the developmental and livelihood impact of bank erosion and flood hazard, Ghana is not related to the conditions of finding long term solutions to these hazards. Displacement due to these disasters relegate the settlers lower in respect of their livelihood pattern losing their farmlands, lands, changes in their economic activities, loss of house structures (Islam et' al, 2010)

Understanding riverbank erosion and flood incidence in the lower basin is relevant for informing decision making to ensure sustainable management of rivers in river basins and also reduces the risk of flooding and bank erosion. Approaches need to be established on the extent of the hazard, assessing the vulnerability conditions and residents' livelihoods, and environment on which they depend (International Strategy for Disaster Reduction [ISDR],2010).

The Pra Basin has been considered a possibility to growth in agriculture, forestry, tourism, and mining, and provides livelihoods for many. Over 63% of the inhabitants along the basin are involved in agriculture and related sectors of the economy (International Center for Tropical Agriculture [CIAT], 2011). Population increase and urbanization associated with urban and industrial development, and increased exploitation of land resources are putting pressure on the Pra River and the nation's water resources resulting in conflicting water demands, supplying of excessive sediments to the basin,water pollution, and environmental degradation across the

country. Water resource development in Ghana has been intensifying to increase focus in ensuring environmental protection in our river systems, but these rivers are under threat (Namara et' al., 2010).

Due to anthropogenic activities like small scale mining, agriculture, and improper land use, the Pra river is exposed to a lot of water pollution, bank erosion, and flooding (WRC, 2012). In 2009, myjoyonline.com reported that areas around Shama experienced a flood due to heavy rainfall and the river exceeding its threshold which led to destruction of houses, crops, and power cut and the DCE urged NADMO to be proactive to help prevent such disaster (Nyarko, 2009). Also, in 2017, many people were rendered homeless in various communities of Shama and Twifo Praso when the Pra River overflowed its banks (Opoku, 2017). After these devastating incidences, the International Federation of Red Cross and the Red Crescent Societies suggested that there is a need to conduct an in-depth assessment to have a better overview of the situation (IFRC, 2017).

Recognizing the extent of bank erosion, and the flood zone, it was beneficial for understanding how the river migrates, locating useful infrastructures, and also planning the excellent restoration of the river and even predict how the river can influence land use and human activities. (Water and Rivers Commission, 2002). Also, understanding the people's exposure (type of materials for their building, activities people engage in etc), susceptibility and resistability of the residents (measures taken by individuals, community and institutions to resolve these hazards) helps to propose long term measures to solve these problem.

Also considering the background knowledge indicates that there has been a lot of research on the Pra river (Awotwi et' al 2018; Oduro et' al, 2012; WRC, 2012). These researches worked on floods to land use and landcover, dissolved chemical analysis but failed to look at the vulnerability studies concerning flood by the people and the resultant impact.

Also, Kusimi (2014, 2017) did extensive work on the Pra river concerning sediment yield to fluvial transport, and bank erosion assessment. The bank erosion assessment focused on the upper basin to the middle basin employing the use of erosion pins to calculate the extent of erosion and concluded that bank erosion is very low at the upper course but increases downstream. The study did not focus on the lower basin, and it is in this sense; that this study tended to study bank erosion at the lower basin of the Pra river using the GIS as new technology. The background study also indicated that residents at the lower basin face a lot of challenges during floods and bank erosion which therefore needs extensive research.

In this regard, the study tends to help propose the extent of the channel bank migration and proposes measures to manage flood to help fight this plight. There was the necessity to understand the people's vulnerability to these hazards, study the impact of bank erosion and flooding to livelihoods in the lower section of the Pra river. The study provides a chance to understand flooding and bank erosion along the Lower Pra river for proper formulation of sustainable and long-term policies for residents of the various communities at the lower Pra basin.

1.2 Research Questions

In other to achieve the required objectives, these questions were analyzed.

1. What is the magnitude of bank erosion at the lower Pra basin?
2. To what extent are human activities and settlements vulnerable to fluvial processes of flooding and bank erosion at the lower Pra basin?
3. How has the processes of flooding and bank erosion impacted on the livelihoods of people at the lower basin?
4. How are inhabitants in the lower Pra basin coping with flooding and bank erosion?

1.3 Research Objectives

The main objective is to examine the impacts of flooding and bank erosion on the livelihoods of communities in the Lower Pra Basin.

Sub-objectives

Specifically, the study seeks to:

1. Measure the extent of river bankline changes at the Lower Pra basin.
2. Investigate the vulnerability of resident's livelihood to bank erosion and flooding.
3. To determine the livelihood impact of flooding and bank erosion on the inhabitant of the Lower Pra basin.
4. Explore the coping strategies or the mitigation measures of the people at the lower Pra basin to these disasters.

1.4 Significance of the study

Flooding and Bank erosion impact individuals and communities, affecting the social, economic, and environmental aspects of their lives. The consequence is as a result of their vulnerability to the flood and bank erosion hazards. This is because residents have insufficient knowledge of these hazards. It is therefore relevant to undertake this research to help understand their vulnerability level to the risks to help reduce their impact to these hazards.

The results of the findings of this research will have a lot of relevance for policymakers, decision-makers, and researchers. The study adds to knowledge of the bankline changes at the Lower Pra basin and the measures to curb flooding and bank erosion. The findings will also serve as a source of review of related literature for researchers researching that field. Based on the findings,

policymakers and decision-makers could come up with mitigation and preventive measures to address the impact of flooding and bank erosion on the livelihoods of people.

1.5 Organization of the study

This thesis is arranged into five (8) chapters. The first chapter looks at the introduction, which includes the background, problem statement, research questions, and research objectives. Chapter two (2) deals with the review of related literature, including the conceptual framework. Chapter three (3) presents the study area description, research strategy, research design, data collection including data source, sample size, and sample techniques, data analysis, and the limitation of the study. Chapters four (4) to seven (7) deal with the presentation and discussion of the results of the data collected from the field. And chapter eight (8) concludes with the summary, conclusions, and recommendations to the various issues.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

2.1 Introduction

This chapter presents the general knowledge base on flood and bank erosion as disasters in recent times. The knowledge base also includes the vulnerability, livelihood concepts, and conceptual framework to support the linkage between their vulnerability and livelihood impact. Issues such as flooding, bank erosion, livelihood concepts, vulnerability concept, and Geographic Information System and Remote Sensing (GIS/RS) are reviewed.

Finally, the chapter also looks at the conceptual framework which provides the basis on how to understand the hazards and existing vulnerability issues linked to people's livelihoods to promote productive livelihoods among people along the Lower Pra basin.

2.2 Flooding

2.2.1 Introduction

Recently, flooding has been a significant problem in the world, and the economic losses and the number of people affected by floods with their livelihoods are rapidly increasing (UNEP, 2007). These losses (social, economic, physical) as a result of flood disasters are very hash and rampant in the developing countries, which has a severe effect on their development programs and processes. According to Parker et' al, 2007, flood disaster is growing, and this is attributed to the changes in the catchment leading to runoff, climate change, and population growth in areas at peril to flooding.

Therefore, understanding flood risk requires thorough knowledge of the type of flood, the people's vulnerability to the incidence, and a risk map to be able to come out with effective flood risk reduction strategies to help reduce the causalities to flooding.

2.2.2 Definition of floods

Floods are seen as the most revenant and frequent disaster nationwide. Various disciplines and scholars have defined floods. Flood is seen as an inability of the river basin to hold the capacity of heavy rainfall, thereby overflowing its banks (National Institute of Disaster Management [NIDM], 2015). This is when a river is unable to hold an amount of water, thereby exceeding its carrying capacity of the river leading to flooding. Floods are also defined as "High-water stages in which water overflows its natural or artificial banks onto normally dry land such as a river inundating its floodplain". Flooding is usually short term and local, but when the flood exceeds the coping capacity of the inhabitants along the riparian zone of the river basin, the flood hazard turns to a disaster that may demand external help.

The Center for Research on the Epidemiology of Disasters (CRED) defines a flood as a "significant rise of water level in a stream, lake, reservoir or coastal region" (EM-DAT, 2009). The happenings and parameters that sludge flood events are diverse, miscellaneous, and interconnected.

The IPCC SREX report defined flood as "the overflowing of the normal confines of a stream or other body of water or the accumulation of water over areas that are not normally submerged (Field et' al. 2012). Floods include river (fluvial) floods, flash floods, urban floods, pluvial floods, sewer floods, coastal floods, and glacial lake outburst floods". Flood is also seen as "an increase of water that has a significant impact on human life and well-being" (WHO, 2010).

From these definitions, floods can be seen as the overflow of water within its catchment when the basin is unable to carry the available water. Flood is, therefore, a function of water within the river basin that exceeds the threshold of the river basin.

2.2.3 Types of flooding

In assessing flood risk, there should be an account for the type of flood occurring in that area to help make proactive decisions to reduce the risk. In this literature, four (4) classes are discussed.

2.2.3.1 Flash flooding

This is a local and sudden flood that occurs in a small catchment and mainly caused by short intensive rainfall. It mostly occurs in hilly or mountainous areas due to conventional rainfall mechanisms. Flooding occurs in a short time but associated with severe damage because of its higher runoff.

2.2.3.2 Fluvial flooding

Rivers usually cause fluvial flooding. This involves the potential for a high level of the river and velocities. The water flows at a higher speed with debris which generally poses a sophisticated threat to habitats and structures. Fluvial or riverine flooding, therefore, occurs when excessive rainfall over an extended period causes a river to exceed its capacity. This mostly happens in two ways, either through overbank flooding (where a river overflow it banks) or flash flooding (where there is torrential and intense rainfall occurring within a catchment) (Maddox, 2014).

2.2.3.3 Pluvial flooding

The overloading of the drainage also causes this during the rainfall event. The overloading mostly happens as a consequence of extreme long rain events. A misconception about this flood is that

one must be close to a river or water body. Still, this myth doesn't hold because it happens in urban areas where runoff on sloppy areas is unable to absorb, thereby causing pluvial flood (Maddox, 2014). This flood combines the effort of both coastal and fluvial flooding to operate.

2.2.3.4 Coastal flooding

This is caused by the rise of the seawater either by tidal surges or waves action (E.A.,2010). The mechanisms of the high tide are the result of gravitational pull effect, surges, and local wave action (LGID,2010). The major risk is structural damage since the seawater is more corrosive. The severity of coastal flood is determined by the strength, size, speed, and direction of the storm and also the onshore and offshore topography of the area (Maddox, 2014)

2.2.4 Causes of flooding

According to Nott (2006), the causes of floods are broadly grouped into physical (Natural) that is the climatic forces and human influence like clearing vegetation at the riparian region and urbanization. Most of the natural causes are related to prolonging rainfall associated with days, and week-long rain. When this prolonged rainfall flows into the river channel and the channels are unable to contain the water, the water, therefore, breaks the bank of the channel to the surrounding causing flooding. According to Tobin and Montz, (1997), physical features such as the soil type, presence of vegetation, and other drainage basin characteristics influence the occurrence of a flood. Also, Bates et' al. (2008), stated that climatic systems, more importantly, rain (intensity, duration, and amount) and drainage basin conditions (water level, soil characteristics) contribute immersely in the occurrence of flood. Residence close to the sea, river may experience flood within the area when there is a tidal event (Brakenridge et' al., 2013). With people living close to the sea, Nwingwe and Emberga (2014) revealed that ocean storm and tidal waves along the coast also expose people along the coast to the hazard of flooding.

Although flooding is often related to natural processes (prolonged rainfall, tidal waves), the impact of human activities such as urbanization and land-use changes has also led to the occurrence of flooding in many areas. According to Ranzi et' al, 2002, continuous growth in population and urban expansion leading to changing land use pattern has reduced surface permeability which increases runoff on the surface of the earth leading to flooding. Therefore, reckless building in the vulnerable areas, poor watershed management, and failure to control the flooding also contribute to flooding in an area. Furthermore, human factors such as structural failures of dams and levees, the alteration of absorptive land cover and inadequate drainage system lead to the cause of flooding. All these and other human activities on the river catchment influence flood behaviour.

2.2.5 Flood Risk Management

The assessment of flood risk is an essential tool in evaluating the potential consequence of a flood. The analysis of flood is applied as floodplain management. It is therefore vital to analyze flood when assessing flood disaster mitigation and possible measures. According to Apel et' al, 2008, flood risk assessment collates both flood hazard assessment and the flood vulnerability assessment. Benjamin (2008) in his study on flood risk management concluded that it is necessary to understand the hazard and the human vulnerability

Over the years, there has been a shift in flood management from flood protection to flood risk management. The change has broadened and deepened the interest from flood hazards to flood risk and impact (Sayers et' al.,2015). This implies that earlier management of flood focused on the physical processes of the flood (river flow and structures) without considering the vulnerability of the people and the impacts which called for the shift to broaden the study interest into flooding. This change has brought more strategies (both structural and non-structural measures) in managing flood.

The efforts invested in risk reduction are proportionate to the magnitude of the risk and how this risk may be reduced effectively. The process of risk management informs multiple decision making available and transparent to the general public (Merz et' al.,2010). Risk management requires sophisticated risk analysis, including vulnerability component (exposure, resilience, and resistance) of flood risk. The flood risk analysis helps to give transparent disaster risk reduction.

Flood risk is a process that includes the catchment, the river process, and the damage that occurs. The process of flood risk takes into consideration the catchment processes and also consists of the global climate contest. The interplay between the atmosphere and catchment processes shapes the flow regime, flood discharge, and riparian environment (Hall et' al., 2014). The interaction between the catchment (topography, soil, land cover, and land use) and the climate (duration and intensity of rainfall) influences and shapes the flow path of the river, water storage, and the river catchment response (Rosberg et' al., 2013).

Aside from these two major processes, the processes within the river system also determine flood hazards. The river system has characteristics of topology, longitudinal river slope, and cross-section, which influence the flood hydrograph and inundation (Hardy & Reany, 2014). Flooding is influenced by the interaction between the river channel and the floodplain. When river water exceeds the bankfull water level, it spreads out across the floodplain. And the effects of this depends on the capacity of the floodplain (Becker et' al., 2014).

2.2.6 Flooding in Ghana

Rainfall is seen as the most important element of the weather in Ghana (Bunnett & Okunrotifa, 1984). Climate change is making the planet we inhabit a more dangerous place to live. This makes the country prone to flooding, exposing towns and communities to catastrophic moments.

Flooding in Ghana is one of the major leading disasters leading to Epidemics. This brings to bear on how the country is unable to manage disaster risk with the inability to formulate efficient policies and institutions to fight existing disaster (Rain *et al*, 2011). This is causing a lot of flood related disasters in the country. A Director of Communications of the National Disaster Management Organization (NAMDO) during flood incidents in 2017 stated that "coupled with other factors such as people building in waterways, choked drains due to the undisciplined behaviour of some individuals as well as factors that were purely due to nature, some people, unfortunately, found themselves living in flood-prone areas."

In Ghana, we don't have natural disasters in terms of rain, and all that; they are all man-made and human-induced by our attitudes and the way we do our things. The Director of Communications of the National Disaster Management Organization (NAMDO) continued to caution that "People living in flood-prone areas within Southern Ghana; are advised to move to safer grounds as the rainy season peaks in the South. This is because, with more rains being expected, there is bound to be flooding in flood-prone areas, and one of the best means to protect life, is for people to vacate these areas during downpours."

2.2.6.1 Flood Profile in Ghana

Ghana is highly exposed to a serious flood problem. This flood occurrence is a result of rainfall variability and land-use changes which have made flooding common throughout the country. In the last 50 years, over 4 million people have been affected resulting in economic damage exceeding USD$ 780 million; as a result, Ghana received grants as at 2017 totalling 47.33 billion from partners like World Bank and the United Nations Development Program (UNDP) (Hammett & Mixter, 2017). These floods in Ghana are mostly triggered by seasonal rainfall, poor drainage, the dumping of waste into waterways, and settlers at low elevation areas (Okyere et' al, 2018). These

have exposed various communities to health risks, food shortages, and mental stress. Ghana has experienced major floods. The table below shows the flood profile in Ghana from 1968.

Table 2.1: Flood profile in Ghana

FLOODS LOCATION	DATE	EVENTS AND PEOPLE AFFECTED
Accra	July 4, 1968	Accra recorded the heaviest rainfall bring normal life to a standstill.
Secondi-Takoradi	June 29, 1971	Torrential downpour leading to collapse of buildings rendering thousands of people homeless
Accra Metropolitan	July 5, 1995	Rainfall at midnight in low areas affected both settlers, vehicle movements, and VRA sub-stations resulting in a power cut.
Accra flood	June 13, 1997	Hours of intermitent downpour for two days with river Odo and Oyansia breaking it banks forcing residents to move from their houses to safer grounds destroying properties and claiming lives
Upper West, Upper East, Northern region as well as the northern part of the Brong Ahafo	1999	Three hundred thousand people and more were affected as a result of the flooding in the area.
Accra (Madina, Dworwulu, Avenor, Santa Maria, and Adbraka official town)	June 28, 2001	Early morning downpour submerged some portion of the towns with residents and a lot of property damaged.

Upper West, Upper East, and Northern Regions	In 2007	Flood-hit these regions affecting three hundred and seven thousand, one hundred and twenty-seven (307,127) people.
Central Accra, Ofankor and Begoro	May 5, 2010	Rains caused havoc within the country's capital city when parts of the city and its streets were deeply submerged in water after two hours of stormy rains.
Nation's worst flood disaster	June 22, 2010	Thirty-five (35) bodies were retrieved from floodwaters across the country by volunteers and rescue workers who described the havoc after the rains as the worst flood disaster in Ghana's recent history
Agona Swedru municipality	June 24, 2010	Three bridges connecting the Agona Swedru municipality to neighbouring communities collapsed as a result of the flooding.
Agona Swedru	June 26, 2010	NADMO registers 3,000 flood victims in Agona Swedru in the Central region.
Nationwide	October 14, 2010	One hundred and sixty-one thousand (161,000) people were displaced across the country as a result of flooding during torrential rains and the opening of the Bagre Dam in Burkina Faso

Fifty-five communities in the Central Gonja District in the Northern Region, including parts of the district capital, Buipe	October 18, 2010	These communities were submerged by floodwaters following the overflow of the Volta lake.
Floods cause havoc in Afram Plains	November 2, 2010	Two thousand and eight hundred people in 120 villages and towns along the Volta Lake in the Kwahu East, Kwahu South, and Kwahu North districts in the Eastern Region were rendered homeless by floods. The floods also destroyed 850 buildings, farms, markets, and roads.
Accra	February 24, 2011	A downpour wreaked great havoc on the property in most parts of Accra and some of its surrounding communities. The property of residents of areas such as Adabraka, Kisseman, Alajo Junction, A-Lang at Santa Maria, Oyarifa, Haatso, Adenta, and the Tema Timber Market was either submerged or washed away.
Atiwa District	July 20, 2011	About 10 hours of torrential rain left 105 farmers stranded on farms at Akyem Osoroase Krobomu in the Atiwa District in the Eastern Region for three days.

Accra	November 1, 2011	The death toll in Accra rose to 14, while 43,087 people were said to have been affected by the downpour, officials of the National Disaster Management Organization (NADMO) declared.
Accra	May 31, 2013	Heavy rains caused flooding in some parts of Accra. The rains, which started in some areas around 4.30 a.m., flooded areas such as the Kwame Nkrumah Circle, Darkuman Kokompe, the Obetsebi Lamptey Circle, and portions of the Graphic Road, Santa Maria and the Dansoman Roundabout.
Accra	June 6, 2014	The heavy rains caused flooding in the city and its environs, including Adabraka, Awoshie, the Kwame Nkrumah Circle, Mallam, North Kaneshie, Abeka, Dansoman and Odorkor
Areas in Accra	July 4, 2014	Areas in Accra such as Anyaa, Taifa, Dome, Nii Boi Town, Dansoman, some parts of Kaneshie, Adabraka, Awoshie, the Kwame Nkrumah Circle, Mallam, Abeka, Dansoman, and Odorkor were submerged as a result of the heavy rainfall.

Accra	June 3, 2015	A heavy downpour in Accra with an explosion of a GOIL fuel station at the Kwame Nkrumah Circle claimed over 152 lives.
Greater Accra, Western, Central, and Eastern	July 10, 2017	There were widespread floods over these four regions from torrential rainfall, leading to overflow of rivers impacting people's health, safety, properties, and livelihoods (IFRC, 2017).
Capita of Accra and Part of the Western region.	30 May-1st June 2019	As a result of the torrential rainfall in the area, the Secondi-Takoradi metropolitan recorded five people dead when their home in the village of Ngyeresia, Essipong district collapsed under pressure from the floodwater. Accra recorded 16 people dead with most people being displaced from their homes, especially areas along the Odaw river (www.floodlist.com/flood profile in Ghana. Retrieved on 27th August 2019).

Source: Jr, D. (2015). Flooding in Accra Research report. Modern Ghana. Retrieved 30 May 2019, from <http://www.modernghana.com/news/223780/1/flooding-in-accra-research-report.html.

2.2.6.2 Management of flooding in Ghana

The National Disaster Management Organization (NAMDO) is responsible for managing the effects of all disasters, including flooding in Ghana. Among others, the NADMO is to perform the following functions:

1. Coordinate the activities of various bodies in the management of disasters.
2. Rehabilitate persons affected by disasters
3. Mobilize affected societies /communities to support various government programs such as poverty reduction programs as well as those aimed at the management of disasters.
4. Ensure that the country is prepared to prevent disasters and manage them well when they occur

These functions clearly shows that NADMO is not the agency for taking action in managing risk in the country but rather to coordinate the various supporting agencies (for instance Fire Service, Police, Personnel's from District, Municipal nad Metropolitan Assemblies, and others) to help manage the existing disasters associated with the various hazards like flooding.

Thus, the NADMO has offices located at the national, district and zonal levels which help in sensitizing and educating Ghanaians on what and what not to do in the event of a disaster like flooding. Further, they are responsible for mobilizing resources to be distributed as relief items often to affected victims.

It has been argued that NADMO is doing its conceivable best, especially concerning offering relief items to victims as and when necessary and within their means, but very little is known of any

activities regarding the education of Ghanaians on what to do pre and post-flooding. That is why many Ghanaians see the institution as Sluggish and not useful.

Also, the Meteorological service department contributes to management of flooding in Ghana in a way. They are responsible for keeping and providing climatic and rainfall data in Ghana. While the Meteorological Department does keep some data on the rainfall pattern in Ghana, it is not quite clear whether they do have any robust data on the history of flooding. But knowing the rainfall pattern will help in predicting flooding in an area to help NADMO educate residents on the rainfall pattern to help increase their resilience to flood disasters in Ghana.

2.2.7 Impacts of flooding on livelihoods

Floods affect a lot of people nationwide. Floods have the greatest damage potential of all-natural disasters worldwide and affect the greatest number of people. Following the various factors that influence the occurrence of floods, the impact is felt differently based on the people's vulnerability and adaptive measures to curb the situation. Globally, flood disasters in the 1990s affected a lot of people leading to a sum of 200 million economic loss and about 63 billion damages of valued property loss (World Disaster Report, 2002). According to Peduzzi & Ruiz 2005, it was assessed that 75 per cent of the world population currently lives in areas that have once been affected by a disaster. Also, according to GAR, 2015 cited in Bhatt et' al 2017, the estimated value of people, build environment, and properties affected by flood is US$104 billion. These figures implythat flood disaster is on the increase.

Recent hastening in population growth and changes in land-use patterns have amplified human vulnerability to floods. Harmful impacts of floods include direct mortality and morbidity and indirect displacement and widespread damage of crops, infrastructure, and property. Immediate causes of death in floods include drowning and trauma or injury (Jonkman & Kelman, 2005). Over

some time, there has also been an increase in mortality due to infectious disease after flooding in various areas (Li et' at, 2004; Alajo et' al, 2006).

The risks posed by future flood events are significant given population growth, proximity of populations to coastlines, expanded development of coastal areas and flood plains, environmental degradation, and climate change (Kahn, 2005).

When it comes to flood, Ghana is no exception. For example, Ghana recorded unprecedented flood events in November 2010, which affected 55 communities and 700,000 people was displaced. In addition, 3234 houses and 23,588 acres of farmland destroyed and submerged concurrently. The total cost of flood was estimated to be US$116,340.22 according to the 2010 report of the National Disaster Management Organization (NADMO), Ghana. In addition, on June 3, 2015, the food incident caused more than 150 deaths (Asumadu-Sarkodie, 2015)

The report of the working group on Management of flood accepted that "The devastating floods not only result in loss of precious human lives, cattle and damage to public and private property but create a sense of insecurity and fear in the minds of people living in the flood plains. The after-effects of flood like the agony of survivors, the spread of epidemic, non-availability of essential commodities and medicines, loss of dwellings, make floods most feared among the natural disasters faced by humankind" (Nandy, 2005)

2.3 Concept of Bank Erosion

Fluvial erosion is the detachment of sediments from the bank surface by the action of the river, the lithology of the river banks, thereby bringing about bank erosion. This process is most prevalent where the nature of the river is braided, which grasps mass failure in such a river (Ophra et' al, 2018).

Riverbank erosion is a significant morphological phenomenon that occurs in the fluvial systems in the world rivers but with varying nature and impact (Pati et al., 2008). This process occurs when the bank line shift and is migrated. Major factors that contribute to bank erosion is the increase and decrease in shear strength, changes in river course, characteristics of bank materials, vegetation cover (Rahman et' al., 2015).

Riverbank erosion occurs through the combination of sub-aerial weakening and weathering, fluvial erosion, and mass failure (Mengoni & Mosselman, 2006). This process is influenced by the pores of the water, pressure, and moisture content within the bank which are mostly influenced by hydrologic processes and riparian vegetation (Simon & Collition, 2002).

The erosion of the river bank leads to the position of the sediment to another river bank. This erosion in the banks mostly occurs when the stress of the water and sediments exceeds the resistance leading to bank erosion (Islam & Rashid,2011)

Riverbank erosion is a local hazard that impacts severely on human lives and properties of the residents in the riparian region (Alam et al., 2012). This also a natural process that occurs and changes the river bank when the river meanders with bank characteristics (resistance, type of bed, topography) (Konsoer et' al, 2016). Residents along the river banks are often the victims of bank erosion which mostly threatens their safety, shelter, and all endeavours of their livelihood (Brander, 2006).

2.3.1 Types of Bank Erosion

Bank erosion as a fluvial process happens through two predominant procedures, specifically hydraulic activity and Mass failures (Posner and Duan, 2012). Pressure driven activity entrains particles from the bank by the abundance of stress power applied on the limit by the flowing water.

The more noteworthy the greatness of the water speed, the greater the vitality of the stream and the more prominent the potential for the pressure-driven activity to detach the materials from the bank.

Mass failures happen when a huge piece of materials shear far from the river bank and slides to the lower position of the stream. This commonly happens when the basic tallness and edge of the bank have been outperformed (Papanicolaou et al., 2007). How inclined a stream bank to mass disappointment relies upon the geometry, structure, and the material properties of the bank (Knighton, 1998). If the base of the bank is undermined, the balancing out powers of the bank is diminished. A stream bank is most vulnerable to drooping when the water level has declined; however, the bank is still completely drenched (Trenhaile, 2010).

2.3.2 Factors Influencing Bank Erosion

It is essential to understand that rivers naturally and artificially change their form and structure over time. Different components influence the erosion rate at waterway banks. The most significant factor is the fluid flow which incorporates the extent, recurrence, and the varieties in the stream waves. Fluid flow properties likewise mull over the shear pressure conveyance that the streaming water applies on the bank, the measure of tempestuous in the water, and the nearness of waves. Other commitment factors that generally impact on the level of stream bank disintegration is the bank material creation (surface and attachment of the dirt), atmosphere (precipitation pattern), organic elements (plant roots, animal activities), channel geometry and human impact (urbanization, farming, drifting and bank protection structures) (Knighton, 1998). In this manner, the area with most serious disintegration is along these lines critical to setting up disintegration aversion structures and offering cautioning to individuals to build the strength to the hazard

2.3.3 Impacts of Bank Erosion on livelihoods

Bank erosion damages riparian habitats along the river basin. Indemnities in the riparian zone create feedback twists by further increasing erosion because the roots of the trees and shrubs along the river bank provide the internal bank strength (Environment Protection Agency [EPA],2012). Land loss is one major impact that riverbank erosion brings about with increasing concerns for property owners. For instance, the Matanuska River in Alaska has eroded private properties over the last decades as well as a major regional highway and farmlands (Curran & McTeague, 2011).

According to Rahman 2010, riverbank erosion is seen as one of the major causes of national poverty. The impacts that are mostly seen are land loss which involves the loss of homestead lands, agricultural lands, agricultural productions, crops, and trees primarily. Livelihood status of people changes due to the impact of property losses to the hazard.

This has a lot of impact (short term and long term) on the issue of riverbank erosion in the area, if the short term is a loss of home, agricultural land, jobs and asserts and the long term are direct and indirect in the living conditions (health, development, education, etc.) (Refugee and Migratory Movement Research Unit, 2007; Das & Sen, 2014). This disaster causes a lot of displacement of inhabitants who live near the river bank. These inhabitants lose their home, means of livelihood and assert and often changes their livelihood as a result of the occurrence of this disaster (Das & Talukdar,2017).

The disaster also causes a lot of loss of land and landholding capacity, affects and changes their livelihood, loss of income, house, crops, and others (Islam et al., 2011). As a result, the inhabitants suffer from poverty, income reduction, displacement, livelihood changes, social destruction, reduction of the quality of life. This also negatively impact on the cultural link with the resident to the landscape at the floodplain and along river bank zones.

This hazard puts a lot of pressure on people's livelihoods, and these people use their available resources to restore the livelihood that helps them to cope with this situation and strategic measures against the hazard (Beckman, 2011).

2.4 Concept of Vulnerability

2.4.1 Introduction

According to Cutter (1996), vulnerability as a concept has no common conceptualization, and its significance is still unclear. Vulnerability is a very challenging concept to understand because different people try to define and understand it differently using a variety of terms like susceptibility, exposure, deficiency, lack of capacity, weakness, and others. Notwithstanding all these diverse meanings of vulnerability, most researchers agree that understanding vulnerability requires more than analyzing the direct impact of the hazard. Vulnerability also concerns the wider environmental and social conditions that limit people and communities to cope with the impact of hazards (Birkmann, 2006).

Also, vulnerability is determined by historical, political, cultural, institutional and natural resource processes that shape the social and environmental conditions people find themselves in (IPCC, 2012). These processes produce a range of immediate unsafe conditions such as living in dangerous locations or poor housing, ill-health, political tensions, or a lack of local institutions or preparedness measures (DFID, 2004).

2.4.2 Concepts of Vulnerability

According to the United Nations Development Programme (UNDP, 1994) "vulnerability depends upon the degree of loss to a given element at risk at a certain severity level. Generally, it is expressed as the percentage of loss (between 0: no damage to 1: total damage) for the given

hazards". Based on the natural sciences, vulnerability is "a measure of the damage suffered by an element at risk when affected by a hazardous process" (Wisner et al., 2016).

Various scholars in the social science perspective defined vulnerability based on their opinions as follows: Blaikie et al. (1994) define vulnerability as "characteristics of a person or group in terms of their capacity to anticipate, cope with, resist, and recover from the impact of natural hazards". Adger (2000) also provided an alternative definition as "the presence or lack of ability to withstand shocks and stresses to livelihood". Cutter et al. (2012) define social vulnerability as "a multidimensional concept that helps identify those characteristics and experiences of communities (and individuals) that enable them to respond and recover from natural hazards."

According to the (Prevention Consortium, 2007), vulnerability is the potential to suffer harm or loss, related to the capacity to anticipate a hazard, cope with it, resist it and recover from its impact. Both vulnerability and its antithesis, resilience, are determined by physical, environmental, social, economic, political, cultural, and institutional factors" expressed as Vulnerability = (Exposure) + (Resistance) + Resilience.

According to the United Nations Office for Disaster Risk Reduction [UNDRR] (2017), vulnerability is determined by physical, social, economic and environmental factors or processes which increase the proneness of an individual, a community, assets or systems to the impacts of hazards. Vulnerability in these senses is multi-dimensional and unequal, Scale-dependent, and dynamic.

Vulnerability in the aspect of exposure is the degree, duration, and/or extent in which the system is in contact with, or subject to the perturbation (Kasperson et al., 2005; Adger, 2006).

The economic dimension of vulnerability offers an approach to provincial vulnerability, especially from the insurance company opinion of damage potential (Kumpulainen, 2006); the socio-cultural dimension relates to the presence of human beings (individually or aggregated in communities) and their coping capacities in the event of hazards/disasters.

It is clear from these definitions that are a function of people's exposure to hazardous conditions; the ability to cope and recover from the effects of the available hazards explains vulnerability. Vulnerability is commonly applied to a social system as a series of conditions and processes occurring from physical, social, economic and environmental circumstances, which increase the susceptibility of society, property or environment to the impact of hazards (United Nations International Strategy for Disaster Reduction 2004; Wilson 2018). A society or city is said to be vulnerable when its characteristics and circumstances make it susceptible to the damaging effects of risk (Kidokoro 2008).

Concerning flood risk about this research, Parker (2007) affirms the significance of applying the environmental approach (social and physical environments) to determine the flood vulnerability of a household or community and that social aspect should be more explored in detail. Besides, maps have become a common tool to present vulnerability due to the increasing use by geographers, urban and regional planner, environment management, geologist, hydrologists, and other experts (Preston et al., 2011). In this regard, the Geographic Information System (GIS) and its related technologies are helping geographers and planners in understanding and explaining vulnerability both in theory and in practice.

2.4.3 Flood Hazard and Vulnerability

Flood vulnerability involves elements at risk, such as the residents of a flood-prone area, a built environment, or an ecosystem exposed to flood risk (Merz et al. 2007). By these, vulnerable communities are evaluated using a variety of vulnerability drivers like the physical, social, economic, environmental, and political factors (Wisner et al. 2004).

There is an increase in the magnitude and scale of natural and human-induced disasters, in particular the hydro-meteorological-related disasters such as floods (Cutter, Boruff & Shirley 2003; Vos et al. 2010). It is widely acknowledged that floods are the most frequent and widespread disaster in the world, causing devastating effects on the lives of millions of people and their properties, as well as infrastructure and the natural environment (EM-DAT 2015; Vojinović 2015). Therefore, an increase in rapid urbanization increased in unplanned land use, and the effects of climate change are the leading cause of our natural and human-made disasters such as flooding and bank erosion.

It also recognizes that flood vulnerability is determined by three factors: (1) the degree of exposure; the probability that population groups and their assets like properties, infrastructure, and cultural heritage will be struck by flooding (Penning-Rowsell et al. 2005). The flood duration, intensity, velocity, frequency and water level of a flooded area are measurable. Also, susceptibility relates to the extent to which economic values, building structures and people in a flood-prone region are likely to be harmed by flood hazards (Balica & Wright 2010). The population density, economic values, and building structures in a specific flooded area can be measured and (3) resilience; relates to long time social, economic, technological, and cultural adaptive coping mechanisms to mitigate flood risk (Cardona, 2013). The adaptive coping mechanisms are largely influenced by individuals'

or households' flood risk perceptions, flood awareness, flood knowledge, experience, and coping strategies to minimize flood risk. Scholars have also acknowledged that vulnerability is primarily attributed to human activities that involve socio-political, historical, and cultural relations (Birkmann, 2007; Vojinović, 2015).

Füssel (2007) posits that four dimensions are essential to explain a vulnerable situation. Firstly, system or unit of analysis such as a geographical area and women group; secondly, an attribute of concern such as housing quality, health issues, and human livelihood; thirdly, the hazard of concern such as floods; and finally, the temporal reference such as a short period or long period of fluvial floods assessment.

Globally, 55% and more of all fatalities are accounted for by flood hazard with nearly 2.5 billion people affected (EM-DAT 2015). It is estimated that the average annual population that is affected by river floods is around 21 million people worldwide and is likely to rise to 54 million by 2030 (World Resources Institute [WRI] 2016). In sub-Saharan Africa alone, 654 floods have affected 38 million people, with around 13 000 deaths recorded in the last 33 years (Tiepolo, 2014). Most cities and urban centres in Africa are regarded as flood disaster risk hotspots (Baker, 2012) because of rapid urbanization, human activity, and their vulnerability to the impacts of multiple hazards (Adelekan et al., 2015; Vojinović, 2015). Pelling and Wisner (2012) posit that poor governance and social and environmental injustice are underlying root causes of the flood risk. For instance, a city with a very low quality of basic or infrastructure services, unplanned growth, and rapid urbanization coupled with the effects of climate change, can turn a heavy rainfall. According to Few (2003) and Vojinović (2015), fluvial flooding is triggered by excessive rainfall over a couple of hours causing rivers to exceed their limit, overtopping natural or artificial defences and inundating urban areas making people highly vulnerable to this hazard.

These factors of flood vulnerability provide different drivers to the study of vulnerability at different area-specific levels which are physical, social, economic, attitudinal, and institutional drivers of vulnerability. This is very beneficial to the study of the people's vulnerability at the Lower Pra Basin.

2.5 Concept of Livelihood

Livelihood is a concept which sustains or improves the different elements of living of an individual or group of people and also encompasses the ability to cope and recover from the stress and existing hazard. Livelihood concept is multidimensional, which deals with the nature of poverty, nature of their portfolio, nature of the vulnerability, and complexities of asserts and entitlement.

Livelihood has been contended for interpreting the needs of the people in the form of basic capabilities, a broad concept permitting culturally miscellaneous gist that include the ability to meet requirements of nutrition, clothing, shelter, and quality of life. Livelihood is seen as the means of making a living with various resources and activities. Chambers and Conway, 1991, the most cited definition of livelihood defines "Livelihoods as the means that enable people to earn a living. This includes the capabilities, assets, income, and activities people require to ensure that their basic needs are covered. A livelihood is sustainable when it allows people to cope with, and recover from, setbacks and stress (such as natural disasters and economic or social upheavals), and improve their welfare and that of future generations without degrading the environment or natural resource base".

There are many other definitions. For example, livelihoods are the "ways in which people access and mobilize resources that enable them to pursue goals necessary for their survival and longer-term well-being, and thereby reduce the vulnerability created and exacerbated by conflict" (Young et al., 2002). "A livelihood comprises the capabilities, assets, and activities required for a means

of living. A livelihood is sustainable when it can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base." (Department for International Development, 2001 and Scoones, 2009).

Household possessions and competences are the basic elements of livelihood. It largely comprises natural, physical, human, financial, public, and social capital as well as household variables. Human assets embody the skills, knowledge, education, ability to work, and good health that enable people to pursue different livelihood strategies and achieve their livelihood objectives. Social assets refer to rank in society, as well as access to an extended family and other social networks. It also includes associations of trust and reciprocity that facilitate cooperation, reduces transaction costs, and can provide the basis for informal safety nets among poor people. They comprise natural resource stocks, which people can access and use to build their livelihoods, e.g. land, forests, water resources. They include livestock, land, shelter, tools, equipment, but may also be community-owned, e.g. road infrastructure. Lastly, the financial assets include income, access to credit, and investments. They may include available stocks, which can be held in several forms, e.g. cash, bank deposits, livestock, and jewellery. They may also include regular inflows of cash, including pensions and remittances (Food Security Information for Action, 2007). The resilience of the livelihood of people is mostly determined by their resources and assets available to them and how they are affected by the disaster.

In the light of these discussions, livelihood is defined as the natural, physical, human, and social assets, and the activities of the people/household that determine their living in an area. These livelihoods may also change as a result of the various changes in the environment caused by river basin

2.5.1 Livelihood Resources

The capacity to seek various livelihood strategies is subject to the essential material and social, unmistakable, and immaterial resources that individuals currently possess. Drawing on a regulatory analogy, such livelihood assets might be viewed as the 'capital' base from which diverse lucrative streams are gotten from which careers are developed. Therefore, the sustainable livelihood framework identifies five (5) types of livelihood resources or capital upon which livelihoods are made. They include Social capital, physical capital, natural capital, financial capital, and human capital.

2.5.1.1 Human Capital

Human capital speaks to the aptitudes, information, capacity to work, and great wellbeing that together empower individuals to seek after various vocation procedures and accomplish their employment destinations. At a family unit level human capital is a factor of the sum and nature of work accessible; these changes are indicated by family measure, aptitude levels, administration potential, wellbeing status, and so forth (DFID, 2000).

Human capital shows up in the nonexclusive system as an employment resource, that is, as a structure square or methods for accomplishing job results. Its amassing can likewise be an end in itself. Numerous individuals consider sickness, wellbeing or absence of instruction as central components of need and in this way, defeating these conditions might be one of their essential livelihood targets.

This capital is important because it is required to utilize the other four types of capital to attain positive livelihood outcomes.

2.5.1.2 Social Capital

Social capital is interpreted as meaning the social assets whereupon individuals attract in the quest for their livelihood destinations. The following social resources are developed through networks and connections, membership of a more formalized group, and the relationship of trust, reciprocity, and exchanges that facilitates co-operation and informal safety among the poor (DFID,2000).

An outstanding social capital improves the efficiency of economic relations, reduce the problem of free rider associated with public goods, and enabling inventions. This frequently contributes to people's wellbeing through identity, integrity, and possessions.

2.5.1.3 Natural Capital

Natural capital is the normal asset stocks (soil, water, air, hereditary assets, and so on.) and natural services (hydrological cycle, contamination sinks, and so forth) from which asset streams and administrations valuable for livelihoods are inferred (Johnson 1997). This capital is important because it is through this that all or part of livelihoods like farming, fishing, mining, and others are derived.

The connection between natural capital and the Vulnerability Context is especially close. A considerable lot of the stuns that decimate the works of the poor are themselves natural and human procedures that demolish natural capital (for example fires that annihilate woodlands, floods, earthquakes that obliterate farming area) and regularity is to a great extent because of changes in the worth or profitability of common capital (DFID, 2000).

2.5.1.4 Physical Capital

Physical capital encompasses the basic structure and manufacturer possessions required to sustain livelihoods. These include transport, shelter and building, water supply, energy, and access to

information. Therefore, inadequate access to these asserts leads to non-productivities, such as the collection of water and firewood. It also affects education, access to proper health care, and income generation (DFID, 2000).

2.5.1.5 Financial Capital

Financial capital is the capital base (money, credit/obligation, reserve funds, and other financial resources, including fundamental foundation and generation hardware and advances) which are basic for the quest for any livelihood procedure (Chambers & Conway 1992). The two major sources of financial capital are the available stock (savings, cash, bank deposits) and regular inflow of money (pension money, other transfer from the state, and remittances). This capital helps in transforming the other capitals with its structures and processes (DFID, 2000).

Therefore, to make livelihood very good and useful, individuals must consolidate the 'capital' gifts that they approach and have authority over. These might comprise individual abilities, substantial resources (for instance, stores and material assets), and impalpable resources (entitlements and access). It is then very vital to analyze how people change these capitals into improving livelihood outcomes (DFID, 2000).

2.6 Concepts of Geographic Information System (GIS) And Remote Sensing (Rs)

2.6.1 Introduction

GIS and RS technologies have been used increasingly in studying the spatial and temporal patterns of events on the earth's surface. The GIS and RS are beneficial to researchers who collect both qualitative and quantitative data and also integrate these data for effective analysis making one comprehensive database. These advancements provide resource directors and decision-makers with apparatuses for effective and proficient storage and manipulation of remotely sensed data and

other spatial data (Estee, 1992). Integrating RS data into GIS software facilitates measurement, mapping, checking, and demonstrating activities. These technologies have helped us with quick and cost-effective analysis for various applications about our environment with accuracy for planning.

2.6.2 The Concept of Geographic Information System (GIS)

The use of geographic information in decision-making processes is often not noticed, but it does exist in many of our daily activities. Decisions are sometimes made, which involves the analysis of this geographical information sometimes unawares. And these decisions can be done or carried out using computers with software which we usually describe it Geographic Information System (GIS).

GIS has played an essential role in planning and optimizing water resources which include mapping flow, the morphology of the river to building solutions to water resource problems. Using this technology helps in the right decision making about the environment and bringing a better understanding of water flow and morphology, its challenges and solutions. This tool is a decision-making tool for integrating referenced spatial data in solving an environmental problem. The United States Geological Survey (USGS) 2013 explained GIS as a tool which assembles, stores, and displays geographically references data according to the information.

GIS is viewed as a computer model of geographic reality to meet specific information needs, i.e., to create, share, and apply useful information based on data and maps (Burrough, 1994). GIS is also a set of tools consisting of hardware, software, data, and users that allow us to capture, store, manage, and analyze digital information, as well as create graphics and maps, and represent alphanumeric data (López, 2015).

For decades, GIS has been applied to land and natural resource management issues, environmental issues, military logistics, or environments directly related to Earth science, such as geography and geology (Pérez Asensio, 2012).

ArcGIS contains a set of applications to solve real-world geographic problems through a sequence of spatial operations. ArcGIS which is the main component of ESRI application suits is a set of tools that allows the visualization and management of geographic information, and also has an extensible architecture through which new functionalities can be added (Olaya, 2011). These are the well-known extensions, among which are Spatial Analyst (raster analysis), 3D Analyst (3D and relief analysis), or Geostatistical Analyst (geostatistics) which are used on the data that are gotten from remotely sensed imageries (Landsat images).

Working with ArcGIS demands data which must be in a digital format. All the elements on the earth's surface can be encoded so that the computer can understand the command, and depending on the type of information, data models are used. What is not apparent is representing the real-world information in a digital medium (ESRI, 2010). Despite the heterogeneity of geographic information, there are two essential ways to simplifying and modelling space so that they can be controlled, stored and operated in a computer system. This leads to the development of two data models; the vector model usually used for processing discrete geographic phenomena and the raster model, which is used to display continuous data. Both data systems are related and exist in GIS, though each of them is comparatively appropriate for reviewing an explicit sort of information (Del Bosque González et al. 2012).

2.6.3 Concept of Remote Sensing (Rs)

The science of remote sensing has become one of the most captivating topics in the past three eras. Earth observations from space using various remote sensing tools have provided a convenient tool

for observing land surface dynamics, managing natural resources, and the general state of the environment (Joseph, 2005). According to Canada Center for Remote Sensing “Remote sensing is a set of techniques for collecting images or other forms of data about objects from measurements taken at a distance from the object and processing and analysis of the data”.

Remote detecting frameworks, particularly those conveyed on satellites, give a rehashing and reliable perspective of the Earth, which is precious to screen the Earth's framework and the effect of human exercises on the Earth (Schowengerdt, 2006). According to United Nation (95^{th} Plenary meeting, 3 December 1986) “The term remote sensing refers to the characteristics of electromagnetic waves emitted, reflected or diffracted by the object being perceived, from the space to the surface of the earth to improve natural resource management, land use, and environmental protection”.

RS is mostly referred to as the act and science of acquiring information about the earth's surface, processing, analyzing, and applying this information in solving societal problems. This technique uses sensing devices that record information about the transmission of the object of electromagnetic energy from reflecting and radiating surfaces. The main principle of RS is “Detecting, and discrimination of objects or surface features which means detecting and recording of radiant energy reflected or emitted by the object of the surface materials. RS has the capability of capturing images, changing the image/data into information to describe change with the law properties (Roy et’ al 2002).

Remote sensing as a technique involves the collaboration amid incident radiation and the surface area of concern for study. The process requires Illumination which provides electromagnetic energy to the target of interest, radiation and the atmosphere. This is where the energy travel from its source to the target, interaction with the target, recording of the energy by the sensor after the

energy has been emitted from the target. Also, Transmission, reception, processing, interpretation and analysis of the data and application of the analyzed data from the imagery helps in solving societal problems.

These seven components include the remote detecting process, which consists of a connection between occurrence radiation and the objectives of intrigue. This is demonstrated by the utilization of imaging frameworks where the accompanying seven components are included. Note, anyhow that remote detecting additionally consists of the detecting of transmitted vitality and the use of non-imaging sensors (Livingstone et' al 1995).

2.6.4 Application of GIS and RS in Channel Migration, Bank Erosion

The reconstructions of the movement of channels mostly involves using historical maps and satellite images in combination with GIS and RS techniques. Satellite remote sensing data is effective in studying the morphology of a river channel in a wide area. This method has been employed using satellite imageries to investigate river channel migration, braided streams, and bank erosion (Gilvear & Bryant, 2003; Ollero, 2010). However, the lack of an appropriate resolution of satellite images sometimes poorly assesses the morphological change of the main channel of river systems. Bhulyan et' al 2014 applied the technology of GIS and RS to study morphological characteristics of the Brahmaputra-Jamuna River, Bangladesh, and concluded that channel widening was evident at the lower reach than the upper reach and was attributed to both natural processes and human-induced processes.

Using GIS AND RS helps in understanding the mechanisms and rates of bank erosion, increased and horizontal channel migration is fundamental, and the results of these studies apply to land and water management, Environmental protection, water technology work, and different aspects of research (Lawler 1993). GIS and RS has effectively substantiated itself as a profitable data

generator for doing waterway morphological/designing examinations and making a geospatial database for investigation. The utilization of multi-time high-goals satellite information, the most recent setup of waterways, change of stream ways, the arrangement of new stations/lakes, and disintegration/affidavit of banks, waste over-burden territories, and so forth can be shown at various scales utilizing the new advances.

Evidence obtained from remote sensing can be used for other studies of river morphological studies, such as monitoring existing flood control works, identifying vulnerable areas, planning bank protection works and improving drainage works, etc. (Manjusree et al. 2013***)***. As per the Assam Water Department, Assam Valley in the Brahmaputra lost about 7.4 per cent of the land region because of waterway disintegration and channel movement. It was likewise noticed that the stream Brahmaputra drastically changed it managing a banking line, which did genuine harm to farming and also territories occupied on the two sides of the river. Gogoi (2013) conducted a bank erosion study on the Subansiri River in Assam, India using remote sensing and GIS technology and it was revealed that the size of the Subansiri River has enlarged and that the erosion process has continued on both banks of the river. In the light of this, Debnath et' al (2017) studied River Khowai in India using GIS & RS to assess the spatial change in the riverine processes and was observed that the river has changed from highly meandering to sinuous. This has endangered the conditions of the people and infrastructures at the riparian zone due to high bank erosion.

The Pra basin, which has been through a lot of anthropogenic processes, provides a good opportunity to study bank erosion, flood hazard, and lateral channel migration. And considering channel processes problems that occur naturally or by human action emanating from the source to the mouth, and this will be done by using the technologies of GIS/RS using the available data.

The presence of aerial photography, orthophoto, and GIS has opened up the possibility of studying riverbank erosion, growth, and horizontal migration of channels. Around the world, several different methods were used to quantify these processes and different time intervals: from 1 to 10 years for measurements and from 10 to 200 years for maps and aerial photographs. (Hooke, 2003; Redmond 1989; Duan 2005)

Studying bank erosion, flood hazard, and channel migration have gained scientific and engineering interest. This is because it plays an essential role in controlling river channel stability, contribution to sediment load, and destruction of floodplain land and land-use changes with severe bank erosion. Therefore, morphological studies that involve the use of GIS play a vital role in the planning, design, and maintenance of engineering structures of the river. To assist engineers in relevant departments and other agencies with morphological research reports have been prepared with broad guidelines.

In conclusion, GIS/RS techniques due to its various advantages, are of great importance to be used by planners to be used in taking measures required for channel stabilization and strengthening of embankments. This also helps in monitoring the vulnerability of flood, changes that occur within the river channel with time, formation of new features (Braided streams, oxbow, channel widening, etc.), and understanding the works and behaviour of the river. GIS/RS serves as a means of idea portrayal that gives local planners ideas based on existing data gathered. Also, the products that are derived from the process of GIS/RS are increasingly utilized as a decision basis for resource management. The lower pra basin reach that is being studied under this research using a case study approach, applying GIS/RS will be beneficial in providing a potential model that can be used by similar study regions of basins.

The issues related to the GIS/RS application, including complex data structure, difficulty in simulations, some data analysis are impossible to perform based on the licensing. It also involves a lot of data and others to resolve by assessing and proposing error reporting standards and lineage documentation, improving existing remote sensing errors assessment procedures. Also, field verification data collections (ground-truthing), Raster and Vector conversion, Locational error characteristics, and development of standardized geometric and thematic reliability legends that can help authenticate the result generated from the result of using GIS/RS.

2.7 Conceptual Framework

According to Camp, 2001, a conceptual framework is a structure in which the researcher believes that it can best explain the natural progression of the phenomenon to be studied. It is also organized in a logical structure to provide a picture or visual display of how ideas in a study relate to one another (Grant & Osanloo, 2014). This section is significant in assisting the researcher in recognizing and constructing views on the phenomenon under investigation.

2.7.1 Sustainable Livelihood Framework (SLF)

Sustainable livelihoods are situations where people can avoid or resist stress and shocks and can bounce back when affected by hazards. According to Thomson (2000), this sustainable livelihood approach has been used by several organizations during the 1990s in development issues and also addressing poverty. Also, the SLF focusses on the capacity and strength of individuals rather than only looking at their needs, assets, weaknesses, and constraints. This is also a tool for improving the understanding of livelihoods; more importantly, the needy.

Kollmair et al., 2002 summarized the framework as follows “The framework depicts stakeholders as operating in a context of vulnerability, within which they have access to certain assets. Assets gain weight and value through the prevailing social, institutional, and organizational environment

(policies, institutions, and processes). This context decisively shapes the livelihood strategies that are open to people in pursuit of their self-defined beneficial livelihood outcomes."

The SLA adopts approaches to understand livelihood and provides ways of conceptualizing the goods/capital of people, means of earning a living, the context in which their support is designed, and factors which strengthen their resilience to risk of hazards and stress (UNDP, 2015).

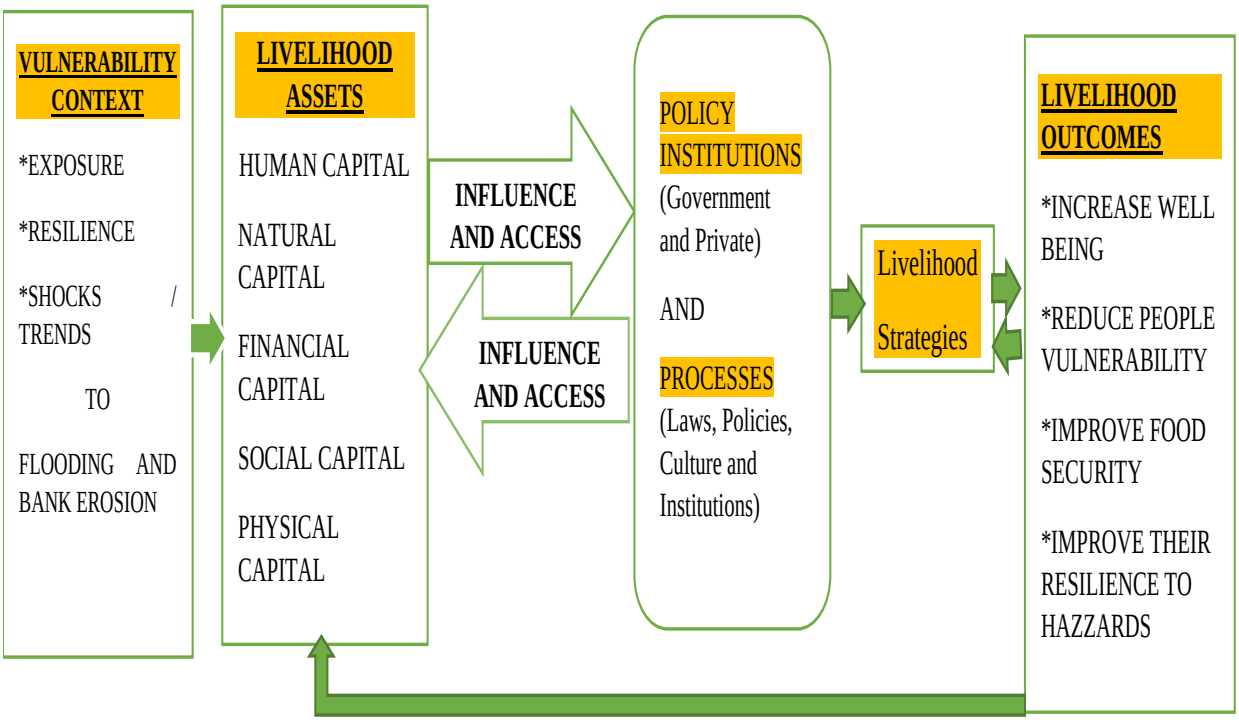


Figure 2.1: Sustainable Livelihood Framework

Source: Sustainable Livelihoods Framework [DFID (2000)]

From the framework, the vulnerability context happens when the individuals are exposed to flood and bank erosion with inadequate capacity to respond to the hazard. The risk and vulnerability help in assessing the impact and poverty level of the people. Related to this study, floods and bank erosion, over which those living in the riparian zone have no control have a great impact on people's livelihoods and other wider assets.

To assess the impacts of flood and bank erosion on livelihoods in the lower Pra basin, there is the need to identify the livelihood assets to help overcome the vulnerability of the people. The framework shows five (5) assets upon which livelihoods are built, namely human (knowledge, skills, information, and others), social (membership of groups, networks access to institutions and others), natural (land, water, environmental resources), physical (basic infrastructures- water, sanitation, hosing and others), and financial (remittances, insurance, credits) capital (McLeod, 2001). This helps us to analyses how people try to convert their strength into positive livelihood outcomes. Floods and bank erosion are critical issues that increase people's vulnerability to such risk. However, if the individuals can turn these capitals/ assets into strength, then sustainable livelihoods will be achieved.

The livelihoods of the people are shaped by the underlying policies, institutions, and processes (PIP's) that go on along the lower Basin of River Pra. These processes determine the way individuals operate and interact with an existing hazard. PIP's promote the achievement of multiple livelihood strategies and sustainable livelihoods (Bingen, 2000). Excellent and efficient PIP's in the areas experiencing flood and bank erosion will help to reduce the risk to such hazards leading to better livelihood outcomes depending on the intensity or magnitude of the processes occurring at the area and the vulnerability of the people. The PIP's work hand in hand with the underlying strategies to help achieve great livelihood outcomes with existing hazards occurring.

The framework aims that if the institutions operating in the community and the country as a whole function properly with the availability of existing capital to support the household, it will reduce people's vulnerability to various hazards that they encounter thereby improving and maintaining good livelihood outcomes. In this sense, Carney (2000) concluded that if people are having better access to assets and capitals, and have more ability to influence structures and processes, it will

provide them with a better responsibility of their needs, they will achieve good livelihood outcomes.

The DFID framework uses the concept of capital assets as its core features, and considers how these assets are affected by the "vulnerability background" that derives them, and how they are constituted by "transformation of structures and processes" or marked as policies, systems and processes to "lead to A livelihood strategy based on livelihood outcomes (Sojola, 2012).

SLA is also widely used for projects and Programming framework. Management plan or development project can define their goals appropriately and refocus on sustaining livelihoods goals, the means to verify the achievement of these goals and targets and monitor progress. Examples of the use of the SLA approach in project design and management include the Chars Floodplain Livelihood Project in Bangladesh and the Andhra Pradesh Rural Livelihoods Programme in India. Considering the livelihood project in Bangladesh, Empowering local communities and within the poorer floodplain natural-resource users has been addressed by NGO initiatives, to some extent by policy decisions through the use of the SLA in creating embankment to fishing during both dry and wet season and the cultivation of rice (Sultana & Thompson, 2017)

With regards to Andhra Pradesh rural livelihood program in India, locally empowering the local people proposed District Planning Frameworks which ensured that water-related planning and regulation issues not covered in village-level planning receive attention when decisions are being made on the allocation of funds at the district and state levels (Rao et al, 2003).

This chapter was dedicated to the review of related literature and the conceptual framework of the study. Specifically, the initials looked at understanding the concepts of a flood, bank erosion, vulnerability, and livelihood strategies. Lastly, the process of flooding and bank erosion on

livelihoods in the study was conceptualized with the help of the DFID sustainable livelihood framework and also how this framework has been used in recent application to rural livelihoods.

CHAPTER THREE (3)

STUDY AREA AND METHODOLOGY

3.0 Introduction

A research methodology is a vital component of any research or study, and it provides the framework upon which research will be conducted. This is an essential aspect of the study that provided ways to which the research was conducted. Therefore, this chapter gives an overview of the study area, and the methodology used to collect, analyze, and interpret the data.

3.1 Study Area

The Pra basin is the next major river basin after the Volta basin in Ghana. The Pra Basin is located between latitudes 5º00´ N and 5º 30´ N and longitudes 1º 15´ W and 1º 45´ W, in south-central Ghana. Its principal tributaries are the river Ofin, Oda, and Birim, with channels flowing from the Mampong-Kwahu and Atewa ridges. According to Kusimi et al., 2014, the Pra basin is generally of low relief with undulating topography with an average elevation of about 450m above sea level.

This study focused on the lower basin of river Pra, and the lower Pra is derived from the three-level operational structure established for the management of what is the Twifo-Praso sub-basin to the Shama Coast where the river meets the ocean.

The Lower Pra River Basin (LPRB) is geographically located in the south-western part of Ghana. The lower basin comprises the Twifo-Heman Lower Denkyira, Mpohor Wasa East, and Shama Ahanta East districts where the four communities under the study are found. The lower basin drains an area of 6,778 km². The LPRB is located between 5º36′52.17″ N and 1º32′43.02″ W and 5º1′9.41″ N, and 1º37′35.82″ W. The LPRB is situated inside the Forest Ecological Zone of Ghana. Due to the higher concentration of illegal small-scale alluvial gold mining activity, the forest has

experienced rapid degradation. Mean annual runoff is estimated to be 4,200 m^3yr^{-1} (Water Resources Commission, 2012)

The landscape is generally flat, characterized by an undulating topography with an average altitude of about 450 m above sea level, which makes people around the river basin more vulnerable to flood when rivers exceed their thresholds (WRC Ghana, 2015). Regarding Fig 3.1 below, the lower section of the river basin from Twifo Praso has an average height of 0-150m above sea level which implies the area is relatively flat and prone to flood hazard.

The LPRB has two rainy seasons, April-June and September-November. The mean yearly precipitation of around 1,600 mm is comparatively high. It, nevertheless, fluctuates from 1,450 mm to 1,900 mm. The disparities with the rainfall pattern within the LPRB increase towards the southern part of the basin.

The soil type in this area is soils weathered from the Tarkwaian and Birimaiain geological formation (Dickson &Benneh, 1995). The soil structure is clay in nature; therefore, it can retain more moisture. The primary soil type for this basin is forest ochrosols. This soil type can be correlated to the following by the World Reference Base 1998 as Acrisol, Alisols, Lixisols, Nitisols, Ferralsols, luvisols, fluvisols, and Plinthosols (Adjei-Gyampong & Asiamah, 2002). From the study map, the soil composition of the Lower Pra basin is the Fluvisols, Luvisols, Lixisols, and Acrisols.

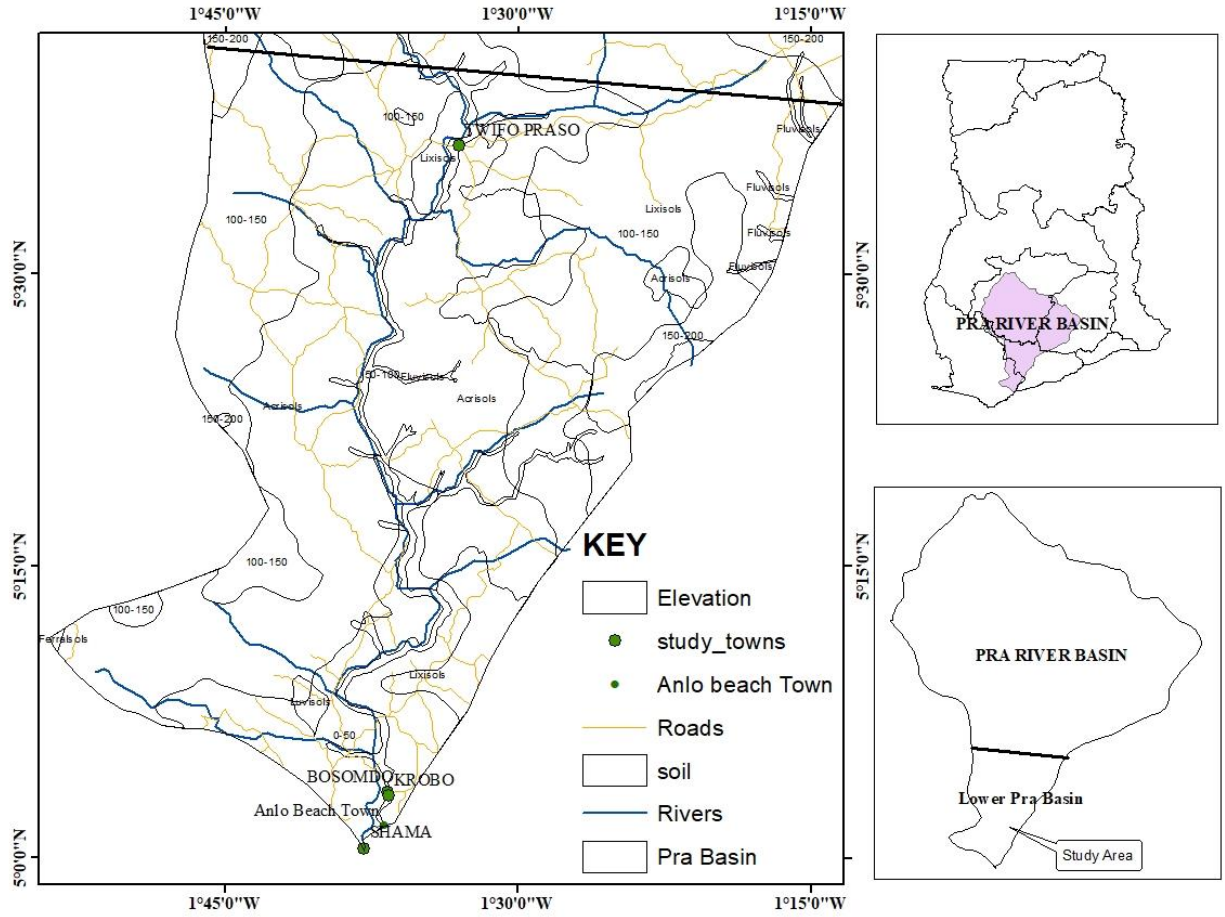


Figure 3.1: Map of Lower Pra Basin (Autors construct)

3.2 Research Design

The research adopted the case study technique. “Case studies investigate properties, actions, attitudes, and social structures of individuals, groups, or institutions by applying one or more methods, such as participant observation, interviews, and analysis of documents” (Thomas, 2011). Also, a case study is a design “that facilitates exploration of a phenomenon within its context using a variety of data sources” (Baxter & Jack, 2008). This was appropriate because the study required an in-depth investigation of the bank erosion and flooding, and their impact on livelihoods in the Lower Pra Basin. Construct validity is a major criticism in case study research because of the

potential researcher's subjectivity, but multiple sources of evidence were used to investigate both flooding and bank erosion to reduce this criticism.

3.3 Research Strategy

The research used the mixed methods approach. The mixed-method strategy, as noted by Creswell (2009), is a concept that involves the use of qualitative and quantitative method in a single research to provide better insight on the problem than either method alone. This consists of the use of both quantitative and qualitative design in conducting research. It was also explained by Teye (2012) that the quantitative methods stress the use of statistics for analytical purposes for generalization and prediction while the qualitative approach entails the experiences, perceptions, emotions, beliefs, and behaviours of respondents. The use of mixed method research helped to deal with the gaps identified in each of the approaches employed. By building on the strengths, acknowledging, and limiting the weaknesses of mixed methods research, flood and bank erosion issues regarding the Lower Pra Basin were addressed. Based on the mixed method used, convergent parallel design was applied during data collection and analysis to compare and relate the quantitative and qualitative data collected and analyzed. This helps to obtain a complete understanding of the two datasets.

3.4 Sampling Techniques

Purposive sampling was used to select the study towns and the respondents for the in-depth interviews. The total sample of 200 respondents was selected for the administering of the questionnaires using simple random sampling within the cluster of communities selected. The Assembly members and the Unit Committee members of the various communities assisted the use of simple random sampling by helping researcher to reach out the various households along the lower Pra basin. This helped us to get rid of human bias and provided samples that is highly

representative of the population. Simple random sampling was appropriate in selecting the 200 respondents because each household head had equal probability of selection for the study and because it was appropriate to make generalization about the larger group (Deperso, 2018). The study covered Four (4) study communities/towns along the lower basin of river Pra. These communities were Twifo Praso, Anlo Beach town, Bosombo Krobo, and Shama. These communities were selected based on the district location, their impact, and the socio-cultural attributes. The sample was chosen relatively based on the proportion of the household data at the lower basin from the Ghana Statistical Service. These qualitative and quantitative data that were taken from the sampled population were used to generalize the vulnerability and impact level of their exposure to flood and bank erosion (Babbie, 2010).

3.4.1 Sample Size

Not all the households were affected, but only those close to the river bank and the floodplain zone. Therefore, the sample size was derived from the Yamane (1967) formula.

$n= N/[1+N(e)^2]$

n - Sample size

N - total number of households

e - the level of precision

Therefore,

$n= N/[1+N(e)^2]$

N=6654, e=0.07,

$n= 6654/ [1+6654(0.07)^2$

n= 6654/ [1+6654(0.0049)

n= 6654/ [1+32.6046]

n= 6654/33.6046

n= 198 sample size.

After the computation of the sample size using the Yamane formula at the level of precision of 7% (0.07), a total sample of 198 was obtained but based on their response rate, 200 sample size was used and proportionally distributed among the various towns based on the 2010 household population data by the Ghana Statistical Service.

Table 3.1: Sample size for the various study communities.

No.	COMMUNITIES	HOUSEHOLDS	SAMPLE SIZE
1	TWIFO PRASO	3110	93
2	SHAMA	2646	80
3	ANLO BEACH TOWN	790	24
4	BOSOMDO KROBO	108	3
TOTAL		**6654**	**200**

This was only used to get a sample from household residents on the questionnaires and not the respondents for the interviews. Also, purposive sampling was used to select the district planners, NADMO officers and the Assembly members in the various communities and the districts for the interviews to be conducted.

3.5 Sources of Data

The research involved the collection of both primary and secondary data. The primary data was gathered from the in-depth interviews, administration of structured questionnaires, and direct field exploration by the researcher and digital photos. The secondary data sources were also acquired from topographical maps on the lower basin from the Ghana Survey Department, existing shapefiles on river Pra from the Center for Remote Sensing and Geographic Information Systems (CERSGIS), and remote sensing images. Also, the literature was gathered from articles, books, online, and others.

3.6 Data Collection

The field survey was undertaken using a structured questionnaire, interviews and observation and taking of photographs at the lower basin of the River Pra. Also, sets of Landsat imagery were downloaded from (earthexplorer.com) for three (3) respective years (2007,2015, 2018) including Digital Elevation Model (DEM) data of the lower Pra basin. Also, 1974 topographical map of Lower Pra basin was retrieved from the Ghana Survey Department.

Structured questionnaires were conducted with household heads who have lived in homes along the riparian region and have been resident there for not less than two decades. The rationale for the choice of these respondents is to get people who have experiences of how vulnerable they are to changes in bank erosion and flooding at the lower basin and how these processes impact on their livelihoods. The open and close information seemed to sought issues such as: the extent of bank erosion and its impact, flood situation in the area, and measures to prevent the situation.

In-depth interviews were also conducted with key stakeholders at the district level and the study towns at the lower basin of Pra River. These stakeholders were selected to expatiate on the people's vulnerability to flood hazards and bank erosion, impact on the people's livelihood, and propose some measures to curb these hazards. The interview used semi-structured interview guide (see appendix II and III) to get deep facts pertaining the research under studied. The stakeholders included the Two District Planning Officers of the affected districts (One per district), two NADMO officers for the districts, and the Assembly members (Four Members) from the areas of interest, on their experiences and the way forward.

Digital photographs were also taken during the field data collection at the lower basin to assist in the pictorial view of places with flooding and bank erosion impacts on livelihoods and to support the digitized bank lines of the various Landsat imageries extracted. This gave a vivid description to the problem understudy.

3.7 DATA ANALYSIS

3.7.1 Objective One (1)

Image preprocessing (gap fill, calibration, etc.) was performed on the satellite images to improve the reflectance of the image to be interpreted and to perform further analysis. The topographical map of 1974 was also scanned and georeferenced using the WGS84 datum to have a real-world coordinate [Map1{A(X=1°45′, Y=5°45′),B(X=1°30′, Y=5°45′), C(X=1°45′, Y=5°30′) D(X=1°30′, Y=5°30′); Map 2 {A(X=1°45′, Y=5°30′),B(X=1°30′, Y=5°30′),C(X=1°45′, Y=5°15′), D(X=1°30′, Y=5°15′); Map 3 {A(X=1°45′, Y=5°15′),B(X=1°30′, Y=5°15′),C(X=1°45′, Y=5°00′), and D(X=1°30′, Y=5°00′)] for it to be used for further analysis.

To determine the rate of erosion and fills, water shapefile was extracted from the 30×30 Landsat images (2007,2015, 2018) and the 1974 georeferenced topographical maps were digitized to generate the bank lines. After these processes, the various bank lines were superimposed on each other to estimate the change in the bank line for the study. Each area of the river for different years was calculated using their attributes to calculate the geometry of the rivers. The left and the right bank shift were also measured to know the direction of the erosion and siltation.

3.7.2 Objective Two (2), Three (3), and Four (4).

Digital Elevation Model (DEM) was used in the analysis considering the elevation at the lower basin and the nearness to the river. The DEM was processed in the ArcGIS software version 10.4.1 to derive the areas that are most floodable and areas that are less floodable. The result helped to predict flood-prone areas at the lower basin and their vulnerability level. The result generated from the DEM data was supported and explained by the response from the interviews and questionnaires on the people's exposure, susceptibility, and resilience to flooding at the riparian region.

The completed questionnaires from the field were sorted, collated based on the study communities, and were subjected to analysis.

Statistical Package for the Social Sciences (SPSS) was used to analyze the questionnaires that were answered by the people. The data was used to generate and compute various statistical analyses based on their responses and their experiences using frequencies, tables, percentages, pie or bar charts, and cross-tabulation derived from the data analyzed.

The in-depth interview was conducted with the key stakeholders. The interviews were then transcribed and themes were manually generated to support and explain the responses from the household heads. This was to help in the better understanding and analysis of the problems relating

to flooding and bank erosion, to deal with the impact of these disasters and improve on the inhabitant's resilience to these disasters.

3.8 Limitation of the Study

The researcher, during the process in this study, faced some challenges, more importantly, during the process of data collection. The challenges included materials, personnel, movements, and finance which did not allow the researcher to cover more areas within the three districts. Also, acquiring data from some of the targeted population in the study communities was a challenge. They were not willing to avail themselves and also did so reluctantly because they had been disappointed by stakeholders. Some officials from the targeted institutions were not willing to speak to the researcher on issues under study. But residents agreed to respond to my questions because I was a student and not from any agency like NADMO and District Planning department.

The study does not consider all the Pra river but only concentrated on the lower basin. Therefore, further studies can be undertaken at a higher level because it needs an amount of time to finish, which this research could not do, due to time restraint.

CHAPTER FOUR

RIVER BANKLINE CHANGES AT THE LOWER BASIN OF RIVER PRA

4.1 River Bankline changes at the lower basin of River Pra.

The result derived from the GIS processing using the different sets of Landsat images from 1974 to 2018 revealed from the figure that there had been yearly erosion and accretion for specific years and various cross-sectioned selected. On the map, multiple colours were used to represent riverbank of different years. The riverbanks indicated that there had been a significant change in the river basin from 1974 to 2018. As a result, cross-sections were picked on the riverbank to show both erosion and accretion at certain zones shown in Fig 4.2.

From figure 4.1, it can be observed that the overall bank of the lower Pra river has changed from 1974 to 2018. These changes are a result of the existing bank materials leading to lateral erosion and sedimentation that occurs within the river basin leading to changes in the river bank (Rahman et' al., 2015).

Table 4.1: Bankline Changes from 1974-2018.

YEARS	AREA	CHANGE
1974_BANKLINE	16.17516	
2007_BANKLINE	18.53238	2.35722
2015_BANKLINE	48.54912	30.01674
2018_BANKLINE	66.8808	18.33168

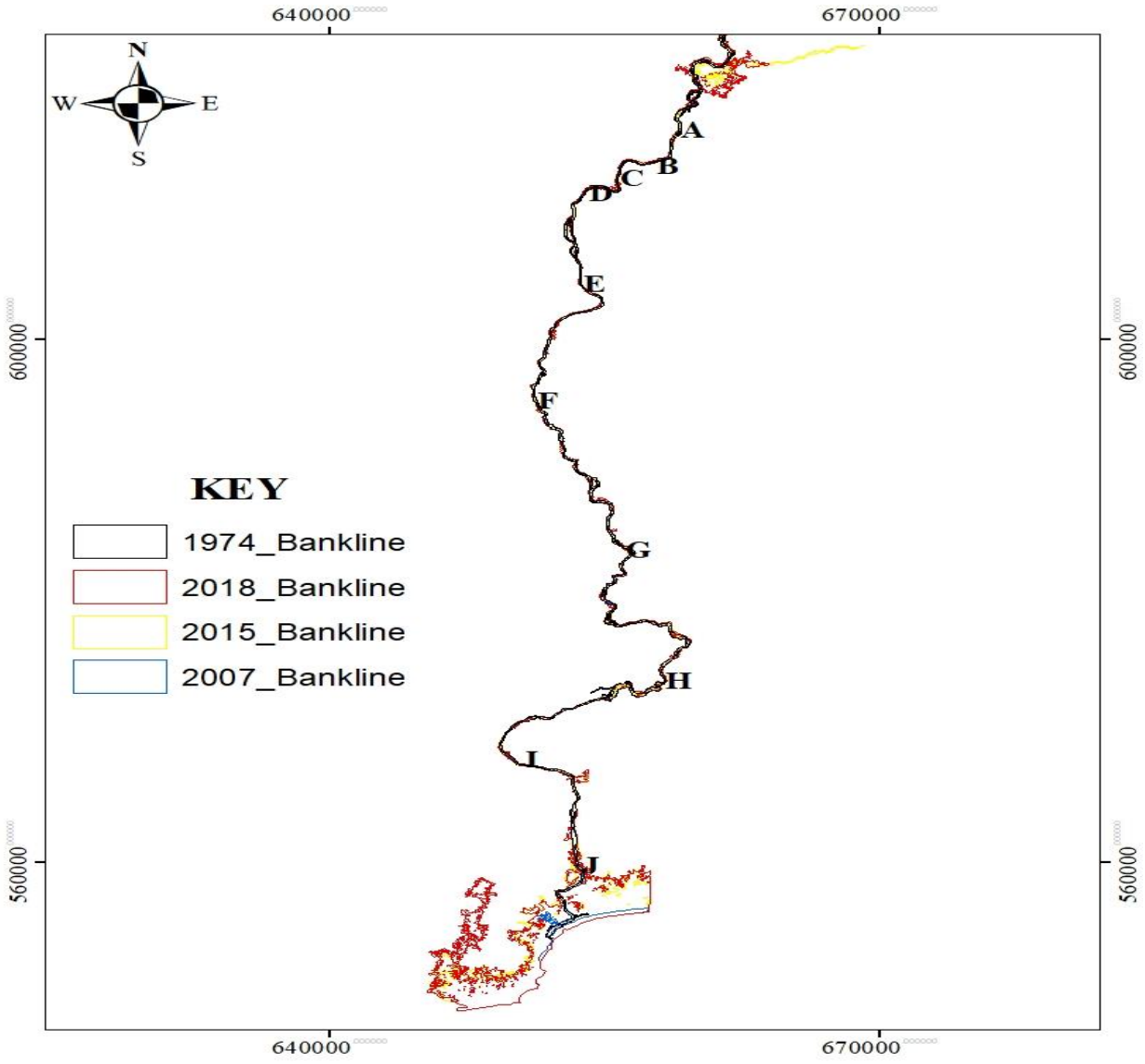


Figure 4.1: Bankline Changes of Lower Pra River.

Over the years, the Pra river has been shifted significantly. From 1974 to 2007, the river saw minimal change of 2.35722km but the river saw a remarkable shift from 2007 and 2015 of 30.01674km. This massive change was as a result of downstream migration of meanders in the basin lowering and increasing the bank height and angle thereby destabilizing the river bank, desilting and other human interventions for example, mining within the river basin and farming along the river basin. These changes were also as a result of the cutting of mangroves at the banks

exposing the bank to erosion. The issue related to Mangrove cutting at the lower basin was confirmed by the Assemblyman of Shama (Apo) that:

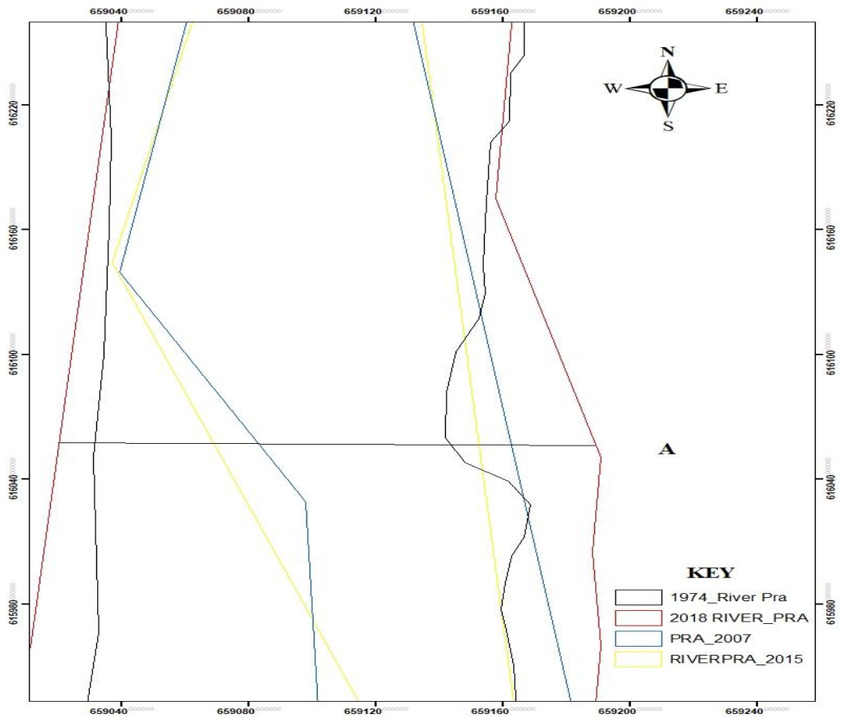
> *Residents cut the mangroves along the banks for their construction of buildings which leaves the banks bare for erosion.*

He also added that;

> *Residents could only cut mangroves along the Pra 50m away from the river because this mangrove support the soil at the bank from further erosion.*

From the result derived from the topographical map and the Landsat imageries for the various years, the overall area of the river has changed significantly from 16.17516km² in 1974 Bankline to 66.8808km² in 2018 Bankline as shown in Table 4.1.

Also, ten (10) cross-sections numbered from A to J was randomly picked on the extracted banklines shown in Figure 4.2 and Table 4.2 to determine the rate of change at specific points and also the direction (right and left bank) of the erosion and sedimentation. These are shown below.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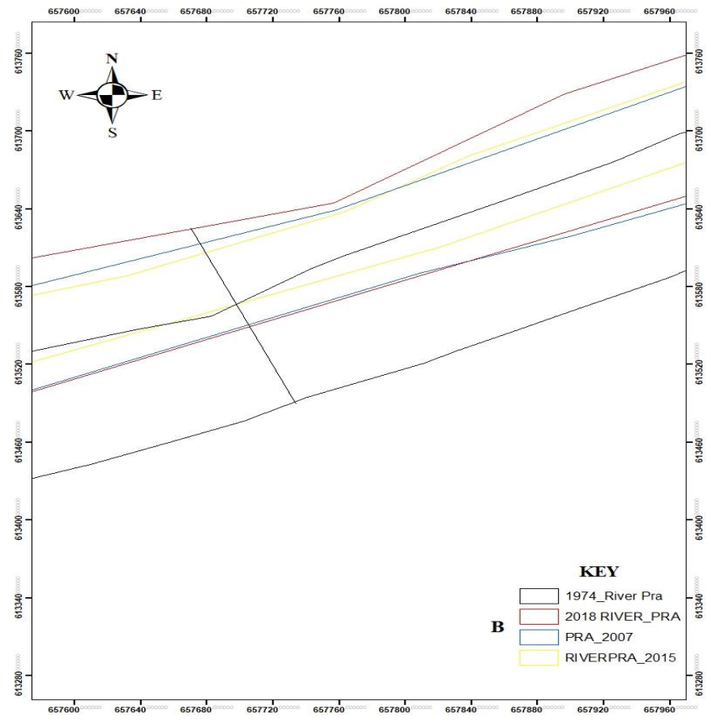
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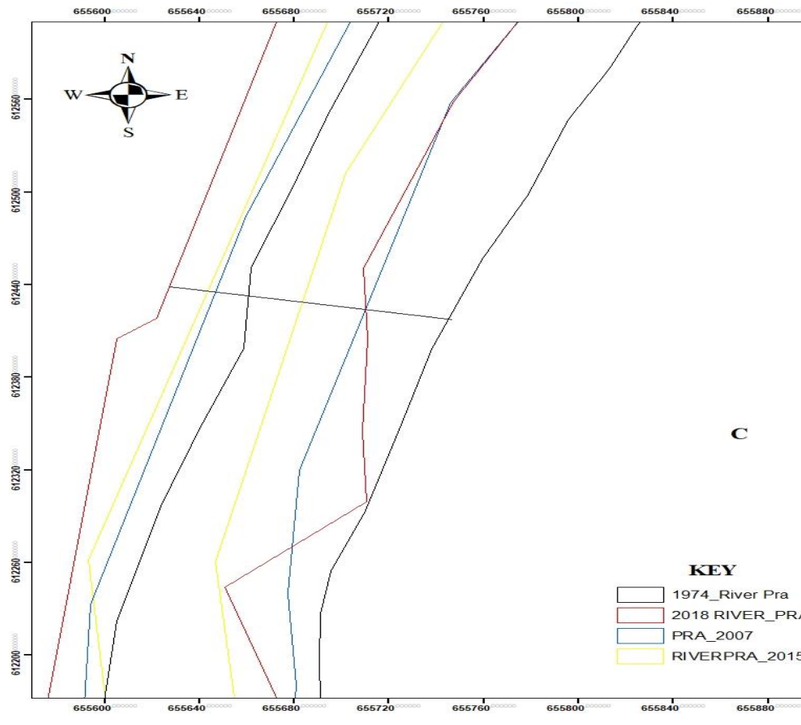
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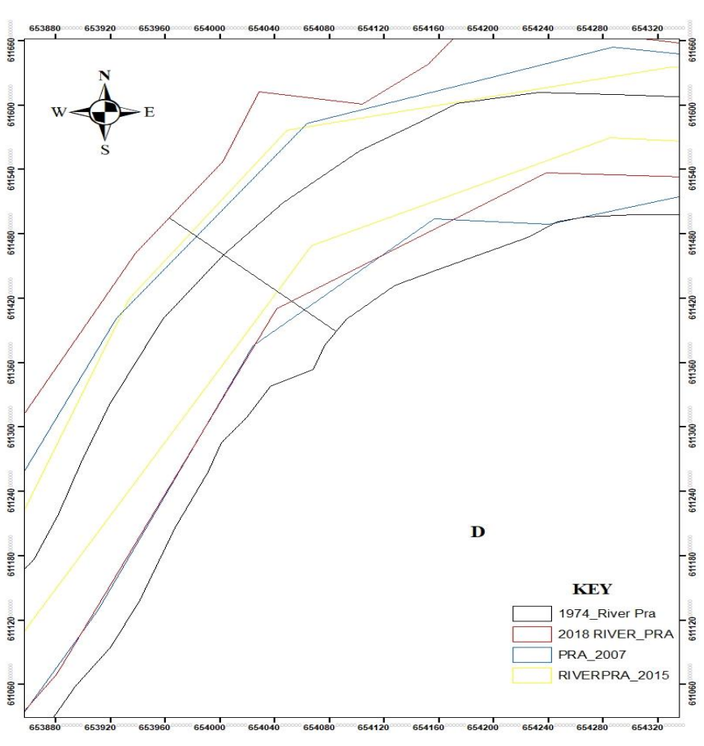
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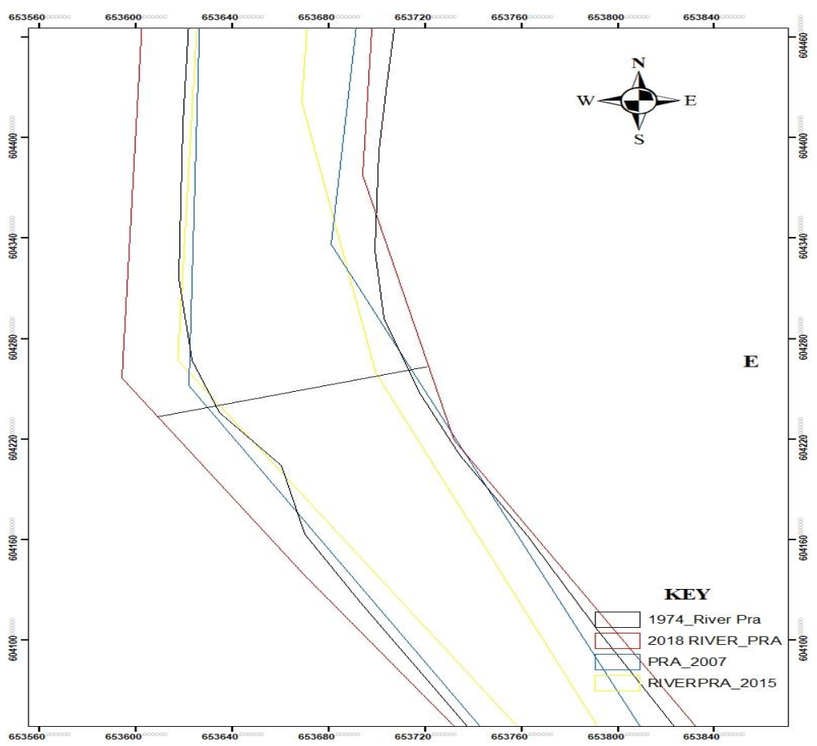
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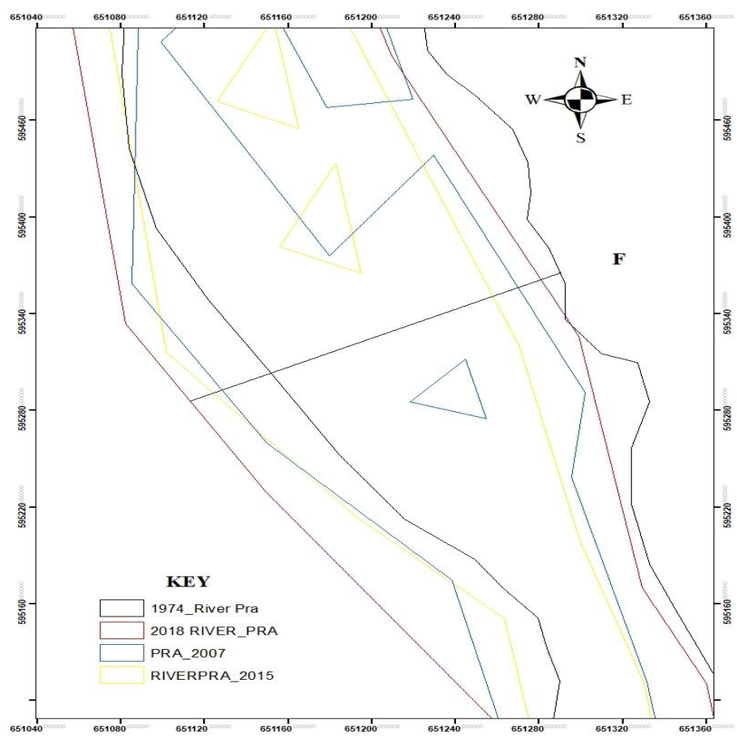
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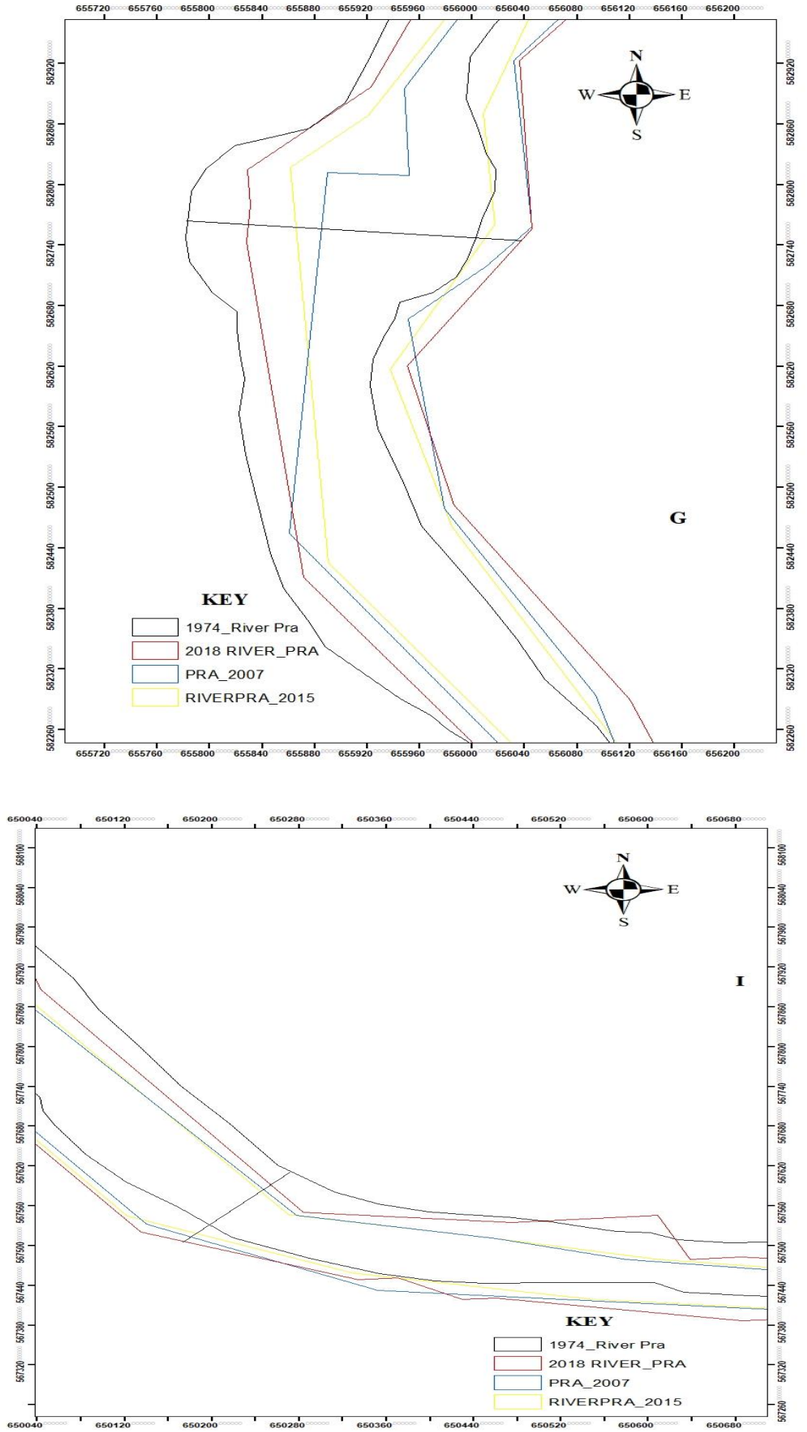

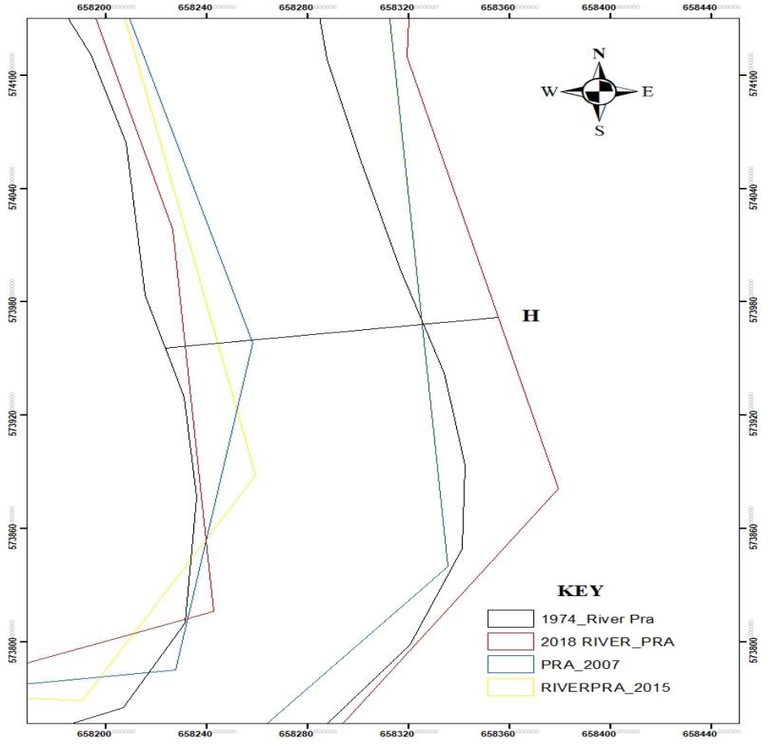

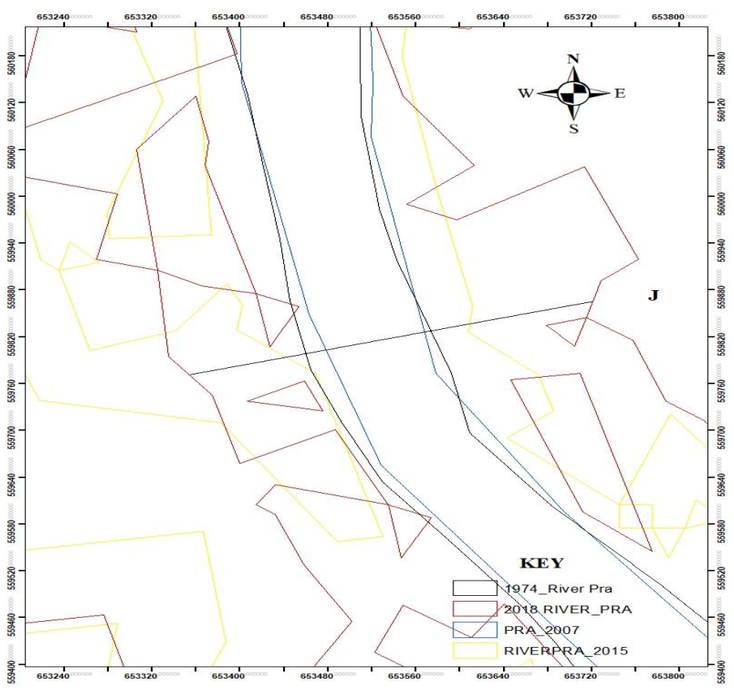

Figure 4.2: Cross Section on the Pra River.

Table 4.2: Shifting of the river along both banks of the river from 1974-2007 and 2007-2018.

CROSS-SECTIONS	RIGHT BANK (1974-2007)	LEFT BANK (1974-2007)	RIGHT BANK (2007-2018)	LEFT BANK (2007-2018)
A	-52.141	20.2567	62.5485	26.0899
B	51.8265	-65.974	12.4138	1.54946
C	14.0339	-35.739	19.1691	0.53373
D	26.3109	-31.129	26.403	-12.047
E	3.59153	1.42615	21.3904	7.26951
F	25.8794	-22.026	16.5122	12.1694
G	-101.92	32.7056	55.5571	4.41653
H	-34.773	0.8423	26.9589	30.1662
I	24.9668	-37.763	10.0994	10.0674
J	-18.843	-5.9012	128.456	156.182
TOTAL	-61.065	-143.3	379.508	236.397

The minus (-) sign means shift due to aggradation (inward shift) and the positive figures mean shift due to erosion (outward shift).

These cross-sections indicate that certain areas of the lower Pra have experienced erosion leading to the expansion of the river bank with certain areas also experiencing aggradation that is the deposition of sediments leading to the river shifting inwardly. For example, using 1974 as the base year, the entire right bank from 1974 to 2007 experienced deposition of sediments but certain areas (B, C, D, E, F, and I) had the bank eroding. Still, from 2007 to 2018 right bank, the results indicate massive erosion and these were mostly attributed to the river action and human activities such as Galamsey and farming shown in Table 5.1. From 1974 to 2007, there were accretion due to the existence of Mangrove and also less existence of Mining within the river. 2007 to 2018 saw massive erosion of the bank as a result of cutting of the mangroves at the banks thus reducing the shear strength of the river bank leading to erosion, and also human intervention such as mining within the river.

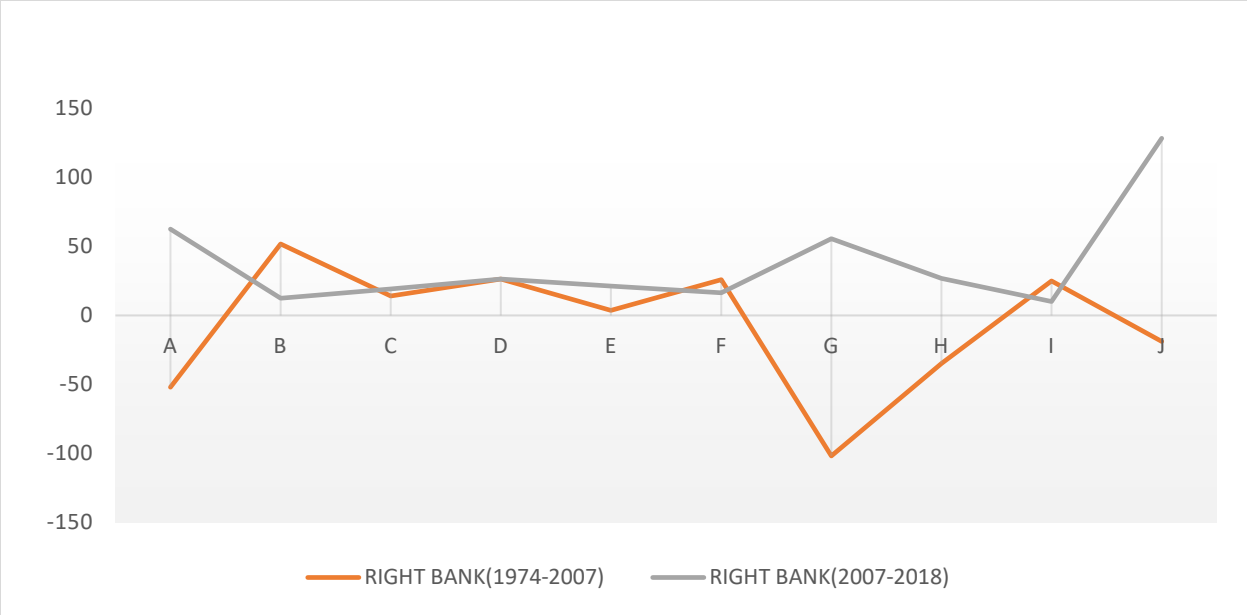

Figure 4.3: Graph showing the right Bankline shift from 1974-2018

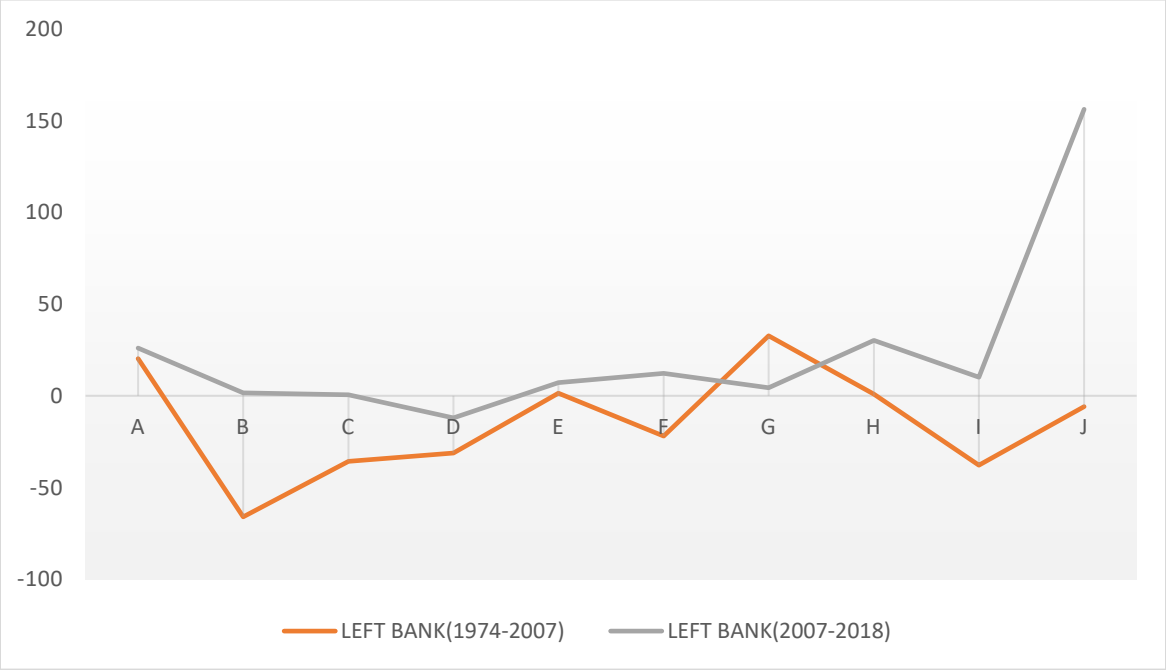

Figure 4.4: Graph showing the left Bankline shift from 1974-2018

From Fig 4.3 and 4.4, the highest erosion took place in the right bank along section B for 1974-2007 and J for 2007-2018. In total, the year's interval in the cross-section indicates that the river

bank shifted to the right than to the left. This implies that the river bank expands due to erosion of the bank and also decreases due to sedimentation within the basin. The study has revealed that the Lower Pra basin has grown from 1974 to 2018 by eroding its bank and entering some communities along the basin. These erosions of the banks are also attributed to the soil composition at the lower basin, as indicated in Fig 3.1. These types of soils are more erosive, especially the fluvisol and the lixisol.

Figure 4.5: Riverbank Erosion at Krobo and Bosomdo.

Field survey, 2019.

Figure 4.5 above visualizes the extent of bank erosion at the lower basin, specifically Krobo and Bosomdo all within the Shama Area.

In conclusion, from the analysis, it has been established that river erosion was very strong and active in the zone, thereby changing the riverbank in the area. The total land change within the river basin was about 50.70562 km² showing the total loss of land within the period 1974 to 2018. This implies that the river will continually change within the river basin therefore there should be mechanisms to help reduce the erosion and the impact that will affects the livelihoods of people at the lower Basin of the Pra river.

CHAPTER FIVE

VULNERABILITY OF THE PEOPLE AT THE LOWER BASIN OF RIVER PRA

5.1 Introduction

Understanding the vulnerabilities of people to river processes combines risk factors associated with the physical, social, and economic viability and the ability of the people to cope and recover from the hazardous events. Vulnerabilities are mostly regulated and impelled by physical factors (Hu et' al, 2017).

5.2 Socio-Demographic Characteristics

5.2.1 Introduction

The analysis starts with an understanding of the demographic data of the respondents. These demographic data include sex, age, marital status, number of households of the respondents, level of education, and occupation. Research has indicated that relationship exists between demographic characteristics of the people and their views, perceptions, and ideas about a phenomenon (Cantiello et al., 2015). Therefore, it is very relevant to assess the essential characteristics and background of the respondents to the study.

5.2.2 Sex Distribution

With the sex distribution, it was very significant to know the differential views based on respondents' experiences and ideas. The males represented 77.5 per cent of the respondent's whiles 22.5 per cent represented females shown in Table 5.1. The higher proportion of males is because the study targeted heads of households for the collection of data, and men are seen as heads and decision-makers in the Akan tradition. Akan's predominantly inhabit the study area. This,

however, does not mean that some of the household heads were not females. In the absence of household heads, any representative of the household was engaged.

Table 5.1 Sex Distribution

Sex	Frequency	Percentages
Male	155	77.5
Female	45	22.5
Total	200	100

Field data, 2019.

5.2.3 Age distribution

With regards to age, the study revealed that 30-40 range recorded the highest percentage of (37.0%) of the total respondent age followed by 41-50 (30.5%) with 51-60 representing 18.0 per cent and finally those between the ages of 61 and above representing 14.5%. The research was interested in household heads who have experiences of the hazards under study area and the category of the various ages indicates that. It was, therefore, essential to look at respondents age data because age groups help us to know the various age group and their vulnerability level to natural hazards based on their physical condition, experience, and financial status (Donner & Rodruguez, 2010)

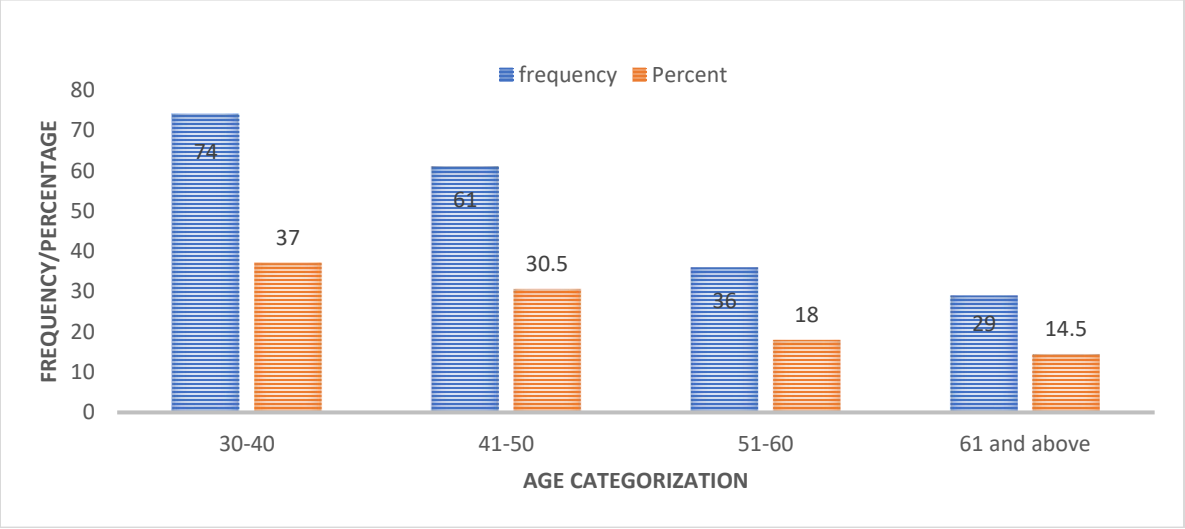

Figure 5.1: Age Distribution
Field data, 2019.

5.2.4 Marital status

With respect to the marital status of the respondents from Fig 5.2, most of the respondents were married representing (89%) of the total respondents. Four (4) per cent of the respondents were both widowed and single and 3 per cent divorced. This explains why the study was focusing on households which mostly consist of couples. Also, the high percentage of the married respondents can be as a result their tradition that encourages early marriage, which does not encourage them to educate to the higher level as shown in Figure 5.3.

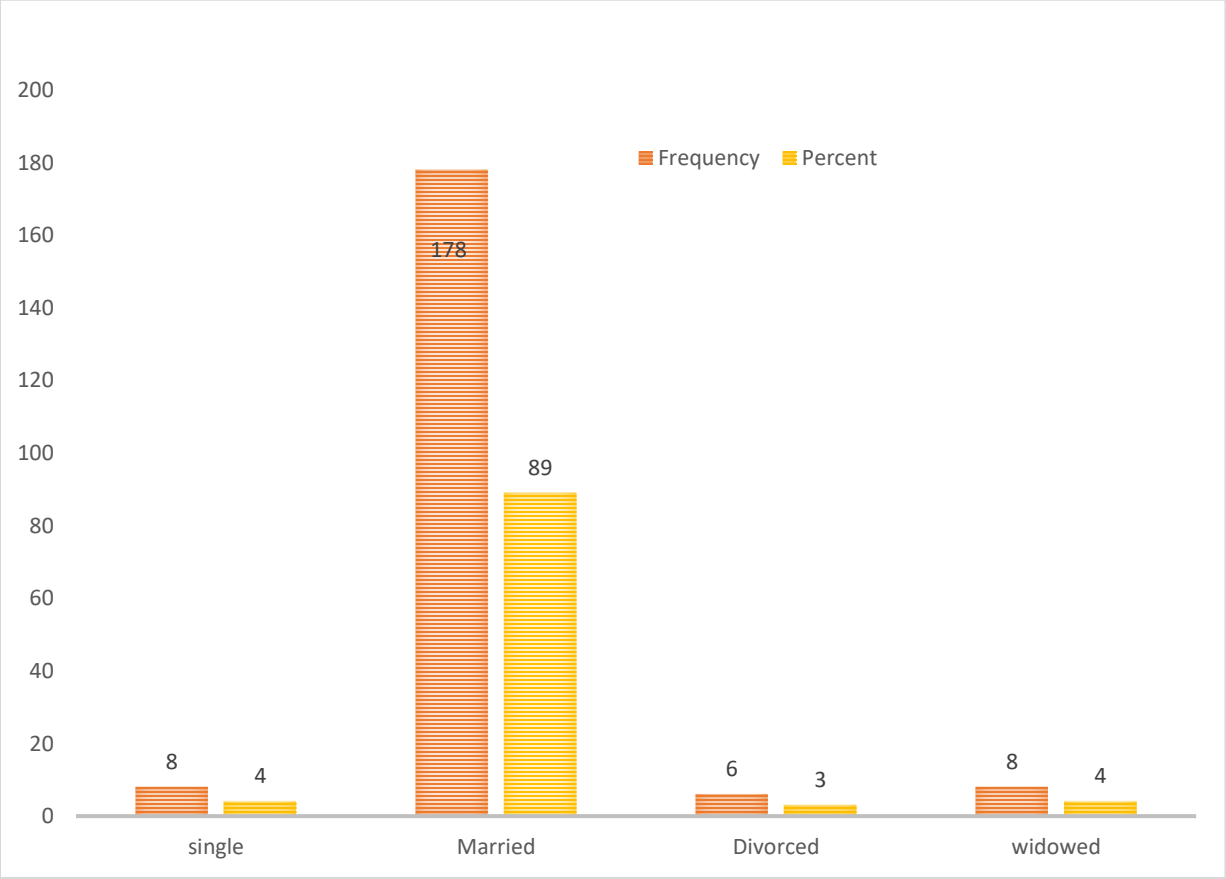

Figure 5.2: Marital Status
Field Data, 2019.

5.2.5 Educational background

The educational background of the respondents was investigated. From figure 5.3, most of the respondents have attained basic education (47%), which is, primary and Junior high school. (26.0%) of the respondents had no formal education, (22.5%) and (4.5%) had secondary and tertiary, respectively. Considering sex and education, the study showed no woman attained tertiary education with the men dominating the educational background because women are seen as managers of the home. This is in line with GSS (2010) that the majority of residents within this zone have obtained basic education.

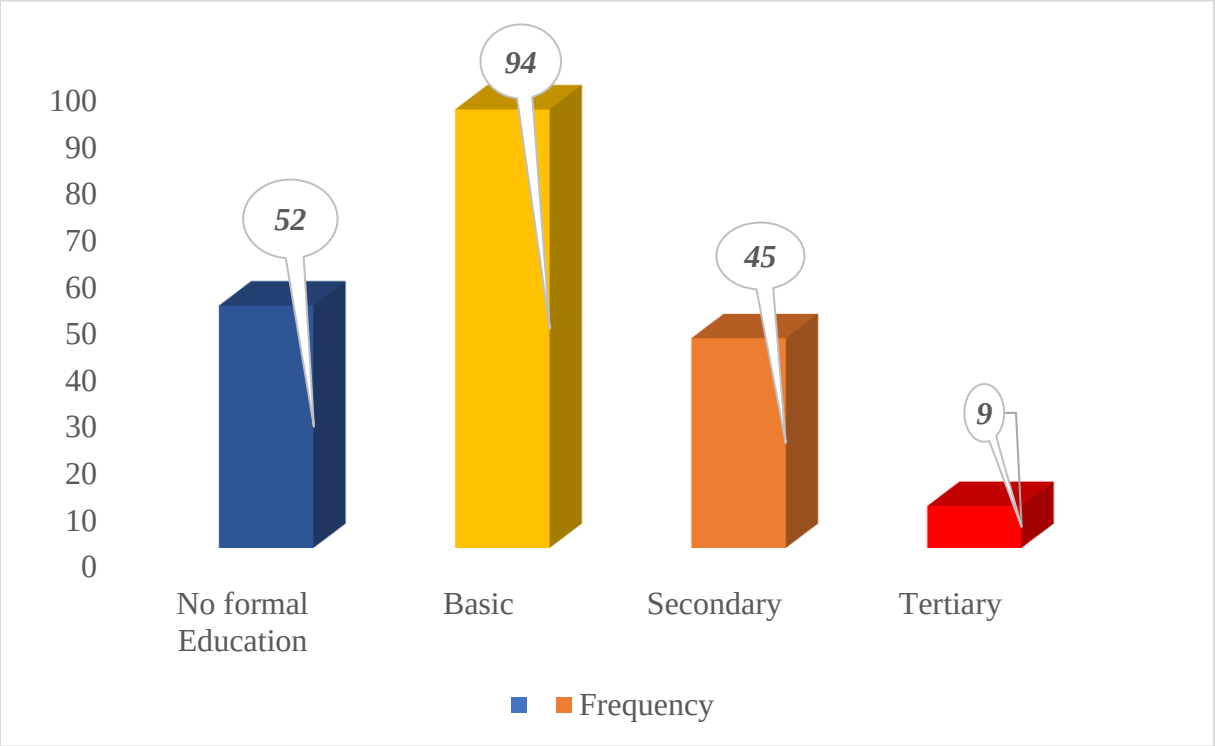

Figure 5.3: Educational Background
Field Data, 2019.

5.2.6 Occupation

Table 5.2: Occupation of Respondents

Occupation	Frequency	Percentage (%)
Fishing	51	25.5
Civil Servant	11	5.5
Farming	63	31.5
Trading	29	14.5
Craft and other related jobs	35	17.5
Unemployed	10	5.0
Retired	1	.5
Total	200	100.0

Field Data, 2019.

Concerning occupation of the respondents, the more significant portion of the respondents are farmers with 31.5 per cent. This is followed by fishing which comprises of fishers and fishmongers representing 25.5 per cent, 17.5 per cent are craft and other related jobs like drivers, maisons, mechanics and others, and 14.5 of the respondents are into trading. Also, 5 per cent are unemployed, 5.5 per cent being in the civil service with pensioners having the lower percentage representing (0.5%). Respondents in public service had only 5.5 per cent of the total respondents, and this is attributed to the educational background of the respondents. Furthermore, most of the communities along the Lower Pra basin are rural folks, and agriculture is the primary occupation for the rural settlers; that is why farming and fishing had more significant percentages.

The occupational distribution among the communities varies. Therefore, cross-tabulation was used to identify the spatial variation of the communities to their occupation. From the cross-tabulation below in Table 5.3, Twifo Praso (73%) had most of the respondents into farming whiles Shama (64%), and Anlo-Beach Town (34%) are dominated with fishing in both the river and the sea.

Table 5.3: Cross-tabulation for Study Towns and Occupation

	Community			
Occupation	Twifo Praso	Shama	Anlo Beach Town	Bosomdo Krobo
Fishing	(3.9%)	(64.7%)	(31.4%)	(0.0%)
Civil Servant	(27.2%)	(45.5.%)	(27.3%)	(0.0%)
Farming	(73.0)	(20.6%)	(1.6%)	(4.8%)
Trading	(58.6%)	(37.9%)	(3.4%)	(0.0%)
Craft and other related trade	(51.4%)	(42.9%)	(5.7%)	(0.0%)
Unemployed	(70%)	(30.0%)	(0.0%)	(0.0%)
Retired	(0.0%)	(0%)	(100%)	(0.0%)

Field Data, 2019.

It is only Anlo Beach Town that had retired person in the study area. Table 5.3 above affirms the fact by (GSS Shama, 2010) that the major occupation of people living along the riparian region of the lower Pra is farming and fishing.

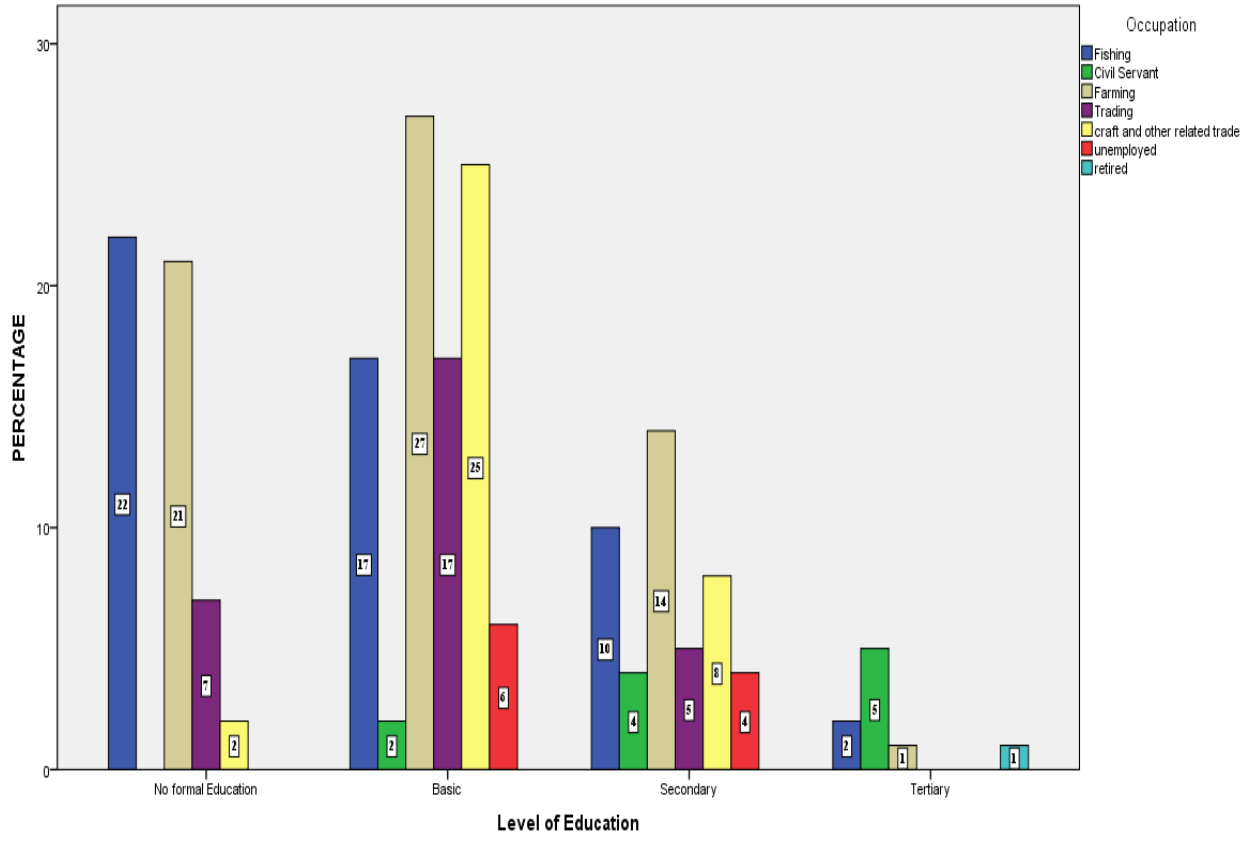

Fig 5.4: Cross-tabulation for Level of Education and Occupation

The figure 5.4 shows cross tabulation between the educational background and the occupation of respondents. This was important to determine their livelihood impact to these hazards. The results show that people with no formal education engages in fishing and farming along the lower Pra. Similarly, those with basic education were also engaging in more of farming, fishing and trading and craft works at the mouth of the river. The 2% and 4% respondents with basic and secondary education respectively were into civil service as teachers in the private schools.

Also, to those who had gained tertiary education, majority were into civil service with small portion engaging in fishing and farming concurrently. This result thus affirms the position that higher education level indeed increases individual opportunity of securing a higher decent job with motivation.

The relatively large respondents which engages in farming and fishing based on their low academic background exposes respondents highly to the shocks of flooding and bank erosion which affects their livelihood assets such as their financial, social and physical capital and subsequently affecting their livelihoods.

5.2.7 Household Composition

Table 5.4: Household composition of the respondents

Number of Households	Frequency	Percentages (%)
1-5	67	33.5
6-10	112	56.0
11-15	14	7.0
16-20	4	2.0
21 and above	3	1.5
Total	200	100.0

Field data, 2019.

Lastly, the household composition is also considered an element in the demographic data. From table 4.5, the households with between 1-5 persons represented 33.5 per cent, and 6-10 persons constituted 56 per cent which represents the highest percentage of the total respondent. A

household with 11-15 persons constitute 7 per cent while those 16-20 persons and 21 and above persons represent (2%) and (1.5%) respectively. The data implies that households along the lower Pra basin consist more of 6 persons per household than those less than six persons per household suggesting that more people are exposed to the hazards of both flooding and bank erosion.

Indeed, the size and composition of the family have been said to be a key factor determining the capabilities, options, and coping strategies available to its members to overcome flooding and bank erosion and any other hazards in their environment (Rakodi, 2002).

5.3 Flood vulnerability using GIS

Geographic information system (GIS) was used to analyze the vulnerability of the people settling at the Lower basin of river Pra. Digital Elevation Model (DEM) was used in the analysis considering the elevation they are at the lower basin and the nearness to the river. The DEM was processed in the ArcGIS to derive the areas that are most floodable (highly vulnerable) and areas that are less floodable (less vulnerable). From the output, it indicates that all areas shown in red are more floodable areas with the yellow showing less floodable areas. Areas within the more floodable zone seem to be having a high vulnerability to flooding at the lower basin.

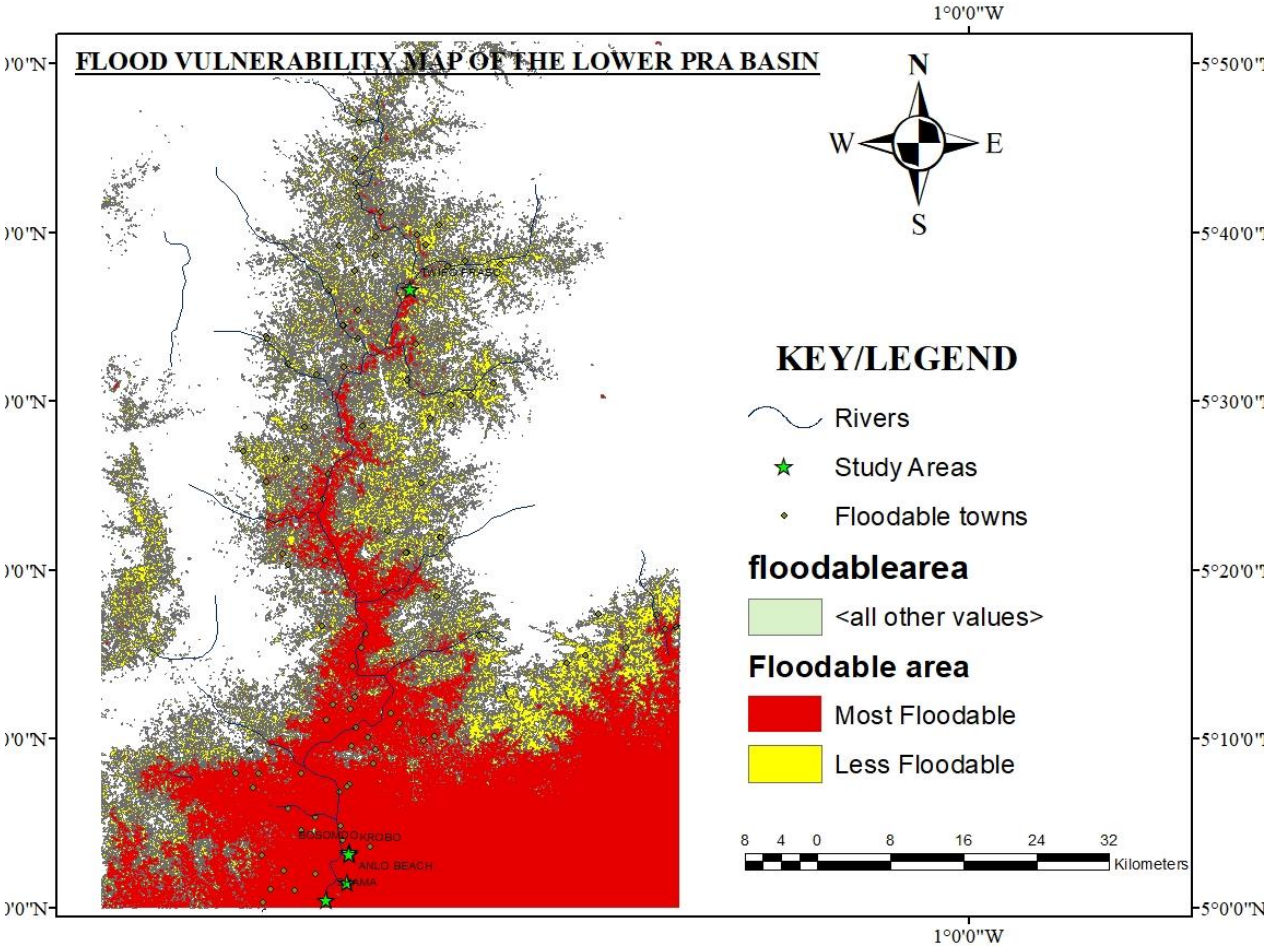

Figure 5.4: Flood Vulnerability Map at the Lower Pra basin

The map was produced using two classes [Most floodable (highly vulnerable) and less floodable (Less Vulnerable)]. The output map indicates that 64.2% of the lower basin of the Pra River is classified into highly vulnerable with 35.8% of the study area being less vulnerable. Most of the residence in the study area is vulnerable to flooding because the area exhibits low elevation as indicated in Figure 3.1, that is the average elevation of the Lower basin is between 0-150m and is very close to the river. The less vulnerable areas are areas that are considered to be located at a high elevation, which prevents the area from flooding. After overlaying all the study towns on the flood vulnerability map, it indicated that they are all within the region of most floodable, which indicates they are highly vulnerable to flooding. This finding supports Hu et' al, (2017) study on

bank erosion which states that, elevation and slope have a significant influence on spatial flood vulnerability assessment where low and plain areas with gentle slope are more vulnerable to flood than those with a high elevation and steep slope.

According to the Prevention Consortium (2007) in other to consider people's vulnerability, you have to examine their exposure, resistance, or susceptibility and resilience to be able to anticipate their vulnerability level. Therefore, these elements from the outcome of the GIS result were used to support and explain the people's vulnerability to flooding and bank erosion at the lower basin of River Pra.

5.4 Exposure of residents to flooding and bank erosion

In considering the resident's vulnerability to flooding and bank erosion, their exposure was considered. The exposure of residents at the lower basin of river Pra was assessed based on the number of years residents have lived there, the causes of the incidents, materials used in building their structures and their degree of exposure to both flooding and bank erosion.

The study revealed that majority of respondents (83 respondents-41.5%) had lived there more than 20 years with 21 per cent, 24.5 per cent, and 13 per cent representing 16-20 years, 11-15 years, and 6-10 years respectively. This means that majority have lived for more than two (2) decades and they have a lot of experience when it comes to flooding and bank erosion at the lower basin.

Table 5.5: Exposure of resident to bank erosion

EXPOSURE TO BANK EROSION	FREQUENCY	PERCENTAGES
How long have you lived here		
6-10 years	26	13
11-15 years	49	24.5
16-20 years	42	21
21 and above	83	41.5
Observation of bank erosion		
Yes	178	89
No	22	11
Extent of bank erosion		
Low extent	23	12.9
Moderate extent	43	24.2
Great extent	112	62.9
Causes of the river bank erosion		
River Action	131	65.5
Human Activities	75	37.5
Not known	4	4

Field Data, 2019.

Based on the years lived by residents at the lower basin as indicated in Table 5.5, 89 per cent of the respondents revealed that they had observed river bank erosion at the lower basin with only 11 per cent indicating they have not seen any change in the riverbank. From the 89 per cent of respondents, 62.9 per cent revealed that the extent of erosion was great, 24.2 per cent said moderate extent with (12.9%) indicating the low extent of bank erosion at the lower basin of Pra. The majority of the respondents attributed the extent of erosion to river action (65.5%) with (37.5%) indicating it's as a result of human activities like farming, sand mining along the riverbank, galamsey activities, and others. Only 8% stated that they had no idea of the extent of erosion at the river bank. This is in conjunction with Swarup (2013), who indicated that channel widening is as a result of the river action within its confined zone and the land use pattern of the occupants along basins are the primary cause of the magnitude, extent, and frequency of riverbank erosion of rivers.

Based on these elements of bank erosion exposure, 56.5% of the respondents attested to the fact that they are highly exposed to bank erosion at the lower basin with 20.5% stating that they are moderately exposed and only 13.5% having little exposure to bank erosion in the study area.

Table 5.6: Exposure of residents to flooding

EXPOSURE TO FLOODING	FREQUENCY	PERCENTAGES
Experience to flooding		
Yes	200	100
No	0	0
Degree of exposure to flooding		
Severe	181	90.5
Moderate	16	8
Low	3	1.5
Causes of river flood		
River Action	167	83.5
Silted river channel	42	21
Building along the river channel	35	17.5
Other human activities	28	14
No idea	6	3

Field Data, 2019.

In relation to the respondents' exposure to flooding at the lower basin, as indicated in Table 5.6, all the respondents attested to the fact that they have experienced flooding in the study region. 90.5 per cent indicated that they are highly exposed to the hazard with only 8 per cent and 1.5 per cent representing moderately and low exposure to flooding respectively at the lower basin of Pra river. They attributed the severity of the exposure of the flooding to the river action (60.1%), silted river channel (15.1%), building along the river basin (12.6%), and other human activities (10.1%) like farming and Galamsey in the river basin. Only 2.1 per cent indicated that they had no idea about the cause of the people's exposure to flooding at the lower basin of the Pra river.

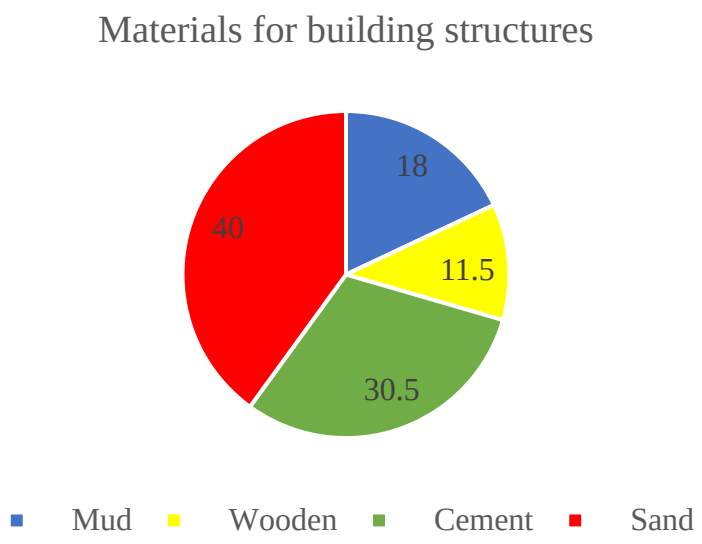

Figure 5.5: Materials for Building structures

The study also revealed that the majority of the respondents used sand in the building (40%) with 13 per cent and 11.5 per cent using both mud and wood respectively in the construction of their structures. Only 30.5% used blocks of cement in constructing their building. These materials used in the building of the structures expose the residence to the hazard of flooding and bank erosion in the area leading to the destruction of the structures. This assertion of materials exposing residents to flood casualties was confirmed by the Assemblyman of Twifo-Twansukoda thus:

> *"There was a massive collapse of the mud houses in the areas leaving the blockhouses. And the river has taken over our cocoa farms but as for oil palm tree, it highly resists the flood".*

Also based on the type of livelihood engaged in by respondents at the lower basin namely settlements, farming, fishing, and education, responses indicate that the livelihoods severely (70%) expose them to flooding and bank erosion with 26% moderately affected and only 4% having low exposure of their livelihood to flooding and bank erosion. The household responses revealed that

they had no maps or data regarding bank erosion and flooding in the area before settling there and that largely exposes them.

Table 5.7: Exposure of residents based on livelihoods

EXPOSURE BASED ON LIVELIHOOD	FREQUENCY	PERCENTAGES
Household Livelihood		
Farming	104	52
Fishing	95	47.5
Education	1	0.5
Livelihoods exposure to these hazards		
Severe	140	70
Moderate	52	26
Low	8	4
Any map or data before settling there		
Yes	1	0.5
No	199	99.5
The motivation for settling at the Lower Basin		
Livelihood	114	57.3
Family reason	66	33.2
Financial problem	19	9.5

Field Data, 2019.

In furtherance to residents' exposure to flooding and bank erosion on livelihoods shown in Table 5.7, they revealed that their livelihood (57%) that they engage in, family reasons (33%), and financial problem (9.5%) are the underlying factors for their settling there, which exposes them to the hazard of flooding and bank erosion.

The various responses from the residents indicate that they are highly exposed to both flooding, and bank erosion hazards since their major livelihood along the basin is farming which involve the cultivation of cassava, maize, rice and other cash crops like cocoa, and fishing. Also, the type of materials (sand) used in constructing their structures along the basin exposes residents during any overflow of the river, putting the entire household in danger. In addition, the kind of human

activities like mining and sand wining that they engage in exposes them to the negative impact of both flooding and bank erosion. The findings corroborate the view of Penning-Rowsell et al. 2005 that population group is exposed to flooding when their assets like property, infrastructure, and cultural heritage are struck by flooding.

5.5 Susceptibility of residents to flooding and bank erosion

The susceptibility of residents was also assessed based on the residents land acquisition, stakeholders' awareness and community protective measures taken before the occurrence of both flooding and bank erosion.

Table 5.8 Susceptibility to land acquisition

SUSCEPTIBILITY TO LAND ACQUISITION	FREQUENCY	PERCENTAGES (%)
Acquisition of the land		
Chief	100	50
Friends	13	6.5
Family members	87	43.5
Flood and bank erosion awareness before acquiring the land		
Yes	17	8.5
No	182	91.5
If yes, reason for acquiring the land		
Family	5	29.4
Livelihood	10	58.8
Nothing	2	11.8

Field Data, 2019

Inquiries were made on how they acquire the land as indicated in table 5.8, and 50 per cent of the respondents indicated that they had it from the chiefs or the traditional leaders. Again, 43.5 per cent attested to the fact that they acquired it from their family members with only 6.5 per cent revealing that they got the lands from their friends. Looking at the respondents' awareness of flooding and bank erosion in the area, the results indicated in table 5.8 that only (8.5%) said they were aware of flooding and bank erosion, but 91.5 per cent revealed they were not aware of these

hazards before settling there. Those who had no awareness claimed that they acquired their land because of their family (29.4%), livelihoods (58.8%) and 11.8 per cent said no idea to that effect.

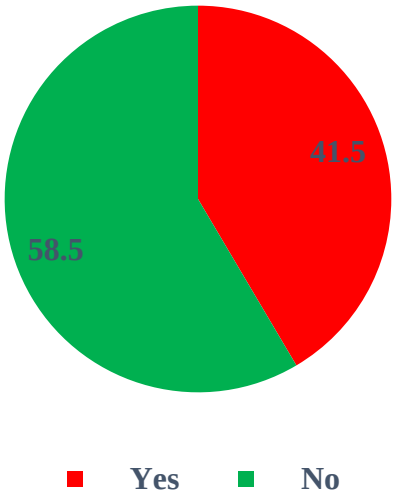

Figure 5.6: Stakeholders awareness to residents

The majority of the respondents (58.5%) stated they had no flood awareness from NADMO/Ghana Meteorological Services before settling at the lower basin whiles (41.5%) indicated that they were aware of the occurrence of flood at the lower basin. Residents with no flood awareness revealed that the occurrence of flood in the year 2007 proved to them that the area is flood prone but they had settled already

Table 5.9 Susceptibility by household and communities

SUSCEPTIBILITY BY HOUSEHOLD AND COMMUNITIES	FREQUENCY	PERCENTAGES (%)
Household activities during flooding and Bank erosion		
Nothing	47	23.5
Evacuate	121	60.5
Leave before the hazards	32	16
If evacuate, where do you go		
Classroom	25	20.7
Friends in nearby towns	32	26.4

Families in nearby towns	64	52.9
Provision of protective measures by communities		
Yes	30	15
No	170	85
If Yes, protective measure		
Dyke	1	3.3
Desilting	19	66.7
Buffer regulations	1	3.3
Provision of basic needs	3	10.0
Education	3	10.0
Rituals	2	6.7
If No, measure communities need		
Desilting of river	21	12.4
Relocation	58	34.1
Proper drains	11	6.5
Performing regular rituals	12	7.0
Provision of river defence	35	20.6
No idea	33	19.4
Degree of susceptibility		
Severe	151	75.5
Moderate	43	21.5
Low	6	3

Field Data, 2019.

As a result, during flooding, most of them evacuate to classrooms, friends in nearby towns on higher elevation and families in the towns around them. Based on the experience of some residents, (16%) of the respondents stated they leave before flooding and 23.5 per cent indicated that they had no place to go, so they stay around till the floodwaters go down.

To their likelihood of being affected, the majority of the respondents (85%) stated that they had no protective measures, with only 15% indicating they had some protective measures in their communities. Those who indicated they had protective measures revealed that the communities provided measures like provision of basic needs, education on flooding, and performance of rituals to the river Pra. The majority of the respondents who said they had no protective measures proposed that their communities need measures like dredging the river channel, relocation of residents to "safe havens". Furthermore, providing good drainage systems linking the communities to the river, performing regular rituals at the Pra to reduce regular flooding at the area, and

provision of river defense to reduce the incidence of flooding and bank erosion. Only a small (11.5%) proportion of the respondents stated they had no idea of any measures to curb these hazards.

The results indicate that majority of the respondents consider their susceptibility to both flooding and bank erosion to be severe (75.5%) with 21.5 per cent indicating that they are moderately susceptible and only 3 per cent having a low susceptibility to these hazards. This means that their likelihood of being affected by these hazards is very high. Respondents' opinions which indicate they are susceptible to flooding and bank erosion unifies with Balica & Wright (2010) that people are susceptible when their social values, economic values, building structures and people in a flood-prone region are likely to be harmed by flood hazards.

5.6 Resilience of residents to flooding and bank erosion

According to EEA (2017), resilience is “the ability of a system, community or society exposed to hazard to resist, absorb, accommodate, adapt to, transform and recover from the effect of the hazard in a timely and efficient manner, including the preservation and restoration of essential basic structures and functions through risk management”. Therefore, to understand the resident’s resilience to these hazards, communities were assessed on their resilience level to flooding and bank erosion and to know how they resist these existing hazards. The resilience was evaluated based on their experience of these hazards, how they recover from the hazards, and the help they acquire from the government through NADMO.

Based on their experiences in bank erosion at the lower basin shown in Table 5.10, most of the respondents (91.5%) responded that they have experiences with the river bank erosion with only 8.5 per cent of the respondents declining that they have less or no experience to bank erosion at

the lower basin. They explained that the river had got closer to them as compared to when they settled, which sometimes leads to the collapse of certain structures.

Table 5.10 Resilience based on experience

RESILIENCE BASED ON EXPERIENCE	**FREQUENCY**	**PERCENTAGE**
Bank erosion experience		
Yes	183	91.5
No	17	8.5
What household does to reduce the risk of bank erosion		
Relocate	8	4.4
Parking of belonging and go	2	1.1
Nothing	173	94.5
Flooding experience		
Yes	200	100
No	0	0
Reducing risk of flooding through experience		
Relocate and come back	58	29.1
Dredging of rivers	4	2
Able to predict and relocate	24	12.1
Creating gutters along with our household	8	4
Nothing	105	52.8

Field data, 2019

Respondents further revealed that their experience has helped reduce bank erosion hazard but most of the respondents (86%) indicated that they do nothing to reduce the hazard of bank erosion. This is because they see bank eroion as a natural process. Only 5 per cent of the respondents indicate they park their belongings and relocate to settle at a different area of high elevation.

Furthermore, in flooding experience, all respondents attested to the fact that they have experienced flooding in the area. But based on their experience, the majority (52.5%) of the respondents have still done nothing to help increase their resilience to flood hazard with 29 per cent of the respondents indicating that they relocate and come back later. Twelve per cent revealed that based

on their experience, they could predict and relocate even before the occurrence of the flood, 4 per cent also revealed that they had constructed gutters along their household that can hold water during a flood. Only (2%) indicated that rivers adjoining the river Pra are dredged sometimes so that anytime the Pra increases in its volume, the tributaries will be able to hold the water to reduce the intensity of flooding occurring in the area.

The study also inquired on how respondents get prepared before and during flooding shown in Table 5.11. And it was revealed that 90.5 per cent of the respondents prepare to move to areas of high elevation and return after the flood, with only 5.5 per cent of the respondents indicating that they have nothing to do so they just adjust to the flood till the water goes down for them to go through the recovery of their items. Only 3 per cent indicate that foods are being stored before floods occur to help them deal with hunger during and after flooding. From their preparation against the flood hazard, 86.5 per cent of the respondents revealed that it is very difficult for their households to recover quickly from the flood incident. This is because the flood causes loss of properties and infrastructure, which makes it more difficult for residents to recover from their loss. The 12.5percent who indicated that they recover quickly after flood explained that most of their items are kept on tables in their rooms during flooding, which prevents their items from being affected. Therefore, they retrieve their items just after the flood incidents and start engaging in their livelihoods.

Moreover, investigating into whether they get help from NADMO or other government agencies, table 5.11 indicates that 51.5 per cent of the respondents get help from NADMO and the help is mostly in form of basic needs like rice, mattresses, mosquito nets, buckets and others. Only 0.5 per cent of the respondents revealed the NADMO officials were being assisted by the community to rescue older people and children who can’t swim through the flood.

Table 5.11 Recovery by household and NADMO

RECOVERY BY HOUSEHOLD AND NADMO	**FREQUENCY**	**PERCENTAGE**
Family preparedness to flood		
Food storage	6	3
Prepare to move	181	91.4
Nothing	11	5.6
Household recovery from flooding		
Yes	25	12.6
No	173	87.4
If Yes, How		
Retrieving belongings and start again	25	100
NADMO support to Households		
Yes	103	52
No	95	48
If Yes, what type of help		
Basic needs	102	99
Rescue	1	1
Source of water during and after the flood		
Pipe-borne	61	30.5
Bole Hole	121	60.5
River	10	5
Reservoir	5	2.5
Rainwater	2	1
Sachet water	1	0.5
Availability of food during and after flooding		
Yes	83	41.5
No	117	58.5
Resilient level		
High	14	7
Moderate	37	18.5
Low	149	74.5

Field data, 2019

Finally, respondents were asked the source of water for their livelihoods during and after floods, and the results indicate that 60.5 per cent depends on borehole during and after the flood, 30.5% indicated that they depend on Pipe-borne water, (5%) indicated they depend on the river body even during the flooding, 2.5 per cent of the respondents revealed that water is stored or reserved before the occurrence of the flood, 1 per cent indicated that they depend on rainwater with only 0.5 per cent who made the researcher understand that they depend on sachet water during and after

flooding in the area. To food availability during and after flood hazard, 58.5 per cent of the respondents indicated that they find it very difficult to find food to feed their households. With 41.5 per cent of the respondents indicating that they don't have any problem with food during and after the flood because foods like corn, cassava, and others are being stored therefore relieving them from hunger during and after flooding.

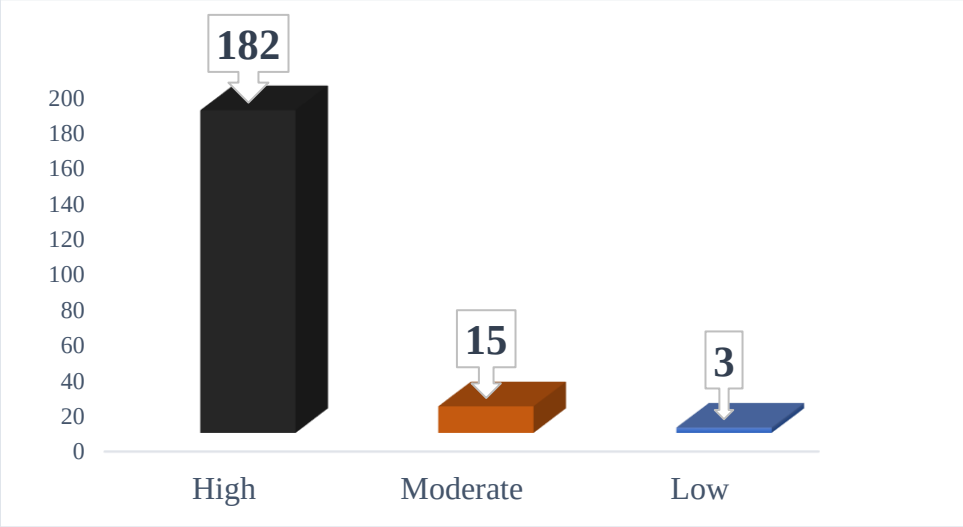

Figure 5.5: Level of Vulnerability of residents to Flooding

Field data, 2019.

Also, residents revealed from the questionnaires administered to them that they are highly vulnerable to flooding. They attribute this to the type of livelihood they engage in at the lower basin and the type of structures they put up along the river basin. This supports the assertion made by Muller et al., 2011 that people living in poor-quality housing and engaging in various livelihood activities along basins cannot recover quickly, making them highly vulnerable.

In conclusion, the study reveales that most of the respondents are highly exposed to both flooding and bank erosion based on the type of materials used in the building, distance of settlements from

the river basin, the type of livelihood that the household engages in at the lower basin considering their exposure, susceptibility and their resilience level to these hazards. Therefore, based on the people's experience of flooding and bank erosion, the majority of the respondents claimed they had done nothing to reduce the impact of these hazards. Only a few claim they prepare to move before the hazard occurs with food being stored to be consumed after flood hazard occurrence. To the district level, the respondents claimed they had help from NADMO, which are relief items like rice, mattresses, mosquito nets, and others. Also, from the GIS analysis of the DEM regarding the vulnerability of the people, it was indicated that the study area is within the high floodable zone, which makes residents highly vulnerable to flooding. Considering all these, it clearly states that residents are highly vulnerable to the hazards, which leads them to higher impact anytime there is an occurrence of these hazards. This point validates the view of Kundzewicz et al., (2002) that the risk of flood grows continuously with increasing level of exposure and insufficient capacity leading to the rising vulnerability of people to the risk of flood.

CHAPTER SIX

IMPACTS AND MEASURES OF FLOODING AND BANK EROSION ON LIVELIHOODS

6.1 Impact of Bank Erosion on Livelihoods

On impact of bank erosion, the study explored residents' views on bank erosion processes impacts at the lower basin in the various study communities. The study explicitly investigated the impacts in the various areas which include crop production and storage, livestock production, water accessibility, health and infrastructure indicated in Table 6.1.

Table 6.1: Impact of Bank Erosion on Livelihood

	Level of impact					
	Non		Moderate		High	
	Frequency	Percentage	Frequency	percentage	frequency	Percentage
Areas		(%)		(%)		(%)
Crop production	97	48.5	52	26	51	25.5
Crop storage	101	50.5	82	41	17	8.5
Livestock	91	45.5	73	36.5	36	18
Water accessibility	113	56.5	76	38	11	5.5
Infrastructures	39	19.5	98	49	63	31.5
Properties	32	16	97	48.5	71	35.5
Health	107	53.5	77	38.5	16	8
Business	132	66	55	27.5	13	6.5

Field Data, 2019.

It was revealed that crop production (48.5%) and storage (50.5%), livestock (45.5%), water accessibility (56.5%), health (53.5%), and business (66%) were seen as areas that had a low impact on bank erosion. 25.5 per cent of the respondents were highly affected by crop production and this

was attributed to the small-scale mining (Galamsey) activities that eroded the banks, thereby destroying the farmlands and widening the river width. To their livestock, it was revealed that 45.5 per cent had no impact, with only 18% high impact on their livestock as a result of bank erosion. Respondents that their livestock moderately and highly affected to their livestock were a result of the rearing of pigs at the banks of River Pra.

Also, for water accessibility, 56.5 per cent representing the majority of the respondent had no impact on bank erosion because bank erosion does not affect their access to water in the river or water availability in their various households. Only 5.5 per cent of the respondents have an impact on water accessibility. This was because their major source of water was the borehole which was not affected during the riverbank erosion thereby only a small portion of the resident are impacted. The smaller respondents who were impacted explained that because they use the river and they get nearer to the river, the bank erosion has led to people polluting the river for the water to become tubid thereby making it unhealthy to use.

When it comes to infrastructure and properties, majority of the respondents were moderately affected (49%) and (48.5%) respectively, with little impact of 31.5 per cent and 35.5 per cent. This was a result of the collapse of the building along the river basin due to bank erosion caused by illegal mining. Also, as the river flows in its channel, it erodes the banks thus expanding the river. This forces residents to move from the river riparian region, leaving their structure vacant with the river destroying those structures along the basin with the possessions of the household residents. This confirms the assertion by Islam & Rashid, 2011 that riverbank erosion renders people homeless and also displaces them, leading them to deferred life.

Lastly, with health and business, bank erosion has not been seen as a threat to their health status and businesses at the lower basin of the river. 53.5 per cent, and 66 per cent of respondents for both health and business respectively had no impact on bank erosion at the lower basin.

In totality, bank erosion has been observed in the area, but it has not been seen as a major environmental hazard that poses a threat to residents at the lower basin of river Pra. This is contrary to Rahman 2010 who stated that riverbank erosion is seen as one of the major causes of national poverty with impacts seen on land loss which involves the loss of homestead lands, agricultural lands, agricultural productions, crops, and trees primarily. This was affirmed by the NADMO officer at the Shama district who said the following:

> *"Some of the areas, the elevation is high like the Krobo and Bosomdo. Except for these two towns, all the towns along the Pra are low lying. These places experience bank erosion, but it is not a major problem in the district as far as erosion is concerned, but our major problem is the extent of flooding." Also, Bank erosion is not seen as a serious threat to the district, but the only thing that comes is sedimentation which is not a bad process to the river. But when we have our torrential rain, and there is flooding in various areas, that is our major problem.*

This implies that the river is changing with shape and size (see figure 4.1) therefore there should be new and vibrant strategies to livelihoods of the communities along the Lower Pra basin in response to these changes to enhance their resilience to settlement along the river basin.

Table 6.2: Cross-tabulation between the impacts of bank erosion and the study communities

IMPACTS OF BANK EROSION	community name				Total
	Twifo Praso	Shama	Anlo Beach Town	Bosomdo Krobo	

Crop production	Non	52(55.9)	36(45)	6(25)	3(100)	97(48.5)
	Moderate	21(22.6)	20(25)	11(45.8)	0(0)	52(26)
	High	20(21.5)	24(30)	7(29.2)	0(0)	51(25.5)
	Total	93(100)	80(100)	24(100)	3(100)	200(100)
Crop storage	Non	49(52.7)	41(51.2)	8(33.3)	3(100.0)	101(50.5)
	Moderate	30(32.3)	36(45.0)	16(66.7)	0(0.0)	82(41.0)
	High	14(15.1)	3(3.8)	0(0.0)	0(0.0)	17(8.5)
	Total	93(100.0)	80(100.0)	24(100.0)	3(100.0)	200(100.0)
livestock	Non	42(45.2)	39(48.8)	7(29.2)	3(100)	91(45.5)
	Moderate	32(34.4)	26(32.5)	15(62.5)	0(0)	73(36.5)
	High	19(20.4)	15(18.8)	2(8.3)	0(0)	36(18)
	Total	93(100)	80(100)	24(100)	3(100)	200(100)
Water accessibility	Non	57(61.3)	44(55)	9(37.5)	3(100)	113(56.5)
	Moderate	28(30.1)	35(43.8)	13(54.2)	0(0)	76(38)
	High	8(8.6)	1(1.2)	2(8.3)	0(0)	11(5.5)
	Total	93(100)	80(100)	24(100)	3(100)	200(100)
Infrastructures	Non	20(21.5)	17(21.2)	2(8.3)	0(0)	39(19.5)
	Moderate	44(47.3)	38(47.5)	14(58.3)	2(66.7)	98(49)
	High	29(31.2)	25(31.2	8(33.3)	1(33.3)	63(31.5)
	Total	93(100)	80(100)	24(100)	3(100)	200(100)
Property	Non	17(18.3)	13(16.2)	2(8.3)	0(0)	32(16)
	Moderate	42(45.2)	41(51.2)	11(45.8)	3(100)	97(48.5)
	High	34(36.6)	26(32.5)	11(45.8)	0(0)	71(35.5)
	Total	93(100)	80(100)	24(100)	3(100	200(100)
Health	Non	44(47.3)	54(67.5)	6(25)	3(100)	107(53.5)
	Moderate	40(43)	22(27.5)	15(62.5)	0(0)	77(38.5)
	High	9(9.7)	4(5)	3(12.5)	0(0)	16(8)
	Total	93(100)	80(100)	24(100)	3(100)	200(100)
Business	Non	59(63.4)	61(76.2)	9(37.5)	3(100)	132(66)
	Moderate	26(28)	15(18.8)	14(58.2)	0(0)	55(27.5)
	High	8(8.6)	4(5)	1(4.2)	0(0)	13(6.5)
	Total	93(100)	80(100)	24(100)	3(100)	200(100)

Field Data, 2019.

In table 6.2, varied impacts on bank erosion are outlined by respondents from the various communities. Respondents generally saw bank erosion as a hazard in the study communities but not a significant environmental threat to their livelihood. Yet, all the respondents in Bosomdo-Krobo admitted that they are highly exposed to bank erosion and it is a substantial threat to their livelihood as it has led to the collapse of their buildings and significant properties in their

households. Therefore, they have had to abandon their old structures to construct new structures far from the river.

As much as bank erosion is a threat to residents at Bosomdo-Krobo, their livelihood is not impacted in the areas of production of crops, storing of crops, livestock rearing, health, business and accessibility of water. To the accessibility of water, residents revealed that they mostly use sachet water for drinking and borehole for other household activities. From the Table 6.2, all other study communities have little or no impact from bank erosion in the areas of crop production, crop storage, water accessibility, livestock rearing, health, and businesses.

6.2 Impact of Flooding on Livelihood

Prior to the impact of flooding, the study explored residents' views on how they are impacted by flooding at the various study communities in the lower basin of the Pra river. These impacts in the various areas are indicated in Table 6.3 below. Concerning the production of crops, 93 per cent of the respondents agreed to the fact that floods affect their crops production. This was affirmed by the Shama NADMO officer who indicated the following:

> *They are agrarians that is they largely engage in agriculture along the basin and those who do artisanal fishing. Even though most of them engage in fishing in the sea, they also do fishing in the Pra. So, their source of livelihood is farming whether fish farming or arable crops so when the floods occur, those who go into tip rice farming are mostly affected by the destruction of their farmlands.*

Respondents revealed that this flood incident reduces food production and limits the distribution of foods among them thereby causing starvation among communities in the flood-prone areas. Because residents along the lower basin of Pra are heavily dependent on agriculture, that is,

farming and fishing, when the flood destroys the production of food, it indirectly reduces household income and their ability to purchase food thereby leading to starvation during and after floods.

Only 2.5 per cent of the respondents indicated that flooding has no impact on the production of crops. As to crop storage, 30 per cent said they are highly impacted, 63 per cent also responded moderately affected with a smaller portion (6.5%) stating that their food storage is not affected. This indicates that flooding affects their stored food because the major livelihood along the lower basin of river Pra is farming; as a result, those foodstuffs that are being stored in the grounds, for example, cassava and potato are flooded leading to a shortage of food, sometimes needing external help from agencies.

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Plate 6.1: Field picture from Twifo Praso indicating flood impact on a cocoa farm

Cash crops are also damaged by some flood events. The cocoa farm (Fig. 6.1) in Twifo Praso was ravaged by a flood event that occurred on July 10, 2017. Household heads stated that their farm

produce that are normally not affected by floods are cereals like rice, maize etc stored in traditional silos built on props (Fig. 6.3). This is also of the fact, from Table 5.4, Twifo praso is dominated by the livelihood of farming into cocoa and rice cultivation along the Pra basin which exposes them to destruction of their crops during flooding.

Table 6.3: Level of Impact of Flooding

	Level of impact					
	Non		Moderate		High	
	Frequency	Percentage	Frequency	percentage	frequency	Percentage
Areas		(%)		(%)		(%)
Crop production	5	2.5	9	4.5	186	93
Crop storage	13	6.5	126	63	61	30.5
Livestock	3	1.5	28	14	169	84.5
Water accessibility	30	15	142	71	28	14
Infrastructures	2	1	32	16	166	83
Properties	1	0.5	28	14	171	85.5
Health	24	12	130	51.5	73	36.5
Business	116	58	67	33.5	17	8.5

Field Data, 2019.

With respect to livestock, (84%) of respondents were highly affected with only (14%) and (3%) of moderately and no impact respectively to flood in the study communities. This was explained that floods wash away their livestock (goats, sheep, chicken, and others) because these livestocks cannot withstand the intensity of the flood, thereby killing them and washing them away. This mostly leads to shortage and scarcity of these livestock after the occurrence of the flood

On, water accessibility, respondents were mostly moderately affected because the major source of water is bore-hole and stored rainwater. These water sources are not mostly affected during the occurrence of floods except water from the river. 14 per cent of the respondents indicated that they are most affected, and they attributed it to those who feed on the river as their major source of

water. 15 per cent of the respondents said they had no impact of flooding, and these were those who stored water during rainfall and also depend on sachet water, and borehole.

In relation to property and infrastructure, residents were highly impacted to a proportion of (80.5% and 83% respectively). The flood incidence leads to a lot of losses of their buildings and property in it accounting for immeasurable economic hardships and makes it difficult to recover very fast from their past. Properties like their televisions, cloths, bags, and others are washed away and destroyed. Also, the collapse of buildings has affected their livelihood in the riparian region after the occurrence of flood incidence. Respondents also mentioned that during the previous flood, their canoes, farm produce, houses and fishing tools were destroyed. The women also explained that their instruments for morging their fish were also eroded away because they were manufactured with clay.

Figure 6.2: Field pictures showing residues and collapse building

Source: Field Survey, 2019.

In the aspect of health, 51.5 per cent were moderately affected with (36.5%) highly affected, and 12 per cent with no impact on flooding. Those whose health moderately and highly affected explained that during and after flooding, there is breeding of mosquitoes leading to the spread of malaria and sometimes cholera outbreak at the flooded communities; as a result NADMO then has to come in to supply mosquito nets and drugs as a relief item.

Lastly, with regards to how flood impact on their businesses and economic activities, 58 per cent of the respondents revealed that they have no impact by flooding, 33.5 per cent had a moderate impact by flooding. The remaining 8.5 per cent of respondents were highly impacted by flooding. The moderately and highly impacted respondents attributed it to their engagement in trading and other economic activities, which is disrupted, and it becomes very difficult to recover. Also, road networks in the various communities become very muddy and make it very difficult for vehicles and residents to move around with their economic activities because the environment and the road networks become slippery.

Table 6.4: Other areas of Impact of flooding

Other areas of impact	Frequency	Percentage (%)
Loss of income/poverty	10	5
Restriction of movement	49	24.5
Education	6	3
No idea	135	67.5
Total	200	100

Field data, 2019.

The study also disclosed that residents have been impacted as a result of flood hazards by the loss of income(poverty), restriction of movement to undertake economic activities, and education by their children. They revealed that it becomes a holiday for schools when these communities

experience flooding in the area because the classrooms are used as “Safe Haven” which negatively affects their academic work. As to the restriction of movement, the assembly member of Twifo-Twansukoda revealed that their street systems are very poor;

> *‘ as a matter of fact when flood occurs, it is very difficult to move our things and items to the nearby town either by car or human because the roads and major streets become very slippery’*

Table 6.5: Cross-tabulation between the impacts of flooding and the study communities

IMPACTS OF FLOODING		community name				Total
		Twifo Praso	Shama	Anlo Beach Town	Bosomdo Krobo	
Crop production	Non	5(5.4)	0(0)	0(0)	0(0)	5(2.5)
	Moderate	2(2.2)	6(7.5)	1(4.2)	0(0)	9(4.5)
	High	86(92.5)	74(92.5)	23(95.8)	3(100)	186(93)
	Total	93(100)	80(100)	24(100)	3(100)	200(100)
Crop storage	Non	7(7.5)	5(6.2)	1(4.2)	0(0)	13(6.5)
	Moderate	54(58.1)	60(75)	12(50)	0(0)	126(63)
	High	32(34.4)	15(18.8)	11(45.8)	3(100)	61(30.5)
	Total	93(100)	80(100)	24(100)	3(100)	200(100)
livestock	Non	2(2.2)	1(1.2)	0(0)	0(0)	3(1.5)
	Moderate	11(11.8)	15(18.8)	2(8.3)	0(0)	28(14)
	High	80(86)	64(80)	22(91.7)	3(100)	169(84.5)
	Total	93(100)	80(100)	24(100)	3(100)	200(100)
Water accessibility	Non	18(19.4)	9(11.2)	3(12.5)	0(0)	30(15)
	Moderate	64(68.8)	62(77.5)	14(58.3)	2(66.7)	142(71)
	High	11(11.8)	9(11.2)	7(29.2)	1(33.3)	28(14)
	Total	93(100)	80(100)	24(100)	3(100)	200(100)
Infrastructures	Non	0(0)	1(1.2)	1(4.2)	0(0)	2(1)
	Moderate	12(12.9)	18(22.5)	2(8.3)	0(0)	32(16)
	High	81(87.1)	61(76.2)	21(87.5)	3(100)	166(83)
	Total	93(100)	80(100)	24(100)	3(100)	200(100)
Property	Non	0(0)	1(1.2)	0(0)	0(0)	1(0.5)
	Moderate	10(10.8)	18(22.5)	0(0)	0(0)	28(14)
	High	83(89.2)	61(76.2)	24(100)	3(100)	171(85.5)
	Total	93(100)	80(100)	24(100)	3(100)	200(100)
Health	Non	13(14)	11(13.8)	0(0)	0(0)	24(12)
	Moderate	64(68.8)	25(31.2)	13(54.2)	1(33.3)	103(51.5)
	High	16(17.2)	44(55)	11(45.8)	2(66.7)	73(36.5)

	Total	93(100)	80(100)	24(100)	3(100)	200(100)
Business	Non	44(47.3)	62(77.5)	8(33.3)	2(66.7)	116(58)
	Moderate	42(45.2)	13(16.2)	11(45.8)	1(33.3)	67(33.5)
	High	7(7.5)	5(6.2)	5(20.8)	0(0)	17(8.5)
	Total	93(100)	80(100)	24(100)	3(100)	200(100)

Field Data,2019.

As to the impact of flooding, there is no spatial variation that exists among the study towns in terms of their impact to flooding in the areas of infrastructures, properties, livestock rearing and crop production because all the study communities are profoundly impacted by the occurrence of flood everytime. Information gathered from the respondents indicates that not all the residents in Bosomdo-Krobo are affected by flood incidence because these two towns are twin-town of which Krobo is located on the low-lying area and Bosomdo located on highland. Therefore, during flood occurrence, residents in Krobo relocate to Bosomdo till the flood is over. The result also shows that, in relation to water accessibility, all study communities were moderately affected because sachet water and bolehole has been used for drinking and other household chores respectively. They largely do not depend on the river as their major source of water. With business, Anlo Beach Town is moderately affected because their town is an isolated town after crossing the Pra estuary which sometimes prevents their movements to Shama and other areas like Beposo to engage in business activities. Furthermore, residents of Shama and Anlo-Beach town are mostly affected by flood in the aspect of health. This is because the floods leave behind clusters of stagnant water which breed mosquitos leading to malaria outbreak and also cholera outbreak. The study also explains that because these areas are located at the Pra estuary, intensify the occurrence of the flood which takes a longer period for these flood waters to move away leading to a lot of health implications.

In all the greatest impact that the flood brings, crop storage, was not seen as a key area that is impacted in Twifo Praso, Shama, and Anlo-beach Town. This was because of residents' stores

most of their maize and rice on bamboo tents and shells which are likely to prevent their goods from being washed away during flooding.

Fig 6.3: Picture showing storage of food in Anlo Beach Town.

Fig 6.3, indicates how food is being stored traditionally, which does not allow flood water to affect it. From this, residents explained that its only food items like cassava, sweet potato, cocoyam and others stored in the soil that are mostly affected during floods, but foods stored in such tents withstand flooding and is safe for use after the flood incident.

From the various responses to the impact of flooding at the various communities, river flood impacts their entire livelihood, ranging from their physical, economic, and social. Flooding at the lower basin causes a lot of destruction to farmlands and properties, making residents highly vulnerable. This incidence also causes a lot of malaria and cholera outbreak to their health and restrain them from their various activities during and after flooding. These impacts of flooding at the lower basin of the Pra river by residents are in consonance with Maurice et' al, 2014 that flooding leads to the collapse of the building, loss of livelihoods, damage of agricultural products,

road, and others. Also, Nott, 2006 indicated that floods have a lot of consequences, that is social, physical, and economic impacts.

6.3 Change of Livelihood

The study also inquired about their desire to changing their livelihoods to their initial livelihood as a result of these hazards. It was revealed that out of the total respondents, 15% (30 respondents) had changed their livelihoods from their earlier livelihood and these were attributed to various factors shown in the table below

Table 6.6: Change of livelihoods

Question	Frequency	Percentage (%)
Change of livelihood		
Yes	30	15.0
No	170	85.0
If yes, why the change		
Loss of assets	18	9.0
change of health status	5	2.5
loss of agricultural land	3	1.5
others	4	2.0
Total	30	15.0
Missing System	170	85.0
Any help for the change of livelihood		
Yes	5	2.5
No	25	12.5
Total	30	15.0
Missing System	170	85.0
How the help was received		
Family and Friends	2	1.0
Government agencies	3	1.5
Total	5	2.5
Missing System	195	97.5

Field Data, 2019.

From the table, these victims changed their livelihoods as a result of the loss of assets (9%), change of health status (2.5%), loss of agricultural land (1.5%) and other factors (2%) which include old age and those continuing the same occupation but on a different scale. Out of these respondents,

only 2.5 per cent of them received help to make the change with 12.5 per cent (25 respondents) receiving no help in the change of their livelihood. The 2.5 per cent of the respondents who received help got them from family members (1%) and government agencies.

In conclusion to the impact of bank erosion and flooding, bank erosion was seen as a major hazard occurring at the lower basin but has little environmental threat to people living in this zone. But flooding is seen as a major threat to residents in the riparian region of the lower Pra, affecting their physical, social, and economic livelihoods which includes lots of destruction to farmlands and properties, malaria and cholera outbreak, and distorting commercial activities. Following the impacts to these hazards, a percentage of residents changed their livelihoods from their previous livelihoods because residents lost their assets, agricultural lands, livestocks and change in their health.

6.4 MITIGATION MEASURES TO PREVENT FLOODING AND BANK EROSION

Mitigation measures to both flooding and bank erosion were examined at the lower basin of the Pra River to know residents' resilience level to the hazards before, during, and after. Respondents at the study communities were asked on their pre, during, and post measures to flood and bank erosion.

6.4.1 Pre-Mitigation measures to Flooding and Bank Erosion

Table 6.7: Pre-Mitigation measures to Flooding and Bank Erosion

Pre-Mitigation measures	Frequency	Percentage (%)
Land-use control measures by the district		
Yes	6	3.0
No	194	97.0
Total	200	100.0
Building permits with specific building codes		
Yes	12	6.0
No	188	94.0
Total	200	100.0

If Yes, how frequent was supervision		
Once	3	25
Very frequent	1	8.3
No supervision	8	66.7
Total	12	100
If no, any sort of supervision during your construction		
No	188	100
Total	188	100

Field Data, 2019.

From table 6.7, about 97.0 per cent of the respondents claimed that the district does not provide them with any land use and human settlement planning before settling in the area and that causes residents along the basin to undertake any land use operations which expose them to the impact of the hazard.

Also, 94 per cent of the respondents asserted the fact that they did not seek building permits with building codes that should be followed before putting up their structures. They claimed that the district refuses to provide them with permits because the place is within the buffer zone that they should not build but because their families have stayed there for years, they undertake the building of structures at the lower basin using their discretion. These 94 per cent of respondents without permits were not in any way supervised during their construction which leads them to the higher risk of flooding and bank erosion than increasing their coping capacities to these hazards. Only 6 per cent obtained permission before settling there but with low supervision.

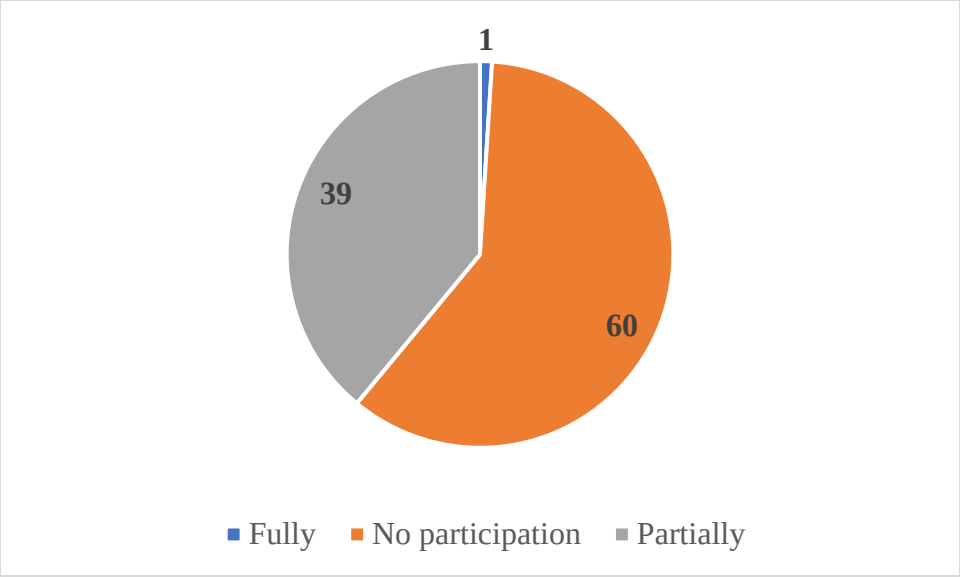

Figure 6.4: Stakeholders participation in flood management

Also, with regards to the participation in flood risk management by stakeholders shown in Fig 6.4, (60%) of the respondents stated that there is no participation of stakeholders, (39%) indicated participation partly and only (1%) said there was participation by stakeholders. The majority were of the view of no participation because they saw relief items provided by the stakeholders as not the best measure to flooding and bank erosion and therefore proper measures should be taken by stakeholders to prevent the incidence of these hazards rather than only providing relief items. The unfortunate thing is that the victims complained that the items do not go to the right persons who are greatly affected by the flood incidence

Table 6.8: Pre-Mitigation measures to Flooding and Bank Erosion

Pre-Mitigation Measures	Frequency	Percentage (%)
Household prior education to flooding		
Yes	22	11.0
No	178	89.0
Total	200	100.0
Knowledge to agencies that forecast floods		
Yes	53	26.5
No	147	73.5
Total	200	100.0
If yes, mention at least one		
Nadmo	35	66
Ghana Meteorological Agency	14	26.4
Radio Station	4	7.6
Total	53	27.0
Emergency systems to flood hazard and bank erosion		
Emergency rescue	11	5.5
Provision of basic need	154	77.0
Nothing	35	17.5
Total	200	100

Field Data, 2019.

The study also enquires about residents prior education on flooding and bank erosion as shown in table 6.8. 89 per cent of the respondents said they had no education on flooding and bank erosion before settling there which exposes them to these hazards. Literacy of the people which was investigated revealed that individuals have a low educational background (see figure 5.3) which makes it difficult for them to find and understand information concerning risk, making them more vulnerable to flooding and bank erosion (Muller et al.,2011).

Furthermore, (73.5%) of the respondents revealed that they do not know the agencies that undertake flood while only (26.5%) with know of agencies forecasting flood. These 26.5 per cent (53 respondents) mentioned these agencies as NADMO (18%), Ghana Meteorological Agency (GMA) (7%), and Radio stations as agencies responsible for forecasting flood or rainfall. But in Ghana, Ghana Metorological Agency (GMA) is responsible for the data storage, but in principle,

NADMO is to be at the forefront in sensitizing and educating people on the dos and don'ts in the events of flood. But NADMO in this sense was seen as only providing and distributing relief items to victims of flooding in the area. In relation to stakeholders' participation, Twansukoda Assembly Member in Twifo Praso revealed this in an interview when he said that:

> *There is poor collaboration between us (the residents and stakeholders) because they only wait for the flood incident to happen then they will supply us with mattresses and bags of rice, but these measures are just a relief measure which is not a long term measure to the problem.*

6.4.2 Mitigation measures taken by the community and assembly against flood hazard and bank erosion

The study also inquired from the respondents about what the community has done to reduce the risk of flooding and bank erosion. Out of the total respondents shown in table 7.3, half of the respondents had nothing to show as a measure taken by the community againsts flood, and bank erosion. The residents were of the view that there is less engagement of the community and the district in any sustainable measures other than providing them with basic items for instance, food, mattresses and others which they do not see as a long term measure to mitigate the problem of flood in the area. 18 per cent indicated that they were relocated by the assembly members of their respective communities, (13.5%) revealed there was desilting exercise by the community as part of community labour, (6%) also pointed out that they were given education on the intensity of the rain for them to be ready for any flooding incidence. Nine per cent claimed they were provided basin items as a measure by the community against flooding. Respondents also revealed that communities provided proper drainage (1.5%) in the communities and river defence (2%) at the back of their households. It was explained that the silt that was desilted from the river channels and gutters was used to create the defence which is easily eroded by the river anytime it increases its volume

Table 6.9: Mitigation measures taken by the community and assembly against flood hazard and bank erosion

Measures	Frequency	Percentage (%)
Relocate us	36	18.0
Desilting or Dredging of river channels	27	13.5
Education	12	6.0
proper drainage	3	1.5
provision of basic needs	18	9.0
nothing	100	50.0
provision of river defense	4	2.0
Total	200	100.0

Field Data, 2019.

The Shama-Apo Assemblyman about what his community and the neighbouring communities are doing to cope with the flooding and bank erosion in the area. He explained that:

> *"We started working on flooding and bank erosion hazard by forming a committee called the Pra Estuary committee, of which I am the chairman. We started educating them on the plants (mangroves) along the river that are being deforested. And through that, representatives were picked in each community along the Pra and started educating them on these hazards. We, therefore, started growing the mangrove to prevent further erosion of the river banks and flooding in the community".*

6.4.3 Coping strategies of residents to flood

The households were also querried on the coping strategies they adopt to help cope with the problem of flooding. In table 6.10 below, 50 per cent of the respondents revealed that they relocate from their residences to different places, 39 per cent had no coping strategies to the hazard, and 9.5 per cent of the respondents claimed they prepare to move their items to safer places before the occurrence of the hazard. The respondents who relocate to the higher elevation towns are not affected by the flood incident. Some also revealed that they relocate to their family members in the nearby towns and return when the flood reduces. The respondents who prepared before the flood were residents who have much experience in the rising and falling of the river during the rainy season and flood incidence, so they prepare their items and leave with their household members. These coping strategies used by the household are short term coping strategies which are adopted during flood occurrence but these are not sustainable enough. Therefore, long term strategies should be initiated by the various districts at the lower basin as lasting measures to the issues of flooding in the area.

Table 6.10: How does your household cope with the problem of flooding

Coping Strategies	Frequency	Percentage
Relocate	100	50.0
Prepare before any hazard	19	9.5
Nothing	81	40.5
Total	198	99.0
Total	200	100.0

Field Data, 2019.

6.4.4 Post Bank Erosion Prevention

Respondents believed that bank erosion processes at the lower basin of the river Pra as a hazard could be prevented. Table 6.11 shows the summary of the suggestions by respondents on how to reduce and also prevent riverbank erosion hazard at the Lower Pra river in the future.

Table 6.11: Measures prescribe to management to help mitigate bank erosion

Measures	Frequency	Percentages (%)
Relocate us	55	27.5
Riverbank defence	48	24
law enforcement at the bank	5	2.5
Stop Galamsey	19	9.5
No idea	62	31
education	1	0.5
missing systems	10	5
Total	200	100

Field Data, 2019.

Aside the 31 per cent of the respondents who had no idea about how to mitigate bank erosion hazard, the remaining majority of the respondent proposed these preventive measures. 27.5 per cent of the respondents preferred to be relocated because they see the erosion as a natural work of the river regardless of the study community; they think it is natural therefore they have to be moved and resettled at safer areas. Also, 24 per cent believe that creating river bank defence along the river will help reduce the natural occurrence of bank erosion. They proposed that the waste materials from the mining companies can be used to design the bank defence as is done for sea defence. Also, about 9.5 per cent of respondents believe that people should stop small scale mining (Galamsey-dredging method) in the river, which leads to erosion into the river bank.

Also, respondents (2.5%) suggested that laws regarding the basin should be enforced to help reduce the human-induced activities that pose a threat to the riverbank erosion thereby exposing people to the threat of bank erosion. Finally, only (0.5%) suggested education and sensitization which is one of the major areas that tend to rekindle the people on the importance of controlling activities at the river bank like the Galamsey and land use activities to help maintain the river bank. These mitigation measures by the respondents in the various study communities were in

conjunction with Afreen's (2009) assertion that water control structures should be renovated, there should be relocation of residents, construction of embarkment, and education of residents to understand the effect of riverbank erosion.

6.4.5 Flood Hazard Mitigation Measures

The majority of the respondents (80%) suggested various measures, if put in place by the stakeholders, will help reduce the risk of flood hazard along the Lower Pra basin. Only 20 per cent of respondents had no suggestions on how to mitigate flood hazard in the study communities. Table 6.12 shows the overview of the ideas and thoughts by the respondents at the study communities along the river basin on how to avert flooding in the area.

The majority (38%) of the respondents were of the view that they shoud be relocated to 'safe heavens' where they will be far away from the risk of flooding. This should be done by providing them with secure land and support to put up structures to help mitigate the incidence of the flood on the people in the area.

Table 6.12: Measures prescribed to manage flood risk

Measures	Frequency	Percentage (%)
Relocate us	76	38.0
Desilting of the river channel	44	22.0
Riverbank defence	28	14.0
Education	5	2.5
Law enforcement	4	2.0
Tradition along the river should be obeyed	3	1.5
No Idea	40	20.0
Total	200	100.0

Field Data, 2019.

Also, 22 per cent of respondents believe that the river, gutters, and drains within the towns joining the river were silted so they should be desilted so that the river will be able to contain the volume of water during the rainy season to help reduce flooding.

About 14 per cent of the respondents think that a river bank defence or defence wall should be constructed on the river valley to prevent the annual flooding in the communities. Also, 2 per cent of the respondents believe that if proper education and sensitization are given to residents along the basin, it will help mitigate a lot of casualties during flooding in the communities.

About 2 per cent of the respondents also suggested that laws along the Pra basin must be enforced and that buildings should be built at right locations without building on waterways. The study revealed that the district was taking demolishing exercise of the settlements on the waterways and along the buffer zone policy of the river to help them move without affected by flood, but these come with motivation and relocation sites to provide them with structures not making them vulnerable.

Lastly, (1.5%) of the respondents believed that traditions along the Pra river should be obeyed. It was believed that the Pra river forbids certain things such as black rubber, snails, a woman menstruating, yam specifically Afase, and dumping of refuse in the river. So, they believe if the individuals continue such an attitude, the Pra becomes angry and floods the area as punishment for their bad deeds. This they believe, is because, during the olden days where these traditions were obeyed, they didn't observe any flooding. From these, the Twansukoda Assemblyman in an in-depth interview advised on how to live along the River Pra.

> *The advice I will give to them is that the river Pra has Taboos that the people should avoid. They are Afase (a type of yam), Ankama (lemon), Temina (a type of snail), a Black utensil*

for cooking and more importantly female having their menses shouldn't go to the river, but they have dumped a lot of rubbish at the banks which include these things that are among the various taboos of the river. Not conforming to these various taboos causes the river to flood the area. So the only advice I will give is that they should stop dumping rubbish along the banks of the river. The community has also advised women not to visit the river when they are menstruating and on Wednesday, but our current ladies do, which is causing all these problems. There are a lot of things causing the flood not only the river action.

These measures suggested by the respondents of the study communities if implemented by stakeholders will be a permanent measure that will help prevent the incident of flood and the casualties that it brings as a result of its occurrence.

The NADMO officer at Shama also affirmed these measures by explaining that:

Since 2000 that we had the IDRR, we are very proactive. We usually focus on prevention. First and foremost, what we believe in most is education and sensitization of the people and other coping capacities. For coping capabilities, we have not thought of embankment of the Pra but it is a good measure that we have to consider to build their resilience. So, we have to intensify the education to build their resilience and coping capacities to flood. We have to focus on the root causes of the hazard. We educate people not to build on the waterway, and the structures of those living there have to be demolished, and that has to come with compensation but the NADMO is not resourced enough to engage in such activities. Maybe punishment for those who violate laws along the basin should be enforced.

In conclusion, the study proposed effective measures, if taken, to help reduce the impact of flooding and bank erosion at the lower basin of the Pra river. Before the occurrence of floods, the study revealed that majority of the residents acquired lands without permission by the districts to build at the riparian because they are within the buffer zone, and stakeholders' participation is not significantly seen to pre-flood prevention which exposes residents to higher risk of flooding and bank erosion. Also, during flooding incident, the study revealed that residents relocate to higher elevation to settle with their relatives and friends based on their experience with flood incidents, while a percentage prepares and leaves the areas based on the signs demonstrated, with majority doing nothing during the incident. Finally, the study reveals that this flood and bank erosion can be prevented by relocating residents to higher elevation, dredging river channels, providing river defense and educating and sensitizing residents to desists from activities that expose them to these hazards to prevents them from the impact of flooding and bank erosion.

CHAPTER SEVEN

SUMMARY, CONCLUSIONS, RECOMMENDATIONS

7.1 Introduction

The study examined the impact of flooding and bank erosion on livelihoods at the lower Pra basin. The study mainly discussed the bank shift, vulnerability of the people to these hazards, impacts of flooding and bank erosion on the people, and the measures to prevent flooding and bank erosion at the lower basin. This chapter presents a summary of the findings related to the study. Also, conclusions regarding the study and recommendations were derived from the findings.

7.2 Summary of the study

Flooding and bank erosion are natural occurrences that create a lot of socio-economic and environmental impacts affecting the community's life and property. It is therefore essential to understand the people's vulnerability and the impact associated with the hazards to be able to come out with proactive measures to improve and even prevent the extent of the impact. The main objective of the study examined the impact of flooding and bank erosion on livelihoods at the Lower Pra Basin. The study also used both quantitative and qualitative methods to undertake the research. The DFID 2002 framework on sustainable livelihood was modified and guided the entire research more importantly, regarding the vulnerability, impact, and measures to curb the problem of flooding and bank erosion in the lower Pra basin.

On the summary of the analysis, regarding the first objective in examining the riverbank changes at the lower basin, the study revealed that the overall riverbank of the lower Pra basin changed from 16.17516km² in 1974 to 66.8808km² in 2018. Various cross-section picked on the lower basin indicated that the right bank shifted more than the left bank of the river. These changes were

a result of the lateral erosion and sedimentation that occurred within the lower basin of the river Pra.

On the second objective which looked at the people's vulnerability to bank erosion and flooding, the study revealed that most of the respondents are highly exposed to both flooding and bank erosion based on the type of materials used in the building, distance people settle along the river basin, the type of livelihood that the household engages in at the lower Pra basin. Therefore, based on the people's experience of flooding and bank erosion, the majority of the respondents claimed they had done nothing to reduce the impact of these hazards with few claiming they prepare to move before the hazard occurs. Also, food is being stored to be consumed after flood hazard occurrence. At the district level, the respondents claimed they had help from the NADMO in form of relief items like rice, mattress, mosquito nets, and others. All of these put the residents at a higher level of vulnerability leading to higher impact anytime such hazards occur.

On the third objective of examining the impact of flooding and bank erosion, bank erosion has been observed in the study area but it has not been seen as a major environmental hazard that poses a threat to residents at the lower basin of river Pra. However, from the responses of residents to the impact of flooding at the various communities, river flood impacts their entire livelihood ranging from their physical, economic and social lives. Flooding at the lower basin causes a lot of destruction to farmlands and property, making residents highly vulnerable. Flooding incidence also causes a lot of malaria and cholera outbreak, impacting their health and restrains their various activities during and after flooding.

Finally, on the last objective of exploring the mitigation measures of the people to these disasters, the study revealed that the districts along the lower basin of Pra do not provide any land-use measure to control the activities of people at the area. Also, stakeholders don't give the residents

education, which makes families not to seek building permits to guide the building of their structures at the lower basin. Stakeholder participation in flooding hazard was minimal with them only providing relief items to victims anytime such hazards occur. It also came out that the percentage of residents who knew about bank erosion hazard prescribed that relocating residents and creating riverbank defense are the major measures to mitigate bank erosion as are educating people to stop some activities like Galamsey that they engage in at the lower basin. Furthermore, respondents suggested that relocating them, constructing river defense, desilting river channel, public education, and obeying traditions at the Pra river are going to help prevent the impact that flooding brings to residents.

7.3 Conclusions

Based on the results acquired from the study, the various conclusions were reached. The study concluded that the lower Pra river has migrated from 1974 to 2018, which has put the residents in this area under threat of bank erosion hazard and flooding. Also, it was concluded that this change was as a result of the river action of eroding the bank naturally and human activities such as small-scale mining (Galamsey) and farming.

Also, the study concluded that the residents along the lower basin of the Pra river are highly vulnerable to both flooding and bank erosion. GIS tools have proved useful in the preparation of flood vulnerability map to categorize areas of high vulnerability to flooding and areas with low vulnerability. The output of the GIS analysis concluded that the study region is highly vulnerable to flood hazards based on the elevation, slope, and nearness to the river. This GIS output was explained by the various elements of vulnerability from the respondents. Residents' vulnerability to these hazards is a result of the distance of residence from the river, type of materials used in the building of their structures, the livelihood they engage in, and the inability to get regular flood

forecasts from the NADMO or the Ghana Meteorological Authority. From these exposures, experience and how these were used to reduce the hazard, the people's resilience level was found to be low. The community had done little to control the disaster of flooding and bank erosion in the same way the district only provided relief items without any proactive measures.

Furthermore, the study concluded that bank erosion has a low impact on their livelihoods in relation to their settlements, properties in their household, farmlands, and other economic activities. Therefore, bank erosion is not seen as a major environmental hazard that poses a threat to the residents at the lower basin. But in relation to flooding, the lower basin of River Pra profoundly impacts on the livelihoods of the people from their physical social and economic life. Flooding at the lower basin causes a lot of destruction to farmlands and property, making residents highly vulnerable. Flood incidence also causes a lot of malaria and cholera outbreak to their health and restrains their various activities during and after flooding. Residents adopted a coping strategy of moving to the higher elevated places with some preparing to leave, but these strategies are seen as short term, therefore long term strategies should be initiated to reduce the risk to the impact of the flood hazard.

Lastly, though bank erosion was not seen as a major threat to their livelihoods, the study proposed that there should be some measures to curb the situation. Thus measures like relocating residents, riverbank defence, law enforcement through education, and stoping Galamsey were proposed to help control the situation of bank erosion in the area if implemented. On flooding, the study concluded that relocating residents, desilting of the river channel, creating riverbank defence, education and sensitization, and law enforcement by obeying traditions along the river basin were measures, when put in place, will help reduce residents' risk and impact to flood hazard at the lower basin.

The findings derived from the study provides acceptance and trustworthiness to the 'Sustainable Livelihoods Framework [DFID (2000)]'. Therefore, if the communities, institutions, and the country as a whole function accurately with the available capital to support the household, it will reduce people's vulnerability to flooding and bank erosion hazards that they encounter thereby improving and maintaining good livelihood outcomes.

7.4 Recommendations

To start with, since the hazards are local phenomena at the lower basin of the Pra river, information relating to these hazards should be gathered as an initial action to be taken in defining the hazard level. There should be an assessment to know the major cause and source of the flood hazard. Also, areas around the floodplain should be a location of interest for a thorough evaluation to be done in such an area. Going through this action will give a greater understanding of the flood hazard in the area based on its location, the significant resources that will be needed and also knowing the landscape is going to help assess the intervention to be considered. Bank erosion should be a major concern to the districts along the basin because it poses a lot of threat to settlements. Data related to Bankline should therefore be derived, using technologies like the GIS to help predict and take appropriate steps to curb this hazard.

The district Assembly, in conjunction with the planning department, should design land use control measures with building codes at the lower basin to regulate people's actions and activities at the lower basin of the Pra river. Also, the buffer zone policy which has not been effective, leading to people building closer to the river should be strengthened through education and sensitization. This is going to expose them to the policy to help build their resilience if they understand the essence and importance of the policy and the need to comply.

Also, acquiring existing data about flooding should be a necessary measure to help know the trend of flooding in the area to prevent the occurrence of the hazard or reduce its intensity of the hazard. Data (both recent and previous) from the Ghana Meteorological Agency, planning agencies, Ghana Hydrological service, and other government agencies should be accessed as an emergency in managing flood risk in the lower Pra basin. There should also be local flood hazard maps of the study area that could be used to mitigate flood hazards in the area because these maps give spatial insight into the area of interest. All these data can be used to create flood archives for this study area to help monitor the incident of the flood hazard. This is because, throughout the study, it was noticed that from the local to the district level along the lower Pra basin, there are limited archives to show what is the significant problem. Therefore, these sources of local knowledge will help to inform likely flood hazards.

Furthermore, Early warning systems (EWS) are critical that can be exploited to reduce the casualties of a flood event. These warnings will provide individuals and residents information on what is going to be happening to help residents prepare thoroughly towards the occurrence of the hazard. But this system has not been effectively initiated to reduce the damage of the hazard. For instance, the government of Ghana through NADMO in partnership with UNDP initiated a policy called Community Resilience through Early Warning (CREW) since 2013, which was a multi-hazard early warning system, but these were installed at the NADMO headquarters and in 20 subnational offices which have not yet gotten to the study area. This CREW project should be transcended to all the flood-prone areas at the lower basin of the Pra river to help reduce economic and human losses and damages.

In managing this flood risk, measures like desilting the river channel regularly, river flood defense aiming to protect the structures from the floodplain activities, relocating people along the river

basin to safe havens, and education and sensitization should be a major work of the District Planners, Environment and Sanitation department and NADMO officers. These are going to inform residents activities at the lower basin to help reduce and even prevent the damage caused by annual flooding at the lower basin. Finally, in other to achieve the objectives in managing flood and bank erosion in the area, it will be vital to assess the vulnerability of the residents or people at the study area to help provide efficient measures to prevent this hazard.

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APPENDIX 1: HOUSEHOLD QUESTIONNAIRE

Please tick, circle, underline or write where appropriate. Thank you.

Community Name: ……...

District: ……

SECTION A- DEMOGRAPHIC DATA

1. Sex:
    a) Male [ ]
    b) Female[ ]
2. Age
    a) 30-40 [ ]
    b) 41-50 [ ]
    c) 51-60 [ ]
    d) 61 and Above [ ]
3. Marital Status
    a) Single [ ]
    b) Married [ ]
    c) Divorced [ ]
    d) Widowed [ ]
    e) Others…….
4. Number of Children
    ……..
5. Level of Education
    a) No formal Education [ ]
    b) Basic [ ]
    c) Secondary/Technical/Vocation [ ]
    d) Tertiary [ ]
6. Occupation

a) Fishing [ ]
b) Civil Servant [ ]
c) Farming [ ]
d) Others (specify) ……...

SECTION B

UNDERLYING VULNERABILITY OF PEOPLE AT THE LOWER BASIN

EXPOSURE

7. How long have you lived in this area of the river?
    a) 1-5 years [ ]
    b) 6-10 years [ ]
    c) 11-15 years [ ]
    d) 16-20 years [ ]
    e) 21 years and above [ ]
8. Have you observed bank erosion of the river?
    a) Yes [ ]
    b) No [ ]
9. If Yes, what is the extent of the erosion
    a) Low extent [ ]
    b) Moderate extent [ ]
    c) Great extent [ ]
10. What did you think is/are the cause(s) of the river bank change?
    a) River action [ ]
    b) Human activities [ ]
    c) Not known [ ]
11. What is your degree of exposure are your family to bank erosion?
    a) Severe [ ]
    b) Moderate [ ]
    c) Low [ ]
12. Have you experienced river flood in your area?

a) Yes [ ]

b) No [ ]

13. What is your degree of exposure are your family to flood hazard?

d) Severe [ ]

e) Moderate [ ]

f) Low [ ]

14. What do u you think is/are the cause(s) of river flood in the area

a) River Action [ ]

b) Silted River Channel [ ]

c) Building along the river bank [ ]

d) Others [ ] ……..

15. What type of materials was used in the building of the house you live in?

a) Mud [ ]

b) Wooden [ ]

c) Cement [ ]

d) Sand [ ]

e) Others [ ]

16. What type of livelihood do you/ the household engage in along the river basin?

……

17. How does your livelihood affect or exposes you to flood hazard and bank erosion?

a) Severe [ ]

b) Moderate [ ]

c) Low [ ]

18. Did your family had any of these maps and data before settling here? (Tick one or More)

a) Flood map or data [ ]

b) Drainage system [ ]

c) Land use map and data [ ]

19. What was your motivation for settling at this zone/area of the community?

……

……

……

……
……

SUSCEPTIBILITY

20. How did you acquire the land at this place?
    a) Chief [ ]
    b) Friend [ ]
    c) Family member[ ]
    d) Estate agency [ ]
21. (a) Were you aware of the risk of flood and bank erosion to you, your Family and the environment before acquiring the land?
    a) Yes [ ]
    b) No [ ]

    (b) If Yes, why did you acquire the land

……
……
……
.

22. Do you get flood warning/ forecast from Meteorologist or NADMO before flooding?
    a) Yes [ ]
    b) No [ ]
23. (a) What does your household do during flooding/bank erosion
    a) Nothing [ ]
    b) Evacuate [ ]
    c) Leaves before flood [ ]

    (b) If Evacuate, where does your household evacuate to during flood

……
……
24. (a) Does the district or the community provide protection measures to flooding?
    a) Yes [ ]

b) No [ ]

(b) If Yes, which of these protection measures are provided in your community

a) Dyke [ ]

b) Reservoir of water [ ]

c) Pumping stations [ ]

d) Others……

……...

(c) If No, does your community needs any protection measure to flood in your area (Yes/No)

In what way:

……

……

…….

RESILIENCE

25. (a) Does your household have any experience to bank erosion in your area

a) Yes [ ]

b) No [ ]

(b) if Yes, what has your household done to reduce the hazard of bank erosion

……

……

26. (a) Does your household have any experience to flooding in your area

a) Yes [ ]

b) No [ ]

(b) If Yes, how has your experience reduced your risk to flooding

……

……

……

……
……

27. How Does your family get prepared before and during flooding?
    a) Food storage [ ]
    b) Prepared to move [ ]
    c) Others ……
    …….

28. (a) Is your household able to recover fast from any flood hazard to the previous state?
    a) Yes [ ]
    b) No [ ]

    (b) If Yes, How

……
……
……

29. (a) Does your Household get help in case of flooding from government and NADMO?
    a) Yes [ ]
    b) No [ ]

    (b) If Yes, which type of help do your household get from NADMO or government

……
……
……
..

30. What is the source of water for livelihood for your household during and after flood hazard?
    a) Pipe-borne [ ]
    b) Bole hole [ ]
    c) River [ ]
    d) Reservoir [ ]

31. Is there enough food available for your household after any flood Hazard?
    a) Yes [ ]
    b) No [ ]

32. What is the vulnerability level of your household to flooding?

a) High
b) Moderate
c) Low

33. What is the vulnerability level of your household to bank erosion

a) High
b) Moderate
c) Low

SECTION C

IMPACT OF BANK EROSION ON LIVELIHOODS

(Indicate the level of impact by 1,2,3)

AREA	LEVEL OF IMPACT NON (1), MODERATE (2), HIGH (3)
34. Crop production	
35. Crop storage	
36. Livestock	
37. Water accessibility	
38. Infrastructures	
39. Properties	
40. Health	
41. Business	

IMPACT OF FLOOD HAZARD ON LIVELIHOODS

(Indicate the level of impact by 1,2,3)

AREA	LEVEL OF IMPACT NON (1), MODERATE (2), HIGH (3)
42. Crop production	
43. Crop storage	

44. Livestock	
45. Water accessibility	
46. Infrastructures	
47. Properties	
48. Health	
49. Business	

50. Was your household engage in earlier livelihood before the recent livelihood

a) Yes [ ]

b) No [ ]

51. If yes, why did your household made such a change

a) loss of asserts [ ]

b) change of health [ ]

c) loss of agricultural lands [ ]

d) others specify……

52. Did your household receive any help to make the change?

a) Yes [ ]

b) No [ ]

53. If yes in Q50, How was this type of help received?

a) Education and Training [ ]

b) Family and Friends [ ]

c) NGO's [ ]

d) Government agencies [ ]

e) others specify……

54. In your views, what do you think are other areas that impact on people's livelihood in the lower basin of Pra to flooding and bank erosion?

……

……

……

……..

SECTION D

MITIGATION MEASURES/COPING STRATEGIES

55. Do the district provide any land use control measures prior to mitigating flood hazard and bank erosion
    a) Yes [ ]
    b) No [ ]
56. Did your family seek for building permits with specific building codes before settling in the area?
    a) Yes [ ]
    b) No [ ]
57. If Yes in (Q54), how frequent was the supervision of your building along this zone
    a) Once
    b) Very frequent
    c) No supervision
58. If no in (Q54), was there any sort of supervision during your construction of your building
    a) Yes [ ]
    b) No [ ]
59. Have stakeholders participated in flood management to help people in your area
    a) Partly [ ]
    b) Fully [ ]
    c) No participation [ ]
60. Did your household had any prior education prior to flooding and bank erosion before settling here
    a) Yes [ ]
    b) No [ ]
61. (a) Do you have any knowledge to agencies that gives forecasting to floods to give residents some level of readiness to flood?

a) Yes [ ]

b) No [ ]

(b) If yes (in Q59), can you mention at least one of these agencies

……..

……..

62. What are the emergency systems put in place to flood hazard and bank erosion when they occur by the district/households/NADMO?

a) Emergency rescue [ ]

b) Provision of basic needs [ ]

c) Other [ ]

…….

…….

63. What mitigation measures are in place by the household/community/assembly to flood hazard and bank erosion

……

……

……

64. How does your household cope with the problem of flooding and bank erosion?

……

……

……

65. What will you prescribe to management to help mitigate bank erosion?

……

……

66. What will you prescribe to management to help mitigate flood risk?

……

……

THANKS FOR YOU COOPORATION….

APPENDIX II: IN-DEPTH INTERVIEW FOR NADMO AND DISTRICT PLANNERS

DISTRICT……

1. Sex
2. Age
3. Level of education
4. Role of respondent
5. How long have you worked in the district?
6. Is flood hazard a problem in the district?
7. Which localities are more exposed to this hazard?
8. How frequent is flooding occurring in the district
9. What are the major impacts recorded by the district to flood hazard?
10. Is bank erosion an environmental issue in the district to people along the Pra basin?
11. If yes in Q10, which localities are more vulnerable to bank erosion?
12. How long has the district experiencing bank erosion
13. How is flood hazard inculcated in your planning about the district
14. What are issues that are addressed with flood hazard and bank erosion in the Pra river basin
15. Was there any buffer policy governing the settlement along the river basin?
16. If Yes to Q15, how was the policy supervised?

17. How is the new buffer policy by the government going to be implemented to the incoming and those settling there?
18. What are the building permit and codes in existence to control destruction of building during floods and bank erosion in the riparian of lower Pra in the district?
19. How are these building supervised and strengthened
20. What is the district readiness to the emergency systems prior to flood hazards when it occurs to people settling there?
21. Is there a comprehensive land use control map and policies along our river basins and how is it supervised to improve your people's resilience along the basin?
22. How does the district and NADMO collaborate in mitigating bank erosion and flood risk in your district?
23. Do the district have any insurance policies governing your peoples living along the basin, if yes, what are these policies
24. What are the future plans that is going to be implemented to prevent future risk of flood hazard and bank erosion?

APPENDIX II: IN-DEPTH INTERVIEW FOR ASSEMBLY MEMBERS

COMMUNITY…….

1. Sex
2. Age
3. Level of education
4. Marital status
5. How many years have you served as assembly member in your electoral area?
6. Do you have any idea about flood hazard?
7. Do your community experiences flood annually/frequently
8. What are the major areas of your community's livelihood are impacted to flood hazard?
9. Is bank erosion a major problem in your community?
10. If Yes to Q9, how long has the community experienced bank erosion and its impact
11. What has been your role in controlling flood hazard and bank erosion in your electoral area.
12. How does you collaborate with stakeholders (District/Nadmo) to curb flooding during and after?
13. Was the community provided with buffer policy before those settling at the lower basin?
14. Do you have prior knowledge to land acquisition by those who live along the river basin?
15. Are there any regulations governing building along the basin from the district to the community?
16. What are the challenges your communities face during flood and bank erosion hazard?

17. What measures have the community put in place to reduce risk of flood and bank erosion hazard?
18. What mitigation measures you think can help reduce flood and bank erosion risk in your electoral area
19. What advice will you give to people living along the river basin in your area