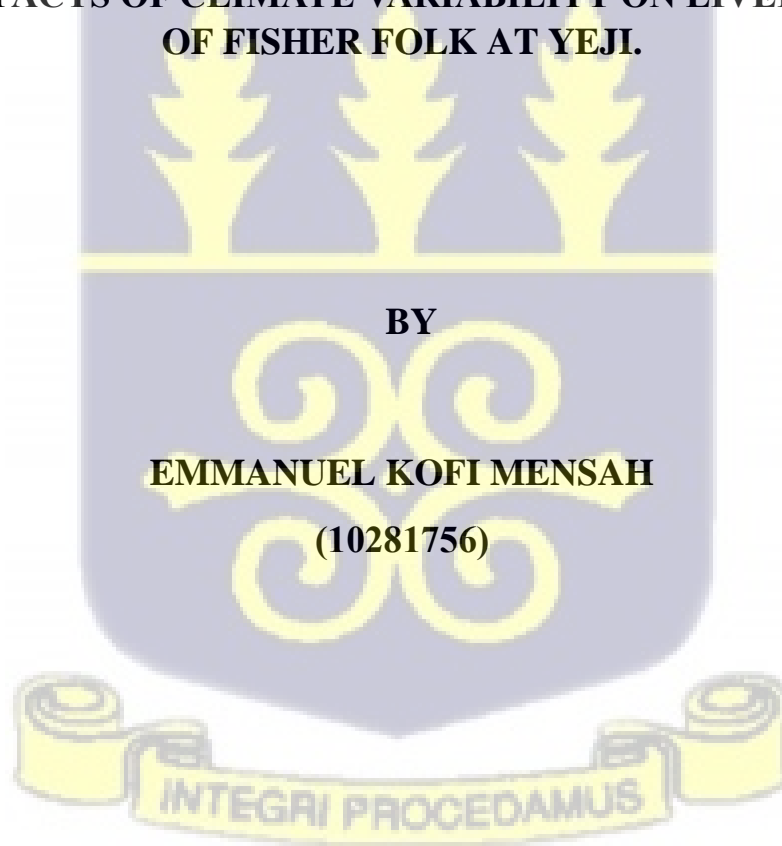




**THE IMPACTS OF CLIMATE VARIABILITY ON LIVELIHOODS
OF FISHER FOLK AT YEJI.**



BY

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**THIS THESIS IS SUBMITTED TO THE UNIVERSITY OF GHANA,
LEGON IN PARTIAL FULFILLMENT OF THE REQUIREMENT
FOR THE AWARD OF MPhil IN CLIMATE CHANGE AND
SUSTAINABLE DEVELOPMENT DEGREE.**

JULY, 2019

DECLARATION

I Emmanuel Kofi Mensah, author of this thesis, do hereby declared that the work presented in this thesis titled “The Impacts of Climate Variability on Livelihoods of Fisher Folk at Yeji” was done entirely by me in the University of Ghana, Legon, except where references of other work was duly acknowledged. This work has never been presented in part or whole for any degree in this University.

.....

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DATE

CERTIFICATION

We hereby certify that the preparation and presentation of this revised thesis was supervised in accordance with the guidelines for supervision laid down by the University of Ghana, Legon.

This revised thesis has been submitted for our approval as supervisors.

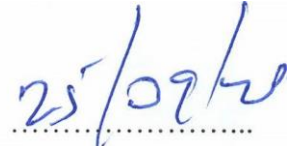
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Date

DEDICATION

This research is dedicated to my parents, and siblings Michael, Vida, Mina, and Stella. I also dedicate this research to my dear wife, Sabina Pokua and children for their prayers, financial and material support, and encouragement. Of course their contribution and positive influence over the years are worth mentioning. I sincerely appreciate the important role they played in helping me reach this far. May the almighty God bless them.

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LIST OF ABBREVIATIONS

BNP	Big Number Project
CBFM	Community Based Farming Model
CPUE	Catch Per Unit Efforts
ENSO	El Nino Southern Oscillation
EPA	Environmental Protection Agency
FAO	Food and Agriculture Organization
FMSP	Fisheries Management Science Programme
GCM	Global Climate Model
GDP	Gross Domestic Product
GMet	Ghana Meteorological Agency
GSS	Ghana Statistical Service
IDAF	Integrated Development of Artisanal Fisheries
IFC-SCI	International Financial Corporation-Science
IPCC	Intergovernmental Panel on Climate Change
LI	Legislative Instrument
MESTI	Ministry of Environment, Science, Technology and Innovation
MOFA	Ministry of Food and Agriculture
MoFAD	Ministry of Fisheries and Aquaculture Development
NCCAS	National climate change Adaptation Strategy
PHC	Population and Housing Census
NTC	National Third Communication
TNC	Third National Communication
UNCTAD	United Nations Conference on Trade and Development
UNECE	United Nations Economic Commission for Europe
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development
WMO	World Meteorological Organization

ABSTRACT

Fisheries-related livelihoods are affected by both climatic and non-climatic factors. Climate variability can play a profound role in the dwindling returns from fisheries and has impacts on socio-economic livelihoods of fisher folks. The objectives of this study were to determine evidence of rainfall and temperature changes, evaluate the effects of rainfall and temperature changes on fish catch, identify the general determinants or drivers of fish outputs at Yeji, determine the impacts of the prevailing climate on the fisheries value chain and assess the current coping and adaptive strategies of fisheries dependent households. Household surveys were conducted with 108 fishers from three fish landing sites in the Pru district in addition to in-depth interviews, key-informant interviews and focus group discussions. Historical data on fish catch, rainfall and temperature conditions were also taken from the Fisheries Department, Ghana Statistical Service, and Ghana Meteorological Agency (GMet). Summary frequencies were generated from the survey data and rainfall and temperature anomalies were generated and compared to ENSO occurrences and fish catch. The qualitative data mainly textual or word-based information from in-depth interviews, key informant interviews and focus group discussions were analyzed, and reported using boxes. The study found that rainfall, rainstorm, drought and flood events, high fishing season temperatures are climatic drivers of fish outputs while non-climatic drivers of fish catch volume include type of fishing boat, fishing experience, number of fishing gears, crew size, lack of knowledge, poor health, lack of credit, cost and irregular supply of premix fuel. The study identified two major coping and adaptation strategies. First, diversification of livelihoods includes rearing of domestic poultry, livestock rearing, crop farming, petty trading and tree planting. Second, movement of fishers across the fishing landscape in search for better fishing grounds during the lean season. The study recommends that in order to reduce risks from climate hazards on livelihoods, local policies should lessen dependence on climate sensitive alternative income sources.

CHAPTER ONE

GENERAL INTRODUCTION

1.1: Background

Factors that account for the decline in fish production in Ghana and the resultant fall in dividends to fishers are multidimensional. The factors which impact inland fisheries are also multidimensional which include environmental (climate variability), economic and social factors (Barange et al., 2018). Non-climatic factors resulting in decreases in yields from both marine (sea) and freshwater (inland) fisheries sectors include insufficient infrastructure such as modern landing sites, inadequate fish processing and storage facilities, inadequate aquaculture infrastructure and inadequate technology in areas such as fishing craft and gear among other factors according to the Fisheries & Aquaculture Department (2016). These non-climatic factors coupled with climatic factors drive fisheries in contemporary era. Water resources, coastal zones and marine systems (fisheries), in addition to agriculture and forestry are seen as some of the most climate-sensitive sectors in the current era (McCarthy et al., 2001).

Although a multitude of factors contribute to the dwindling fish outputs, it is important to note that climate change/variability is a key driver of fish stock and catch. Zooplankton biomass (total quantity of plants and animals) in the Gulf of Guinea has experienced a substantial reduction over the past 24 years (Wiafe et al., 2008). The impacts of climate change and variability on the fisheries sector include loss of marine and freshwater production systems, decrease in marine and freshwater catch levels, increase in food insecurity and unemployment, and salinity intrusion and coastal erosion (Daze & Echeverria, 2016). Additional effects on hydrology as well as fisheries are that first, higher inland water temperatures are expected to reduce availability of wild fish stocks through worsening dry

season mortality, bringing new predators and pathogens and variability in the abundance of food available to fishery species (Muir & Allison, 2007). Second, year by year precipitation, flood and drought extremes are likely to be the most significant drivers of change in inland aquaculture and fisheries (Muir & Allison, 2007).

In a regional assessment of the impacts of climate change on fisheries resources, Burke et al., (2004), estimated that coral composition in the Caribbean basin declined by 80% since the 1970s while mackerels declined by almost 50% in Taiwan (Sun et al., 2006). In a related development, a research conducted in Wisconsin, United States of America indicated that a 3°C increase in air temperature is predicted to cause the loss of 343,034km of freshwater habitat for cool and cold-water fishes as well as fish species annihilation (Lyons et al., 2010). The scourge of climate change and variability has also been widely documented in Ghana by the research community. For example, a downward trend in the amount of fish catch in Ghana since 1995 has been detected by the Ministry of Fisheries and Aquaculture (MoFA, 2009). According to the Bank of Ghana (2008), the fisheries zone in general has experienced persistent output decline over the period. The inland fish production sector has experienced a year-by-year decline since 2011, in percentage terms, the year 2014 recorded -8% fish production, 2015 experienced -7% while 2016 recorded a staggering -9% (MoFA, 2016). Over the past years, the Volta Lake has experienced rise and fall in its water level and surface area of about 1 000 km², according to (Ottaviani et al., 2017). Earlier study by Owusu et al., (2008), attributed the declining lake levels in the entire Volta basin to the increasing variability and declining rainfall totals in the West African sub region since the early 1970.

Generally, impacts of climate change/variability on livelihoods can be viewed in two ways, namely, livelihood strategies and livelihoods outcomes (Balgis et al., 2005; Elasha et al., 2005). In various countries across the globe, the natural resource production systems are

vastly sensitive to rainfall and temperature changes, and drought, this is most likely to undermine food security and people whose livelihood depends on agriculture (WMO, 2019). Livelihoods of farmers in North Africa have been affected by changing temperature, for instance, El Nino Southern Oscillation caused closely 50% reduction in citrus fruit production in Morocco (WMO, 2015). Weather and climate variability can also affect fisher folk and fishing activities in ways such as fishing duration, fish catch rates, fishing equipment and fisher folk livelihood such as loss of income from fishing, loss of revenue, abandonment of fishing job, reduced access to fish for a source of protein (Odhiambo, 2013; Mahon, 2002). Climatological impacts such as erratic upwelling and changes in rainfall patterns can affect fisheries outputs as well as families along the coast and around the Volta Lake whose livelihoods largely depend on fisheries (Badjeck et al., 2010). The Volta Lake in Ghana contributes to about 80% of inland fish catches and stocks about 80% of aquaculture production, again, the Volta Lake is rich in fish species *Chrysichthys*, *Tilapia* and *Synodontis* (Mensah et al., 2016A; Dankwa et al., 1999). Economic potential of the Volta Lake cannot be underestimated; the Lake has economic value estimated at approximately 40,000 metric tons per year (Vanderpuy, 1984; Bank of Ghana, 2008). A trend analysis of fish catch volume over the years revealed that from 16.4 kg/canoe/day in 1991, size of fish catch fell to 12.2 kg/canoe/day in 1996 (De Graaf & Ofori-Danson, 1997) and by the year 2000 there was a further decline of about 5.8 kg per canoe per day (IDAF, 2001).

1.2: Problem statement

As the climate system continues to show signs of variability from one fishing season to another, this current study attempts to determine how rainfall and temperature changes are expected to meaningfully drive fish production and the cascading effects on livelihood strategies of fisher folk in the Yeji environs. There is compelling evidence to suggest that the changing climate is resulting in climate variability and in the frequency, intensity, spatial

extent, duration, and timing of extreme weather and climate events across the globe (IPCC, 2012). The fisheries sector (both marine and inland) is highly sensitive to climatological factors, McCarthy et al., (2001) hinted that climate related stimuli comprise all the elements of climate, including mean climate characteristics, climate variability and the frequency and magnitude (extent) of extreme.

Research works have established that the annihilation of freshwater fish species is caused by increases in habitat modification, changes in stream temperature, and changes to the flow of streams (Poff & Zimmerman, 2012; Sievert et al., 2016). In Ghana, changes in climatological variables such as rain patterns is expected to affect production and catch of inland wild fish and aquaculture fish, according to the (Ministry of Environment, Science, Technology and Innovation (MESTI), 2012). A set of studies have already discovered a steady decline in fish catch from the Volta Lake in Ghana (Brammah 1995; De Graaf & Ofori-Danso 1997). Past studies have suggested that climatic effects on fish also have social and economic ramifications for farming communities and individuals (including fishers) whose livelihoods depend on fisheries and aquaculture, (Pittaluga et al., 2003; Al-Hassan & Poulton, 2009, Athula & Scarborough, 2011; Asante & Amuakwa-Mensah, 2015,).

There are several gaps relative to climate change impacts and adaptation studies. One of the major limitations is that knowledge of climate-induced impacts on the local scale of fisheries livelihoods still remains limited for the reason that much of the literature have focused on national level of vulnerability of fisheries (production) systems (Allison et al. 2009; Quest_Fish 2012). At the local level, a great deal of research into ecosystems response to climate change impacts is fundamental, however, it is interesting to note that several studies about the nexus between climate variability, ecosystems, the fish stock, and the people (fishers) are limited to selected regions (Daw et al., 2009). Undeniably, both the marine and

freshwater fisheries sectors are susceptible to a wide range of climate change impacts because the ecological systems which support fisheries are already known to be sensitive to climate variability (Daw et al., 2009). Furthermore, there is limited literature on climate change adaptation at the local scale, therefore, climate change studies in Africa should focus on assessment of impacts and adaptation to climate change/variability in several regions and sectors (including the fisheries sector), according to United Nations Economic Commission for Africa (UNECA) (2011). In Ghana, too much attention is given to three major physical changes/impacts relative to climate change, these include temperature and rainfall changes, and sea level rise (World Bank, 2014). Nonetheless, it is troubling that rainfall data in several locations across the agro-ecological zones are limited, available studies on rainfall (and temperature) in Ghana are restricted to selected regions or a few rainfall stations (Adiku et al., 1997).

It is worthy to notice that fishers are well aware of climatic variability/change and its associated impacts on fish prices, livelihoods, employment and changed fishing methods according to (Ministry of Environment Science Technology and Innovation (MESTI), 2011). An estimated 300, 000 individuals directly depend on the Volta Lake for their means of livelihood including fishers, fish processors, traders among other post-harvest sector livelihood strategies (Fisheries & Aquaculture Department, 2016). This current study focuses on how to determine the impacts of climate variability on both male and female dominated livelihood strategies in the fisheries value chain. Fisheries related economic activities have been the mainstay of communities around the Yeji side of the Volta Lake as the inhabitants directly or indirectly depend on fisheries as their means of livelihoods. The study also seeks to further determine how sensitivity of the fisheries sector to rainfall and temperature changes is expected to significantly affect fish catch rates. Also, in the wake of climate variability, the prevailing climate is expected to affect livelihood strategies in the fisheries value chain and

livelihood outcomes (outputs of livelihood strategies) such as fish availability, fish accessibility, employment and income from fisheries. Finally, this research output seeks to further determine how the impacts of climate variability are likely to influence the coping and adaptive strategies of fisheries dependent individuals and their households at Yeji.

1.3: Research objectives

The general objective of this study is to determine the impacts of climate variability on livelihoods of fisheries dependent households at Yeji.

The specific objectives of the study are to:

- Determine evidence of rainfall and temperature changes.
- Evaluate the effects of rainfall and temperature changes on fish catch.
- Identify the general determinants or drivers of fish outputs at Yeji.
- Determine the impacts of the prevailing climate on the fisheries value chain.
- Assess the current coping and adaptive strategies of fisheries dependent households.

1.4: Research questions

The main research question for this study is “What are the impacts of climate variability on fisheries livelihoods in households at Yeji?”

Sub-research questions:

- What is the evidence to show rainfall and temperature changes?
- What are the effects of changes in rainfall and temperature on fish catch levels?
- What are the key determinants or drivers of fish outputs?
- What are the impacts of the prevailing climate on fisheries related livelihoods?
- What are the current coping and adaptive strategies of fisheries dependent households?

1.5: Rationale/Justification of study

There is very limited literature on the potential adverse impacts of climate variability on fishers' livelihoods at the local level, in particular household levels at Yeji and adjoining fishing communities around the Volta Lake. There is the need to periodically study the dynamics in changing climate and the manifold pathways of its associated impacts. In the wake of climate variability and the expected location-specific impacts, there is a clear need to research into how the climate is expected to impact on livelihoods of the fisher folk at Yeji. Therefore, this study served as a further research into understanding the impacts of climate variability at the household level. This study aims at adding to the pool of knowledge already available and not to undermine previous studies.

1.6: Organisation of the study

The study consists of six chapters. The first chapter introduces and gives the background and the problem of the study. The second chapter reviews both theoretical and empirical literature which was analysed in thematic areas. Chapter three takes a look at both the description of the study area and definition of the methodology. Chapter four presents the results. Chapter five discusses the results using comparative assessment. Finally, the sixth chapter gives a summary of major findings, conclusions and recommendations.

1.7: Summary

This chapter discussed background of the study, problem of the study, objectives of the study and research questions. The final two sections were used to provide the rationale/Justification of study of the study and the organization of the thesis.

CHAPTER TWO

LITERATUR REVIEW

2.1: Introduction

This section involves the review of both theoretical and empirical literature and scholarly works. This chapter has been organized under nine thematic areas. The first section takes a look at introduction of the chapter. The next section gives an overview of the socio-economic importance of fisheries. The third section discusses variability in the climate system. Section four assesses the relationship between climate variability and fisheries. Section five discusses the socio-economic impacts of climate variability. Section six takes a look at the review of determinants/drivers of fish catch. Section seven assesses the potential adaptive strategies. Section eight examines the conceptual framework while section nine gives a summary of the chapter.

2.2: Overview of the socio-economic importance of fisheries

By and large, inland and marine fisheries sectors enhance food security and contribute to poverty alleviation at the national and household levels through GDP, income tax, foreign exchange and improve standard of living and serve as safety net to fisher folks (Béné et al., 2007; World Bank, 2008). Overall, about 25 to 27 million fishers are employed in fishing and post-harvest activities in developing countries, in Ghana and Senegal additional 5 to 10% of fishers are employed in other linkages (World Bank, 2008).

In Ghana, the fisheries sector contributes to national development in several ways, it represents 4.5% of GDP, enhances food security accounting for 60% of the domestic animal protein, employs 10% of the labour force as fishers, in addition to poverty alleviation, it generates foreign exchange earnings from international trade (Fisheries & Aquaculture Department, 2016). According to the Ministry of Food & Agriculture (MoFA) (2016), the

marine, freshwater (inland) fisheries and aquaculture accounted for 6.1% of Agricultural GDP in 2016.

According to MoFA (2011), overall, more than 2 million fishermen, processors and traders participate in the fisheries value chain (both marine and inland fisheries). The contributions of the Volta Lake fisheries to job creation and food security cannot be underestimated. For example, within the context of inland sector fisheries, the Volta Lake is the main source of fisheries and there are over 72, 000 fishermen using canoes of various sizes working on the Lake (MoFA, 2011).

2.3: Variability in the climate system

Climate variability refers to variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate on all spatial and temporal scales beyond that of individual weather events (IPCC, 2013). Several studies have proven that the climate of West Africa has experience substantial spatial and temporal variability, this variability has been associated with variations in the movement and intensity of the ITCZ, variations in the timing and intensity of the West African Monsoon, and the El Niño Southern Oscillation (ENSO) (Stanturf et al., 2011; Owusu, 2018).

There is proven evidence that greater part of the West African sub-region is located within the Inter Tropical Convergence Zone (ITCZ), this is where both humid monsoon air masses from the Gulf of Guinea and the hot, dry Harmattan winds from the Sahara Desert converge (Béné & Russell, 2007). Seasonal rainfall patterns (wet and dry seasons) across West Africa (including Ghana) is influenced by the African Easterly Jet (AEJ), the Tropical Easterly Jet (TEJ) and movement of the ITCZ which is controlled by the position of the sun (Jung, 2006). Movement of the ITCZ northward from the Equator marks the start of the first rains along the coastline of Ghana in March, and the Sahel area of Burkina Faso by April-May while a

reverse movement of the ITCZ southwards creates a second peak of rainfall across several parts of Ghana in August-September (Rodgers et al., 2006; Béné & Russell, 2007).

According to the World Meteorological Organization (WMO) (2019), El Niño Southern Oscillation (ENSO) is one of the major drivers of seasonal variability in both global weather (and climate) patterns and temperature. The El Niño-Southern Oscillation (ENSO) is associated with global teleconnections which is responsible for changes in rainfall as well as weather patterns in different parts of the world (Davey et al., 2011; Collins et al., 2010). Research works have shown that the effect of ENSO on West African rainfall has intensified since the 1970s (Janicot et al., 1996; Janicot et al., 2001). Generally, sea surface temperature and rainfall changes have been observed in several parts of Africa, these include heat wave in South Africa, delay and poor distribution of precipitation in parts of the Sahel region, and rainfall deficits of about 17% below the long-term mean in parts of West Africa (WMO, 2015). A study carried out in West Africa by the International Research Institute for Climate and Society (IRI) (2009) found heightened odds of below normal rainfall during El Niño events in Côte d'Ivoire and Cameroon in October-December, in Côte d'Ivoire, Ghana and Nigeria in January-March and in Côte d'Ivoire and Nigeria in July-September. Empirical evidence shows that La Niña occurrence is associated with high annual rainfall inputs for most areas in the West African sub-region (Mason & Goddard, 2001). In Ghana, historical rainfall studies have established a link between ENSO events and amount of rainfall received across the Volta River Basin (Owusu et al., 2008; Waylen & Owusu, 2014; Boadi & Owusu, 2017). A study by Owusu et al., (2018) found that about 15% of variability in total annual rainfall recorded in the Ho municipality was exclusively caused by ENSO phenomenon, in effect, El Niño causes decreases in rainfall amounts while La Niña causes increases in the mean annual rainfall amounts.

This section takes a look at further evidence of climate variability and change. The evidence of climate variability and change since 1950 include changes in temperature and precipitation, El Niño, drought and floods (IPCC, 2012). Potential climate related hazards across the southern, middle and northern belts of Ghana include rainfall associated with storm, drought, extreme temperature, floods, famine, pest infestation, desertification, bush and wild fires (Nelson et. al., 2010). From the perspective of temperature, there is overwhelming scientific evidence that seasonal changes in temperature is a major physical indicator of climate variability. For example, the IPCC (2007) projected that global mean temperatures are most likely to increase by between 1.4 and 5.8 °C. According to Hulme et al., (2001) temperature across Africa is expected to rise by 2-6 °C. Another temperature study projected differences in temperature based on location, for example, Jung (2006) projected an average increase in temperature by between 1°C along the coast and 1.5°C in the sahel areas from April-May and November-December. Generally, the climate of Ghana has been characterized by temperature increase of 1°C over the past 40 years (1960 – 2000) at an average increase rate of about 0.21°C per decade across the agro-ecological zones of Ghana (Agyemang-Bonsu et al., 2008; MESTI, 2012). In effect, currently a warming climatic trend has been observed, the climate change report (2015) found that between 1960 and 2003 the average number of hot days per year has increased by 48, the number of hot nights per year has also increased by 73, frequency (regularity) of cold days per year has decreased by 12, while the number of cold nights per year has decreased by 18.5. The prevailing climatic condition in the Volta Basin is most likely to be warmer as well because temperature around the Volta Lake is projected to increase by 1°C and 1.5 °C (Mensah et al., 2016). It is worthy to notice that the mean annual temperature increase is similar to the temperature for the rest of the West African sub-region with the exception of local cooling conditions along the fringes of countries such as Ghana, Burkina Faso and Cote D'Ivoire (Daron, 2014).

The Changing rainfall pattern is another important physical indicator of climate variability. Over the period, rainfall in the West African sub-region has experienced inter-annual and inter-seasonal variability, there is evidence that differences in rainfall between the two major seasons (dry and wet) is expected to reach 50% (Jung, 2006). Besides, past rainfall records show inter-decadal variability (Jung, 2006; Nicholson et al., 2000). A study by Weldeab et al., (2007) observed declining rainfall pattern across West Africa over the past 5 decades while Kunstmann & Jung (2005) reported a marginal increase in total annual precipitation by 5% and as large as 70% decrease in April in the Volta catchment. Although there is no consensus on future rainfall outlook, past rainfall records across most agro-ecological zones of Ghana indicate a decreasing trend in total annual precipitation (Minia, 2008; Owusu & Waylen, 2009, 2013). The climate change report (2015) examined the trajectory of rainfall across the agro-ecological zones of Ghana and the findings include initial increase in rainfall especially in the 1960s and subsequent decrease in rainfall in the late 1970s and early 1980s representing an average reduction of 2.3mm per month per decade. The report also projected a reduction in mean annual rainfall by about 10%. An assessment of rainfall trends from 1990 to 2008 for six selected synoptic weather stations found negative departures of rainfall in 1990s (Nkrumah et al., 2014). Overall, the impacts of climate variability and change on rainfall include late onset of rains, early cessation (termination) of rains in addition to constant decreased span of the rainy season coupled with increased number of dry spells as well as decrease in rainfall totals and changes in the rainfall regime (Akponikpè et al., 2010; Klutse et al., 2013).

Sea level rise is another distinguishing feature or indicator of Climate change and variability, according to the Intergovernmental Panel on Climate Change (IPCC) (2007), the coasts are susceptible to increasing risks emanating from coastal erosion, climate change and sea-level rise. Elsewhere, sea level has risen on average by 18cm, according to (McField, 2017). Over

the past 30 years Ghana has experienced sea-level rise by 2.1 mm per year, and a further rise of about 5.8 cm, 16.5 cm and 34.5 cm has been projected by 2020, 2050 and 2080 respectively (Agyemang-Bonsu et al., 2008). Climate variability and change, and sea level rise are closely related, according to Nelson et. al., (2010) tidal waves and sea rise are projected to wreak havoc along the Eastern Coast of Ghana especially Keta and Ada.

Climate variability and change has wider potential implications on water resources, according to the United Nations Economic Commission for Africa (2011), over the past 40 years, the African continent has experienced repeated impacts of climate change and variability on water resources such as lakes, rivers and snow covers. The United Nations Water (UN-Water) (2010) noted that climate change is likely to impact on the entire element in the water cycle. Climate change and variability can as well alter the rate of recurrence and magnitude of both floods and droughts across the globe (Jiménez et al., 2014). In Ghana, the EPA (2000) observed runoff decline of 20% and 30% across the river basins as a result of temperature increase of 1°C over the past thirty years (1961-1990). Kankam-Yeboah et al., (2011) found that extreme rainfall has caused flooding in 2007, 2008 and 2009 in parts of Accra, Upper East, Upper West and Northern regions while rising temperatures have led to the drying up of some rivers in the dry season. The observable impact of climate change on water resource in Ghana is consistent with the trend in other regions. For example, the effects of climate change on water resources are manifested through various path ways including flooding, drought, sea level rise, change in the rate of recurrence and distribution of rainfall, drying-up of rivers and receding of water bodies (Bates et al., 2008; Urama & Ozor, 2010). Generally, the impacts of climate change at the global scale include altered rainfall patterns and river flows among other impacts (FAO, 2011).

2.4: Relationship between climate variability and fisheries

2.4.1: Effects of climate variability on marine and inland fish production sectors

National climate report such as the Republic of Mauritius Third National Communication Report (2016) noted that climate change (and variability) is expected to exacerbate non-climatic stresses leading to local fluctuation in catch, altered growth rates of fish population and stock migration. Evidence indicating the increasing warming of the global climate system and the potential effects on fisheries include El Nino Southern Oscillation (ENSO), sea level rise, changes in rainfall, changes in river flow and lake levels, changes in storm frequency and severity, threats to distribution and productivity of both marine and inland fish stock (Badjeck et al., 2009; FAO-Adapt, 2011; Fisheries Management Science Programme (FMSP) Policy Brief 4). Generally, climate related hazards such as floods, drought, storm and Tsunami have serious implications for agricultural livelihoods, and the most vulnerable agricultural sector is the crop sector, followed by livestock, and fisheries while the forestry sector is the least affected sector (FAO, 2017). Other studies have also assessed the impact pathways of climate change and variability relative to fisheries (Ficke et al., 2007; WorldFish Center, 2007). The climate change impacts study conducted by Muir & Allison (2007) identified seven (7) primary drivers of the fisheries sector outputs and yields, these are changes in sea surface temperature, El Niño-Southern Oscillation, rising sea level, higher inland water temperatures, changes in precipitation and water availability, increase in frequency and intensity of storms, and drought.

These potential drivers have far reaching implications for fish production, for example, temperature increase and its associated warming of freshwater ecosystem is likely to cause losses of fish habitat, annihilation and extinction of aquatic organism (Matthews & Zimmerman, 1990). Warming of the climate can result in losses of about 15-59% of cool and cold water bodies (fish habitat) (Eaton & Scheller, 1996; Mohseni et al., 2003). Given the

location of Africa within the tropics and the warming effects of the climate, Christensen et al., (2007) hinted that amplification of temperature of approximately 1.5°C to 2.0°C will adversely affect fisheries in West African lakes. Historical climate record showed that the mean temperature of the Volta Lake is about 29.8°C and averaged between 31.0°C at the top and 29.3°C near the bottom (Czernin-Chudenitz, 1971). In recent past the rise in Sea Surface Temperature (SST) and global warming have driven more than 50% of fluctuations in the biomass of zooplankton in the Gulf of Guinea, and have also caused failures of fishing activities (Africa Action, 2007; Wiafe et al., 2008). Generally, previous studies (Koranteng & McGlade, 2001; Wiafe et al., 2008) have found that major upwelling periods enhance high zooplankton production while high seas surface temperature (SST) cause low zooplankton production.

Changes in hydrological flow (fluctuation in lake/river levels due to drought and flood) is another basic and fundamental mechanism through which climate variability and change can impact on inland ecological organisms as well as the fisheries sector (FAO, 2011; Field, 2014; Ottaviani et al., 2017; FAO, 2018). Previous study carried out by Béné (2007) noted that water level is a major determinant of the output of the Lake Volta fishery. Another study conducted by De Graaf & Ofori-Danson (1997) established a link between Catch Per Unit Efforts (CPUE) and the lake level which denotes that when lake level was high, catches were high as well and vice versa. There is compelling evidence from the research community to suggest that despite the negative connotations, not all effects of climate change and variability have negative implications for fisheries. According to Daw et al., (2009), climate change has both negative and positive impacts on inland fisheries. For example, increases in extreme weather (and climatic) events, such as droughts and floods can affect the fisheries sector differently (Barange et al., 2018). Studies have found that flood event, which is the result of increased basin run off and discharge rates may raise fish yields Allison et al.,

(2005), for the reason that seasonal flooding is a major driver/determinant of biotic (fish) productivity (Junk et al., 1989; Bene, 2007). Elsewhere increase discharge rates and flooded areas of rivers have coincided with high biomass production while dry conditions have caused low production (Halls et al., 2001). On the other hand, several climate change impact studies in the West African sub region found that climate induced low flooding, decrease of floodplains, and drying up of lakes have caused decreases in fish catch rates (Welcome, 1986; Laë, 1992; Laë, 1994; Oyebande et al., 2002). Prolonged dry spell can also cause series of effects such as reduce fish availability as well as collapse or failure of the fisheries sector (Allison et al., 2007).

El Niño Southern Oscillation (ENSO) has series of effects (positive or negative) on the production ecology as well as fish yield. For example, ENSO is partly associated with rains, flooding or very hot or cold weather (and climate) (FAO, 2019). Several studies have reported that Peruvian scallop fishery has experienced changes as a result of changes in upwelling and sea temperature caused by La Niña and El Niño episodes (Badjeck, 2008; Badjeck et al., 2009). According to Blanco et al., (2007), in Columbia, the La Niña event (and its attendant cooling of sea surface temperatures (SST)) of 1999 to 2000 boasted tilapia fishery. Also, Ordinola (2002) noted that La Niña events drove high catch of anchovies and increased revenues for the industrial sector. It is important to note that previous El Niño event exacted a heavy toll on people whose livelihoods depend on fisheries (FAO, 2019). Arguably, the 1982-1983 and 1997-1998 El Niño episodes were viewed as the most severe El Niño events (Executive Committee, 2010). Impacts of El Niño on the fisheries sector include the drastic decline in anchovy catch caused by warming of water bodies previously known to be cold with nutrient-rich and conducive temperature which support fisheries (World Meteorological Organization, 2014). The 1998 El Niño event affected the anchovy biomass production leading to a reduction of 1.2 million tonnes, the lowest production recorded in the

1990s (Ñiquen & Bouchon, 2004). In a related development, the 1997-1998 El Niño episodes led to a significant reduction in the volumes of fisheries output by 55% compared with 1996, according to (CAF, 2000). Climate change impacts studies have reported severe bleaching and mortality caused by El Niño, according to Graham et al., (2006), coral population dropped from 27% to a staggering 3%, leading to the extinction of coral-feeding fish species.

The changing fishing seasons (wet and dry seasons) have significant effects on fisheries, in the sense that fish stocks vary with the changing fishing seasons causing correspondent changes on fish-stock size, fish quantity and availability as well as changes in catch (Fisheries Management Science Programme (FMSP) Policy Brief 4; Trotman, 2009; Odhiambo, 2013). Impacts of climate change and variability on inland fisheries and aquaculture production system are expected to vary (FAO, 2010). According to Pittaluga et al., (2003), the major fishing season for the Volta Lake fisheries is the rainy season between June to September whereas the lean season is the dry season between November to April/May when the lake levels is receding. Owusu et al., (2018) noted that generally, temperature and sunshine periods are important climatological determinants of the prospect of the agricultural sector including crop adaptability, nonetheless, in the tropics, the most important driver of agricultural activities is rainfall since rainfall has dominating effect over temperature and sunshine hours. The climate change report (2011) revealed that conducive climatic environment such as ideal temperatures, good precipitation and rainfall and river runoff can enhance spawning and larval growth and feeding, and recruitment.

2.4.2: Impacts of climate variability on post-harvest activities

A Study shows that approximately 38 million people are employed in fisheries and aquaculture across the globe, and ancillary businesses such as fish processing and marketing employ around 50 million fisher folk (Fisheries Management Science Programme (FMSP)

Policy Brief 4). According to Mensah et al., (2012B), almost 80% of fish landed in Ghana is processed through smoking and other means of preserving fish such as sun drying and frying. In the area of post-harvest fish losses, a study conducted in Ghana, Kenya, Mali, Tanzania and Uganda by Akande & Diei-Ouadi (2010) found that rainy season is a major contributing factor to post-harvest fish losses. At 95% confidence levels, the study found a strong relationship between the causes of fish losses and the season in which the losses occur. The study also estimated quality loss for inland and coastal areas in Ghana at 63.3%. Other sets of studies have associated fish losses with poor drying of fish landed due to weather and climate constraints during the wet season, in effect, post-harvest losses are predicted to increase during intensified rainy periods (Kabahenda et al., 2009; Timmers et al., 2012). The net effects of unpredictable rain patterns on fish processing are post-harvest losses, changes in processing technologies and costs (Ficke et al., 2007; WorldFish Center, 2007).

The impacts of climate change and variability on post-harvest fish transportation/supply, fish marketing and trading efficiency is at the core of post-harvest fisheries assessment. For instance, the likely outcome of inaccessible trade routes and scarcity in fish supply are lack of access to markets, changes in both market routes and transport times, price increases, and decrease revenues (Ficke et al., 2007; WorldFish Center 2007). Arendt et al., (2014) noted that rise or fall in levels of inland water bodies is projected to adversely affect inland navigation in different regions. The economic impacts ensuring this may be immense (Krekt et al., 2011). The impacts of climate change on Rhine include longer periods of low flow which is estimated to increase the average annual number of days during which inland navigation is either hampered or stagnated as a result of restricted load carrying capacity of the river (Middelkoop et al., 2001). Increased storm conditions are most likely to raise cost of transport in two ways, first, through additional safety measures and second, using longer routes that are less storm prone (UNCTAD, 2009; UNECE & UNCTAD, 2010). In addition

to this, the effects of extra atmospheric Carbon Dioxide (CO₂) emission are that changes in water levels, and severe climatic conditions can increase annual transportation cost by 29%, while moderate conditions can cost as much as 13% increase (Millerd, 2010). At the local scale, throughout the year approximately 40,000 metric tons of fresh fish are processed and transported to the markets in southern Ghana from major inland fish trading centers along the Volta Lake such as Yeji, Kpandu-Tokor, Buipe, Atimpoku, Agormenya and Kete Krachi (Samey, 2015). The predominant local threats to efficient fish supply and trade/market is frequent boat accidents on the Volta Lake caused by climatic factors such as strong winds/storms, heavy rains, thunder and lightning, lake level fluctuations (Kwame, 2008). A source at Yeji disclosed to the Daily Graphic in 2016 that a boat carrying between 60 and 70 passengers from Nantwie Akura to Yeji struck a tree stump, split into two before eventually capsizing (Adu-Gyamerah, 2016).

2.5: Socio-economic impacts of climate variability

The Ghana Living Standard Survey Round 5 (GLSS-5) income and non-income indices are composed of healthcare, income (revenue) generation, employment and food security (GSS, 2008). For the purpose of this study, the index may be a useful framework for assessing the effects of climate variability on fisher folks. Livelihood strategies are collection of activities and choices of persons which aim to achieve their livelihood goals (DFID, 2000). On the other hand, livelihood outcomes are the dividends of livelihood strategies, such as incomes, well-being, lessen vulnerability, food security and sustainable (judicious) use of natural resources (GLOPP, 2008).

Non-income related impacts of climate change can be viewed from the perspective of food security components such as aquatic food availability, aquatic food access, food supply stability and food utilization (FAO, 2008). A study in Sub-Sahara Africa by Mohammed &

Uraguchi (2013) indicated that in Ghana a reduction in fish production by 10,000 metric tons (partly due to climate change) would as well increase the prevalence of hunger and food insecurity from moderate to serious level while in Kenya and Ethiopia, a similar reduction in catch level could drive their prevalence from the current serious level to alarming and extremely alarming levels respectively. It is important to notice that even well-managed coastal fisheries in various West African coastal regions have not been able to sustain adequate fish supply. So, declining fisheries outputs are likely to have ripple effects on fish availability and food (fish) accessibility (Katikiro & Macusi, 2012). Food (fish) availability will decrease in some parts of the globe due to a decline in food production from agriculture, forestry and fisheries as a result of extreme events (FAO, 2011). According to Müller-Kuckelberg (2012), extreme climatic occurrences such as droughts (due to less rainfall) or heavy/extreme rainfalls (and floods) can cause serious damage to climate sensitive crops which in turn may affect food production and food security. According to Asante & Amuakwa-Mensah (2015), decline in the fisheries sector may hamper the ability to meet domestic demand and may also threaten the economic and food security of many Ghanaians (including fishers). The UN SDGs report (2018) noted that hunger at the global scale appears to be on the rise and the underlying causes are conflict, drought and disasters associated to climate change. In addition to food security, climate change and variability is expected to adversely affect fish growth leading to loss of employment from fisheries (climate change report, 2011). Across the globe nearly 10% of the labour force mostly low income earners of less than USD\$1.90 are not self-sufficient, it is troubling that almost 34% of the labour force and their dependence in sub-Saharan Africa lived in extreme poverty, according to (United Nations Sustainable Development Goals (UN SDGs), (2017).

The income related impacts of climate change on livelihoods of fisher folk are that variability in the availability of fish products can affect total revenue generation and harvesting costs

resulting in high costs in managing and accessing natural capital (Badjeck et al., 2009). Apart from fish quality and fish production losses, high fishing season temperatures can cause revenue losses, and at the macro level low earnings from fish export (Mohammed & Uraguchi, 2013). There is documented evidence to suggest that the livelihood of fishermen is closely linked to outputs from fishing activities, so when fish catch is affected livelihoods are affected as well (Massamba et al., 2005; Gnimadi et al., 2006). A study in Morogoro, in Tanzania, noted that extreme climatic events impact livelihoods in specific ways and that vulnerability of households in rural areas compared to urban environments is triggered by low incomes and consumption levels, greater levels of poverty, and more limited access to markets and other services (Paavola, 2008). A survey conducted by Müller-Kuckelberg (2012) solicited views of farmers and agricultural workers in Ghana about climate change and its associated impact on livelihoods. Overall, about 88.4% of the respondents attributed reduction in sales to climate change, in terms of income decrease; another 90.9% of the respondents attributed this to loss of crops or livestock due to bad weather conditions.

2.6: Determinants/drivers of fish catch

For a comprehensive assessment of drivers of economic returns from the fisheries sector, a research work in Uganda by Timmers (2012) revealed that stakeholders involved in fisheries in Uganda generally consider the impacts of climate change and variability to be inseparable from non-climate related drivers of change.

A study conducted by International Financial Corporation (IFC) World Bank Group (2015) threw the spotlight on the role of inputs. The study identified (discovered) a wide range of fishing gears required for driving the rates of fish catch such as fishing boats, motors, fishing nets, lines, hooks, fuel for powering the boats, and ice for preserving fish. Conversely, inadequate supply of fuel and electricity is most likely to hamper the capacity to fish, and the

frequency (number of trips), distance fishers cover, and duration of trips. Limpus (2002) noted that lack of access to fuel, catch storage, crew requirements and onboard processing facilities are also responsible for limiting fish catch. Binyam (2011) noted that fish catch levels can be determined by boat type, crew size, fishing experience, access to ice, fisher's household size, access to credit facilities, non-fishing income and age of the fisher (head of the fisheries household). According to FANRM, MKK, MRAG (2003A), generally, inadequate financial support to fisher folk for the purchase of modern fishing gear and vessels tend to hinder fishers from gaining access to sea worthy boats. Apart from this, factors such as labour, credit, and cold storage facilities, access to larger and effective fishing boats with the capacity to reach deep sea (rich fishing grounds) can enhance fish catch rates according to (Akanni, 2010). A study carried out by FANRM, MKK, MRAG (2003B) revealed that lack of knowledge on the part of fishers about the existence and location of off-shore resources (amount of fish) affects artisanal small-scale fishing. Using socio-economic features, ecological indicators and fish catch data from Yala swamp, Mwakubo et al., (2007) proposed that the length of boat, household sizes, total nitrogen, and phosphorus is positively related with catch level. Munirul et al., (2013) found that the main indicators of adaptive capacity are health and experience, here emphasis was put on the effect of long ill-health on household head (fishermen) and the ripple effects on the livelihood activities (fishing). According to Inoni & Oyaide (2007), factors that contribute to the up-scale in (increase in) fish catch are adequate investment in fishing vessels, and government policy of input subsidy. Then again, the erratic supply of premix fuel has been identified as a major factor that undermines fishing activities in communities along the coast (Mensah et al., 2006C). Irregular supply and lack of affordable premix fuel and the resultant diversion and hoarding gave rise to low fish catch which in turn led to low household income and low development of fishing communities (MoFA, 2011). Finally, research has shown that various fishing methods used for fishing on

the Volta Lake determine fish catch levels, these include: Gill nets, Line fishing, traps, cast nets, Nifa Nifa, Beach seines, purse seines, mosquito nets, Winch nets, Atigya, Wangara, Bamboo-pipe, Spears, poisoning (MoFA, 2003). Active fishing gears contribute between 65 and 70% to the total fish landings from the Volta Lake (Braumah, 1991).

2.7: Potential adaptation strategies

There is overwhelming evidence that low income (developing) countries and the poorest people in society are the most vulnerable to the scourge of climate variability and change, this can be attributed to low adaptive capacity to climatic stimuli (IPCC, 2001). Across the globe food security is increasingly becoming a mammoth challenge, therefore, the Food and Agriculture Organization (FAO) recommends diversification of livelihoods and income generating activities through integrated farming, forestry and fisheries systems, small-scale enterprise development and off-farm activities (FAO-Adapt, 2011).

Generally, climate-smart agriculture aims at addressing food security and impacts of climate change by sustainably increasing agricultural productivity and incomes, adapting and building resilience to climate change and reducing greenhouse gases emission (FAO, 2010; FAO, 2013). Within the Ghanaian context, the national climate-smart agriculture and food security action plan (2016-2020) was designed to achieve climate-resilient agriculture and food systems across the agro-ecological zones (Essegbey et al., 2015). Using climate-smart agriculture option, the FAO (2013) has outlined the effective measures for reducing vulnerability in the fisheries sector. From the perspective of inland fishing, the study indicated that resilience of fishers can be increased through access to higher value markets, increasing fishing capacity, reducing costs while increasing efficiency, diversification of livelihoods, implementation of insurance schemes, changes in fishing strategies and processing facilities, and improving weather warning systems and communications. With

regards to the post-harvest livelihood activities (processing, trade and market), resilience can be increased through better forecasting and information systems, modernizing processes and technologies, and diversifying markets and products (FAO, 2013). Again, at the local scale, there is the need to incorporate climate predictions into management decisions to be able to reduce the negative economic impact of weather (and climatic) conditions (Executive Committee, 2010).

According to the National Climate Change Adaptation Strategy (NCCAS) (2012), the basic and fundamental goal of Ghana within the context of adaptation is strengthening adaptive capacity and building resilience of the society (including fishing communities) and ecosystems (including fish habitats). In terms of livelihoods and fisheries management, the focus should be on improvement of output and income of vulnerable groups, promotion of fish farming, fish management and disease control, and development of alternative sources of livelihoods (non-fishing activities) for fisher folk, according to the (National Climate Change Adaptation Strategy (NCCAS), 2012). The most effective adaptation practice available for smallholder farmers (and fisher folk) is that household decision-making on livelihood activities should be the preserve of both the husband and wives (Egyir et al., 2014). Climate change is expected to have significant adverse effects on the livelihoods of fishers, therefore, there is the need to adopt specific adaptation strategies to both reduce these effects and provide effective options to improve livelihoods (Allison et al., 2009). Study has shown that Ghanaian fisher folk along the coastal areas and around Lake Volta will need to adopt non-fishing (farm and non-farming) activities (Badjeck et al., 2010).

According to Lehodey et al., (2006), the rapid rate of change is already putting most fisheries livelihoods under stress. Migration and mobility have been used as a key adaptation strategy or response strategy for migrant fishers in the West African sub-region particularly Ghanaian

fishers who migrate to richer fishing grounds on fishing seasonal basis in response to decline in catches (Brugere et al., 2008). The National Climate Change Adaptation Strategy (GNCCAS) (2012) noted that both climate change and socio-economic vulnerabilities are responsible for the upsurge in rate of migration in Ghana.

2.8: Conceptual framework

This study explores the direct and indirect impacts of climate variability on fisheries livelihoods and the potential coping and adaptive strategies of fishers at Yeji side of the Volta Lake. Climate variability is expected to impact the fisheries sector through multifarious pathways. Figure 2.1 is a useful tool for assessing the impacts of climate variability on the ecological production (inland production system), fish stock, and the livelihoods of fisheries dependent communities.

With regards to inland fishery, fishers operate within an environment shaped by seasonal climatic constraints. Climate-related drivers of the fisheries sector outputs or yield include temperature changes, changes in rainfall total, ENSO, drought, floods, fluctuation in lake levels, storm severity and frequency. Physical changes in these climatological variables are expected to affect the fisheries sector in two primary ways. First, these changes are expected to affect the inland production ecology (fish habitat) and the fish stock/species in it. In effect, the potential outcomes are changes in yield, changes in species distribution, changes in catches, and changes in seasonal production. Second, fishing operation and the post-harvest activities can be affected through damage to fishing gears, loss of inland navigation routes, difficulties associated with fish processing (sun drying due to unpredictable rainfall pattern). The impacts include risk to life, market impacts and cost, impacts on livelihoods of fishing communities, impacts on livelihood strategies and livelihood asset. Climate variability is expected to influence the coping and adaptive strategies of fisheries dependent households

such as cage farming/fish farming, alternative livelihoods and migration. The value chain is described as the full range of activities which are required to bring a product or service from conception, through the different phases of production, delivery to final consumers, and final disposal after use (Kaplinsky & Morris, 2001).

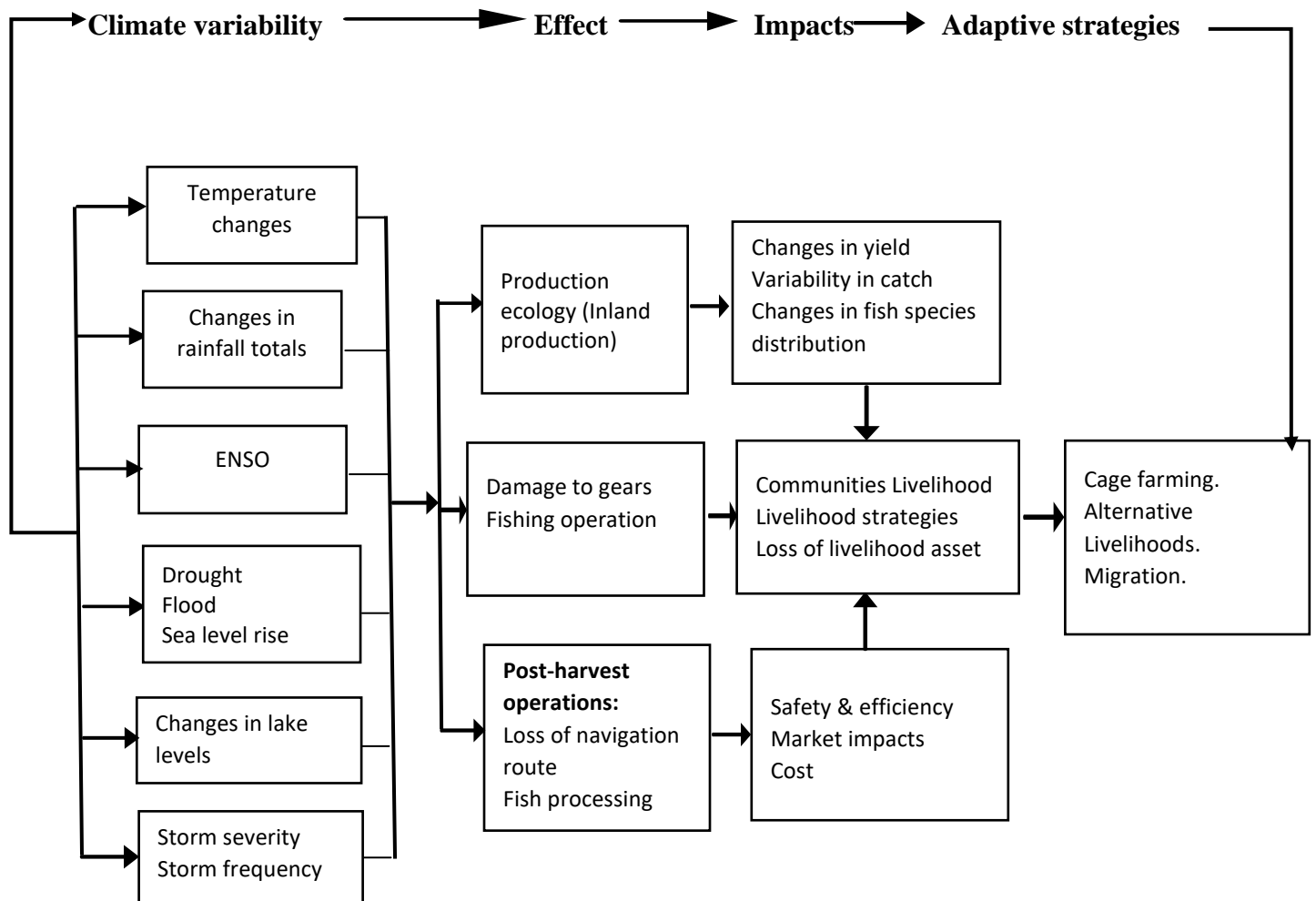


Figure 2.1: Conceptual Framework for the Analysis of the impacts of Climate Variability on Fisheries livelihoods and the coping and adaptive strategies.

Source: Adapted and Modified from Badjeck, et al., (2009)

2.9: Summary

This chapter discussed the impacts of climate variability on the fisheries sector. The chapter discussed the socio-economic importance of fisheries. Moreover, the chapter discussed variability in the climate system and as well as ENSO events. Again, the chapter assessed the

relationship between climate variability and fisheries. This chapter discussed the socio-economic impacts of climate variability. Furthermore, a review of the determinants/drivers of fish catch was conducted. Also the potential coping and adaptive strategies were discussed. Finally, this chapter examined the conceptual framework.

CHAPTER THREE

PROFILE OF THE STUDY AREA AND RESEARCH METHODOLOGY

3.1: Introduction

This chapter highlights profile of the study area and research methodology is structured into eight (8) sections. The section after this introduction gives a description of the study area. Section 3 presents the research design while section 4 describes the type and sources of data. Section 5 describes the sampling procedure. Section 6 defines the sample size while section 7 explains the data collection method and techniques. Section 8 explains the data processing and analysis procedures. Section 9 describes the ethical consideration. The next section discusses the limitation of the study while the last section describes the summary of the chapter.

3.2: Description of the study area

The study was carried out at Yeji, the capital of Pru district and its environs. The Pru District was created in 2004 under Legislative Instrument (L.I) 1778 of 2004 (GSS, 2014). The district is found between latitudes 7° 50'N and 8° 22'N and longitudes 0° 30'W and 1° 26'W. The District's Population is about 129,248. Males constitute a slightly higher percentage of 50.9% while females are 49.1%. Agriculture is the main stay of inhabitants in the Pru District with farming and fishing as the main economic activities in the district. Yeji, the District capital is viewed as the largest inland (freshwater) supplier of smoked as well as salted fish. Cattle rearing and food crops are the other livelihood activities carried out by inhabitants in the district.

The Pru District has area coverage of 3220.7kmsq and it is drained by the Pru River, one of the main tributaries of the Volta Lake. The area is also drained by a collection of about 15 different streams. The prevailing climate type of the District is that of Tropical Continental

or Interior Savannah with mean annual temperature which ranges between 26.5⁰C and 27.2⁰C (GSS, 2014). Sometimes, temperatures rise to about 40⁰C. In terms of rainfall, the study area has double maxima rainfall pattern with annual rainfall ranging between 800mm to 1400mm

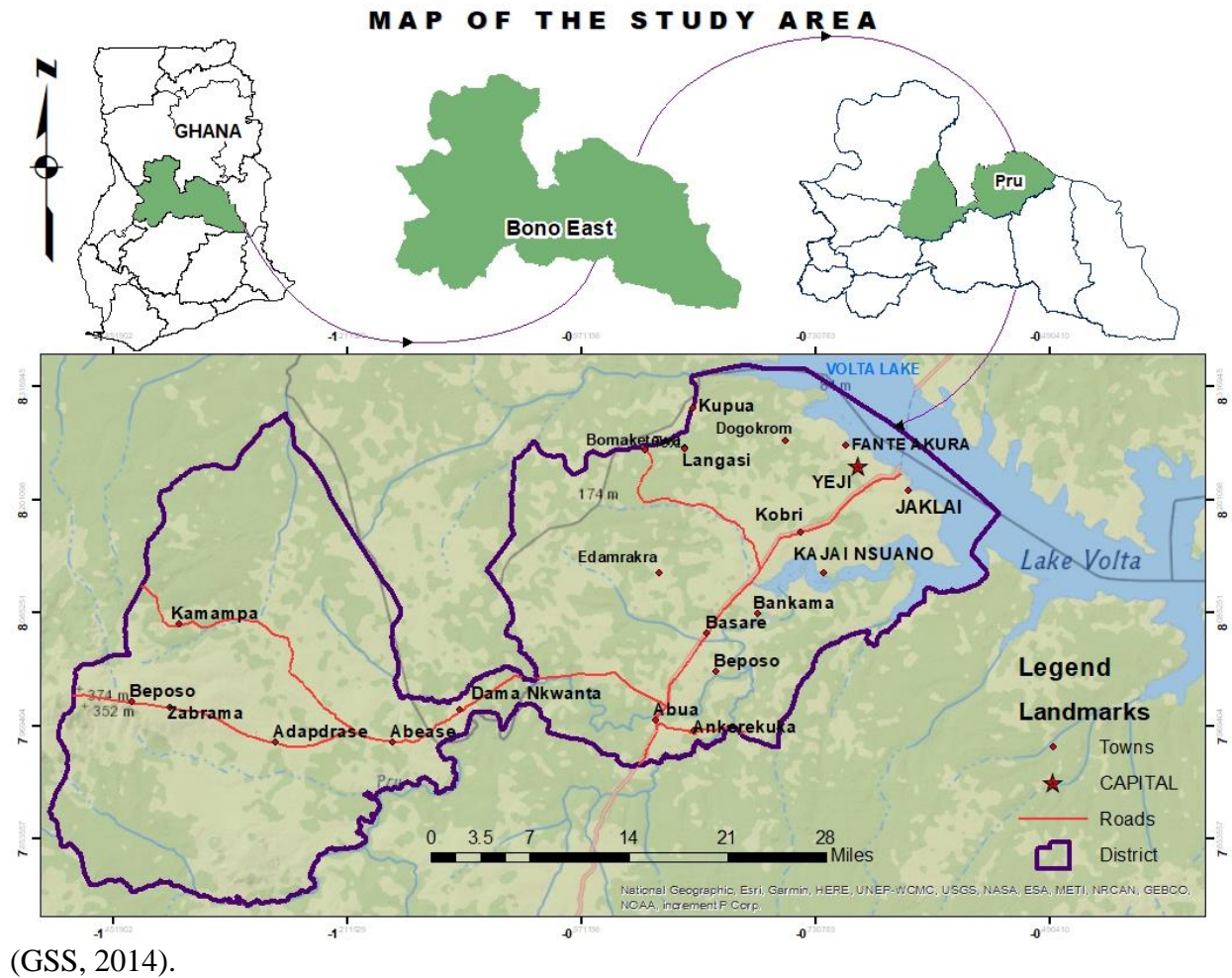


Figure 3.1: Map of Pru District

Source: GIS Lab, Department of Geography and Resource Development, University of Ghana, Legon.

3.3: Research Design

The research approach used to collect and analyse the impacts of climate variability on livelihoods of fishers was the mixed methods. The interactive continuum is the category of mixed methods that is based on the qualitative and quantitative interactive fields (Newman &

Benz, 1998). This study employed the mixed methods as it offers the opportunity to combine both qualitative and quantitative methods by collecting, analysing, and mixing both data sources in a single study in a sequential, and simultaneous and rigorous manner (Creswell & Plano Clark, 2011).

Out of six mixed method designs posited by Creswell (2003), the explanatory sequential design has been identified as the most popular mixed methods design among researchers (Dhanapati, 2016). According to Plano Clark (2011), the initial phase involves collecting quantitative data and later collecting qualitative data which aimed to help further elucidate or clarify the quantitative results. Creswell (2003) also highlighted that with the explanatory sequential design the researcher first collects and analyses the quantitative data while the second qualitative phase builds on quantitative data by helping to explain or elaborate on the quantitative results.

This research output was designed using the explanatory sequential design to obtain substantial amount of data from both quantitative and qualitative sources sufficient for the assessment of the impacts of climate variability on fisheries related livelihoods at Yeji. With the first phase, which is quantitative data source, the data collection procedure/technique used to assemble the data was household survey which mostly involved closed-ended questionnaires. For the second phase, qualitative results were used to elaborate vague or unclear quantitative results. To locate unclear results within the quantitative data set, the researcher sought and identified patterns of connections or linkages within the themes.

3.4: Types and sources of Data

Secondary data were collected on fish catch and climate data (rainfall and temperature) from the Fisheries Department and Ghana Meteorological Agency (GMet) respectively. Climate data about rainfall from 1986 to 2017 and temperature from 1986 to 2012 were obtained from

the Ghana Meteorological Agency (GMet). Fish catch data from 1989 to 2014 was obtained from office of the Fisheries Department at Yeji. Moreover, critical information for profiling the study district in terms of its population, physical attributes and commercial activities was obtained from the Ghana Statistical Service (GSS). In addition, map of the study area and the Landsat satellite images were designed by GIS Lab, Department of Geography and Resource Development, University of Ghana, Legon. Historical data was obtained from sources such as journals, articles and the internet. The primary data was collected through fieldwork using questionnaires and qualitative focused group discussions (FGDs) and key-informant interviews. Field data was used to determine the impacts of climate variability on fisheries related livelihoods of fisheries dependents households and, the adaptive strategies. Table 3.1 presents a summary of the type of data, data variables and sources of data.

Table 3.1: Types of Data Collected

Data collected	Type of data	Data Variables assessed	Source of data collection.
Evidence of climate variability	Secondary	Changes in rainfall (1986-2017) and temperatures (1986-2012).	Historical data from Ghana Meteorological Agency (GMet).
Fish catch trends	Secondary	Seasonal fish catch data (1989-2014)	Documentary source (Fisheries department)
Impacts of changes in rainfall and temperature on fish catch quantity.	Secondary	Effects of changes in rainfall (1990-2012) on fish catch rates	Historical data from Ghana Meteorological Agency (GMet).
		Effects of temperatures (1990-2012) on fish catch rates.	Documentary source (Fisheries department)
Non-climatic drivers/determinants of fish catch	Primary	Boat type, Crew size, Experience, Poor health, Lack of access to capital, Lack of knowledge and access to information, Cost and supply of premix fuel. Unsustainable fishing practices such as bamboo fishing	Household questionnaires (QHs). Focus Group Discussions (FGDs), in-depth interview and non-participant observation.

Data collected	Type of data	Data Variables assessed	Source of data collection.
Impacts of climate variability on fisheries related livelihoods	Primary	<p>Impacts on fish harvesting sector livelihoods:</p> <p>Impacts of low fish output on availability of aquatic food (fish), access to aquatic food (fish), employment from fisheries, income generation from fisheries.</p> <p>Impacts on the post-harvesting sector livelihoods: such as fish processing, fish transportation/supply, fish trading and marketing efficiency</p>	<p>Household questionnaires (HQs).</p> <p>Focus Group Discussions (FGDs), key informant interviews and non-participant observation.</p>
Current coping and adaptive strategies	Primary	<p>Diversified livelihoods:</p> <p>Crop farming, livestock rearing, domesticated poultry and petty trading)</p> <p>Migration to rich fishing grounds</p>	<p>Household questionnaires (HQs)</p> <p>Focus Group Discussions (FGDs), key informant interview and non-participant observation.</p>

Source: Fieldwork, 2019

3.5: Sampling procedure

3.5.1 Target population and sampling design

The target population of this study was fisher folk living around the Volta Lake and those who are engaged in fisheries related activities. At the institutional level the target population was officials of the Fisheries Department. It is important to note that this study focused on stakeholders in the fish harvest and post-harvest value chain. Therefore, at the community and household levels, 5 main categories of respondents were targeted comprising (a) fisheries community members, (b) fishermen, (c) fish processors, (d) fish traders/marketers, and (e) fish transporters/suppliers (boat crew).

The Fisheries Department at Yeji side of the Volta Lake has divided the landing sites (fishing communities) into three broader groups for operational purposes such as catch rate and fish stock evaluation. These three groups include Left of Yeji, Right of Yeji and Pru Arm. To allow for equal or spatial representation, one landing site from each group was purposively selected. These include Fante Akura (representing Left of Yeji), Jaklai (representing Right of Yeji) and Kajai Nsuoano (representing the Pru Arm). Then again, respondents who participated in the key informant and in-depth interviews were purposively selected based on their knowledge, extensive experience (specifically number of years) and expertise in fisheries. Besides this, gender was a critical consideration because both males and females play diverse roles in fish production, fish processing, fish trading/marketing and fish transportation. As a result, two separate gender-based focus group discussions were conducted as well. All the participants in the first focus group discussions were entirely males who practiced fishing and fish transportation while the participants in the second focus group discussions were entirely females who were engaged in fish processors and fish marketers/traders. Age was another important consideration, because the lived or extensive experience of fishers concerning the impacts of climate variability on fisheries dependent households over the period is at the core of this study. In the selection of participants, all males and females aged 20 years and above in fisheries households were all eligible for interview.

3.6: Sample size

There are different fishery cooperatives at Yeji, however, for this study 3 cooperatives were selected purposively. Fisheries cooperatives with ten or more years in operation and constituting total of 994 members were selected; Yamane (1967:886) cited in Israel (2013) offers a formula to calculate sample size.

$$n = \frac{N}{1 + N(e)^2}$$

Where; n= Sample size N = population size e = marginal error of 9.6% or 0.096

Where n is the sample size, N is the population size, and e is the level of precision.

$$n = \frac{994}{1 + 994(0.096)^2} = 108.39$$

Using this formula, 108 respondents were selected for the survey. A high response rate was achieved due to proper co-ordination with the Director of Fisheries, and leaders of the various fishing associations. Households were selected using proportional sampling.

The qualitative sample size for this study was also determined. Explanatory sequential design allows participants in the qualitative study to participate in the quantitative study. In essence the sample sizes can be equal or less, however, the qualitative study uses smaller sample (Niobe et al., 1994). Based on this, at the institutional level two (2) officials of the Fisheries Department were selected for in-depth interviews. At the community level, four (4) respondents were selected for key informant interviews. Again, two separate gender-based focus group discussions (FGDs) were conducted for stakeholders in the fisheries value chain. Participants in the first focus group discussions (FGDs) for the males who practiced fishing/fish transportation were eight (8) while participants in the second FGDs for females who were engaged in fish processing, fish marketing and trading were six (6).

3.7: Data Collection Methods and Techniques

3.7.1: Method of collecting quantitative data set

Household surveys were conducted at the community level. Distributions of structured and unstructured questionnaires were done through interviewer administered household questionnaires. Closed-ended questions were used in the survey to elicit information from

respondents. Generally, the household survey was used to describe the demographic and socio-economic characteristics of respondents from fisheries dependent households. Information from the household survey also described the prevailing climate at the research site, effects of rainfall and temperature changes on fish catch, impacts of the prevailing climate on livelihoods in the fisheries value chain, key determinants/drivers of fish catch, and current coping and adaptive strategies.

3.7.2: Method of collecting qualitative data set

The second phase, which is basically qualitative data set, was used to elaborate vague or unclear quantitative results. Four main data collection procedures/techniques were used to collect the textual/word-based data, these include: key informant interview, in-depth interview, two separate gender-based focus group discussions and observation. The key informant interviews were used to elicit responses from participants based on their knowledge, and their lived experience in terms of the number of years in the fisheries related activities. At the community level, four (4) interviewees participated in the interviews. An open-ended interview guide was used to collect information about, first, climate and non-climate constraints undermining fish transportation efficiency and second, migration of fishermen as a coping strategy. Mikkelsen (1995) suggested that key informants are people expected to have knowledge of or insight into a subject matter or topic and can give expert opinions and views about it.

Again, at the institutional level two (2) officials of the Fisheries Department were selected for in-depth interviews based on their expertise in the fisheries sector. In-depth interview was used to gather information from officials of the Fisheries Department at Yeji about unsustainable fishing practice used to boost fish catch, and the impacts of rainstorm, droughts and floods on fish outputs. According to Barusman, (2019), the in-depth interviews are

mostly paired with other research methods like survey, focus group among others in recounting opinions, experiences, values and different aspects concerning the population under study.

Moreover, two separate gender-based focus group discussions (FGDs) were conducted for stakeholders in the fisheries value chain. Participants in the first focus group discussions (FGD) for the males who practiced fishing/fish transportation were eight (8) while participants in the second FGD for females who were engaged in fish processing, fish marketing and trading were six (6). Two different open-ended focus group discussion guides were used for males and females operating in the fisheries value chain. The first gender-based focus group discussion for males who practiced fishing/fish transportation explored the effects of irregular supply and high price of premix fuel on fish catch, and impacts of low fish returns on labour. The second gender-based focus group discussions for females who engaged in fish processing, fish marketing and trading was used to assess the effects of unpredictable climate elements on fish processing, fish marketing/trading efficiency and the effects of gender orientation on the choice of alternative livelihood. According to Kitchen & Tate (2000), the dynamics of a group discussion often bring to the fore the feelings and experiences that might not be expressed in the case of the research asking just one person questions about a topic or subject matter.

Finally, non-participant observation was used to give pictorial account or records of issues. A different data collection technique was used, for example, photography was used to capture scenes/events happening at the various landing sites. Images in Plates 4.1, 4.2, 4.3, 4.4 and 4.5 were used as thematic images. Non-participant observation was used to collect information about unsustainable fishing practices such as the use of bamboo pipes to boost fish catch, and the combined effects of rainstorm, prolong dry spell and the menace of tree

stumps on fishing materials (fishing nets and boats). Other data collected using this technique included data about the types of processed fish sold at Yeji weekly market and the impacts of prolonged dry spell on ferry services and effects of rainstorm, tree stumps and dry spell on boat services. According to Basil, (2011) photographs are basically used to record visual depictions of both people and events. Most importantly, these images (pictures) are used as additions to field notes. Nonetheless, if the inquiry is predominantly visual, photographs could be the principal source of data.



Plate 3.1: Interaction with Some fish processing, trading and marketing women during focus group discussions

Source: Field Survey, 2019

3.8: Technique of Data Processing and Analysis

First of all, there is a need to understand the difference between these two important terms. Strictly, data processing implies editing, coding, classification and tabulation of collected data so that they are responsive/agreeable to analysis. On the other hand, the term analysis refers to the calculation of certain measures along with searching for patterns of connection that exist among data-groups (Kothari, 2004).

3.8.1: Quantitative data analysis

With the first phase, thus the quantitative data analysis, numeric analysis was carried out. The quantitative data set was processed by editing, coding and entering into the Statistical Package for Social Sciences (SPSS) for subsequent analysis. Data from the household survey was processed and analysed using simple statistics such as totals, frequencies, tabulations and cross tabulations percentages, and displayed in the form of graphs, tables, graphs and charts.

The researcher used variety of indicators to monitor climatic trends. For this study, the climate data parameters encompass rainfall, land surface temperature, maximum and minimum temperatures. Another index that was used to analyze climate variability is ENSO episodes from 1986-2012. Also, the researcher used variety of tools and techniques to analyze the climate data. The technique used to analyze rainfall was annual rainfall anomalies/abnormalities graph. Heights of rainfall anomalies bars were used to analyze changes in annual rainfall totals. Again, deviation of the anomalies bars from the base to the top is the positive (+) annual rainfall anomalies representing the wet periods while the bars to the opposite direction are the negative (-) annual rainfall anomalies representing dry periods.

Similarly, the maximum and minimum temperatures were analyzed using the annual temperature anomalies graphs. Temperature anomalies bars were used to assess temperature changes over the period. Deviation of the anomalies bars to the top represents the positive (+) annual temperature anomalies bars which imply high temperature as well as potential warm condition. Conversely, negative (-) annual temperature anomalies bars imply temperature decrease as well as potential cold climatic conditions. Relative to land surface temperature, satellite observation was another technique used to analyze the temporal and spatial variation in temperature.

For ENSO, the technique used to analyze ENSO occurrences was the temperature and rainfall anomalies graphs. Departure of the ENSO line from the mean ENSO has implications for temperature and rainfall changes. In the context of temperature, deviation of the line above the mean ENSO baseline implies prospective warm conditions while the line below the mean ENSO baseline implies the likelihood of cold conditions. From the angle of rainfall, deviation of the line above or below the mean ENSO baseline has implication for rainfall variability. The line above the mean ENSO baseline has implications for low rainfall as well as possible dry conditions while the line below the mean ENSO baseline implies the likelihood of high rainfall inputs and wet conditions. The ENSO values represent severity of the phenomenon.

Annual fish catch data was also examined. Using the line graph, annual variations in fish catch trends over the years were examined. Besides, correlation, a statistical procedure was used to determine how strongly climatic figures (rainfall and temperature figures) and fish catch figures are related. Tables were used to match rainfall and temperature changes with annual fish catch to examine the link between changes in the climate variables and fish catch rates. The assumption is that fish catch volumes are controlled by climatic variables. When rainfall figure is low, fish catch figure is expected to be low as well. It means that low catch was due to the failure of the rains. Similarly, the study assumes that high rainfall years and corresponding high fish catch figures indicate a correlation between amount of rainfall and fish catch levels. Within the context of temperature, the assumption is that when temperature figure is high, fish catch figure is expected to be low. This indicates that low catch was due to the high fishing season temperature and its associated warm condition. Likewise, when the temperature figure is low, fish catch figure is expected to be high indicating a relationship between low temperature and high fish catch.

3.8.2: *Qualitative Data Analysis*

With the second phase, textual (word-based) analysis was conducted. The qualitative data collected and the analysis aim to explain or highlight the statistical results by exploring participants' views, opinions, knowledge, and the lived experiences in detail (Rossman & Wilson 1985; Tashakkori & Teddlie 1998; Creswell 2003). The qualitative data analysis was done through thematic coding; a process which involves recording or identifying passages of text or images linked by a common theme or central idea, and allowing the indexation of text into categories (Peersman, 2014). The Dedoose qualitative research coding software package was used for the analysis. The thematic analysis involves six stages; these have been summarized below.

Stage 1: Familiarization was done by transcribing, reading through the text and taking preliminary notes.

Stage 2: Coding of data was done by highlighting segments of the text and labelling the text.

Stage 3: Themes were created by combining several codes into a single theme.

Stage 4: Reviewing of themes by splitting, integrating, and either discarding or creating new themes:

Stage 5: Defining and naming of themes.

Stage 6: Writing up the thematic analysis (Creswell, 2007).

Thematic analysis was designed to answer the research questions. The text data (responses) were transcribed and analyzed for themes. For the purpose of this study, the results segment represents each theme. The researcher identified, analyzed, and reported patterns within the data (Braun & Clarke, 2006). Finally, the researcher combined results from the qualitative

phase with results in the quantitative phase for interpretation and presentation of the results in the analysis section of the study (Finch, 2013).

3.9: Ethical Consideration

Ethical issues were at the core of this study. Therefore, information collection was done devoid of lies and deceit. Ethics guiding research projects was strictly adhered to. Participants or respondents were fully briefed on what to expect before the commencement of data collection. Again, any sensitive information given by respondents was reported in secrecy and confidential

3.10: Limitations of the Study

One of the major limitations of this study relates to the inadequacy of climate data needed in the analysis of the temperature for the study site. As can be seen in figure 4.2: maximum temperature and figure 4.3 minimum temperatures, there is lack of adequate temperature data from 2013 to date. Access to complete climate data has become a major setback to climatological studies at the local level. Another limitation has to do with availability of fish catch data. In figure 4.4, fish catch data for four consecutive fishing seasons were not examined in the analysis. Again, currently there is little or no fisheries model for inland fisheries at the local level making it difficult to understand the nexus among climate variability, ecosystem, and livelihoods at the study site. Notwithstanding these limitations, the available data was enough to assess the effects of rainfall and temperature changes on fish catch as well as the impacts of climate variability on livelihoods of fisher folk at the study site.

3.11. Summary

Methodology of the study was discussed in this chapter. The study area was first described. The research design and type and sources of data were presented. The chapter also described

the sampling procedure as well as the sample size. The data collection method and techniques were discussed. Also the data processing and analysis procedures were explained. Ethical issues were considered while the limitations of the study were presented.

CHAPTER FOUR

PRESENTATION OF RESULTS AND ANALYSIS

4.1: Introduction

This chapter of the study seeks to present the results and analysis of the data. The presentation of results and analysis of data was done in accordance with the objectives of the study. The chapter was organized into 7 broader thematic areas. The section next to the introduction gives a description of the demographic characteristics of the respondents. Section 3 presents the evidence of rainfall variability and temperature rise while section 4 describes the link between variability in climatic elements and quantity of fish catch amount. Section 5 describes the general factors that determine/drive fish catch in the study area. Section 6 defines respondents' perceptions about the impacts of seasonal climatic constraints on livelihoods while section 7 describes the adaptive and coping strategies currently used by fisher folk. Finally, section 8 presents a summary of the chapter.

4.2: Demographic background of respondents

The demographic characteristics of fisheries households are at the core of this study. Table 4.1 presents the results which include gender of respondents, age distribution, level of education, main fisheries related income source, type of work, number of dependents in households and size of households. Result from the study showed that majority of respondents surveyed 80.6% were males while the remaining 19.4% were females.

In terms of the age distribution, 39% of the respondents were between 31-40 years. Approximately 30.6% of respondents were between 41-50 years, 20.4% of respondents were 21-30 while about 10% of the respondents were 51+ years.

In the context of the education level of respondents, out of the total people surveyed, quite a number of them (respondents) have attended school. However, the overall level of education

among the respondents in the study area is low. Approximately 25% of the respondents had only primary school education, 10.2% attended Junior High School (JHS), 17.6% attended Senior High School (SHS) and the remaining respondents, 47.2% had no formal education at all.

From the perspective of the fisheries related income earning activities, residents of the communities are predominantly fishers. Majority of the respondents 66.7% of respondents are into fish harvesting. Sections of the population 13.9% were employed in fish harvest and fish transportation, about 12.9% of the people surveyed were engaged in fish processing and fish marketing/trading while around 6.5% were into fish trading/marketing. Another distinguishing feature about the people surveyed is that large proportions, 81.5% of the respondents, were full time fishers while the remaining 18.5% were part-time fishers. This is a clear indication that the households are heavily dependent on fishery related activities for their means of livelihood.

In the context of the number of dependents in households (including biological and adopted children and other depending relatives), the result showed that households with number of dependents 1-2 accounted for 4.6%, households with dependents 3-4 accounted for 25.9%, households with dependents 5-6 represented 47.3% while households with dependents above 7 represented 22.2%. Concerning household size, the number of individuals or members in the households surveyed including dependents, the study revealed that 5.6% of the respondents live in households with size 1-2 members, 19.4% stated that they live in households with size 3-4 members, 20.4% of respondents were in households with 5-6 members while 54.6% claimed they live in household with above 7.

Table 4.1: Demographic and socio-economic characteristics of respondents

Characteristic	No. of respondents	Percentages
Gender		
Males	87	80.6
Females	21	19.4
Age distribution		
21-30	22	20.4
31-40	42	39.0
41-50	33	30.6
51+	11	10.0
Level of education		
Primary	27	25.0
JHS	11	10.2
SHS	19	17.6
Non-formal education/illiterate	51	47.2
Fisheries related income sources		
Fish harvest only	72	66.7
Fish harvest & fish transportation	15	13.9
Fish processing & trading/marketing	14	12.9
Fish trading/marketing only	7	6.5
Type of work		
Full time fishers	88	81.5
Part time fishers	20	18.5
Number of dependents in household		
1-2	5	4.6
3-4	28	25.9
5-6	52	47.3
Above 7	24	22.2
Size of household		
1-2	6	5.6
3-4	21	19.4
5-6	22	20.4
Above 7	59	54.6

Source: Field survey, 2019

4.3: Assessing the evidence of rainfall variability (1986-2017) and temperature rise (1986-2012)

4.3.1: Analysis of trends in annual rainfall variability 1986-2017

Visual evidence from the annual rainfall anomaly plot in Figure 4.1 indicates that rainfall has been erratic from the late 1980s through to the 1990s. This is because several years have experienced relatively greater reduction in annual rainfall amount from the mean. For example, in 1987 rainfall anomaly from the annual mean was 17.9mm. Subsequently, a marginal increase of 21.3mm was recorded in 1991. Since then there has been a persistent downward trend in annual rainfall totals across many parts of the 1990s. Relatively greater reduction in annual rainfall amount were experienced in 1990 (-27.4mm), 1992 (-25.0mm) and 1994 (-26.3mm). The analysis further showed that annual rainfall totals for particular years in the 2000s were relatively high. For instance, increases in annual rainfall were recorded in 2002 (28.5mm), 2007 (14.9mm), 2008 (45.1mm) and 2009 (14.6mm).

Overall, the results revealed 19 years of positive (+) annual rainfall anomalies (wet periods) and 14 years of negative (-) annual rainfall anomalies (dry years) from 1986-2017. Effects of ENSO events on annual rainfall inputs were also assessed. It is important to note that deviation of the line above or below the mean ENSO baseline has effect on seasonal rainfall totals. For the wet periods, in terms of frequency twelve (12) years were found below the mean ENSO baseline. These periods include 1989, 1995, 1996, 1999, 2000, 2004, 2006, 2007, 2008, 2009, 2010 and 2017. Incidentally, those periods coincided with high annual rainfall inputs. Conversely, six (6) periods including 1987, 1991, 1997, 1998, 2014 and 2015 were located above the mean ENSO baseline. From the perspective of the dry periods, eight (8) years were found above the mean ENSO baseline. These periods include 1990, 1992, 1993, 1994, 2001, 2003, 2013 and 2015. Only four (4) years 1988, 2005, 2001 and 2012 were below mean ENSO baseline.

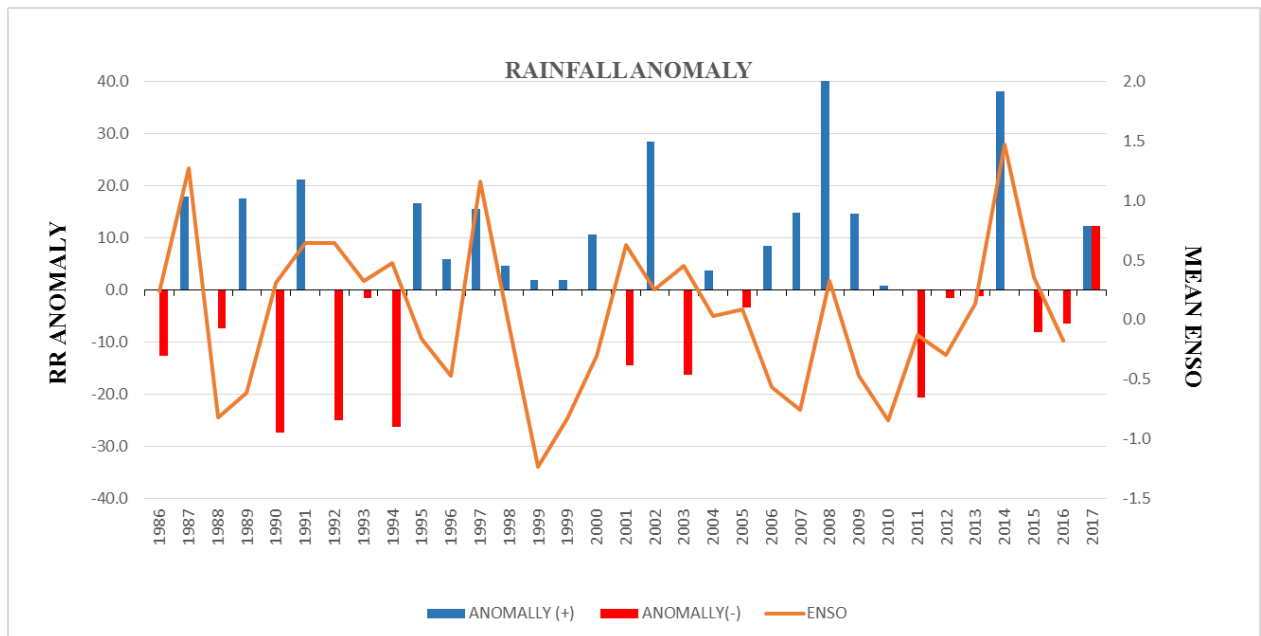


Figure 4.1: Annual positive and negative rainfall anomalies and ENSO events 1986 to 2017

Source: Based on data from the Ghana Meteorological Department, 2019

4.3.2: Evidence of warming 1986-2012

For maximum temperature, Figure 4.2 showed results of temperature changes over the study period. The results showed that temperature for several years had risen indicating a potential warm trend. Generally, 16 positive (+) temperature anomalies (warm periods) and 12 negative (-) temperature anomalies (cold periods) were experienced from 1986 to 2012. Deviation of the line above or below the mean ENSO baseline has potential effect on temperature changes. With regards to the warm periods, seven (7) years experienced temperatures which were above the mean ENSO baseline in 1987, 1994, 1997, 1998, 2001, 2003, and 2005 while five (5) years experienced temperatures below the mean ENSO limit in 1995, 1996, 1999, 2007 and 2012. From the Angle of the cold periods, six (6) years recorded temperatures which were above the mean ENSO baseline in 1990, 1991, 1992, 1993, 2002, and 2004 while five (5) years experienced temperatures which were below the mean ENSO baseline in 1988, 1989, 2000, 2010 and 2012. The high ENSO values (+1.3) in 1987, and

(+1.2) in 1997 indicates severe El Nino events. This implied potential warm than and cold climatic conditions.

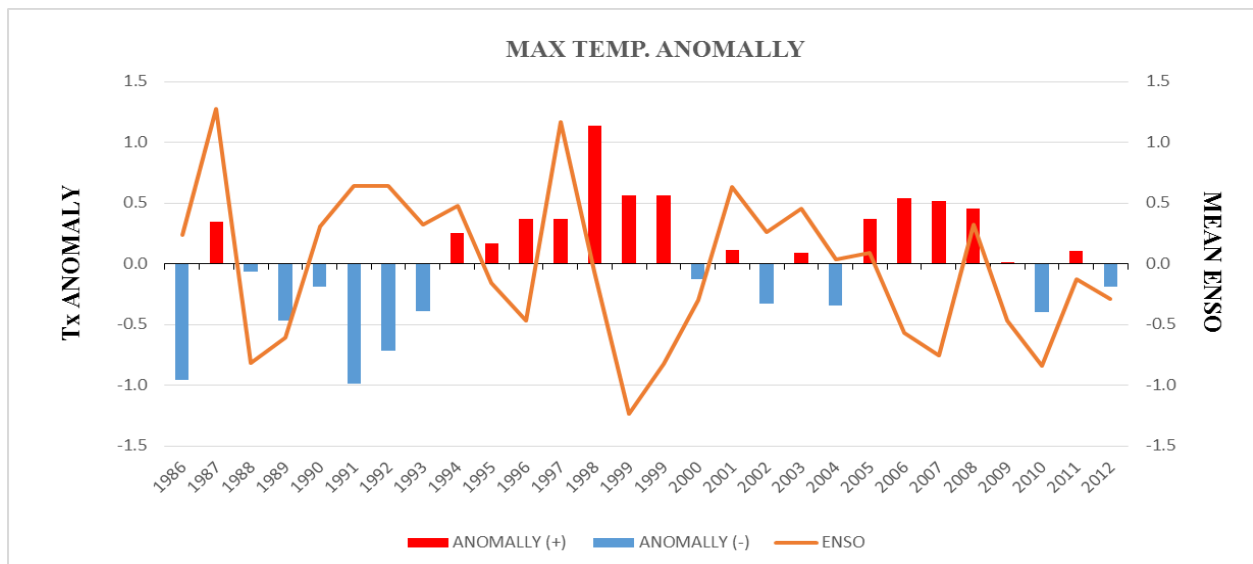


Figure 4.2: Anomalies of annual maximum average temperature 1986 to 2012

Source: Based on data from Ghana Meteorological Agency, 2019

Similarly, Figure 4.3 demonstrates annual temperature anomalies in minimum temperature for the study area from 1986 to 2012. The result demonstrates the evidence of potential rising temperature and warming trend but it slightly varies from year to year. Generally, 16 positive (+) annual temperatures anomalies (warm periods) and 11 negative (-) annual temperature anomalies (cold periods) occurred from 1986 to 2012. For the warm period, nine (9) years experienced temperatures which were above the mean ENSO baseline in 1987, 1990, 1991, 1993, 1998, 2002, 2003, 2004, and 2009. The temperatures for seven (7) different years were below the mean ENSO baseline in 1988, 1996, 2001, 2008, 2010, 2011, and 2012. From the perspective of the cold era, six (6) years recorded temperatures which were above the mean ENSO baseline in 1986, 1992, 1994, 1997, 2005, and 2006 while five (5) years recorded temperatures below the mean ENSO baseline in 1989, 1995, 1999, 2000, and 2007. This implied potential warm than cold climatic condition.

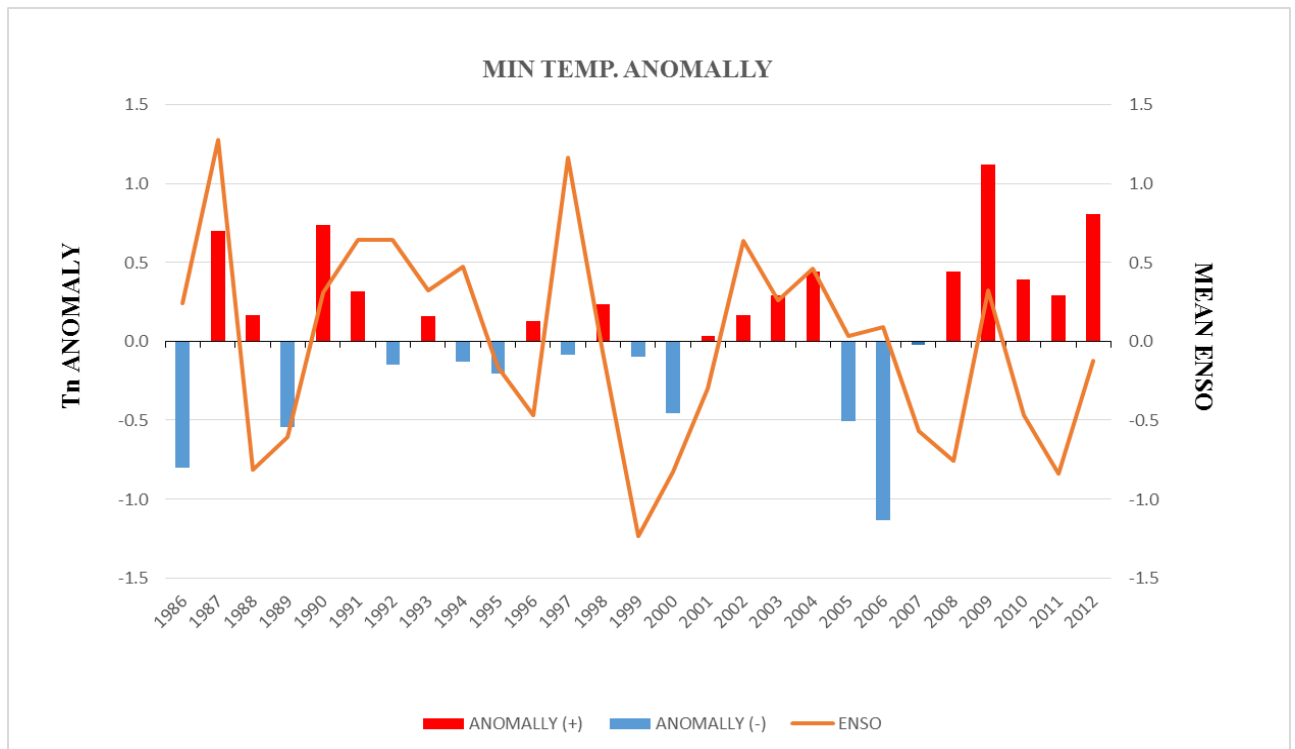


Figure 4.3: Anomalies of annual minimum average temperature 1986 to 2012.

Source: Based on data from Ghana Meteorological Agency, 2019.

Also, satellite observations have been used to view the spatial and temporal variability in land surface temperature. Based on this index, the result is presented in figure 4.4. Three Landsat satellite images were obtained from the United States Geological Survey (USGS). The images used are the Landsat LTO5 1994, Landsat LCO8 2013 and 2020. The images have clear weather conditions with the exception of the 2013 image which experienced a negative figure in low temperature probably due to interference from shades of cloud cover. In the year 1994, the temperatures recorded were 25.123°C and 10.108°C for high and low temperatures respectively. The year 2013 recorded high temperature of 27.658°C and low temperature of -20.271°C perhaps due to cloud captured by the satellite image. The year 2020 recorded the highest temperature of all time of about 30.794°C and low temperature of 10.151°C. Overall, from the three images, areas which recorded high temperature levels are communities around or bordering the Volta Lake such as Yeji, Jaklai, Edamrakra, Kapua, and

Langasilanga while regions that experienced low temperature are mostly areas farther away from the Volta Lake including Beposo.

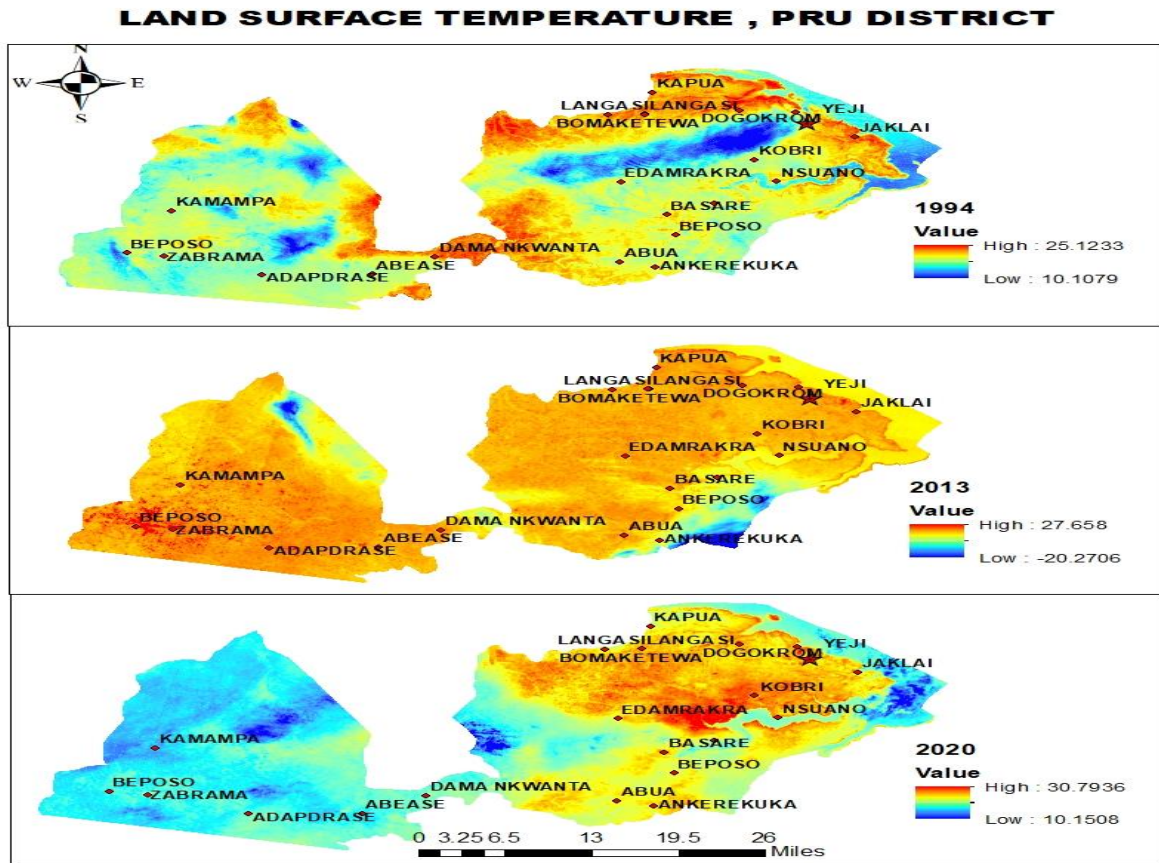


Figure 4.4: Land surface temperature.

Source: GIS Lab, Department of Geography and Resource Development, University of Ghana, Legon.

4.3.3: Respondents' perceptions about the general climatic pattern

Here respondents' first-hand experiences of the general climatic pattern over the past 10 fishing seasons were examined. The results are presented in Table 4.2. In terms of the dominant climatic feature, the largest number of fishers 88.9% admitted that they observed rainfall associated storm, 9.2% acknowledged that rainfall associated with storm has been less prevalent while 1.9% stated that they did not experience rainfall associated with storm.

Also, 88.0% of fishers perceived that high fishing season temperatures have been prevalent over the past 10 years. About 8.3% accepted that they observed lower temperatures whereas 3.7% claimed that high temperatures have not been prevalent.

Again, as large as 85.2% of fishers acknowledged that late start of rainfall has been prevalent in the past 10 years, a fraction of the respondents 12.9% observed that late start of rainfall has been less prevalent while 1.9% thought that the phenomenon has not been prevalent.

Majority of respondents 75.9% perceived that erratic rainfall has been prevalent; others 24.1% indicated that erratic rainfall has been less prevalent while none of the respondents observe erratic rainfall.

More so, quite a sizeable proportion of fishers 75.0% affirmed that low rainfall has been prevalent over the past 10 years, 17.6% claimed that low rainfall has been less prevalent whereas 7.4% did not observe low rainfall.

Furthermore, majority 71.3% of the people surveyed hinted that flood events have been prevalent. Around 14.8% stated that in terms of annual occurrence, flood events have been less prevalent while 13.9% of fishers indicated that floods have not been prevalent.

Also, 66.7% of respondents assumed that generally early termination of rainfall has been prevalent in the study area in the past 10 years, a segment 21.3% indicated that they observe less of early termination of rainfall while the remaining 12.0% stated that the phenomenon has not been prevalent.

In addition to this, relatively small segment 3.7% of the respondents asserted that extreme rainfall has been prevalent. Most of the respondents 63.9% stated that extreme rainfall is less prevalent while 32.4% of the respondents affirmed that extreme rainfall is not prevalent.

Finally, within the context of dry conditions in terms of frequency, 60.2% of the fishers acknowledged that prolonged dry spells have been prevalent, 32.4% of respondents assumed that they had experienced less dry conditions while 7.4% of respondents perceived that dry conditions have not been prevalent.

Table: 4.2: Perceptions of respondents about the general climatic patterns

Climate element	Prevalent		Less prevalent		Not prevalent	
	F	%	F	%	F	%
Rainfall associated with storm	96	88.9	10	9.2	2	1.9
High fishing season temperature	95	88.0	9	8.3	4	3.7
Late start of rainfall	92	85.2	14	12.9	2	1.9
Erratic rainfall	82	75.9	26	24.1	0	0
Low rainfall	81	75.0	19	17.6	8	7.4
Flood events	77	71.3	16	14.8	15	13.9
Early termination of rainfall	72	66.7	23	21.3	13	12.0
Extreme rainfall	4	3.7	69	63.9	35	32.4
Prolonged dry spell	65	60.2	35	32.4	8	7.4

Source: Field survey, 2019

4.4: Link between variability in climatic elements and quantity of fish catch

4.4.1: Assessing the fish catch trends for 1989-2014 fishing seasons.

The overall fish catch in tons in about two decades is demonstrated in fig 4.1. In the first decade, the statistics showed a steady increase in fish catch in four consecutive years. Thus, initial fish catch rose from 4000.4 tons in 1989 to about 10305.5 tons in 1992. In 1993 fish catch declined to 8202.1 tons but increased to 9305.4 tons in 1994. Nevertheless, from 1994, fish landings declined for four consecutive years to about 6777.8 tons in 1998. It is worthy to note that the lowest decline occurred in 1997. Even though this analysis could not account for

fish catch in four years (1999, 2000, 2001 and 2002) due to lack of data. However, in the subsequent years, production continued to decrease and increase from 11657.5 tons in 2003 to 18924.18 tons in 2009 respectively. It is essential to note that fish catch rose exponentially to 25974.6 tons in 2008. Production again declined from 2801.198 tons in 2010 to around 808.126 tons in 2014.

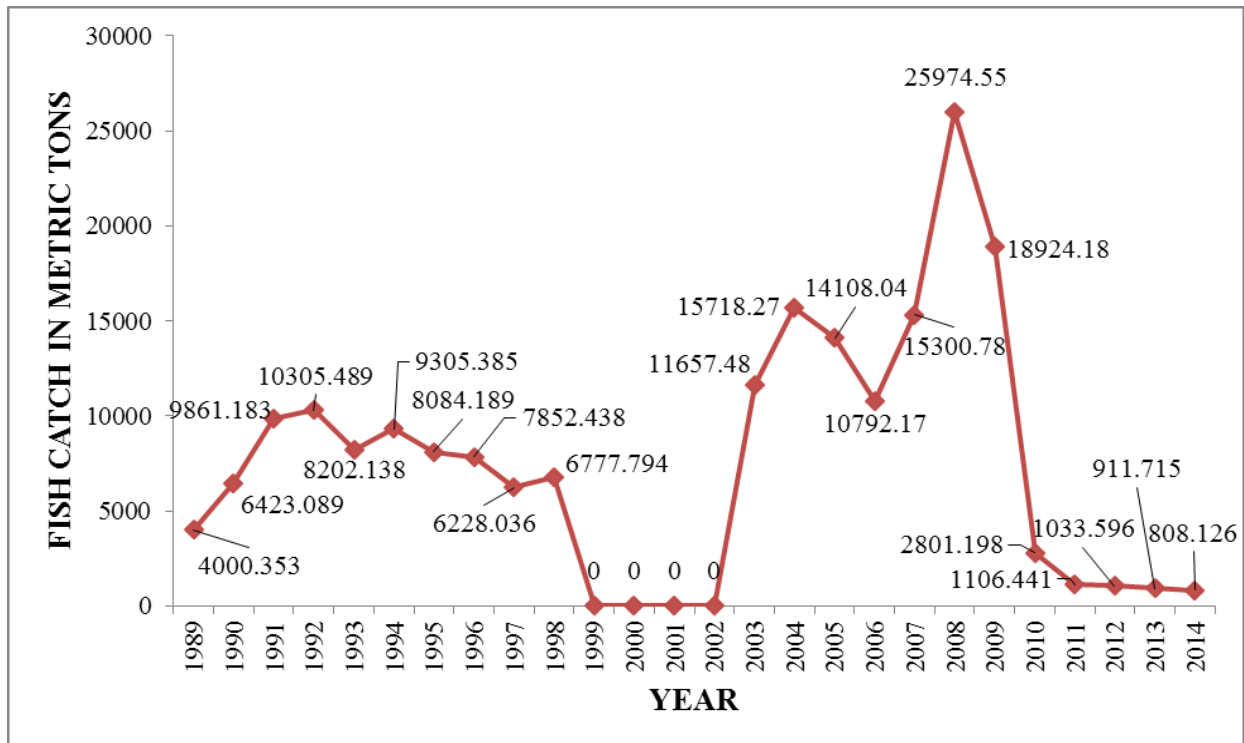


Figure 4.5: Annual trend in fish catch for Yeji 1989-2014

Source: Based on data from the fisheries Department, 2019.

4.4.2: Effects of annual rainfall anomalies on Volume of fish catch 1990-2012

Table 4.3 shows the effects of positive rainfall anomalies (wet periods) on fish catch. The wet periods have been matched with annual fish catch to examine the correlation between rainfall figures and fish catch figures. The results indicate that rainfall and fish catch size are characterized by seasonal variability. Generally, increases in rainfall figures correlates with increases in fish catch figures and vice versa. For example, initial high annual rainfall totals 21.3mm matched fish catch level 9861.18 tons in the 1991 fishing season. For the next two

fishing seasons, low rainfall value correlated with low fish catches levels. For example, in 1995, low rainfall inputs 16.8mm compared to 1991 correlated with low fish catch figure 8084.19 tons while a further decline in rainfall 6.0mm matched a decline in fish catch 7852.44 tons in 1996 fishing season.

Interestingly, there is a departure from the expected outcome in 1997 and 1998 fishing seasons, (probably El Nino periods). The temperature and fish catch figures do not seem to correlate. For example, rainfall amount 15.6mm rather resulted in decline in fish catch figure 6228.04 tons while low rainfall input 4.7mm caused a marginal fish catch increase 6777.79 tons.

Beyond the year 2000, high rainfall figures correlate with high fish catch figures. For instance, in 2007 fishing season, an increase in annual rainfall total 14.9mm correlates with the high fish catch figures 15300.78 tons. It is important to note that the highest rainfall figure 45.1mm for the study period coincided with the highest fish catch figure 25974.55 tons in 2008. Again, in 2009 a decline in rainfall total 14.6mm compared to the previous year (2008) matched the fish catch figure 189224.18. Finally, a substantial reduction in rainfall 0.8mm in 2010 correlated with a substantial reduction in fish catch 2801.2 tons. Overall, the highest fish catch over the study epoch coincided with the wet period in 2007, 2008 and 2009. Generally, for the wet period rainfall figures seem to correlate with fish catch figures for the fact that fish catch rates change as rainfall inputs change.

Table 4.3: Effects of positive rainfall anomalies (wet periods) on fish catch levels

Year	Wet periods	Fish catch size (in tons)
1991	21.3mm	9861.18
1995	16.8mm	8084.19
1996	6.0mm	7852.44
1997	15.6mm	6228.04
1998	4.7mm	6777.79
2004	3.8mm	15718.27
2006	8.5mm	10792.17
2007	14.9mm	15300.78
2008	45.1mm	25974.55
2009	14.6mm	189224.18
2010	0.8mm	2801.2

Source: Based on data from Ghana Meteorological Department and Fisheries Department, 2019

Table 4.4 shows the effects of the dry periods on fish catch. Similarly, both fish catch rates and climate events are characterized by annual or seasonal trends. Initial rainfall figure - 27.4mm was accompanied with 6423.08 tons in 1990. Furthermore, change in rainfall figure - 25.0mm resulted in a change in fish catch figure 10305.49 tons in 1992. Rainfall amount - 1.5mm was accompanied with fish catch 8202.138 tons in 1993 while rainfall input -26.3mm was accompanied with fish catch rate 9305.39 tons in the next year. In 2003 rainfall figure - 16.2mm was accompanied with fish catch rate 11657.48 tons. Besides, rainfall total -3.3mm was followed by high fish catch figure 14108.04 tons in 2005 while rainfall amount -20.5mm was followed by the lowest fish catch figure 1106.441 tons for the entire study period. Generally, with the dry period rainfall changes seem to also correlate with fish catch figures.

Table 4.4: Effects of negative rainfall anomalies on fish catch levels

Year	Dry periods	Fish catch size (in tons)
1990	-27.4mm	6423.08
1992	-25.0mm	10305.49
1993	-1.5mm	8202.138
1994	-26.3mm	9305.39
2003	-16.2mm	11657.48
2005	-3.3mm	14108.04
2011	-20.5mm	1106.441
2012	-1.5mm	1033.596

Source: Based on data from Ghana Meteorological Department and Fisheries Department, 2019

4.4.3: Link between annual temperature anomalies and fish catch size 1990-2012

Table 4.5 shows that temperatures and fish catch are characterized by seasonal variation. It is expected that high temperature figure compared to the previous year will result in low fish catch figure and vice versa. Initial temperature of 0.3°C is followed by fish catch figure 9305.38 tons in 1994. It is intriguing that low temperature figure in the following year did not result in the expected high fish catch figure. For example, temperature figure 0.2°C in 1995 was followed by a decline 8084.19 tons in fish catch. Temperature rise 0.4°C corresponded with low fish catch figures 7852.44 tons in 1996 and a further decrease 6228.04 tons in 1997. Notwithstanding the observed high temperature figure 1.1°C in 1998, fish catch figure 6777.8 tons showed a marginal increase compared to the previous year. In 2003 low temperature figure 0.1°C commensurates with high fish catch figure 11657.4 tons. In the subsequent years, high temperature figures did not influence the predictable decreases in fish catch figures. In 2005, temperature 0.4°C was followed by relatively high fish catch figure 14108.04 tons while high temperature figure 0.5°C matched low fish catch value 10792.17

tons in 2006. Nonetheless, the temperature value 0.5°C did not match fish catch values 15300.8 tons in 2007, and 25974.4 tons in 2008. Interestingly, in 2009 relatively low temperature figure 0.0°C was unexpectedly followed by a reduction in fish catch figure 18924.2 tons compared to the previous year (2008) while a marginal increase in temperature 0.1°C corresponded with a substantial decrease in 1106.44 tons. Generally, high temperature figures for several years did not result in the expected decreases in fish catch volumes. This implies that the warm period did not seem to correlate with low fish catch.

Table 4.5: Effects of positive temperature anomalies on fish catch levels

Year	warm periods	Fish catch size (in tons)
1994	0.3°C	9305.38
1995	0.2°C	8084.19
1996	0.4°C	7852.44
1997	0.4°C	6228.04
1998	1.1°C	6777.8
2003	0.1°C	11657.4
2005	0.4°C	14108.04
2006	0.5°C	10792.17
2007	0.5°C	15300.8
2008	0.5°C	25974.4
2009	0.0°C	18924.2
2011	0.1°C	1106.44

Source: Based on data from Ghana Meteorological Agency and Fisheries Department, 2019

Evaluation of the potential effects of the cold years on fish catch has been summarized in table 4.6. Temperature figure -0.2°C was followed by fish catch 6423.08 tons in 1990. Temperature change for 1991 fishing season -1.0°C was followed by fish catch figure 9861.18 tons while in 1992 temperature was -0.7°C and fish catch rate was 10305.49 tons. In 1993, temperature was -0.4°C and fish catch value was 8202.14 tons. Beyond 2000,

temperature was -0.3°C and fish catch figure was 15718.27 tons in 2004. In 2010, temperature was -0.4°C and fish catch was 2801.20 tons while temperature -0.2°C was linked with fish catch 1033.60 tons in 2012. This analysis seemed not to show a significant relationship between the cold period and quantity of fish catch.

Table 4.6: Effects of negative temperature anomalies on fish catch levels

Year	Cold periods	Fish catch size (in tons)
1990	-0.2°C	6423.08
1991	-1.0°C	9861.18
1992	-0.7°C	10305.49
1993	-0.4°C	8202.14
2004	-0.3°C	15718.27
2010	-0.4°C	2801.20
2012	-0.2°C	1033.60

Source: Based on data from Ghana Meteorological Agency and Fisheries Department, 2019

4.4.4: Respondents' perceptions about the effects of changes in climatological factors on fish catch volumes

Table 4.7 indicates the relationship between changes in climatic conditions and fish catch size. With regards to the leading climatic driver of fish catch volume, none of the fishermen perceived that rainstorm can contribute to increases in fish catch size, the extra 3.7% acknowledged that rainstorm has no effect on fish catch whiles majority 96.3% of fishers agreed that perhaps due to the potential risk posed to fishermen and to fishing materials (fishing nets and boats), rainfall associated with storm may undeniably result in decreases in fish catch quantity, (Plate 4.1).

More so, of the total fishers surveyed, only 1.8% assumed that prolonged dry spell can induce increases in fish catch volume, 2.8% perceived that prolonged dry spell have no effect on fish catch volume while 95.4% of respondents overwhelmingly held the opinion that prolonged dry spell may lead to low fish catch volumes.

Furthermore, about 23.1% of the respondents assumed that high fishing season temperatures can well increase fish catch quantity, not a single fisherman proposed that high fishing season temperatures has effect on fish catch numbers whereas a large proportion 76.9% of fishers were of the view that high fishing season temperatures can certainly decrease fish catch size.

In addition to this, 7.4% of respondents assumed that late start of fishing season rainfall can contribute to high fish catch size, another 17.6% of the respondents stated that late start of rainfall has no effect on fish catch volume while majority 75.0% of fishers acknowledged that delays in fishing season rains can certainly contribute to low quantity of fish catch.

Moreover, majority 74.1% of fishers acknowledged that floods can enhance fish catch volume, 0.9% of the respondents suggested that floods do not affect fish catch size while 25.0% asserted that flood may give rise to decreases in fish catch size.

Approximately 6.5% of respondents perceived that extreme rainfall may increase fish catch size, 26.0% stated that extreme rainfall has no effect on catch numbers whereas more than half 67.5% of respondents hinted that extreme rainfall may decrease fish catch volume.

The result showed that about 2.8% of respondents indicated that erratic fishing season rainfall can induce high fish catch size, 34.3% of respondents noticed that erratic rainfall has no effect on fish catch size while more than half 62.9% of the respondents observed that erratic fishing season rainfall can give rise to low quantity of fish catch.

Again, considering the effect of early termination of fishing season rainfall on fish catch volumes, 13.9% of respondents assumed that early termination of rainfall may undeniably cause high quantity of fish catch, a segment 28.7% held the opinion that early termination of rainfall has no effect on fish catch numbers while majority 57.4% of them (respondents) admitted that early cessation of fishing season rainfall may produce low fish catch numbers.

Besides, less than half 40.7% of the respondents asserted that low rainfall during fishing season may induce high fish catch, another 11.1% responded that low rainfall had no effect on catch quantity, 48.2% stated that low rainfall may result in low fish landing.



Plate 4.1: The combined effects of rainstorm, prolonged dry spell and the menace of tree stumps on fishing nets.

Source: Field survey, 2019

Table 4.7: Perceived effects of changes in climatic elements on fish catch size

Climate element	High fish catch		No effect		Low fish catch	
	F	%	F	%	F	%
Rainfall associated with storm	0	0.0	4	3.7	104	96.3
Prolonged dry spell	2	1.8	3	2.8	103	95.4
High fishing season temperature	25	23.1	0	0.0	83	76.9
Late start of rainfall	8	7.4	19	17.6	81	75.0
Floods	80	74.1	1	0.9	27	25.0
Rainfall extreme	7	6.5	28	26.0	73	67.5
Erratic rainfall	3	2.8	37	34.3	68	62.9
Early termination of rainfall	15	13.9	31	28.7	62	57.4
Low rainfall	44	40.7	12	11.1	52	48.2

Source: Field survey, 2019

4.5: Respondents' perceptions about the key determinants/drivers of fish catch volume.

Respondents were required to identify the non-climatic determinants or drivers of fish catch in the research area. In terms of the leading socio-economic driver of fish catch, as large as 93.5% of fishers suggested that lack of credit provision aimed towards fishers or lack of investment in the area of fishing inputs (fishing boats and fishing nets) can stagnate fish catch while the remaining 6.5% suggested that lack of access to credit has no influence on fish catch size.

Moreover, 91.6% of fishers acknowledged that fuel price hikes and irregular supply can play a monumental role in fish catch decline while 8.4% stated that fuel price does not determine quantity of fish catch.

Given the number of hours, days or months fishermen may have to stay away from work due to inactivity caused by ill health, a large section 86.2% of fishers claimed that essentially, poor health can contribute to low fish catch level, 13.8% stated that poor health has no effect on volume of fish catch.

Considering the ability of fishers to cover long distances, about 84.3% of respondents assumed that the type of fishing boat (motorized fishing boats) can influence high fish catch levels while 15.7% suggested that influence of the type of boat on quantity of fish catch is inconsequential.

Besides, approximately 73.1% of the respondents affirmed that crew size improves fish catch while 26.9% declared that crew size has no effect on quantity of fish catch.

Furthermore, around 69.4% respondents acknowledged that the experience of fishermen in terms of the number of years in fishing can contribute to increases in fish catch while about 30.6% assumed that experience played a virtually insignificant part to fish catch size.

Moreover, a large segment 65.7% of the population accepted that indeed the number of fishing gears can enhance fish catch while 32.4% of respondents perceived that the type of fishing gear (including the use of bamboo pipes) played irrelevant role in fish catch volume. Surprisingly 1.9% of respondents perceived that the number of fishing gears rather reduce fish catch quantity (Plate 4.2).

More so, majority 59.3% of fishers agreed that lack of knowledge and access to information (including fishing and climate information) can give rise to low fish catch while 40.7% of fishers assumed lack of knowledge and access to information plays immaterial role in quantity of fish catch (Table 4.8).

Table 4.8: Non-climatic determinants/drivers of fish catch size

General determinants of volume of fish catch	High fish catch		No effect		Low fish catch	
	F	%	F	%	F	%
Lack of credit provision to fishers	0	0.0	7	6.5	101	93.5
Cost and irregular supply of premix fuel	0	0.0	9	8.4	99	91.6
Poor health	0	0.0	15	13.8	93	86.2
Type of fishing boat (motorized boats)	91	84.3	17	15.7	0	0.0
Crew size	79	73.1	29	26.9	0	0.0
Fishing experience	75	69.4	33	30.6	0	0.0
Number of fishing gears	71	65.7	35	32.4	2	1.9
Lack of knowledge	0	0.0	44	40.7	64	59.3

Source: Field survey, 2019

4.6: Respondents' perceptions about the impacts of seasonal climatic constraints on livelihoods

4.6.1: Perceptions of respondents about the impacts of seasonal climatic constraints on livelihoods in fish-harvest (production) sector

The results encapsulate two critical livelihood components of the fisheries value chain. Figure 4.5 demonstrates the impacts of the prevailing climate on fish production. Overall, 50% of respondents admitted that the quantity of fish catch has indeed decreased substantially. The analysis presented in Figure 4.5 showed a downward trend in volume of fish catch. This information could serve as a basis for examining the socio-economic impacts of low fish catch.



Plate 4.2: The types of processed fish (dried, salted and smoked) sold at the Yeji weekly fish market

Source: Field survey, 2019

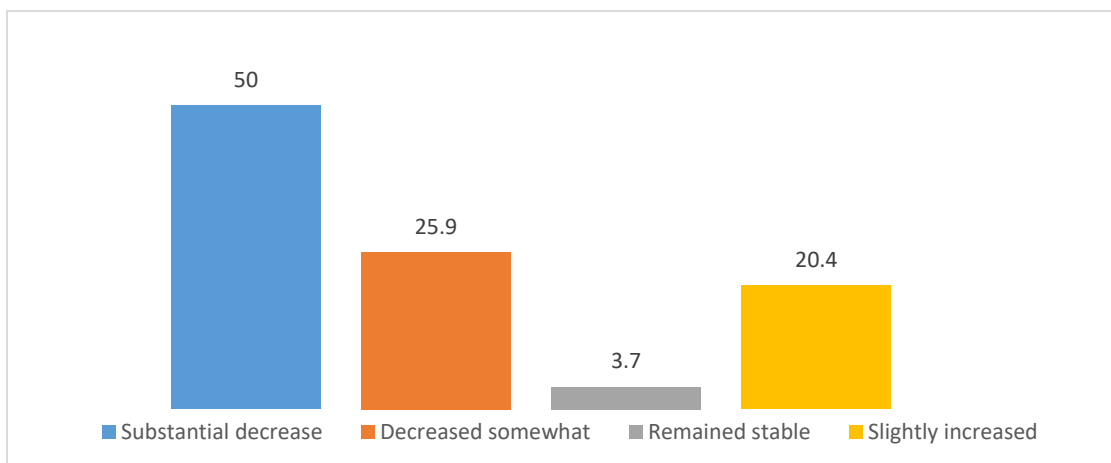


Figure 4.6: Perception of respondents about effects of prevailing climate on fish catch size

Source: Field survey, 2019

4.6.2: Perceptions of respondents about the impacts of seasonal climatic constraints on the post-harvest sector

The study sought to assess the separate impacts of climate related constraints on the post-harvest sector livelihood strategies such as fish processing, fish transportation/supply, fish trading and marketing. The results are presented in Table 4.10. The main indicators examined

were impacts of the prevailing climate on fish processing, fish transportation/supply, fish trading and marketing efficiency.

Responses of the respondents suggested that perhaps considering the combine effects of climatic risks and hazards such as rainfall associated with storm, and prolonged droughts and the resultant effects on lake level, only 3.7% of the respondents agreed that impact of the prevailing climate on fish transportation was high. It is significant to notice that overwhelming number 96.3% of respondents acknowledged that the prevailing climate poses a real threat to fish transportation/supply (Table 4.9). The risk posed by the prevailing climate on boat transportation is shown in Plate 4.5. The red arrow shows damage caused by tree stumps which resulted in the boat tragedy.

Additionally, in terms of the impacts of the prevailing climate on efficiency of fish trading and marketing, only 0.9% respondent suggested that the impact has been very low, 10.2% admitted that the impact has been low, 22.2% stated that the prevailing climate has no impact. Interestingly, probably taking a cue from the dangers associated with fish transportation/distribution to market centers due to the menace of tree stumps during low lake levels, the responses of the majority were different. It is important to notice that more than half 65.7% of respondents acknowledge that the impact of the prevailing climate on fish trading and marketing efficiency was certainly high while another small proportion 0.9% of respondent claimed that the impacts was very high (Plate 4.9.).

Finally, having in mind the changing pattern of the fishing season rainfall and temperature and the attendant effects on traditional fish drying method, 2.7% of the respondents presumed that impacts of the prevailing climate on fish processing is very low, about 16.7% indicated that the impacts is low, 25.0% stated that the prevailing climate has no impacts while more than half 55.6% of the people surveyed acknowledged that impacts has been high.



Plate 4.3: Low level of the Volta Lake as a result of prolonged dry spell can adversely affect ferry services

Source: Field survey, 2019

Table 4.9: Perceived impacts of the prevailing climate on the post-harvest sector

Climatic constraints on the post-harvest sector.	Very low impacts		Low impacts		No impacts		High impacts		Very high impacts	
	F	%	F	%	F	%	F	%	F	%
Fish transportation/supply	0	0.0	0	0.0	0	0.0	4	3.7	104	96.3
Fish marketing and trading efficiency	1	0.9	11	10.2	24	22.2	71	65.7	1	0.9
Fish processing	3	2.7	18	16.7	27	25.0	60	55.6	0	0.0

Source: Field survey, 2019



Plate 4.4: Rainstorm and tree stumps exposed by prolonged dry spell can result in boat accident on the Volta Lake.

Source: Field survey, 2019

4.6.3: Perceptions of respondents about income and non-income impacts of low fish outputs

Socio-economic impact assessment was carried out to assess the cascading impacts of low fish output. Performance analysis or appraisal of key socio-economic indices such as income and non-income indicators was investigated. From the perspective of income generation, the study revealed that about 2.7% of the respondents were satisfied with the role of fisheries, 7.4% stated that income from fisheries is normal, additional 5.6% were less satisfied. Interestingly majority of respondents 84.3% assumed that income from fisheries was not satisfactory.

In terms of job opportunities from fisheries in relation to fishers' ability to hire or employ more labourers, only 0.9% of respondents were very satisfied with performance of fisheries. Three point seven (3.7%) were satisfied while 17.6% viewed the performance of fisheries as normal. About (7.5%) were less satisfied. It is striking to note that majority 70.4% of fishers were not satisfied.

Moreover, from the point of view on the contribution of fisheries to availability of aquatic food (fish), 2.8% of the respondents claimed they were very satisfied, some 7.4% were satisfied, 20.4% stated that fish availability was normal, majority 66.7% of fishers claimed they were less satisfied while 2.7% of respondents stated that they were not satisfied.

Finally, responses from fishers showed that only 0.9% respondent was very satisfied with the performance of fisheries in terms of access to aquatic food (fish), and 3.7% of the respondents were satisfied. Another 1.9% thought access to fish was normal, 36.1% were less satisfied while more than half 57.4% claimed that they were not satisfied with the contribution of fisheries to access to food (fish). The result has been presented in Table 4.10.

Table 4.10: Socio-economic impacts of low fish yield as perceived by respondents

Performance variable	Very satisfactory		Satisfactory		Normal		Less satisfactory		Not satisfactory	
	F	%	F	%	F	%	F	%	F	%
Income generation	0	0.0	3	2.7	8	7.4	6	5.6	91	84.3
Jobs from fisheries	1	0.9	4	3.7	19	17.6	8	7.4	76	70.4
Availability of food (fish)	3	2.8	8	7.4	22	20.4	72	66.7	3	2.7
Access to food (fish)	1	0.9	4	3.7	2	1.9	39	36.1	62	57.4

Source: Field survey, 2019

4.7: Current adaptive and coping strategies as perceived by respondents

4.7.1: Perceptions of fisher folk about the need for additional livelihood sources

The study enquired from the respondents about whether there is a need to look for other income generating activities and why they would need to look for alternative livelihood sources. The result showed that majority 96.3% of respondents proposed that there is a need

to augment their income by looking for other income generating activities while the minority 3.7% suggested otherwise. Quite a large number 82.4% of respondents alluded that income from fisheries is not enough to cater for the living expenses of their families. Only 17.6% stated the opposite, (Table 4.11.).

Table 4.11: Perceptions about the need and reason to look for other income earning activities

Do you need to look for other income earning source?	Yes		No	
	F	%	F	%
What is motivating you to look for other income source?				
Necessary to look for other income generating activities	104	96.3	4	3.7
Income from fisheries is not enough to pay for the living expenses of my family	89	82.4	19	17.6

Source: Filed survey, 2019

4.7.2: Diversified income activities as perceived by participants

Apart from fisheries-based livelihood activities, the study also enquired from fishers about other income generating activities engaged by members of fisheries households. Table 4.12 highlights the five (5) main alternative livelihood strategies that have been identified. First, quite a large proportion 66.7% affirmed that they were involved in the rearing of domestic poultry while 33.3% were not. Second, majority 63.0% of respondents acknowledged that they were actively involved in livestock rearing while 37.0% stated the opposite. Third, it is worth-noticing that only 3.7% of respondents were engaged in crop farming while a large majority representing 96.3% acknowledged that they were not involved in crop farming. Fourth, another 3.7% of the people (mostly females) suggested that they were engaged in petty trading while a large segment 96.3% of the people claimed that they were not into petty

trading. Fifth, as few as 1.9% of the people surveyed actively participated in tree planting while an overwhelming majority 98.1% claimed that they were not involved in tree planting.

Table 4.12: Alternative income activities of fishers

Farm and non-farm income earning activities.	Yes		No	
	F	%	F	%
Domestic poultry	72	66.7	36	33.3
Livestock rearing	68	63.0	40	37.0
Crop farming	4	3.7	104	96.3
Petty trading	4	3.7	104	96.3
Tree planting	2	1.9	106	98.1

Source: Field survey, 2019

4.7.3: Perceptions of participants about migration as a coping and adaptive strategy

Respondents were asked to state whether or not they move across the fishing landscape in search for richer fishing grounds during the periods of low fish catch. The study revealed that relatively a small number of fishers 11.2% acknowledged that they migrated to richer fishing grounds in response to low catch. Overall, 88.9% of fishers claimed that they did not migrate to other fishing areas in search for richer fishing grounds (Table 4.13).

Table 4.13: Perceptions of fishers about migration as a coping strategy

Migrate to richer fishing grounds	Yes		No	
	F	%	F	%
	12	11.1	96	88.9

Source: Field survey, 2019

This study also organized and presented the qualitative results. The interview guides were designed to elicit views, opinions, knowledge, lived experiences of participants. The text data

or interview transcripts were coded and analyzed for themes. The results from the qualitative phase revolve around themes such as dominant climate trend, effects of climatic characteristics on fish catch, climatic and non-climatic determinants of fish catch amount, impacts of low fish returns on labour force, climate and non-climate constraints undermining fish transport efficiency, effects of unpredictable climate on fish marketing and trading efficiency, effects of unpredictable climate elements on fish processing, factors influencing the choice of alternative livelihoods and seasonal migration as a coping strategy. For this study, extracts of the coded transcripts aim to answer the 5 research questions set out. The major findings are presented as quotes in Chapter 5 for discussion.

Research question 1 was, “What is the evidence to show rainfall and temperature changes?” During the interview process, fishers and officials of the Fisheries Department were enquired to describe the current climatic trends in their locality. Participants highlighted the dominant climatological characteristics, the results or major themes are rainstorm, unpredictable rainfall, rising temperature, drought and floods.

Moreover, research question 2 asked, “What are the effects of changes in rainfall and temperature on fish catch levels?” During the interview process, participants were enquired to describe the effects of climatic characteristics (rainstorm, rainfall and temperature changes, drought, floods) and fluctuations in lake levels on fish catch. The robust theme evident is that first, the predominant climate certainly affects fishing operation in diverse ways. For example, the result shows that rainstorms can destroy fishing cages and nets, also, rainstorms can overturn fishing boats. The other theme or result has to do with the effects of extreme climatic occurrences such as floods and drought on fishery. According to a fisherman the best explanation seems to be that *“During the wet season sections of the lake overflow their banks to join small rivers and streams. In the end different species of fish migrate into the*

headwaters to feed and spawn. Also, migration of the fish species to headwaters inadvertently protects adult and juvenile fish from fishermen who use under-size fishing nets for fishing. On the other hand, prolong dry condition and its associated reduction in lake levels restricts movement of the fish species to the lake.”

Furthermore, research question 3 was, “What are the key determinants or drivers of fish outputs? During the interview process, participants were asked to identify the climatic and non-climatic drivers of fish catch levels. Overall, the result presented three themes (results). First, some fishermen use unsustainable fishing practices such as the use of bamboo pipes and under-size fishing nets to boost fish catch. Another important theme is that inadequate supply of premix fuel negatively affects fish catch rates. Finally, rainfall associated with storm (rainstorm) and drought events were identified as the drivers of low fish catch rates.



Plate 4.5: Use of bamboo pipes to boost fish catch levels on the Volta Lake at Yeji.

Source: Field survey, 2019

In addition, research question 4 asked, “What are the impacts of the prevailing climate on fisheries related livelihoods?” The interview guides were designed to find out from participants impacts of the dominant climatic trends on livelihood activities in the fisheries value chain. During the two separate gender-based interviews, responses from participants

(males) who practiced fishing and fish transportation, and participants (females) engaged in fish processing and fish marketing/trading were also transcribed. From the perspective of the main factors affecting Volta Lake transport, participants identified factors such as tree stumps exposed by severe drought, lack of weather information, and inaccessible trade routes on the Volta Lake due to prolonged dry spell. Second, fishers were enquired to identify the effects of unpredictable climate on fish marketing and trading, the participants suggested that when the Lake level fall boat crew use long routes which normally result in delays, and high cost of transport. Again, boat accidents can result in injuries, loss of fish and lives. Finally, fish processors were also enquired to describe the effects of unpredictable climate elements on fish processing, the fundamental theme (major result) is that longer periods of cold temperature increases likelihood of fish spoilage due to difficulties involved in sun drying.

Finally, research question 5 asked, “What are the current coping and adaptive strategies of fisheries dependent households?” First, during the interview process fishers were asked to identify the factors that influence the choice of alternative livelihoods. Response from a fisherman indicates that full-time fishermen are concerned with the extent to which alternative livelihoods are likely to interfere with fishing operation in terms of the number of fishing trips in a day and duration of fishing trips. Second, with regards to the coping strategies, a fisherman revealed that movement of full-time fishermen across the fishing space in search for high yield fishing grounds has been a common feature during the lean season.

4.8: Summary

This chapter of the study sought to present results from the analysis of the data. First and foremost, the demographic characteristics of respondents in the study were described. This chapter also presented evidence of rainfall variability and temperature rise and described the

link between variability in climatic elements and quantity of fish catch amount. The general factors that determine/drive fish catch in the study area were identified. The chapter also examined participants' perceptions about the impacts of seasonal climatic constraints on livelihoods. Finally, the adaptive and coping strategies used by fisher folk were presented.

CHAPTER FIVE

DISCUSSION OF RESULTS

5.1: Introduction

This chapter builds on the presentation of results and analysis of data in the previous chapter. The chapter attempts to discuss the results from quantitative and qualitative data sets as well as the major study findings. The discussions have been organised under six thematic areas to enhance orderliness. The first section describes the evidence of climate variability in the study area. The next section describes the link between changes in climatic elements and quantity of fish catch amount while the third section takes a look at the general (socio-economic) determinants of fish catch. The penultimate section outlines impacts of the prevailing climate on fisheries livelihoods. The last section describes the current adaptive and coping strategies of fishers at the study area.

5.2: Evidence of climate variability in the study period

5.2.1: Assessing seasonal variability in temperature 1986-2012 and rainfall 1986-2017

Within the context of climatic trend, the major finding was the evidence of temperature and rainfall changes. In terms of temperature changes, the result indicates a steady rise in annual temperature in both maximum and minimum temperature anomalies over the study area. Generally, the maximum temperature recorded 16 positive (+) temperature anomalies (warm periods) and 11 negative (-) temperature anomalies (cold periods). Again, result from the analysis of the minimum temperature showed another 16 positive (+) temperature anomalies (warm periods) and 11 negative (-) temperature anomalies (cold periods) over the study area. Previous research works have linked variability of the West African climate to several factors including variations in the movement and intensity of the Inter-Tropical Convergence Zone (ITCZ) and the West African Monsoon, as well as El Niño Southern Oscillation (ENSO)

(Stanturf et al., 2011; Owusu 2018). The annual temperature increase as well as the potential warming climatic pattern over the study area is consistent with the national temperature observations for Ghana. For example, previous studies found that 1°C increase in temperature has been observed in Ghana over the past 40 years (1960 – 2000) (Agyemang-Bonsu et al., 2008). There is compelling evidence from historical national climate reports to suggest that there have been increases in the number of hot days and decreases in the rate of cold days and cold nights in some seasons in Ghana. For example, previous national climate reports have discovered temperature rise from 1960 to 2003 in all agro-ecological zones and projected temperature increases of 1.7°C to 2.04°C by 2030 in the northern Savannah regions, with average temperatures rising to 41°C (Climate change report, 2012; Climate change report, 2015).

Moreover, within the context rainfall variability, the result indicates that rainfall in the study area from the late 1980s through the 1990s to 2017 has been characterized by seasonal variability. Overall, 19 wet periods and 14 dry periods were observed from 1986-2017. Nonetheless, the most important feature or discovery is the general decline in the seasonal rainfall amount (using the annual rainfall anomalies plot). For example, in 1987 the annual rainfall was 17.9mm. Subsequently, a marginal increase of 21.3mm was recorded in 1991. Thereafter, there has been a persistent downward trend in annual rainfall totals across many parts of the 1990s. Conversely, annual rainfall totals for a few years such as 2002 (23.5mm), 2007 (14.9mm), 2008 (45.1mm) and 2009 (14.6mm) were relatively high. Reduction in annual rainfall totals observed in the study area is consistent with the national rainfall observations for Ghana for the reason that past rainfall records over most of the eco-climatic zones of Ghana indicate a general decreasing trend in total annual precipitation (Minia, 2008; Owusu & Waylen, 2009). A research work conducted by Nkrumah et al., 2014 found negative departures of rainfall in 1990s. Other study projected annual total rainfall decline by

20%, a runoff declines by 30% across the river basins over the past thirty years (1961-1990) (EPA, 2000). It is important to notice that the observed increase in annual rainfall totals for 2007, 2008 and 2009 is in line with the intensive rainfall with the associated flood events in 2008 and 2009 in parts of Accra, and the floods in 2007 in Upper East, Upper West and Northern regions as revealed by (Kankam-Yeboah et al., 2011).

ENSO was incorporated in both temperature and rainfall anomalies. The results revealed that several potential fishing seasons within the locality coincided with ENSO occurrences. For the maximum temperature, the results showed that within the context of the warm periods, temperatures of seven (7) potential fishing seasons were above the mean ENSO (warm conditions) while temperatures of five (5) potential fishing seasons were below the mean ENSO (cold conditions). During the cold era, temperatures of six (6) potential fishing seasons were above the mean ENSO (warm conditions) while temperatures of five (5) potential fishing seasons were below the mean ENSO. For the minimum temperature, in the warm periods nine (9) potential fishing seasons experienced temperatures which were above the mean ENSO (warm conditions) while seven (7) potential fishing seasons recorded temperatures which were below the mean ENSO (cold conditions). In the cold era, six (6) years recorded temperatures which were above the mean ENSO while 5 years experienced temperatures which were below the mean ENSO. This implied potential warm than cold climatic condition. The high mean ENSO values (level of severity) for the periods 1987 (+1.3), and 1997 (+1.2) is indicative of severe El Nino periods. Previous El Niño years are as follows 1972/1973, 1982/1983, 1987/1988 and 1997/1998. Previous La Niña years are 1973/1974, 1975/1976, 1988/1989, 1999/2000, 2008 and 2010.

Within the context of rainfall, the results showed that with the wet periods, all the twelve (12) potential fishing seasons below the mean ENSO coincided with high annual rainfall inputs

while six (6) potential fishing seasons above the mean ENSO recorded low rainfall over the period. In the dry era, eight years (8) were above the mean ENSO threshold while four (4) years were below the mean ENSO limit. This implies that in the study period probably wet conditions are prevalent when ENSO is below the mean while dry conditions are prevalent when ENSO is above the mean. This is consistent with the findings of (Mason & Goddard (2001) that La Niña occurrence is associated with high annual rainfall inputs for most areas in the West African sub-region. According to the WMO, (2019) El Niño Southern Oscillation (ENSO) is one of the major drivers of seasonal variability in both global weather (and climate) patterns and temperature. The impacts of ENSO in Africa are heat wave, delay and poor distribution of precipitation, and rainfall deficits of about 17% below the long-term mean in parts of West Africa (WMO, 2015). In Ghana, a collection of studies has established a link between ENSO events and discharge rates across the Volta Basin (Owusu et al., 2008; Waylen & Owusu, 2014; Boadi & Owusu, 2017).

A collection of the literature reviewed support the line of reasoning that reduction in annual rainfall totals and amplification of temperature as well as the potential drought are most likely to have cascading effects on water resources which is the primary inland fish production system. For instance, a study by Jiménez et al., (2014) noted that it is likely that across the globe climate change will alter the frequency and magnitude of both floods and droughts. Another study hinted that intensification of temperature has led to the drying of some rivers in the dry season which were until now perennial rivers (Kankam-Yeboah et al., 2009). The potential effects of climate change (and variability) on water resource encompasses extreme climate events such as flooding and drought, change in the frequency and distribution of rainfall, drying-up of rivers and receding of water bodies (Urama & Ozor, 2010).

5.2.2: The lived experience about the prevailing climate from the perspective of respondents

Within the context of the prevailing climatic characteristics over the past fishing seasons, the largest number so far 88.9% of fishers perceived that rainfall associated with storm has been prevalent. This implied that rainfall associated with storm was the dominant climatic feature over the past 10 fishing seasons. The second most dominant climatic feature was high fishing season temperature. Approximately 88.0% of fishers perceived that in terms of intensity, fishing season temperatures have been high. This finding is consistent with previous study. According to Nelson et. al., (2010), the potential climate related hazards across the southern, middle and northern belts of Ghana include rainfall associated with storm, drought, extreme temperature, and floods among others.

With regards to rainfall changes, as large as 85.2% of fishers acknowledged that the late start of rainfall in terms of frequency has been prevalent. About 75.9% of respondents perceived that erratic rainfall has been prevalent. More so, another 75.0% of fishers affirmed that low rainfall has been prevalent. Also, around 66.7% of respondents assumed that early terminations of rainfall have been prevalent. Furthermore, majority 63.9% of the respondents affirmed that extreme rainfall has been less prevalent. Smallholder farmers specifically in the Transition Zone of mid-Ghana and the transition agro-ecological zone of Ghana have observed reduction in rainfall amount, changes in rainfall regime, changes in onset and cessation of rainfall and increase in temperature (Klutse et al., 2013; Egyir et al., 2014).

Beside this, in terms of extreme climatic events such as flood and drought, a large section 71.3% of fishers indicated that flood events have been prevalent. In the context of prolonged dry spell, 60.2% of the fishers acknowledged that the climatic event has been prevalent. According to the Pru-Ministry of Food and Agriculture, the Pru district experience prolonged

dry season between the months of November and March/ April (prumofa.gov.gh). Previous study has associated El Nino Southern Oscillation (ENSO) with flood and drought (WMO, 2014).

5.3: Assessing the link between changes in climatic elements and quantity of fish catch

5.3.1: Assessing the effects of annual variability in rainfall and temperature on fish catch (1986 -2012)

Another distinguishing finding of this research output was that generally, the climatic variables (rainfall and temperature) and fish catch volume over the past fishing seasons were characterized by seasonal variability. Fish stocks often fluctuate seasonally in abundance and availability producing high and low fishing seasons (FMSP Policy Brief 4). In the previous section, this study established that the fishing seasons over the research area indeed experienced rainfall variability and temperature changes. Overall, the effects of rainfall and temperature changes on fish catch was assessed, comparatively, over the past fishing seasons fish catch was enhanced during the rainfall season (wet periods). This implies that rainfall and its associated floods are important factors for assessing the viability of inland or freshwater fisheries in the study area. There is high confidence that impacts of climate change include seasonal variability in the dominant climatic variables (including rainfall and temperature changes) from one fishing season to another, this may affect fish-stock size (Trotman, 2009; Odhiambo, 2013)

In the context of the effects of changes in rainfall on fish catch volume, results from the analysis of more than a decade potential fishing seasons (1990-2012) explicitly indicated a year to year variability in rainfall totals and fish catch quantity. The increases in fish catch volume in four fishing seasons such as 2004, 2008 and 2009 was consistent with the high annual rainfall totals recorded during the same period. It is important to note that the wet

fishing seasons might have probably induced the high fish catch. This seemed to show a strong association of high fish catches quantity during wet periods. Conversely, the dry years (periods) recorded low fish catch size. This, therefore, revealed a strong association of low fish catches volume during low rainfall or dry periods. According to Owusu et al., (2018), generally, temperature and sunshine periods are important determinants of the prospect of agricultural sector including crop adaptability, nonetheless, in tropical regions, the most important driver of agricultural activities is rainfall since rainfall has a dominating effect over temperature and sunshine hours. The WMO (2014) attributed the decline in anchovy catch to El Nino-related warming of water bodies previously known to be cold and nutrient-rich thermocline which support fisheries.

Pittaluga et al., (2003) also found that the major fishing season is the rainy season when lake levels are high whereas the lean season is the dry season when the lake levels are receding. Studies in other jurisdictions supported the view that particular climate may be estimated to have positive impacts on fisheries in inland waters during periods of increases in flooded areas (Daw et al., 2009). Impacts of the changing climate such as low flooding, decrease of floodplains, low or drying up of lake level have caused decreases in fish catch rates in the West African sub region (Welcome, 1986; Laë, 1992; Laë, 1994; Oyebande et al., 2002). On the basis of this, probably the high annual rainfall totals in particular fishing seasons in the study area may have had significant effects on fish catch volume. There is high confidence that sustained drought may adversely affect fish size, availability in aquatic habitats, lead to drying up water bodies which may in turn lead to total collapse of fishery activities (Allison et al., 2007).

From the perspective of the effects of high fishing season temperature on fish landing, result from the study established rising temperature and potential warming climatic conditions.

Notwithstanding the evident of potential warming conditions over the study area, interestingly, fish catch levels were very high in particular fishing seasons. This shows that the rise in temperature did not result in low fish catch amount. This result is inconsistent with previous studies and therefore revealed a very weak association of low fish catches volume during warm periods. It is significant to notice that both the warm and wet periods in the 2007, 2008 and 2009 fishing seasons separately experienced substantial fish catch rates. The result showed that warm periods in these specific fishing seasons (2007, 2008 and 2009) coincided with high total annual rainfall. Against this backdrop, probably precipitation may have compensated for the expected effects of the warm periods thereby preventing decreases in fish catch levels. A collection of studies in other jurisdictions have indeed associated decreases in fish catch quantity with the warming of water bodies. For example, there is robust evidence that warming of water bodies (lakes, streams and rivers) may result in severe losses of about 15-59% cool and cold fish habitats Mohseni et al., (2003), and pose real threats to stream fish (Matthews & Zimmerman, 1990; Eaton & Scheller, 1996; Allison et al., 2005; FAO, 2010).

5.3.2: Respondents' perceptions about relationship between the prevailing climate and fish catch volumes

Generally, the respondents also agreed that the prevailing climate has significant effects on fish catch volume. Specifically, about 96.3% of fishers observed that rainfall associated with storm is the leading driver of low fish catch size. Research has shown that changes in river flow and lake levels as well as storm frequency and severity may result in fish catch decline (FAO-Adapt, 2011).

From the standpoint of extreme climatic occurrences (drought and floods), fishers acknowledged that prolong dry spell is the next most important climatic driver of low fish

catch. About 95.4% of fishers assumed that extreme climate occurrence such as drought result in lessening of the amount of fish catch. Conversely, about 74.1% of respondents suggested that floods boost fish harvest. A study in Nigeria found that inland fish catch recorded changes in size due to drought, as the shores of Lake Chad recede decrease in the area flooded has led to a decrease in fish catch (Oyebande et al., 2002). There is high consensus that seasonal flooding caused by increased basin run off and discharge rates is a major driver/determinant of biotic (fish) productivity and fish yields (Allison et al., 2005; Bene, 2007; Junk et al., 1989;).

Moreover, high fishing season temperature has been identified as another key climatic determinant of low fish catch. About 75.0% of fishers acknowledged that high fishing season temperature may cause falls in the bulk of fish catch. Climate variability and change is predicted to affect inland or freshwater ecosystems such as wetlands, floodplains, and shallow lakes and rivers as a result of changes in precipitation and temperature (FAO, 2010).

Furthermore, respondents assumed that changing rainfall features have wide-ranging effects on fish catch as well. Around 75.0% of fishers surveyed indicated that when rainfall delays fish catch size declines as well. Again, 67.5% of fishers acknowledged that extreme rainfall may result in decreases in size of fish catch. Approximately 62.9% perceived that erratic rainfall contributes to decreases in fish catch size. Nearly 57.4% of fishers agreed that early termination of rainfall may cause drops in quantum of fish catch. With regards to low rainfall, the responses were mixed, 40.7% believe that low rainfall leads to increases in fish catch high size while 48.2% observed that low rainfall leads to increases in fish catch size.

5.4: Perceived socio-economic determinants/drivers of fish catch levels

This research work has also found that apart from the climate variables, other local factors equally determined fish catch volumes in the study area (Box 2). The study showed that non-climatic drivers of fish catch levels in the study area are multifaceted and runs across economic, material, financial and social dimensions. One of the basic and fundamental assumptions was that for a robust attribution of changes in fish catch rates to changes in climatological factors, the general determinants or drivers of fish catch (mostly socio-economic factors) must be identified and factored in the discussions. A study in Uganda by Timmers, (2012) divulged that stakeholders in the fisheries sector in Uganda generally consider that impacts of climate change and variability should not be separated from non-climate related drivers of change.

Results from the multiple choice responses indicated that in terms of the topmost drivers, quite a large section 93.5% of fishers suggested that lack of credit to fishers for the purchase of fishing inputs (fishing boats and fishing nets) may cause low fish output. A research conducted in Kenya and Tanzania identified a combination of fishing related challenges emanating from the lack of access to credit targeted at fishermen. The challenges identified were unproductive fishing gear and vessels. That study proposed that lack of capital injection in fishing activities tend to hinder fishermen from gaining access to deep sea worthy boats and more effective gear. The study concluded that lack of capital restricts fishers to inshore fishing and also compel some of them to adopt destructive fishing methods such as beach seines (FANRM, MKK, MRAG, 2003).

More so, approximately 91.6% of fishers assumed that the cost (rising price) and irregular supply of premix fuel may have an adverse impact on fish catch volume. This perception was validated by a previous study by the International Financial Corporation World Bank Group

(IFC, 2015). Their findings revealed that a lack adequate supply of fuel and electricity is most likely to hamper the capacity to fish, and the frequency (number of fishing trips), distance fishers cover, and duration of trips. Various studies also identified fuel price increases and irregular supply as a major constraint undermining fishing activities in communities along the coast and concluded that this may give rise to low fish catch level resulting in low household income and low development of fishing communities (Mensah et al., 2006; MoFA, 2011). During a gender-based focus group discussion for fishermen, a full-time fisherman pointed out that:

“Availability and affordability of premix fuel is at the core of fishing. Because premix fuel plays a monumental role in fish harvesting through motorized fishing boats operators”. He further explained that in terms of the post-harvest sector, “Premix fuel contributes to fish transportation and trading through commercial boat operators. However, due to high cost and periodic shortages of the product, the activities of fishermen are often grounded to a halt sometimes for days or weeks thereby affecting the quantum of our catch for the week.”

Box 1: Effects of irregular supply and high price of premix fuel on fish catch volume/size

Source: Field survey, 2019

More so, given the number of hours, days or months fishermen may have to stay away from work due to inactivity caused by ill health, a large section of about 86.2% of respondents cited poor health as a major driving force that can affect fish catch levels. According to Munirul et al., (2013) one of the main indicators of adaptive capacity is the number of days in a year within which household head (fisherman) becomes physically fit to carry out his livelihood (fishing) activities. Inferring from this, probably longer periods of absence (days, weeks and months) from fishing activities by fishers due to ill health may affect outputs (catch rates) from fisheries sector.

Again, respondents assumed that indeed the type of fishing boat (motorized or non-motorized fishing boats) has the potential to influence fish catch levels. Approximately 84.3% of the respondents acknowledged that the fishing boat equipped or furnished with outboard motor has enormous influence on fish catch level due to its capacity to fish in richer fishing grounds within the fisheries landscape (Box 8). A study established that increase fish catch can be realized if artisanal fishers are resourced/equipped with the useful and larger fishing boats to enable them practice offshore and deep ocean fishing (Akanni, 2010).

Approximately 73.1% of respondents acknowledged that certainly there is interaction between crew size (including hired labour) and amount of fish catch. Previous study by Inoni & Oyaide (2007) confirmed that fishing vessels, household size, labour, fishing experience, gender and season are also statistically significant effect on catch level. The study also found that factors that contribute to up-scaling (increasing) fish catch are adequate investment in fishing vessels, and government policy of input subsidy.

Once more, about 69.4% of fishers held the view that the experience of fishermen has significant impact on fish catch levels. Munirul et al., (2013) placed emphasis on the extensive experience of household head (fisherman) in terms of the number of years in fisheries-related economic activities.

In relation to the roles of the respective (non-climatic) drivers identified, almost 65.7% of participants admitted that one of the driving forces underpinning fish catch levels is the number of fishing gears employed in fishing activities. The use of unauthorized and inappropriate fishing methods (active gears) are known to contribute between 65% and 70% of the total fish landings from Volta Lake (Braumah, 1991; MoFA, 2003). A research work noted that fishing methods vary greatly during the year, because changes in fishing method were aimed or targeted at specific fish species (Bene and Russell, 2007).

In addition, the result showed that 59.3% of the respondents indicated that indisputably there is a close interrelationship between the knowledge of fishermen and fish catch. A research work by MRAG, FANRM, MKK (2003B) in both Kenya and Tanzania established that there is lack of knowledge about off-shore (fisheries) resources. The study explained that there is no evidence whatsoever from a single operator (fisherman) pointing that currently significant resources exist offshore except in isolated locations along the coast which are already under stressed by commercial and artisanal small-scale fishers. During an in-depth interview the district director of fisheries, Mr. Gregory N. Naasg, gave his expert opinion on the main climatic and non-climatic drivers of fish catch volume. Mr. Naasg made an important disclosure about the mystery behind the high fish catch rates during the warm periods.

According to him, *“Fish catch over the years has shown a rise and general decline as a result of various factors including unsustainable fishing practices. Reduction in fish catch is increasingly compelling some fishermen to use unsustainable fishing methods such as the use of bamboo pipes purposely to boost fish catch” (Plate 4.1). He further explained that in 2016, fish catch was expected to be low due to the dry conditions, however, fish catch increased to a record high because of the increasing use of bamboo pipes in fishing. According Mr. Naasg, “Droughts and floods currently being experience have also affected fish catch differently. Moreover, rainstorms over the years have also destroyed fish cages, over turned fishing boats and torn fishing nets.”*

Box 2: Climate and non-climatic determinants of fish catch amount

Source, Field survey, 2019

5.5: Perceived impacts of the prevailing climate on fisheries livelihoods

5.5.1: Respondents perceptions about the socio-economic impacts of low fish outputs

The study discovered that fishers largely depend on fish-harvesting (catching of fish) for their means of livelihoods, therefore, a fall in fish outputs had a corresponding impacts income and non-income sectors of the local economy (research site). A research has proven that El Niño/La Niña events may alter the livelihood of particular climate pattern around the world, (WMO, 2015).

Result from this study indicated that climate variability has an important impact on employment opportunities and income from the fisheries sector. For example, with regards to income or revenue generation from fisheries, about 84.3% of respondents assumed that they were not satisfied with the performance of fisheries. One study found that changes in the availability of fish products (fisheries resources) can affect total revenues (income generation) and harvesting costs (net revenues), resulting in greater costs in managing and accessing natural capital (Badjeck et al., 2009). Changes in climate factors (high fishing season temperatures) may have a significant impact on fishers in the form of reduced fish quality and fish production, loss of revenue and at the macro level low earnings from fish export (Mohammed & Uraguchi, 2013).

Again, from the perspective of employment creation from fisheries, 70.4% indicated that the outlook for employment creation from fisheries was not encouraging; therefore, they were not satisfied with the role of fisheries in that regard. Documented evidence suggested that men's activities (fishing) come to a halt when fishing activities comes to a standstill due to low fishing catch levels (Brugere et al., 2008). During a gender-based Focus Group Discussions on the impacts of low fish catch on employment, a full-time fisherman disclosed that:

“Quite a number of young and energetic fishermen have quitted fishing at the peak of Galamsey operations as a result of the reduction in fish outputs. Many fishermen from fisheries households have abandoned their fishing job ostensibly with the hope of changing their fortunes. Some of these fishermen have sold off their fishing assets such as motorized boats, fishing nets and other fishing materials and invested the proceeds in Galamsey operations.”

Box 3: Impacts of low fish returns on labour force

Source: Field survey, 2019

According to the Inland Fishermen Association, the departure of fishermen from the fisheries sector poses a real challenge. Therefore, in an attempt to curtail the drift of fishermen from fisheries activities into small scale mining popularly known as “Galamsey” the group made an appeal. The association appealed to the Ministry of Fisheries and Aquaculture Development to develop an aquaculture module that incorporates alternative livelihood strategies such as fish cage farming, irrigation farming as well as small scale animal rearing (peacefmonline.com)

Considering the performance of fisheries from the perspective of availability of aquatic foods, more than half 66.7% of the respondents admitted that they were less satisfied. Food availability has been defined as the overall ability of a production system to meet the people’s basic food (fish) demands. Decrease in food availability was attributed to the disruptive impacts of climate variability and change on productive systems such as agriculture, forestry, fisheries and rural livelihoods which in turn may affect the four dimensions of food security (FAO, 2008). Study has also shown that in many countries in the West Africa even well-managed fisheries productive system has not been able to adequately supply the required fish for future food security. Consequently, decline in fisheries production is expected to reduce fish availability with additional implications for food accessibility (Katikiro & Macusi, 2012). In effect, this hampers the ability to meet domestic demand (fish requirements) and threatens the economic and food security of many Ghanaians (including fishers and fish consumers) (Asante & Amuakwa-Mensah, 2015).

More so, in connection with access to aquatic food (fish), 57.4% of fishers reported that they were not satisfied with the role of fisheries. One study noted that *“Food security exist when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preference for an active and healthy*

life.” FAO, (2010). As noted by Katikiro & Macusi 2012, from the angle of fisheries, climate change will affect food (fish) accessibility through impeding fish allocation.

5.5.2: Perceptions of respondents about the impacts of climatic constraints on the post-harvest sector

Another important finding was that fishers likewise dependent on the post-harvest activities such as fish processing, fish transportation/supply, fish trading and marketing for their means of livelihoods. Consequently, seasonal climatic constraints such as unpredictable rain patterns and extreme weather events affect fish processing, fish transportation/supply, trading and marketing efficiency.

In respect of the livelihoods in the fish supply system, records showed that approximately 40,000 metric tons of fresh fish are preserved and transported annually from major inland fish trading centers around the Volta Lake such as Yeji, Kpandu-Tokor, Buipe, Atimpoku, Agormenya and Kete Krachi to the urban markets in Southern Ghana (Samey, 2015). In the wake climate risks and hazards such as rainfall associated with storm, prolong dry spell, and the menace of tree stumps, the result revealed that about 96.3% of respondents agreed that changes in climatological conditions hamper fish transportation/supply efficiency. A source at Yeji disclosed to the Daily Graphic in 2016 that a boat carrying between 60 and 70 passengers from Nantwie Akura to Yeji was said to have struck a tree stump, split into two before eventually capsizing according to (Adu-Gyamerah, 2016). Kwame (2008) noted that climatic factors such as strong winds/storms and, lake fluctuations among other factors have caused series of fatal accidents on the Volta Lake. Elsewhere, studies showed that increased rate of recurrence and severity of stormy conditions are expected to raise costs of shipping through additional safety measures and use of longer routes that are less storm prone (UNCTAD, 2009; UNECE & UNCTAD, 2010). For further understanding of the effects of unpredictable climatic pattern on post-harvest sector, during key informant interview a

fisherman/boat owner shared his views on the outcome of unpredictable climate on the post-harvest fish transportation.

He, noted that the main factors affecting Volta Lake transport are tree stumps exposed by severe droughts, lack of the fore-knowledge about impending rainstorm and lack of demarcations of safe navigation routes on the Volta Lake. He explained further that “Storms continues to be a threat because our wooden boats were not designed to withstand storms of incredible speed.

Box 4: Climatic and non-climatic constraints undermining fish transportation efficiency

Source: Field survey, 2019

Furthermore, bearing in mind the inherent challenges in the fish transportation/supply line as a result of climatic factors mentioned earlier (rainstorm, prolong dry spell and the menace of tree stumps), more than half 65.7% of fishers observed that this can have ripple effect on fish marketing and trading efficiency. Previous studies have found that climate variability/change can affect trade routes resulting in supply scarcity, generally, the impacts are lack of access to markets, changes in both market routes and transport times, price increase, and decrease revenues (Ficke et al., 2007; WorldFish Center, 2007). There is high agreement that rise or fall in Lake Levels (as a result of climate related factors) is estimated to negatively affect inland navigation Arendt et al., (2014) and the economic impacts ensuring this is expected to be immense (Krekt et al., 2011). Fish marketing and trading efficiency could be disrupted by longer periods of delays in inland navigation as well as limited load carrying capacity of rivers and lakes (Middelkoop et al., 2001). Extreme weather and climatic patterns could cause loss of fishing days, pose a danger to life, cause damage to fishing equipment, rise in annual transports costs up to 29% (Millerd, 2010; Barange et al., 2018). During a gender-based focus group discussion for female, a fish trader throws more light on the climatic constraints on fish trading and marketing efficiency, box 5.

According to a fish trader/marketer, during low level of the Volta Lake as a result of severe drought boat crew use longer routes in order to avoid tree stumps. Based on this, boat owners pass on the cost of transport to women in fish marketing and trading, and other passengers. She narrated that “The use of longer routes has caused delays for several hours.” The woman added that boat accidents have also led to injuries, the loss of fish and sometimes lives.

Box 5: Effects of unpredictable climate on fish marketing and trading efficiency

Source: Field survey, 2019

Finally, the result showed that about 55.6% of fishers acknowledged that the impacts of unpredictable rainfall (in terms of timing or when to expect rainfall) and changes in temperature on fish processing is certainly high. With 95% confidence levels, Akande & Diei-Ouadi (2010) established a link between fish losses and the fishing season (mostly rainy season), the research associated the rainy season with challenges such as difficulties in fishing, fish preservation (sun drying) and delays in transportation of catches. Kabahenda et al., (2009) reiterated that substantial post-harvest losses in terms of fish processing is linked with the rainy seasons. During a gender-based Focus Group Discussions (FGDs), a fish processor gave an account about the effects of unpredictable climatic pattern on fish processing through sun drying. According to the woman:

“To avoid fish spoilage due to the lack of modern preservation and storage facilities, fish must be processed through the usual sun-drying, smoking or salting methods soon after harvesting the fish.”

She recounted that unpredictable climatic conditions in terms of extended period of rainfall or longer periods of cold temperature within a particular fishing season increases the likelihood of fish spoilage due to the difficulties involved in processing fish through the usual sun drying method. She added that, gender orientation has no influence on the choice of alternative livelihood since most women are engaged in male dominated activities such as fish harvesting and crop or vegetable farming.

Box 6: Effects of unpredictable climate elements on fish processing

Source: Field survey, 2019

5.6: Current coping and adaptive strategies of fisher folk at the study area

5.6.1: Diversified livelihood activities

The study found that climate variability influences the coping and adaptive strategies of fishers through diversification of income earning activities. The study revealed that overall, 96.3% of respondents declared that undeniably there was the need to look for alternative livelihood sources to augment their income. In terms of supplementary income activities, the study revealed that generally, 66.7% were engaged in domestic poultry, 63.0% raised livestock, 3.7% of the respondents were engaged in crop farming while another 3.7% were engaged in petty trading and 1.9% were doing tree planting. These survival strategies mean a lot to the fisher folk for the fact that these are ways of augmenting income and providing basic needs during low fisheries output. According to Badjeck et al., (2010) fisher folks will need to adopt farm and non-farming alternative livelihood activities in order to make up for the declining returns from fisheries sector during erratic upwelling and changes in rainfall patterns. During a gender-based Focus Group Discussions a fisherman disclosed that most of the full-time fishers viewed non-fisheries related activities as time consuming. A fisherman had this to say:

He stated that the risks associated with crop farming are high. "In recent past, extreme climate events such as floods and drought both wreaked havoc on our crops making fishers unable to recover their investment. Full-time fishermen consider whether or not the alternative livelihoods activities will disrupt the number of fishing trips in a day, and duration of the trips. Normally, full time fishers spend most of their time fishing, repairing their boats and mending fishing nets after the day's fishing activities. In the wake of the unpredictable climate, many fishers prefer livestock rearing and domesticated poultry using free range method."

Box 7: Factors that influence the choice of alternative livelihood

Source: Field survey, 2019

This observation appears to highlight the conclusion of Müller-Kuckelberg (2012), that extreme climatic occurrences such as droughts or heavy/extreme rainfalls (and floods) could cause a lot of damage to climate sensitive crops which in turn may affect food production and food security.

5.6.2: Coping strategy from the perspective of mobility as perceived by respondents

This current research established that climate variability influences the coping and adaptive strategies of fishers through seasonal migration of fishers to better fishing grounds. The results show that overall, a total of 11.1% respondents confirmed that during the period of decline in fish catch rates, they migrated to other fishing grounds along the Volta Lake in search for fish.

He explained that seasonal migration of fishermen along the Volta Lake is influenced by variability in fish catch volumes between dry and wet fishing seasons. Some full-time fishermen from Yeji side of the Volta Lake travel long distances to fish at Kete Krachi, Yapei and Dambai when colour of the lake is “white” (during the dry season). He added that fishermen return to Yeji when colour of the lake changes to “Yellow” (during wet season). He concluded that other fishermen migrate to the coastal areas to do ocean fishing.

Box 8: Seasonal migration of fishermen as a coping strategy

Source: Field survey, 2019

Fishermen in West Africa adapted by switching to both alternative livelihoods and by means of geographical mobility (McCarthy et al., 2001). Also, Brugere et al., (2008) found that in the context of variability in fish catch and fish stocks, essentially, a section of Ghanaian fishers migrated to richer fishing grounds. During a key informant interview, a 45-year fisherman disclosed that indeed a few fishermen seasonally move from the Yeji side of the Volta Lake to fish in other regions. Interestingly, the fisherman identified the main fishing seasons with changes in colour of the Lake between the dry and wet seasons. He identified

the observed “yellow” colour with wet season. Apparently the observed “yellow” colour of the lake is the effect of sediment transportation into the Lake from surface runoff, box 8.

5.7: Summary

This chapter attempted to give interpretation and explanation of the results from the analysis. Evidence of variability in climate elements (rainfall and temperature) was presented. The chapter also described the link between changes in climatic elements and quantity of fish catch. Again, non-climatic determinants/drivers of fish catch were identified in this chapter. Moreover, impacts of the prevailing climate on fisheries related livelihoods as well as outputs of livelihood strategies such as fish availability, fish accessibility, income and jobs were identified. Finally, the adaptive and coping strategies of fishers at the study area were also discussed.

CHAPTER SIX

SUMMARY, CONCLUSION AND RECOMMENDATION

6.1: Introduction

This chapter of the study presents a summary of the major findings discovered from the study, conclusion and inferences that can be drawn from findings of the study. The final part of this chapter takes a look at recommendations drawn from the findings of the study and then key actors as a guide for policy direction, further research and most importantly for effective adaptation and coping strategy.

6.2: Summary of key findings

This study attempted to carry out a baseline analysis of the impacts of climate variability on fisheries related livelihoods. The core findings of the study have been summarized in accordance with the objectives of the study.

Evidence of rainfall and temperature changes in the study area was established using both primary data, and secondary data which is the observed climate data from the Ghana Meteorological Agency (GMet). The secondary data showed annual rainfall changes from 1986-2017 and annual temperature changes in maximum and minimum temperature from 1986-2012. Overall, rainfall in the study area was characterized by inter-seasonal variability, for example, 19 positive (+) rainfall anomalies (wet periods) were recorded while 14 negative (-) rainfall anomalies (dry periods) were experienced. In terms of temperature changes, the study site was also characterized by temperature changes. For example, 16 positive (+) temperature anomalies (warm years) and 11 negative (-) temperature anomalies (cold years) were recorded in maximum temperature while in minimum temperature another

16 positive (+) temperature anomalies (warm periods) but 11 negative (-) temperature anomalies (cold periods) were experienced over the study area.

ENSO was used as an index to investigate the meteorological or climatic trends such as potential warm and cold periods, wet and dry occurrences. For the maximum temperature, generally, the results showed that temperatures of thirteen (13) potential fishing seasons were above the mean ENSO baseline while temperatures of ten (10) potential fishing seasons were below the mean ENSO baseline. For the minimum temperature, overall, fifteen (15) potential fishing seasons experienced temperatures which were above the mean ENSO baseline while twelve (12) potential fishing seasons recorded temperatures which were below the mean ENSO baseline. Within the context of rainfall, overall, the results showed that all sixteen (16) potential fishing seasons which were located below the mean ENSO baseline coincided with the wet period while the fourteen (14) potential fishing seasons located above the mean ENSO baseline coincided with dry period. Moreover, the primary data also revealed perceptions of respondents about the prevailing climatic characteristics. Results from quantitative source discovered that the prevailing climate in the past decade was characterized by rainfall associated with storm 88.9%, high fishing season temperature 88.0%, late start of rainfall 85.2%, erratic rainfall 75.9%, low rainfall 75.0%, 71.3% of respondents claimed that flood events have been prevalent, early termination of rainfall 66.7%, 63.9% of respondents indicated that extreme rainfall was less prevalent and 60.2% respondents assumed that prolong dry spell is prevalent.

Furthermore, the effects of rainfall and temperature changes on fish catch were examined using both secondary (climate and fish catch) data and primary data. First, with the secondary data, the climatic variables (rainfall and temperature changes) were matched with annual fish catch trends from 1990-2012 to examine the link between the two. The result showed a strong

association of high fish catches quantity during wet periods and low fish catch size during the dry years (periods) recorded. Nonetheless, temperature had little effects on fish catch. Second, the primary data showed that indeed the prevailing climatological features had diverse effects on fish catch rates. From the quantitative source, majority of respondents about 96.3% have associated low fish catch with rainfall associated with storm while 76.9% attributed low fish catch to high fishing season temperature. In relation to rainfall changes, responses included late start of rainfall 75.0%, rainfall extreme 67.5%, erratic rainfall 62.9%, early termination of rainfall 57.4%. In the context of low rainfall, responses were diverse between high catch 40.7% and low catch 48.2%. From the angle of extreme climatic occurrences, 95.4% of respondents perceived that prolong drought can induce low fish catch while 74.1% of fishers acknowledged that high fish catch could be influenced by floods.

Moreover, the general (non-climatic) determinants/drivers of fish catch were determined using only the primary source. First, the quantitative data set indicated that drivers of fish output included lack of credit to fishermen 93.5%, high cost and irregular supply of pre-mix fuel 91.6%, poor health of fishermen 86.2%, boat type 84.3%, crew size 73.1%, fishing experience 69.4%, number of fishing gear 65.7%, and lack of knowledge 59.3%. Second, results from the qualitative data set indicated that unsustainable fishing practices such as the use of bamboo pipes are normally used by fishers to boost fish catch while inadequate supply of premix fuel negatively affects fish catch rates. Climatic factors such as rainfall associated with storm (rainstorm) and drought (which expose tree stumps) were also identified as drivers of low fish catch rates.

Besides, the impacts of the prevailing climate on livelihoods in the fisheries value chain were assessed using the primary data source. From the perspective the quantitative data source, the quantitative results revealed that climatic constraints affected the post-harvest sector

livelihoods. The climatic constraints identified were the impacts of the prevailing climate on livelihood sources such as fish processing 55.6%, fish transportation 96.3%, fish trading and marketing efficiency 65.7%. Socio-economic impacts assessment of low fish catch indicated that income generation from fisheries was not satisfactory 84.3% while employment from fisheries was also not satisfactory 70.4%. Performance of fisheries in two components of food security such as availability of aquatic food (fish) was less satisfactory 66.7% while access to aquatic food (fish) was not satisfactory 57.4%. Again, the qualitative source identified the impacts of low fish output on jobs such as fish processing (sun-drying), fish trading and marketing efficiency through delays as result of rainstorm. Other impacts are high boat fares due to the use of longer routes (caused by the menace of tree stumps and low lake levels) as a result of severe drought.

Finally, the current coping and adaptive strategies of fisheries dependent individuals and households at Yeji were examined using the primary source. First and foremost, the quantitative results identified two key adaptation strategies. First, a section 66.7% of respondents perceived that they are engaged in domesticated poultry activity, livestock rearing 63.0%, crop farming 3.7%, petty trading 3.7%, and tree planting 1.9%. Most importantly, the number of fishing trips in a day and duration of fishing trips determined the choice of livelihood diversification. Second, relatively a fraction 11.1% of respondents was identified with migration. The qualitative source also identified seasonal migration of fishermen to richer fishing grounds as one of the current coping and adaptation strategies of fishers at the study site.

6.3: Conclusions

Identifying and employing the appropriate research tools to help answer the research questions was a big challenge. Despite the limited availability of data, using quantitative as

well as qualitative data sources, the study had been able to collect the relevant data to assess the underlying factors that drive fish catch volume. For a robust attribution of changes in fish catch rates to climate variability, the general determinants or drivers of fish catch (non-climatic factors mostly socio-economic factors) were identified. Evidence from the study showed that rigorous assessment of the determinants of fish catch volumes cannot be made without considering climatological factors. The results showed that fishers appreciate the impacts of climate variability in their scheme of things.

This study found that fish catch is closely associated with variability in climatic variables (factors). Hence both climatic variables and fish catch levels were characterized by seasonal variability. Optimum climatological condition, such as positive rainfall anomalies (wet periods) significantly boosted fish catch. Conversely, negative climatological conditions, rainfall anomalies (dry periods) recorded a reduction in fish catch volume. Temperature on the other hand, had a minimal effect on catch rates.

Again, climate variability had a significant impact on livelihood strategies in the post-harvest sector such as fish processing, and fish transportation, trading and marketing. In addition to livelihood strategies, climate variability also provoked impacts on income and non-income livelihood outcomes (outputs of livelihood strategies) such as fish availability, fish accessibility, employment from the fisheries sector and income from fisheries.

It is clear that climate variability is expected to have far reaching implications for rural development. Because the sheer impacts were evident in the key socio-economic sectors in the fisheries value chain. These impacts are likely to negatively affect fisheries dependent household and communities. Therefore, this study concludes that diminishing return from fisheries in the form loss of employment, livelihood support, food insecurity, and income and revenue will most probably affect the development of rural fishing communities.

6.4: Key recommendations for adaptation and policy direction

6.4.1: Recommendations drawn from results of the study

Assessment of the impacts of climate variability on landing of fish is at the core of the study. Diminishing returns from the fisheries sector is expected to cause unsustainable competition among fishing fleets. In the quest for sustainable use of fisheries resources in the face of climate variability, this study recommends that:

- ❖ In the general scheme of things there is the need to identify the tradeoffs and synergies between the pursuit of increase fish production and sustainable fishing practices. Maintaining fish species diversity should be at the top of the agenda. The sector Ministry and other department with oversight responsibilities over the fisheries sector should invest in the development of fishing equipment such as fishing nets that will not disturb the ecosystem.
- ❖ Moreover, in the wake of climate variability, the Ministry of fisheries and aquaculture should formulate a deliberate policy that aims at enhancing resilience of fishers. The policy direction should be geared towards fast tracking the diffusion of aquaculture to fishing communities around the Volta Lake to minimize the dependence on wild fish.
- ❖ Again, to avoid over exploitation as well as depletion of aquatic resources, particularly the fish stock, the PNDC Fisheries Law 256 of 1991 which opposes the use of illegal methods of fishing should be enforced. This may go a long way to minimize the capture of adult pregnant and juvenile fish species to ensure spawning and sustainability as well.
- ❖ Results from the study showed that fishers' vulnerability is shaped by the problem of low income, food insecurity, and lack of employment from the fisheries sector. According to FAO-Adapt (2011) diversification of livelihoods and income generating

activities through mixed farming, forestry and fisheries systems, small-scale enterprise development and off-farm activities are effective adaptive strategies.

6.4.2: Recommendations from the standpoint of key stakeholders and actors

- ❖ The district Fisheries Director suggested that in the face of climate variability, to achieved sustainability in the fisheries sector, fishermen should adopt best and responsible fishing practices. According to him, “good and collective management of fisheries resources by traditional leaders, the local authority, fishers and the entire fishing communities will help to sustain the fishing of wild fish”.
- ❖ In the context of diversification of income sources, the District Fisheries Director recommended that fishers should be trained in non-fisheries alternative livelihoods such as snail keeping, bee keeping and mushroom farming. Again, “Efforts must be made to scale up fish cage farming since it will minimize the overdependence of fishermen on wild fish”.
- ❖ A fisherman who is at the same time boat owner took his turn to explain that efforts should be made to demarcate routes on the Volta Lake to avoid tree stumps during drought periods. He also highlighted information sharing and dissemination as an adaptive response: “We can minimize boat accidents if other key stake holders (probably Ghana meteorological Agency) liaise with boat owners’ association for regular weather updates. The fore-knowledge of the weather can help boat operators to make informed decision before setting off” he added.

Undeniably, there is a clear need to find effective ways of increasing the resilience of fishers in the study area. The letter of intent signed in 2016 by the Ministry of Fisheries and Aquaculture Development (MoFA) and IRIS Corporation Berhad (IRIS) from Malaysia should be put into effect. The agreement aimed to develop rural fishing communities in Ghana using an aquaculture focused integrated Community Based Farming Model (CBFM).

Experts have assumed that certainly when the project is properly carried out within the local Ghanaian context, it may offer alternative sources of fish catch and additional income source for fishers (MoFA, 2018).

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APPENDICES

APPENDIX G: QUESTIONNAIRE FOR HOUSEHOLD SURVEY

UNIVERSITY OF GHANA

MPHIL: CLIMATE CHANGE AND SUSTAINABLE DEVELOPMENT (CCSD)

PROGRAMME

Research Topic: The impacts of climate variability on livelihoods of fisher folk at Yeji.

HOUSEHOLD QUESTIONNAIRE

I am Emmanuel Kofi Mensah an MPhil student of Climate Change and Sustainable Development in the University of Ghana undertaking a research on the impacts of climate variability on livelihoods of fishers at Yeji.

The purpose of this questionnaire is to investigate the impacts of climate variability on fisheries livelihoods of communities around the Volta Lake, specifically at Yeji. This will undoubtedly provide relevant information necessary as entry points for designing adaptation strategies in local communities to help them effectively adapt to the adverse impacts of climate variability.

SECTION A: DEMOGRAPHY CHARACTERISTICS OF RESPONDENTS

ATTRIBUTE	Response	
Name of Community		
Gender	1. Male	2. Female
Age		
Fisheries related occupation	Fish harvesting []	Fish transportation/distribution []
	Fish marketing & trading []	Fish processing []
Type of occupation	1. Full-time	2. Part-time
Educational level	1. Primary	2. JHS 3. SHS 4. Tertiary/polytechnic
	5. No formal education	

1. How long have you been living at Yeji?

A. Less than 1-year B. 1 – 5 years C. 6 – 10 years D. 11-15 years E. More than 15 years

2. Please state the number of dependents in your household

A. 1-2 B. 3-4 C. 5-6 E. Above 7

3. What is the size of your household?

A. 1-2 B. 3-4 C. 5-6 D. Above 7

4. Apart from fisheries related activities are you engaged in other income generating activities?

A. Yes B. No

5. How much do you earn from your supplementary income activity per month? (Please tick one). GH¢50-GH¢99 [] GH¢100-GH¢149 [] GH¢150- GH¢199 [] GH¢200+ []

SECTION B: PERCEPTIONS OF RESPONDENTS ON GENERAL CLIMATIC PATTERN

6. Have you observed changes in the climatic trend over the past 10 years? (*Please choose one*) A. Yes B. No

7. Do you agree that there has been changes in the rainfall pattern in the past 10 years? (*Please choose one*) A. Strongly agree B. Agree C. Strongly disagree D. Disagree E. Not sure

8. What is the pattern of changes in rainfall over the past 10 years? (*Please choose one*) A. Increasing rainfall B. Decreasing rainfall C. Rainfall variability D. No change

9. Do you think rainfall is becoming erratic and unpredictable over the last 10 years? (*Please choose one*) A. Yes B. No

10. Do you think there have been changes in temperatures in the past 10 years? (*Please choose one*) A. Yes B. No

11. What has been the changes, increasing or decreasing? (*Please choose one*)

A. Increasing B. Decreasing

12. How would you describe the general climatic pattern over the past 10 fishing seasons? (*Please tick the appropriate box*)

Climate variable	Prevalent	Less prevalent	Not prevalent
Erratic rainfall			
Late start of rainfall			
Early termination of rainfall			
Low rainfall			
Rainfall extreme			
Flood			
Prolong dry spell			
High fishing season temperature			
Rainfall associated with storm			

13. What is your source of information concerning the changing climate? (*Please choose one*)

A. Personal observation B. Media C. Internet D. School E. Friends

SECTION C: GENERAL DETERMINANTS/DRIVERS OF FISH CATCH

14. Have you observed changes in the levels of fish catch in your locality? (*Please choose one*) A. Yes B. No

15. What is the nature of changes in fish catch in your locality? (*Please choose one*)

A. Decreasing B. Increasing C. Stable

16. What are the effects of these factors on fish catch quantity? (*Please tick all that apply*)

Non-climatic determinants/drivers	Fish catch quantity		
	High fish catch	No effect on fish catch	Low fish catch
Type of fishing boat (motorized)			
Fishing experience			
Number of fishing gears			
Crew size			
Lack of access to information			
Poor health of fishermen			
Lack of credit provision to fishers			
Cost and irregular supply of Pre-mix fuel			

17. What is the average number of fishing gears do you use in fishing activities? (*Please choose one*) A. 1-2 gear B. 3-4 gear C. Above 4 gear

18. How will you describe your access to the water resource (Volta lake)? (*Please choose one*)
 A. Open access B. Limited access C. Mixture of open & limited access D. No idea

SECTION D: IMPACTS OF CLIMATE VARAIBILITY ON FISH-HARVEST

SECTOR

19. Will you assume that decreases or increases in fish catch is caused by changes in climatic conditions?

A. Yes B. No

20. How will you assess the effects of changes in climatic conditions on fish catch level.

(Please tick the appropriate box)

Climate variable	Effects on fish catch amount		
	High fish catch	No effect	Low fish catch
Erratic rainfall			
Late start of rainfall			
Early termination of rainfall			
Low rainfall			
Rainfall extreme			
Flood			
Prolong dry spell			
High fishing season temperature			
Rainfall associated with storm			

21. How will you assess impacts the prevailing climate on fish catch quantity over the past 10 years? *(Please choose one)*

- A. Substantial decrease B. Decrease somewhat C. Remained stable D. Slightly increased
 E. Increased considerably

SECTION E: CLIMATIC AND NON-CLIMATIC CONSTRAINTS IN THE POST-HARVEST SECTOR

22. What are the impacts of changes in climatic conditions on the post-harvest sector such as:

a) Effects of unpredictable rainfall on fish processing (sun drying method) in terms of when to expect rainfall *(Please tick the appropriate box)*

b) Effects of rainstorm, long dry spell, reduce runoff and the menace of tree stumps on fish transportation, marketing and trading efficiency? *(Please tick the appropriate box)*

Climatic constraints on the post-harvest sector	Impacts Ranking				
	Very low	Low	No impacts	High	Very high
Fish processing					
Fish transportation /supply efficiency					
Fish marketing and trading efficiency					

23. Do you think lack of access to climate information on when to expect rainstorm, and drought can negatively affect fish transportation? *(Please choose one)*

- A. Yes B. No

24. Do you think inadequate investment in the area of improved fish preservation technology (Solar drier and refrigerators) can lead to fish loss? *(Please choose one)*

- A. Yes B. No

SECTION F: SOCIO-ECONOMIC IMPACTS OF LOW FISH OUTPUTS

25. How will you describe the contributions of fisheries in the following variables?

Variables	Performance				
	Very Satisfactory	Satisfactory	Normal	Less satisfactory	Not satisfactory
Fish accessibility					
Fish availability					
Income generation					
Jobs within fisheries value chain					

26. What is your family’s living standard (decreased or increased)?

- A. Better B. Worse

SECTION G: DETERMINANTS OF ADAPTIVE STRATEGIES

27. Do you need to look for other sources of income activities (second job) in addition to fisheries? *(Please choose one)* A. Yes B. No

28. Do you think your income from fisheries is enough to pay for the living expenses of your household? A. Yes B. No

29. Do you engage in any income supplement activity?

- A. Yes B. No

30. Which diversified income earning activities are you engaged in?

Diversified income Variable	Yes	No
Crop farming		
Livestock rearing		
Tree planting		
Domesticated poultry		
Petty		

31. How will you deal with the problem of changes in fish catch? *(Please tick all that apply)*

Migrate to richer fishing grounds Engage in farm and non-farm livelihood activities
] Both

FOCUS GROUP DISCUSSIONS INTERVIEW GUIDE FOR FISHERMEN

**MPHIL: CLIMATE CHANGE AND SUSTAINABLE DEVELOPMENT (CCSD)
PROGRAMME**

UNIVERSITY OF GHANA

1. Across the fisheries value chain (fish harvest, fish processing, transportation/supply, fish trading/marketing) what are you doing to earn a living?
2. How will you describe the current climatic trends in their locality?
3. What are some of your experiences about the effects of extreme climatic occurrences such as floods and drought on fishery?
4. Over the past years how would you describe the impacts of extreme climatic conditions (droughts and floods) on alternative livelihoods (crops, livestock, etc.)?
5. Apart from the climate, what other factors may adversely affect the work you do?
6. How will you describe the effects of high fuel price and short fuel supply on fishing operation and fish transportation/supply?
7. Apart from fisheries related activities, what factors influence selection of the other work you do?
8. How will you describe the impacts of low fish outputs on sustainability of your work?
9. Please can you briefly explain why some fishermen in your community have abandoned their work?
10. What work do native fishermen do when there is a decline in fish catch in your community?
11. What work do migrant fishermen do when there is a decline in fish catch in your community in your community?
12. What contributions have you made to ensure the sustainability of the fish stock in your locality?
13. What role should government play in improving the livelihoods of fishers?

FOCUS GROUP DISCUSSIONS INTERVIEW GUIDE FOR FISH PROCESSORS/TRADERS

MPHIL: CLIMATE CHANGE AND SUSTAINABLE DEVELOPMENT (CCSD) PROGRAMME

UNIVERSITY OF GHANA

1. How did you become involved in the work you are doing?
2. How will you describe the importance of your work to the survival of your household?
3. What are some of your experiences as a fish processor, and trader/marketer considering the effects rainstorms, prolong dry spell and low lake levels on your work?
4. In the context of fish processing, what are the effects of rainfall and temperature changes on fish processing (sun drying method)?
5. What factors hinder your ability to improve on your means of incomes?
6. Considering the male dominated occupations, what do you think can be done to break some of the tradition that thwarts the efforts of females from adopting the work?
7. How will you describe the effects of gender orientation?
8. As a fishmonger, do you often get support of cooperative groups in terms of fish marketing/trading?
9. What role should stakeholders in fisheries play in attempt to reduce the impacts of climate variability on the fishery industry?

INTERVIEW GUIDE FOR KEY INFORMANT

1. Please can you give a brief history about the means of transport in your community?
2. How important is the Volta Lake transport to the members of your community?
3. What is your primary means of transport to the Yeji weekly market center?
4. How would you describe the impacts of climatic conditions such as storm, drought and low level of the Volta Lake on fish distribution/transportation?
5. How will you describe the dangers associated with safety on Volta lake transport due to lack of periodic climate forecast?
6. What are the effects of lack of navigation routes on the Volta lake transport?
7. What do you suggest should be done to improve on Volta Lake transport?

**INTERVIEW GUIDE FOR IN-DEPTH INTERVIEWS (OFFICIALS OF FISHERIES
DEPARTMENT)**

1. Can you give a brief overview of fishing in the areas of your operation?
2. Please can you give a brief overview about the predominant climate trends in your area of operation?
3. Can you please describe the effects of the climatic characteristics (storm, rainfall and temperature changes, fluctuation in lake levels, drought and floods) on fish catch?
4. Apart from rainfall and temperature variability, what other factors influence fish catch?
5. What factors pose threat to sustainability of the fishery?
6. What do you think can be done to ensure sustainability of the fishery sector?
7. What potential exist for fishery in your areas of operation?
8. What do you think can be done to improve on the livelihoods of fishers?
9. What are practical measures have you put in place to improve the livelihoods of fishers?
10. What are the difficulties associated with the enforcement of fisheries regulations in your area of operation?