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IMPACT OF CLIMATE CHANGE ON FISHERY-BASED LIVELIHOODS IN THE NORTHERN REGION

BY

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DECLARATION

I, AMOS ARAPIERA AWUNI, do hereby declare that this thesis titled 'IMPACT OF CLIMATE CHANGE ON FISHERY-BASED LIVELIHOODS IN THE NORTHERN REGION' is my own original work for the award of the Master of Science in Agricultural Economics and that to the best of my knowledge, it contains no material previously published by myself or another person, nor material which has been accepted for the award of any other Sdegree in this University or any other University, except the references which are used and are duly acknowledged.

…… …….....

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ABSTRACT

Climate change has gained tremendous global attention in recent times, due to the risk it poses to human survival. And in order to reduce the risk of climate change on human beings, there is the need for a research to be conducted to help provide mitigation measures to reduce the negative impact of climate change on human beings. Thus, this study was conducted to determine the impact of climate change on fishery-based livelihoods in the Northern Region of Ghana. Specifically, it examines climate change awareness and perceptions in riparian communities in the Northern Region and establishes the impact of climate change on fish catchability in the study area. The study finally assesses fishers' vulnerability to climate change by employing the livelihood vulnerability indexes, and also analyzed the factors that influence fishers' decision to diversify. The researcher sampled 270 fishermen for the study. Afterward, the study used a line graph to depict the results of climate change on fish catchability and the livelihood vulnerability index and the Binary Logit model to assess the level of vulnerability and the factors influencing fishermen decision to diversify, respectively. It was concluded that fishermen have low knowledge of climate change. It was further established that climate change affects fish catchability and since the respondents were facing deleterious climate change indicators, they were very vulnerable to climate change. In general, fishermen were vulnerable and fishermen who have a high dependency ratio, less experience, and many household members to support them in fishing were more likely to diversify into other activities than their counterparts. This study recommended that policymakers and other stakeholders and players in the fish value chain should put in measures to educate fishermen on climate change and some adaptation measures to help them to protect water bodies. This will help to reduce the high degree of vulnerability to climate change the respondents are facing in the study area.

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DEDICATION

I dedicate this work to God the Father, Son and Holy Spirit for His unmerited favour.

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LIST OF ABBREVIATION

ATLAFCO	African States Bordering the Atlantic Ocean
BOG	Bank of Ghana
CGIAR	Consultative Group on International Agricultural Research
DFID	Department for International Development
EPA	Environmental protection Agency
FAO	Food and Agriculture Organization
FASDEP	Food and Agriculture sector Policy
GSS	Ghana Statistical Service
IPCC	Intergovernmental Panel on Climate Change
LVI	Livelihood Vulnerability Index
METASIP	Medium Term Investment Agriculture Plan
MOFA	Ministry of Food and Agriculture
NASA	National Aeronautics and Space Administration
NGO	Non-Governmental Organization
NOAA	National Oceanic and Atmospheric Administration
SFC	State Fishing Corporation
SHD	Sustainable Human Development
UN FCCC	United Nations Framework Convention on Climate Change
USD	United States Dollars

CHAPTER ONE

INTRODUCTION

1.0 Background

The contribution of fishery activities to national economies is multifaceted. Fishery's contribution can be put into three groups; livelihood empowerment, food security, and economic development. Fisheries promote the availability dimension of food security by providing the vital nutrients through fish which is not part of the typical starchy essential supply that dominates a poor person's diets (Tim *et al*, 2009; FAO, 2015).

Aquatic food is a major source of macro and micronutrients desirable for a balanced diet. The total world fish supply of food is 140.8 million tonnes live weight equivalent and a per capita of 19.7 per year. Worldwide, fish provides about 17 percent of protein supplied by animal and about 50 percent in several least developed countries. In Africa, the fish supply of food is 10.9 million tonnes and a per capita of 9.8 kg/ year (FAO, 2016). Ghana is fed through fishing and farming (FASDEP II, 2007). What this means is that most or all of the food supply in Ghana is from farming or fishing. For instance, it is reported that about 60 percent of the consumed animal protein is fish and approximately 75 percent of the total fish produced is utilized within the country (Tall &Failler, 2012; MoFA, 2013).

Households spend an estimate of 22.4 percent of their food expenditure on fish. This results in an annual estimate of 25.5kg per capita consumption, which is greater than the global and low income, food-insecure countries average of 19kg and 10kg (FAO, 2014; MoFA, 2013).

Throngs of people on earth depend on fisheries and aquaculture sector for their survivals and income since, it is reported that about 12 percent of the world's population have their livelihood supported by this sector and a constituted 56.6 million labour force were engaged in the capture fisheries and aquaculture subsector in 2014 and an additional 140 million were engaged along

the fishery sector value-added chain (FAO, 2016). Developing countries employ a large share of fishers, fish farmers and people employed in fish processing where employment in this sector is characterized by very low income, high seasonality and low productivity (FAO, 2016). An estimated 10 percent of Ghana's populations representing about 2.6 million people are employed by the fish industry (Tall &Failler, 2012). About 69.5 percent of households involved in home processed agriculture produce are into fish processing. This processed fish is able to yield an amount of GHS 327.33 million (GSS, 2014)

However, with all these contributions, the fishery sector is confronted by climate change. Its impacts are said to be severest on natural resources. In fact, climate change has turn out to be a global issue recently because of its negative impact on human livelihood. These negative consequences of climate change is worst in African countries particularly, sub-Saharan Africa, not excluding Ghana, which is very much capable of being hurt by climate change and its variability than the developed countries (FAO, 2014). This may be partly because most African countries depend largely on agriculture, which is directly linked to climate change. For example, Ghana is still very vulnerable to poverty and food insecurity because of its dependence on rain-fed agriculture, at a time rains are very erratic due to climate change and variability.

Besides, the erratic rainfall patterns, Ghana has lost about 35% of its total productive landmass through climate change in the form of desertification (EPA, 2008). These negative outcomes of climate change are, however, much worst in northern Ghana (Arndt *et al*., 2015).

For example, the northern part of Ghana suffers serious Harmattan than the southern part of Ghana (UNDP climate change rep 2013). Similarly, it was projected that by 2050 the temperature will rise in the Northern, Upper East and the Upper West regions by 2.1–2.4 °C, against a suggested increase in the Ashanti, Western, Eastern, Central, and Volta regions by 1.7–2.0 °C, and that of the Brong Ahafo region by 1.3–1.6 °C in 2050 (FAO, 2014). Northern

Ghana has an average temperature ranging from 21°Cto 28°C (70 to 82°F) with a comparative humidity which ranges from 77 percent to 85 percent (Ghana weather average report, 2013). These and other climaticfactors, in turn, may result in lower productivity in the northern part of Ghana since seasonal climate factors and cropping time as well as water requirement status and adaptability of the whole vegetation are directly related (Stanturf *et al.*, 2011).

In light of this background, the researcher executed a study on the consequences climate change may have on fisheries in the Northern Region, particularly the livelihoods of fishers. The research sought to found the result of climate change on fish catch levels and how that contributes to fishers' overall vulnerability to climate change. The researcher will also assess the level of awareness of climate change which will actually end up creating climate change awareness in fishers' and this may help them to start to search for adaptation measures to help reduce/ mitigate the effect of climate change.

1.1 Problem Statement

It is clear from the background that, the importance of fishery in the world, Africa, and Ghana cannot be overemphasized. However, climate change impact fishery and the livelihoods of consumers and producers who engage in fishing activities from fish capture up through the value chain. Rural farmers and fishers depend indirectly on rainfall and temperature for their economic well-being (Ejembi & Alfa, 2012).

Perry *et al.*, (2007), suggested that low income countries are much hurt by climate change than high income countries. Also, greatly affected is the livelihood of the poor who depend on climate-sensitive sectors (Vorsah, 2016); particularly fishery. According to Daw *et al.*,(2009), freshwater fisheries are very susceptible to climate change challenges.

Even though, Ghana has signed the United Nations Framework Convention on Climate Change (UNFCCC) at the Rio de Janeiro Earth Summit in June 1992, which aimed at mitigating climate

change, Ghana still face rising temperatures and decreasing rainfall patterns (EPA, 2011). Just like in other developing countries, this is impacting negatively on climate-sensitive sectors. This may be partly due to inadequate resources, institutions and adaptation measures to mitigate or reduce climate change.

The negative impacts of climate change are, however, much worst in the northern part of Ghana (Arndt *et a*l., 2015). Akudugu *et al.,* (2 012) conclude in their research on smallholder farmers that Northern Ghana is more vulnerable than Southern Ghana. It said that the exposure component of the LVI-IPCC framework defined as LVI-IPPC = (Exposure-Adaptation)×Sensitivity),contributed more than adaptation and sensitivity.

It is, therefore, paramount to determine Fisher's awareness of climate change. Furthermore, since it has been indicated that climate change and the quantity of fish available are directly related (Dontwi*et al*., 2008), it will be adequate to study the consequences of climate change on fish catchability in Northern Region over time.

Even though various surveys have estimated the economic effect of climate change on developing countries like Ghana (Schlenker & Lobell 2010; Nutsukpo *et al.,* 2013;Arndt *et al*., 2015), but no such study has been conducted on the fishery in Northern Region.

Moreover, it is not known whether fishers in Northern Region diversify as an adaptation measure and if so what factors influence their decisions.

Finally, it is empirically unknown whether climate change really affects the livelihood of fishermen in the Northern Region. These and other gaps left unsolved inform the research questions and objectives of this current study.

1.2 Research Questions

The main research question is: What is the impact of climate change on fisheries based livelihood in the Northern Region?

Specific research questions:

1. What is the level of awareness of climate change in riparian communities in the Northern Region?
2. What is the impact of climate change on fish catchability in the Northern Region?
3. How vulnerable are fisheries in the study area to climate change?
4. What factors influence fishers' decision to diversify their livelihood?

1.3 Research Objectives

The main objective of this study is to examine the impact of climate change on fishery-based livelihoods in the Northern Region.

Specific objectives of the study include:

1. To examine climate change awareness in riparian communities in the Northern Region;
2. To establish the impact of climate change on fish catchability in the study area;
3. To assess fishers' vulnerability to climate change using a livelihood vulnerability index;
4. To analyze the factors influencing fishers' decision to diversify.

1.4 Justification of the Study

METASIP has emphasized the need for determining the impact of climate change on agricultural production in order to meet the demand of the growing Ghanaian population (MOFA, 2010). This emphasis notwithstanding, there are various loopholes in knowledge of the consequences of climate change on agricultural production, forestry, aquaculture and fishery livelihoods.

The impact of climate change on agricultural activities (particularly smallholder farms) has received quite asubstantial study. Even though the fishery sector is not left out in remains studies, the concentration so far has been on the offshore fishery. I am yet to find literature on the impact of climate change on inland fisheries and the livelihood it supportsin Ghana even though, inland fisheries are important in the survivals of rural people (Smith *et al.,* 2005).

This study is necessary because it will help provide information on fishermen's awareness of climate change and if it turn out that fishermen are unaware of climate change, the stakeholder will learn from the study and a climate change sensitization may becarried out among fishermen in Ghana particularly, the northern part. This research will also sensitize fishermen as the researcher and enumerators will be asking them questions on climate change. This sensitization is important because it will make fishermen equip themselves with some adaptation measures which will help reduce their vulnerability.

Results from this study could be used by stakeholders in the sector to do forecasting and thus, put in some adaptation strategies to help minimize climate change shocks on human livelihood since there is a direct relationship between the catch dynamics of the major commercial fish species and the rate of change in the various climatic indices (James, 2013). Specifically, results on the effects of climate change on fish catchability will help inland fishers and other stakeholders in the sector to make long-term forecasting as well as put in climate change adaptation measures which will help to improve their livelihood.

The study will provide information on the livelihood vulnerability status of Northern Region's fishers. Also, the exact factors that influence fishers' diversification decisions will be known and this may go a long way to help reduce fisher vulnerability status. Furthermore, the result of this research will help provide information to the government and other stakeholders who are

interested in climate change. Finally, this research will contribute to the existing research work on the impacts of climate change on fishery-based livelihoods.

CHAPTER TWO

LITERATURE REVIEW

2.0 Chapter Outline

This chapter reviews the literature that is related to the study. It is composed of the definition of terms in subsection 2.1, a brief review of the fishery sector (2.2), literature on the marine fisheries sub-sector (2.3). The remaining subsections contain literature on the inland fisheries sub-Sector in Ghana (2.4), review of the importance of fisheries in subsection 2.5,review of climate change and variability (2.6), review of the effect of climate change on fisheries (2.7), review of the effects of climate change on livelihood (2.8), review of the livelihood functions of fisheries (2.9), review on Climate change vulnerability (2.10), review on the hypothetical approach to livelihoods (2.11), conceptual framework for analyzing the level of vulnerability in the study(2.12), conceptual framework of the Study (2.13) and finally, review on the factors influencing fishermen decisions to diversify (2.14).

2.1 Definition of Terms

2.1.1 *Climate change*

Climate is an average weather condition of a place over a long period of time. The climate is seen as a composite of daily weather conditions that describe the average and variability of weather typically over 30 years (CGIAR, 2009). The key elements of the weather are the sunshine, rainfall, atmospheric pressure, humidity, wind direction and speed, solar radiation, and ionization (CGIAR, 2009).

The climate is usually termed as the average of weather. Statistically, it is the variability and mean quantities of relevant weather variables over a period of time ranging from months to millions of years. According to the World Meteorological Organization, the basic period for

averaging these variables is 30 years. The major quantities are most often surface variables such as temperature, precipitation, and wind (Field *et al*, 2012)

The climate system is the entirety and interrelationship of the biosphere, the hydrosphere, the atmosphere and the geosphere (UNFCCC 1992). According to Field *et al.*, (2012), the climate system comprises five main constituents: the atmosphere, the oceans, the cryosphere, the land surface, the biosphere, and the interrelationship between them.

Climate change is a decadal alteration in the climatic situation that can be identified by the modification in the means or the variability of its properties. These changes may be influenced by natural internal processes or external and anthropogenic forces (Field *et al*, 2012).

However, according to the United Nations Framework Convention on Climate Change (UNFCCC,1992), climate change is "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods."

The difference here is that, IPCC perceives changes in climate to be the result of both natural forces and anthropogenous forces whereas UNFCCC perceives that climate change is entirely cause by human activities and that natural force only brings about climate variability.

Climate variability refers to fluctuation in the average state and other relevant statistics of climatic variables at spatial and temporal levels above that of human weather events. Variability may be caused by natural internal or external and anthropogenic forces (Field *et al*, 2012).

2.1.2 *Fishery*

A fishery is any pursuit that aims at harvesting fish (National Oceanic and Atmospheric Administration (NOAA), 2006). This includes aquaculture and wild fish capture. It can also be seen as a unit (people involved, species of fish, the area of water and others) that has the mandate to raise or harvest fish ((NOAA, 2006).

In Contemporary biology, fish is an animal with a backbone that has gills throughout life and may have fins shape limbs (Nelson, 2006). Most aquatic animals that are not fish in strict terms are usually referred to as fish. For instance: shellfish, cuttlefish, starfish, crayfish, and jellyfish. However, in fisheries**,** fish is a general term for use all aquatic animals (includes mollusks, crustaceans, etc.) which is harvested (NOAA, 2006).

2.1.3 *Livelihoods*

This current research will use the explanation of livelihood by Chambers & Conway (1992) as its working definition of livelihoods. They defined livelihood to encompass the capabilities, assets (social and natural) and activities that are essential for the survival of individuals and communities. Sustainable livelihood is a livelihood that is capable of surviving or regaining from tensions or shocks and maintaining its abilities and resources now and in the future, even as the natural resource base is not undermined.

With the intention of enhancing understanding of livelihoods, the Department for International Development (DFID) built on the work of practitioners and academics to /and developed Sustainable Livelihoods Framework (SLF). This is an analysis tool used for understanding the many factors that influence an individual's livelihood. SLF has five major components. That is livelihood assets, livelihood strategies, livelihood context, livelihood vulnerability and livelihood interdependence (Chamber& Conway, 1992).

Livelihood assets can be either tangible or intangible. The tangible assets may be land, livestock, fisheries (inland or marine) and other natural resources. The intangible assets may be information, education, health services and others of the like. Aside from categorizing these assets into tangible and intangible assets or capitals that people obtain a livelihood can be put into natural, social, human, physical and financial resources. Natural assets are make-up of

natural resources such as soil, land, water bodies, vegetations, and fisheries (Chamber& Conway, 1992).

2.1.4 *Vulnerability*

Vulnerability is termed as the magnitude to which a system is inclined to and unable to meet, negative effects of climate change and climate variability and extremes. Vulnerability depends on the nature, extent, and rate of climate alteration and variation to which a system is opened, its responsiveness, and its adaptive capacity' (Parry *et al.,* 2007).

2.2 Review of the Fishery Sector in Ghana

Ghana's fishing sector is made up of marine (artisanal, semi-industrial or industrial), inland capture fisheries and aquaculture (N'jie & Jones, 1996). In an attempt to influence the supply of fish, the government of Ghana adopted a policy which aimed at promoting the fishery sector by constructing fishponds among all irrigation schemes within the country after independence in 1957 (BoG, 2008). Other measures were to promote mechanize fishing together with outboard motors, inboard motors and significant fishing vessels through the State Fishing Corporation (SFC) establishment in 1961 and the development of the Tema harbor, in 1962 (BoG, 2008). These and other policies have resulted to a substantial increase in the quantity of capture marine fish within the late 1960s, from 105,100tons in the late 1960s to 230,100 tons in 1971 (BoG, 2008). Similarly, in 1982 the captured marine fish increased to 234,100 tons, composing of 199,100 loads of marine varieties and 35000 loads of seafood from Lake Count Alessandro Volta (BoG, 2008). But, the country began to experience a decline in the fisheries sector, particularly the marine fisheries in1999 as the capture declined from about 420000 to about 202 000 tonnes in 2014 (FAO, 2016). This decline was partly because of mismanagement, overfishing and negative impact of climate change (FAO, 2016). In order to prolong the per capita used of fish, the government of Ghana puts in some measures in 2005, which increased the number of fish

farmers' from 1 200 in 2005 to 38 500 in 2014 (FAO, 2016).This has promoted the total production of capture fisheries in Ghana from 231,600 tonnes in 1980 to 293000 tonnes in 2014 (FAO, 2016). Nonetheless, the increased supply could not still sustain the estimated 24.2 kg annual per capita consumption of fish, and as a result, the country resorted to the importation of fish, amounting to USD 373 million in 2013 (FAO, 2016). This pushed the trade balance of seafood from a USD 33 million excess in 1997 to a USD 319 million shortfall in 2013(FAO, 2016).

2.3 Review of the marine fisheries sub-sector in Ghana

The marine sub-sector, which covers about a 225000km square of the total land, contributes about 80 out of 100 of the total fish supply in Ghana (FAO, 2016). This subsector has a total of 304 landing centres which is made up of 189 fishing villages along the coast of Ghana which employs about 77000 people in 2014 (FAO,2016). The subsector has declined from almost 420 000 tonnes in 1999 to 202 000 tonnes in 2014, nonetheless, it provides an annual average catch of about 300,000metric tonne (FAO, 2016).

The marine subsector is made up of industrial (offshore), semi-industrial (inshore) and small-scale (artisanal). The artisanal sub-sector provides approximately 70% of the overall marine supply of fish in Ghana and provides livelihood to an estimated 1.5 million people. The inshore and offshore sub-sectors produces about 2% and 6% of the total marine supply, respectively (FAO, 2016). It is further reported that an estimated 12 000 marine artisanal canoes operates along the coast, with 150 and 84 being in the semi-industrial and the licensed industrial trawlers, in Ghana, respectively. Some of the marine fishing communities or districts in Ghana includekwidaa, in the Ahanta West District, Chokor in the Accra Metropolis District, Ada Foah and Prampram, Ningo,Tema Canoe Beach, Akplabanya ,Ahwean, Sekondi,Winneba, Funkoe and New Amanful (FAO,2016).

2.4 Review of the Inland Fisheries Sub-Sector in Ghana

The inland fisheries sector in Ghana composed of inland capture and aquaculture (Braimah, 2003). Ghana's inland water area is about 11000km square of the total land (FAO, 2016). It employed about 175000 people in 2014 (FAO, 2016). The total production of the inland fisheries sector has increased from 40000 tonnes in 1980 to 90,000tonns in 2014 (FAO, 2016). About 85 percent of the inland fisheries output is from Volta Lake, which produces about 75,000 tonnes of fish annually (FAO, 2016).

According to FAO (2016), the peak harvest of inland fish occurs in July to August whereas the lowest fish harvest period is within February and January. Some of the inland capture fish landing sites in term of regional distributed include : Northern (Nasiaand Buipe,); Upper East (VieraTono, White & Red Volta Rivers); Upper West (Bagri,Jawia, Sankana, and Bilibor); Volta (Abotoase, DambaiDzemeni, KpandoTorkor,); Brong-Ahafo (Yeji);Eastern Region (Kpong, Akosombo, Akateng); and Central (Dunkwa-on-Offin)(FAO, 2016).

2.5 Review of the Importance of Fisheries

Generally, fisheries provide financial gain, offer food for native, national and international markets and create vital contributions to nutrition (FAO, 2012). Fisheries' contributions can be put into three groups; livelihood empowerment, economic development and food security (Tim *et al*, 2009; FAO, 2015). Also, the importance of fishing, particularly, inland Capture fisheries can be grouped into direct and indirect (Garcia and Rosenberg, 2010). For instance, fishery directly employs about 56.6 million individuals in the capture fisheries and aquaculture sub-sector and indirectly engages about 140 million people along the value chain in 2014 (FAO, 2016).

Also, an estimated 10 percent of Ghana's population representing about 2.6 million people is employed by the fish industry (Tall &Failler, 2012). Specifically, more than 250,000 artisanal fishers are employed, who are using more than 29 300 fishing vessels (FAO, 2016).

Moreover, about 12 percent of the world's population has their livelihood supported by the fisheries and aquaculture sector. According to Braimah (2003), about 300,000 Ghanaians citizens who live along Lake Volta mainly depend on inland capture fishery for their livelihood. Similarly, Minta, (2003) revealed that about 10% of the approximately 25% of the people in Ghana who live in the coastal area hinge on the fishery for their survivals. This implies that fishing helps to reduce vulnerability, particularly in rural communities (Kawarazuka, 2010)

Other studies have also highlighted the contribution of a fishery to food supply. For instance, FAO (2016), indicated that the total world fish supply of food is 140.8 million tonnes live weight combining and a per capita of 19.7 per year. Fish supply of food is 10.9 million tonnes live weight combining and a per capita of 9.8kg/ year in Africa. Finally, in Ghana, the per capita fish consumption was about 20-25 kg, which accounts for 22.4% of unit food spending (BoG, 2008).

In terms of fishery contribution to food security, studies have shown that food from the aquatic environment is a prominent means of macronutrients and micronutrients desirable for a good health (FAO, 2016). Specifically, fisheries contribute to food security by providing the vital nutrients through fish which is not in the typical starchy essentials that dominates the poor persons's diets (Tim *et al*, 2009; FAO, 2015).

Universally, fish provides about 17% of animal supply of protein and about 50 percent in several least developed countries. Fisheries provide about 22% of animal protein consumed, particularly in the coastal areas (FAO, 2005).

2.6 Literature on Climate Change and Variability in Ghana

Ghana is hard hit by climate change, because it suffers, serious rate of desertification, high temperature, erratic rainfalls and global warming (Arndt, *et al.*, 2015). Ghana has recorded a decreasing rainfall pattern within and between the years (World Bank, 2010). Moreover, Cameron, (2011) used 20 years data to analysis climate change in Ghana and have concluded that Ghana is experiencing increasing temperatures coupled with declining and erratic rainfall patterns. Other studies have also anticipated that there will be great changes in the annual temperatures and precipitations in Ghana (Arndt, *et al.*, 2015). Moreover, the World Bank has also projected that Ghana will face high temperatures within the period 2010 to 2050 (World Bank, 2010). Of this projection, the highest temperature parts of the country will be in the Northern part of Ghana (World Bank, 2010). Specifically, it was noted that temperatures in Northern Ghana shall rise from 2.1–2.4 °C by 2050 while that of the Western, Ashanti, Eastern, Central, and Volta Zones shall rise from 1.7–2.0 °C, with the Brong-Ahafo region being 1.3–1.6 °C. (World Bank, 2010). Similar projection was made about sea-surface temperatures as it was projected that sea-surface temperature will increase by 0.13 m to 0.60 m by the end of 21st century (Stanturf *et al.*, 2011).

On precipitation, Stanturf *et al*., (2011) projected a decreasing precipitation in Ghana. For example, the authors projected that the capital of Northern region will experience an alteration in precipitation of 36% decline to a 32% increase in the wet season and this may result in decreased rainfall (Stanturf *et al*., 2011).

2.7 Review of the Effect of Climate Change on Fisheries

Climate change has been demonstrated to have a positive influence on the fishery sector and the agriculture sector (FAO, 2010). For instance, the World fish report (2010) has reported that

Ghana is seriously vulnerable to climate change, as it was ranked the 25th highly vulnerable nation out of the 33nations which were under the study.

Moreover, a study by FAO (2005) which looks at the dynamics of global Climatic indices and main commercial catches concluded that there is a direct relationship between the commercial marine species, catch dynamics, and the patterns of various climatic indices.

Similarly, Minta (2003) has found that the lower fish population and catchability occurred in years of higher sea surface temperature and precipitation. Thus, the researcher concluded that climate positively affects the productivity of the ecosystem and its catchability and particularly, the growth rate of the number of species in water bodies.

Climatic factors could directly or indirectly influence the biotic and abiotic components that determine the quantity and distribution of fish species (Minta, 2003). The abiotic components are composed of water temperature, salinity, nutrients, and sea level as well as present conditions. The biotic components, on the other hand, include food accessibility and presence and species composition of predators and competitors (Minta, 2003). In conclusion figure 2.1 show a brief of the interaction between climate change variables and the abiotic and biotic element of fish.

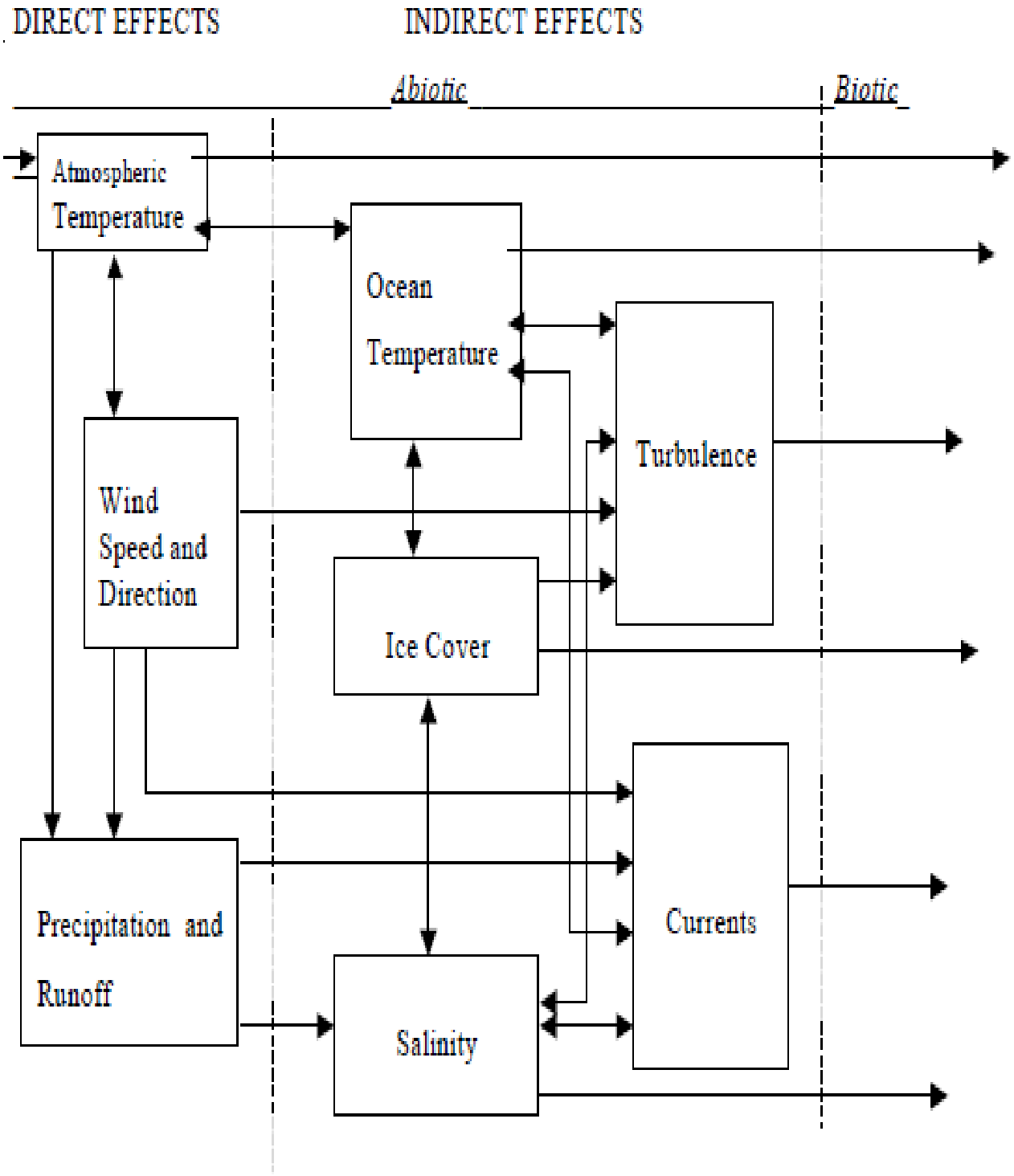


Figure 2.1.The key Climatic Pathways Affecting the Abiotic Environment of Fish

Source: Glantz, (1992)

2.8 Literature on the Impact of Climate Change on Livelihood

Various researches have showed that climate change negatively affects the livelihood of fishermen. For example, Arndt *et al.*, (2015) concluded that climate change and variability negatively affect fish catchability which may affect the livelihood of fishers especially those in the northern part of Ghana.

Similarly, Nutsukpo *et al*., (2013) conducted a study covering Ghana, where they employed a global partial equilibrium to link high-resolution crop models and concluded that climate change decreases livelihood in terms of food supply in two of the four climate scenarios considered.

Minta (2003), assessed the vulnerability of Ghana's Coastal artisanal fishery to climate change and revealed that climate change positively affects the productivity of the ecosystem (fish) and the quantity of fish as well as its catchability which goes a long way to reduce the livelihood of fishermen thereby, making them more vulnerable.

From the analysis, some authors have indicated that climate change has a direct link to low livelihood (poverty). This is shown in figure 2.2 below. The arrows show the causes.

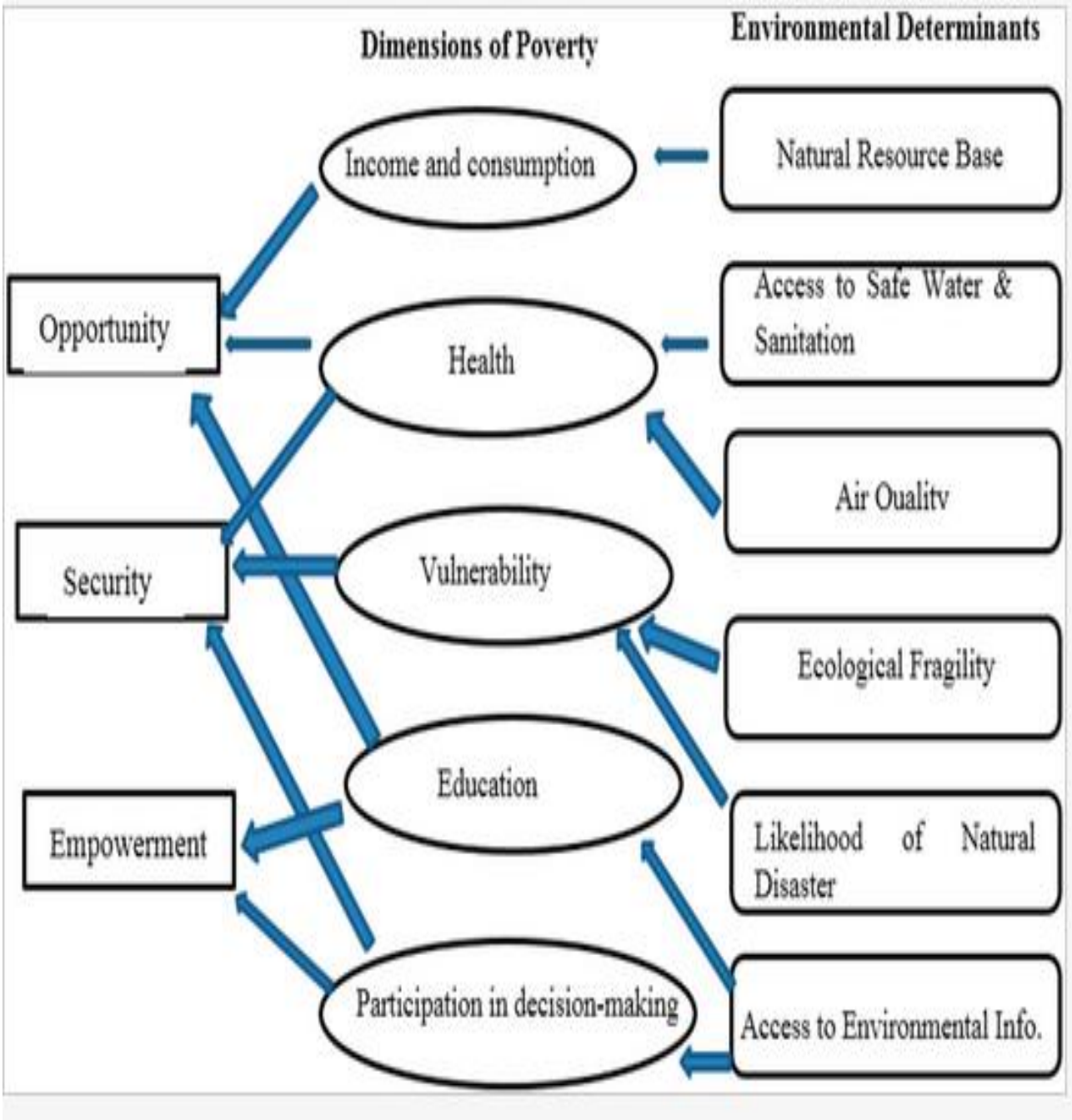


Figure 2.2. Climate change (Environment) and livelihood (poverty) linkage

Source: Bucknall *et al., (*2002).

From figure 2.2 above it can be seen that the availability to natural resources and ecosystem services influence survivals (dimension of poverty), accessibility to safe water and sanitation and pollutants on the other affect the health dimension of poverty; and ecological fragility and

the probability of natural disasters influence the vulnerability dimension of poverty (Arndt *et al.,* 2015).

2.9 Review of the Livelihood Functions of Fisheries

The livelihood functions of inland fisheries are complex, thus, it needs an analytical framework which can incorporate an appraisal of a wide range of issues, and which will be robust, elastic and negotiable (Smith *et al.,* 2005). Various studies have varying understanding of the frameworks for analyzing livelihood function. For instance, Béné (2003) believes that the livelihood function of fishermen can be simply presented as "fisheries=poverty" (p. 955). This, according to the author further implies that fishing gains hinges on labour real cost and not what occurs within the fishery itself. Thus, he concluded from his analysis that fishermen are peoples of low-status, marginalized families. But, Smith *et al*. (2005) argued that even though Bene's conclusion is true, it is very limited to enhance a sufficiently robust and negotiable equation of the livelihood functions of inland fisheries. Specifically, Smith *et al*., (2005), used a multidimensional construct of poverty and livelihoods analysis as the livelihood function for fishers which was made-up of economic, institutional and political environment as well as the resources or assets that are used for existence and those owned, obtained through exchange and obtained through rights of access, and how these assets can be used in a range of activities. Moreover, their model includes Fishery characteristics (e.g. fishing methods and costs), the micro-, meso-, and macroeconomic environment, the institutional environment, fisher household characteristics (such as diversification) and other Livelihood outcomes in their livelihood function.

Also, other external risk elements and the institutional and policy environment were also considered in their function (Smith et al., 2005). This is represented in figure 2.3 below.

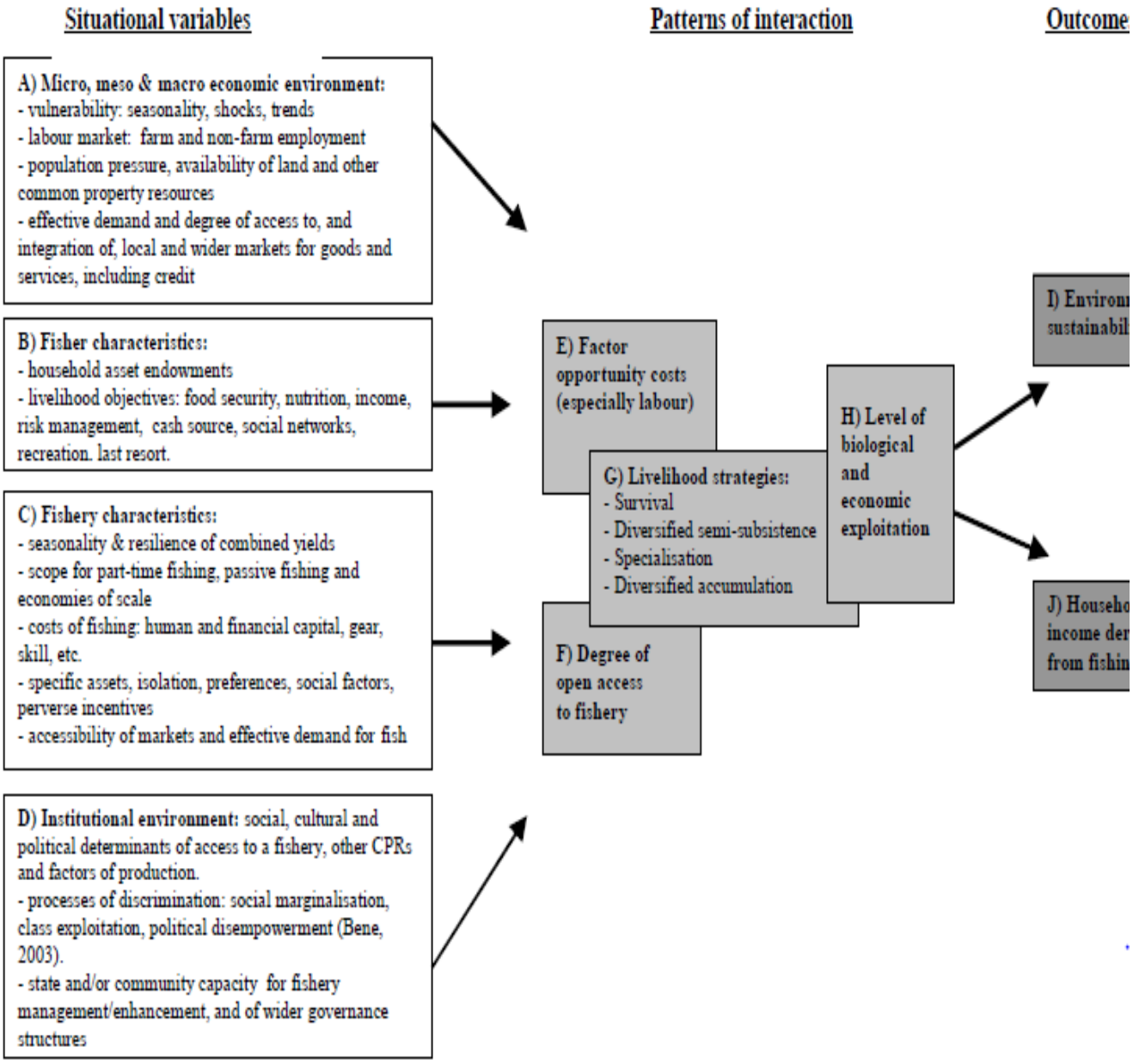


Figure 2.3.A framework for understanding the factor influencing livelihood outcome inland fishing.

Source: Smith *et al*.,(2005).

2.10 Climate change vulnerability

The Intergovernmental Panel on Climate Change (IPCC) studies has noted that climate vulnerability is still a developing idea and policy even though, vulnerability is directly/ indirectly cause by climate (Handmer *et al.*,1999). Vulnerability is viewed differently by divergence schools of thought. For instance, Blaikie *et al.,* (1994) viewed vulnerability as an attribute of an individual or individuals in terms of their capacity to expect, cope with, resist and regain from the impacts of natural risks and as well as their resilience to susceptibility. Schneider et al.,(2007) on the other hand, have viewed vulnerability to climate change as the extent to which a species habitat or ecosystem is susceptible to risks from the impacts of climate change. However, the international body that has been mandated to undertake climate change impact vulnerability assessment IPCC, defined vulnerability as the level to which a system (species) is susceptible to, or unable to match with the negative effects of climate change, including climate variability and extremes. Vulnerability is made- up of the feature, magnitude and rate of climate variation to which an organ is exposed to, its sensitivity, and its adaptive capacity" (IPCC, 2007)

Climate change affects all aspects of a system (Baidoo, 2015), therefore different types of vulnerability. According to UNU-EHS (2006), vulnerability can be physical, economic or social. The physical vulnerability is the susceptibility or inability of the built environment and population to cope with climate impacts leading to physical damage. Economic vulnerability is the likely impact on livelihoods. Social vulnerability is the possible adverse impact on social grouping (the poor, rich, handicapped, men, women, children, etc.).

In climate change literature, vulnerability is conceptualized in two main approaches. The two are the starting and ending point approaches. The ending point vulnerability conceptualization approach looks at the quantum of damage to an organ by a specific climate-related risk. The

other approach is the starting point method which considers vulnerability within a system before a potential hazard befall it (Brooks, 2003)

2.10.1 *Review of livelihood vulnerability index (LVI)*

Various studies have used the livelihood vulnerability to analysis to weather extremes. Some these studies include, Nguyen *et al,* (2013) who used the LVI to evaluate flood vulnerability of the villages of Ta Danh and PhuHuu in a Giang province and concluded that PhuHuu village, which is located an early flooded area is more vulnerable than Danh village, which is located in a late flooded zone.

Etwire *et al.*, (2013), also analyzed the extent of peasant farmers' vulnerability to climate change and variability in Northern Ghana using data from a sample size of 320 farmer households and data on rainfall and temperature and employing the Livelihood Vulnerability Index revealed that of the Northern Region is the most vulnerable, followed by the Upper East and Upper West regions.

Hahn *et al.,* (2008), conduct a study titled, "the Livelihood Vulnerability Index: A pragmatic approach to assessing risks from climate variability and change—A case studies in Mozambique" and concluded that Moma was much hit by water resources vulnerability while Mabote on the other hand, was highly vulnerable to socio-demographic structure.

2.11 Hypothetical approach to livelihoods

The aim here is to provide a brief review of some theoretical approaches to livelihoods that exist. This will provide clarity on the basic principles the support the livelihood approaches. One of the approaches will justifiably be adopted for this study. The review will particularly cover three livelihood approaches that were developed by different agencies specifically: the United Kingdom department for international development (DFID); Oxfam committee for famine relief (Oxfam); and the United Nations development program (UNDP). This and other livelihood

approaches builds on the work of Chambers and Conway (1992) particularly the definition of livelihood they provided (Carney *et al.,* 1999).

2.11.1 *The DFID Livelihood approach*

Eminent among the various livelihood approaches developed is the DFID (1999) livelihood approach which is reputed to have portrayed the cardinal concept of livelihood well (Baumgartner & Högger, 2004). This approach is a people-centered approach (Sampson Knust) build around five broad components with a number of subcomponents. The five main components are vulnerability settings, livelihood resources, and livelihood strategies, transforming systems and procedures and livelihood results (Carney *et al.,* 1999).

Vulnerability context

According to DFID (1999), knowledge of the system of the vulnerability is a major leap in the sustainable livelihood analysis. The Vulnerability setting in the DFID model is the environment in which people exist and gain other benefits through the impacts of their asset status (Devereux, 2001). This includes shocks (human health, fish biomass, and agricultural production through climate change); tendencies (i.e. demographic tendencies, fishery resource trends, trends in management); and seasonality (lean and abundance catch). Stakeholders have very little or no control over this component of the framework.

The effects of the different sub-constituents of the Vulnerability Context are different and affect individuals in different ways (DFID, 1999). For instance, seasonality and trends can have both positive and negative effects (Kollmair & Gamper, 2002) not so with shock. Climate change shocks have more adverse effects on climate-sensitive natural resources (Akudugu *et al.,* 2012) than mineral resources and other sources of urban livelihood.

Livelihood assets

The DFID Framework presents five primary forms of livelihood resource or capital in a pentagonal shape. The Pentagon depicts the nexus of the assets. A livelihood cannot be achieved by an asset but rather an association of assets of different kinds. These livelihood resources or capital are human resources/ asset, natural resources/ assets, social resources/ assets, physical resources/ assets and financial resources/ assets. Knowledge of resources/ assets and a combination of resources are of essence for empirical purposes, such that if a particular combination improved livelihood, it can be replicated (Kollmair &Gamper, 2002).

The term natural asset stands for natural resources from which livelihoods are driven. Some examples of natural capital/asset are land, forest, marine/wild resource, water, air quality, waste assimilation, biodiversity degree and rate of change, etc. from the examples it is clear that natural capital can either be tangible or intangible. There is a strong relationship between natural capital and the vulnerability settings in the sustainable livelihood model. This is because most of the shocks that tear down natural capital happen within the natural or are a natural process (DFID, 2000). The importance of natural capital to fishing, farming, gathering in the forest, and other resource-based activities cannot be overlooked (Nicol, 2000). Notwithstanding, the importance of natural capital is not limited to, resource-based activities. Without an environmental service and food supplied by natural capital, none of us would stay alive. Although the understanding or knowledge of the linkage between resources is limited, it is clear that health (human capital) will be at risk when the air quality (natural capital) is bad (Ellis, 2000).

The physical asset on the other hand, stands as the primary producer goods and infrastructure required to aid livelihoods (DFID, 2000). The infrastructures relevant to sustainable livelihoods are low-cost transport; good homes and buildings; decent water supply and sanitation; clean, low-priced energy; and access to information. These are alterations to the physical environment, which aim at assisting people to be more productive and to meet their basic necessity.

The physical asset is a very vital asset as most poverty appraisals have reported that the unavailability of a particular type of social amenity is a possible key dimension of poverty. The lack of decent infrastructure for a longer time periods may lead to non-productive activities which may go a long way to promote poverty which may negatively affect livelihoods. Also, inadequate access to infrastructure may promote production and transport expenditure, which may lead producers to be operating at a comparative disadvantage in the market (Ashley, 2000).

Considering the importance of physical capital to livelihoods, there is a need to learn how to develop and sustain physical capital. According to DFID (2000), the intended users of physical capital should lead its development by demanding it. This is because without a need the infrastructure may not be maintained hence its service may not be sustainable.

The livelihoods approach therefore focuses on the user's demand to enable access to appropriate infrastructure necessary for livelihood objectives to be achieved.

The financial resources that households use to facilitate their livelihoods targets are the financial capital in the DFID livelihood model. This definition includes flows and stocks and also portrays a vital livelihood building block, which is the availability of cash or cash equivalent which aid individuals to adopt, different livelihood measures (DFID, 2000; Kollmair &Gamper, 2002). Nonetheless, this definition is not economically robust because it does not consider both consumption and production (DFID, 2000).

According to DFID (2000), the financial capital needed to enhance livelihoods depends on two main sources, namely, the available stock and the continuous inflows of income. The available stock refers to the savings that can be held in different forms; such as cash, bank deposits or liquid assets such as livestock and jewelry. Regular inflows of income, however, may be in the form of pensions, or other transfers and remittance. Earned income is excluded (DFID, 2000). Apart from the two main sources, financial capital also can be sourced from institutions that provide credit.

Human capital

There are various meanings of human capital in development studies (Vorsah, 2015). However, human capital in the context of the DFID livelihood framework is defined as the accomplishment, cognition, ability to work and good health that together aid individuals to pursue different livelihood strategies and achieve their livelihood objectives (DFID, 2000). At the family level, human capital is a determinant of the quantity and quality of skill labor available. This varies from family to family according to, household size, accomplishment levels, leadership potential, health status, etc. Human asset is an end in itself and also a means to an end (achieving livelihood outcomes). It is a livelihood capital, a building block of gaining livelihood results. However, overcoming unhealthiness and lack of education which many see as a major dimension of poverty may be one of their main livelihood objectives.

Social capital

Even though the exact meaning of social capital is being debated a lot in the context of the sustainable livelihood framework, it refers to the social resources upon which people draw in pursuit of their livelihood objectives. Social capital is directly correlated with the transformation of structures and processes than any of the other livelihood building blocks. There are two way and likely self-reinforcing correlation between social capital and transforming structures and procedures. For instance, there is a high probability that individuals may form new organizations in order to promote their interest, if they are already linked through common norms and sanctions. Also, societal groups (strong) enable households to shape policies and ensure that their interest is reflected in statute law.

In addition, for shocks such as the death of a family member and intense insecurity, social capital can act as a buffer and an informal safety net respectively. Also, social capital impacts directly the other forms of capitals by promoting efficient economic relations (increases in financial

capital) or to decrease the "free rider" challenges related with public goods. The valuation of the levels of social capital is hard and laborious and hence more times it is not quantifiable. This is because the nature and choice of a group are as important as group people and the number of groups. However, social capital is developed through "network and connectedness"; membership of formalized groups; and the relationship of trust that facilitate cooperation.

2.11.2 *Transforming structures and processes*

Transforming structures and processes are the legislations, organizations, policies, and institutions that affect the livelihoods. The DFID framework aims at securing livelihood targets through the activity of transforming structures and processes. They operate at all levels and determine access and term of exchange among the various types of capital and outcomes of livelihood settings (Shankland, 2000). This level of the framework is dual in its operation, that is the hardware (structures) and software (processes) (DFID, 2000).

Structures and processes are complementary in developing livelihood strategies to achieve livelihood outcomes. However, structures are the organizations (both private and public) through which policies and legislations are set and implemented; services are delivered and carried out all forms of other functions that influence livelihoods. Even though, organs exist at different degrees, but the most obvious is the governmental level. Depending on the nature and extent of decentralization, structures operate in drop-down stages with different levels of liberty and scope of dominances.

Just as software determines the operations of hardware, so do processes that determine the way in which structures works and interact. Many forms of procedures exist at a variety of difficulty degrees of operations. Some of the vital transforming procedures to livelihoods are policies that tells the development of new legislations; institutions that are implanted and developed out of the

culture of large communities; and hierarchical power relations recognized by a culture that confers status on people and constrains their behavior and opportunities.

The grandness of transforming systems and processes cannot be overemphasized. Being at the center of the livelihood framework, they find access to and terms of exchange between different forms of asset. Also, they have a positive impact on livelihood results feedback to vulnerability.

Livelihood strategies

According to DFID (2000) livelihood strategies is the main term that stands for the range and amalgamation of activities and choices that individuals make in order to achieve their livelihood goals. By extension, livelihood strategies are continuous processes in which people undertake different activities to meet their needs depending on their geographical location or economic conditions within a given time period at the household level (Kollmair & Gamper, 2000). This is not about people moving from one kind of employment to another. For instance, it is not about fishers becoming farmers or miners. The choice of livelihood strategies is majorly influenced by levels and combinations of assets.

Livelihood outcomes

The achievement of livelihood strategies is known as livelihood results (DFID, 2000). The livelihood outcomes within the DFID livelihood framework is composed of more incomes, promote well-being, decreased vulnerability, improved food security and more sustainable use of the natural capital base. Livelihood results may not be consistent and may lack parity. Also, conflict may exist between livelihood outcomes (DFID, 2000). For instance, fishers may increase their income through overfishing and bad fishing practices which are harmful to the fishery.

Livelihood outcomes facilitate the apprehension of the following;

- The type of causality. That is the configuration of factors within the livelihood framework that resulted in the current livelihood outcome.
- Why individuals behave the way they do. People are more likely to replicate their own behavior or other behavior depending on the resultant livelihood outcome.
- How individuals are likely to respond to new opportunities.
- Peoples priorities
- The performance indexes to be used to determine aids activity.

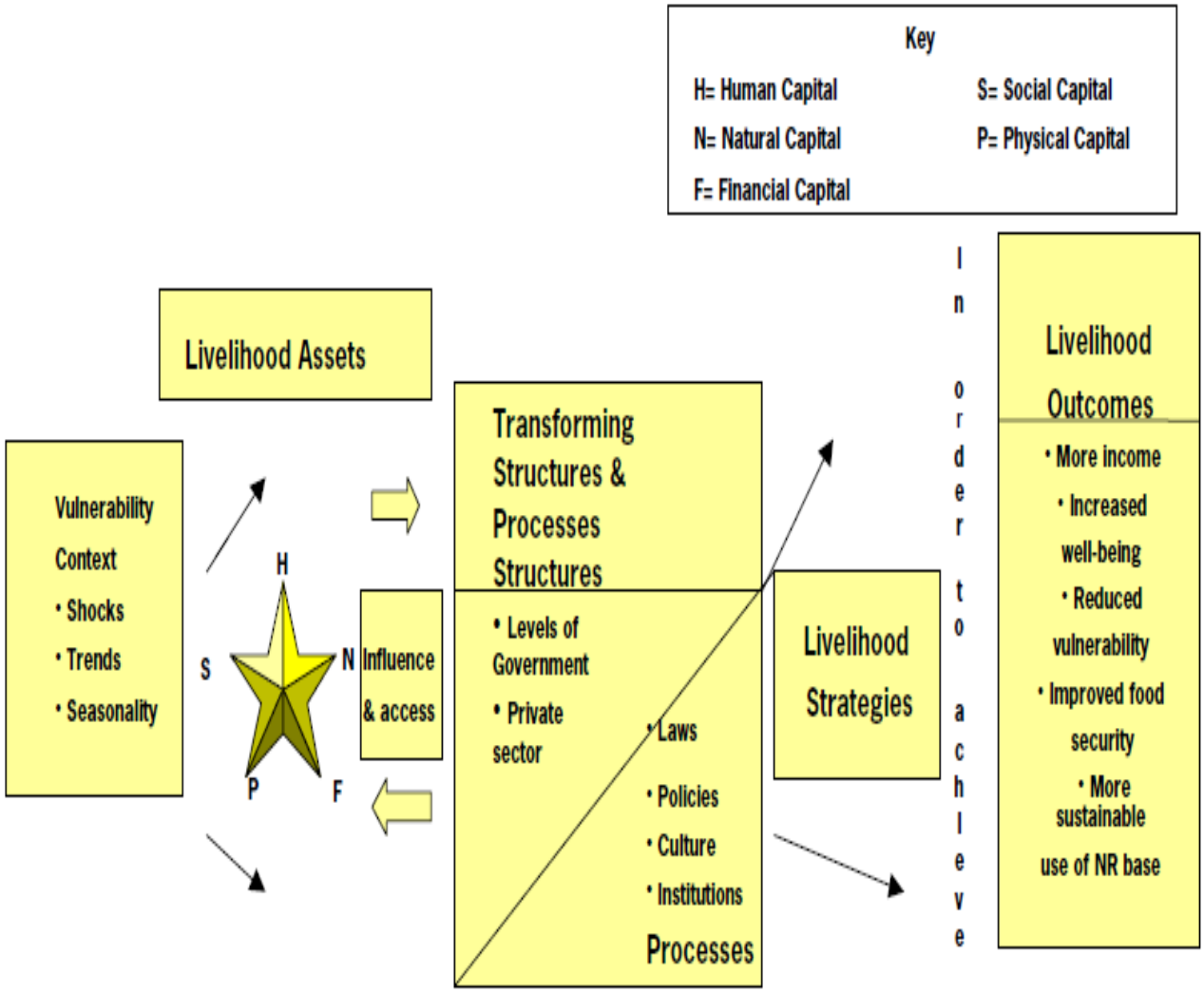


Figure 2.4.Livelihood outcomes

Source: DFID, (2000)

2.11.3 *The Oxfam Livelihood Approach*

Similar to most livelihood approaches, the Oxfam livelihood approach. The Oxfam's sustainable livelihood approach, has highlighted four dimensions of sustainability. The four dimensions are economic (for instance the functioning of markets); social (networks for mutual benefits, gender equity); institutional (political freedom, capacity building and access to services and technology) and ecological (quality and availability of environmental resources, particularly pristine flora and fauna) (Carney *et al*., 1999).

The Oxfam framework, unlike other NGOs (e.g. CARE) places a little more emphasis on the micro-macro links, which is key to agencies such as UNDP and DFID. There is much similarity between Oxfam and DFID frameworks such that one will think that they are the same. The reason being that, DFID adapted Oxfam's sustainable livelihood framework (Carney *et al.*, 1999).However, the Oxfam livelihood approach stressed that everyone has the right to a sustainable livelihood (Drinkwater & Rusinow, 1999).

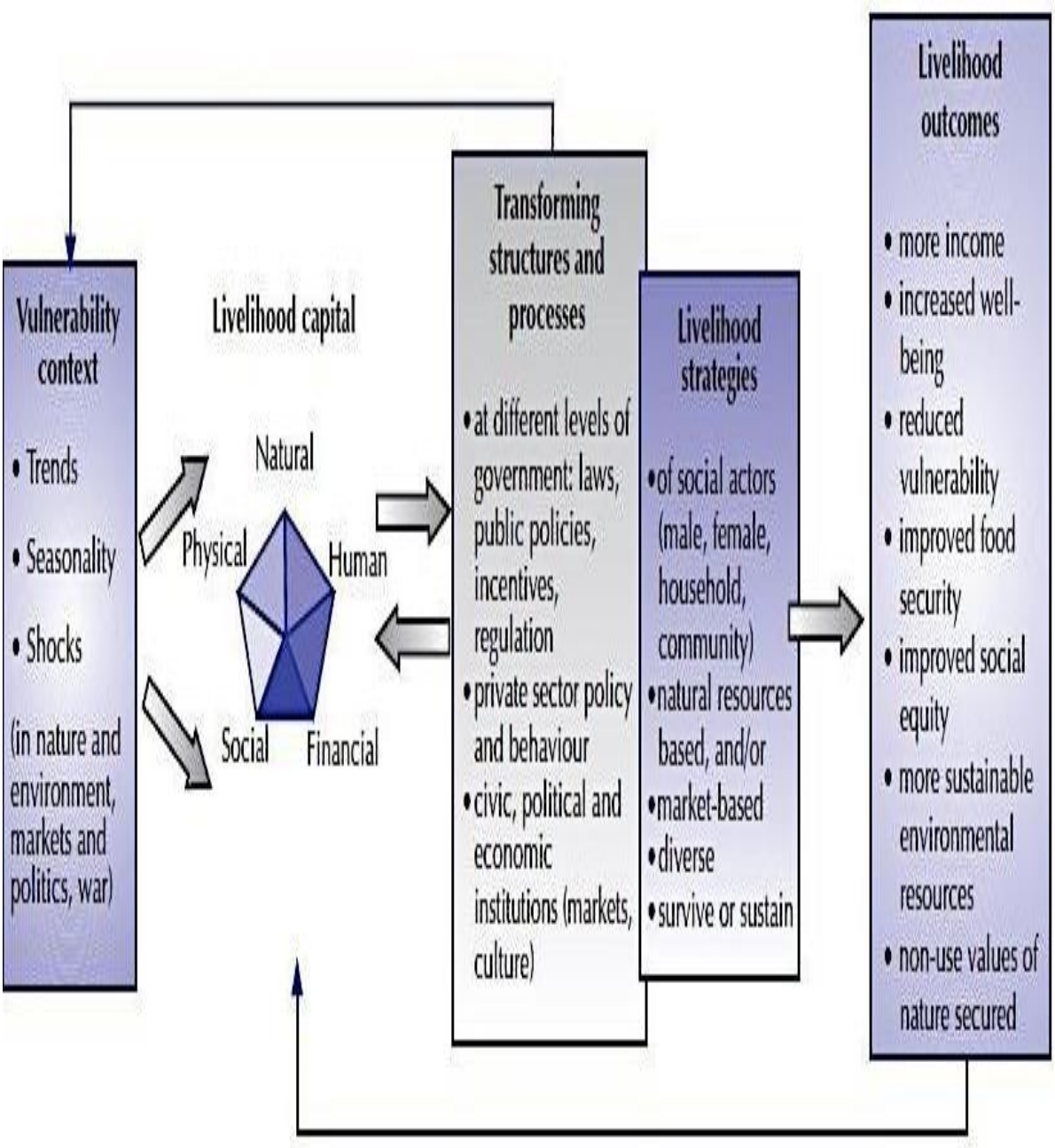


Figure 2.5: Livelihood outcomes using the Oxfam Livelihood Approach.

Source: Carney *et al.*, (1999)

2.11.4 *CARE's Livelihood Approach*

From the livelihood definition by Chamber and Conway, CARE identifies three basic livelihood attributes, namely, the possession of human capabilities, availability of tangible and intangible

assets and the availability of economic activities. However, CARE's livelihood approach is not directly a sustainable livelihoods approach. Rather, it is a programming framework for relief and development work (Drinkwater & Rusinow, 1999).As NGOs are less involved in micro-macro issues, CARE, therefore, places less emphasis on it. Also, structures and processes are clearly missing in the CARE's framework.

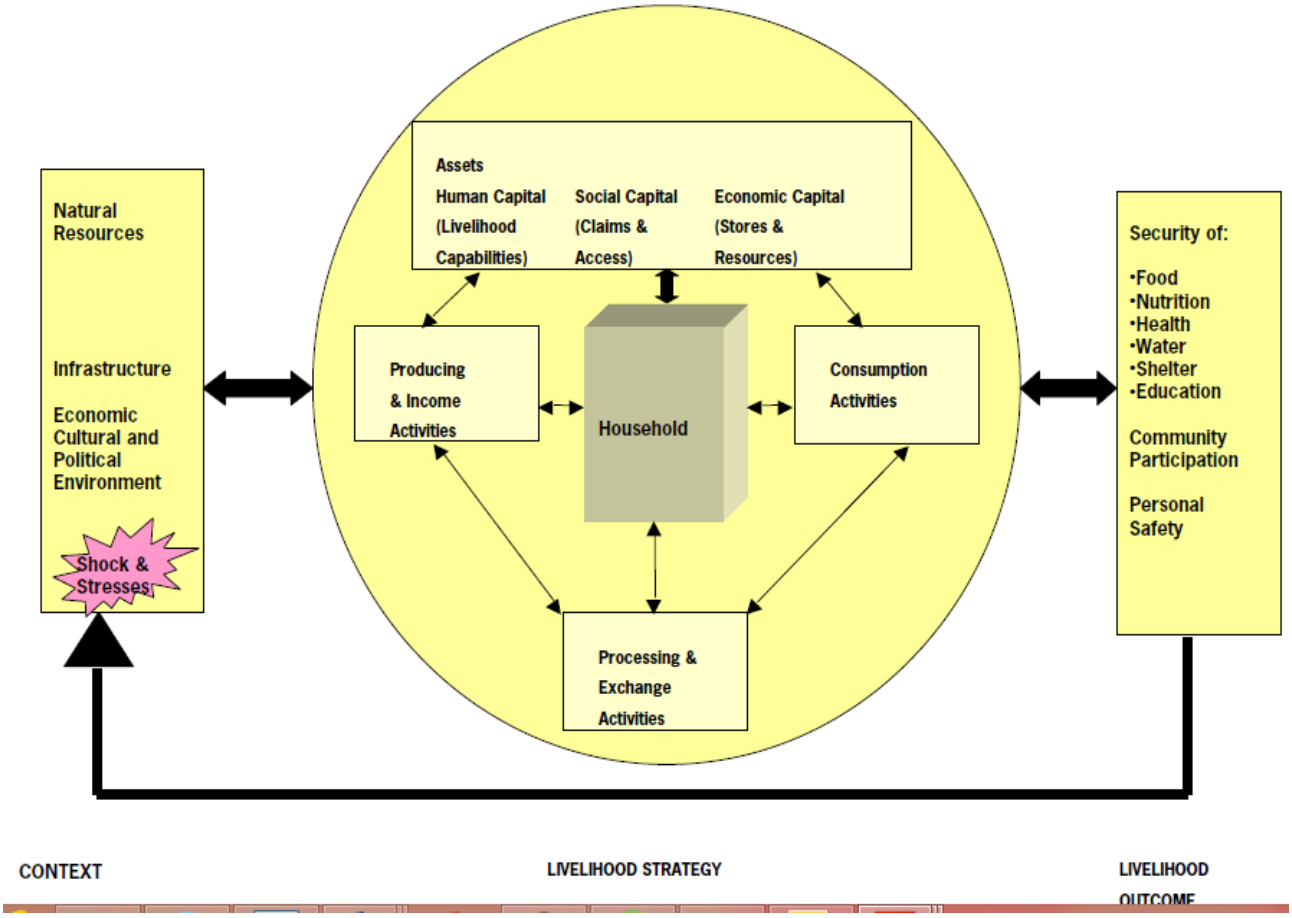


Figure 2.6, CARE's Livelihood Approach.

Source: Drinkwater & Rusinow, (1999)

2.11.4. *UNDP Livelihood Approach*

According to the United Nations Development Program'S (UNDP'S) livelihoods are the means, activities, gains, and assets through which people end a living. With the UNDP approach a livelihoods are sustainable if they are: (a) able to cope with and recover from shocks and

stresses; (b) economically effective; (c) ecologically sound and; (d) socially equitable (DFID, 1999). The UNDP sustainable livelihood approach is a part of the agency's overall Sustainable Human Development (SHD) mandate, with a goal to increase access to and promote sustainable use of assets. Like other governmental agencies the UNDP places emphasis on the micro-macro link. But unlike any other agencies covered in this review, governmental and non-governmental alike, the UNDP focus on the importance of technology as a tool for poverty eradication is obvious (Carney *et al*., 1999).

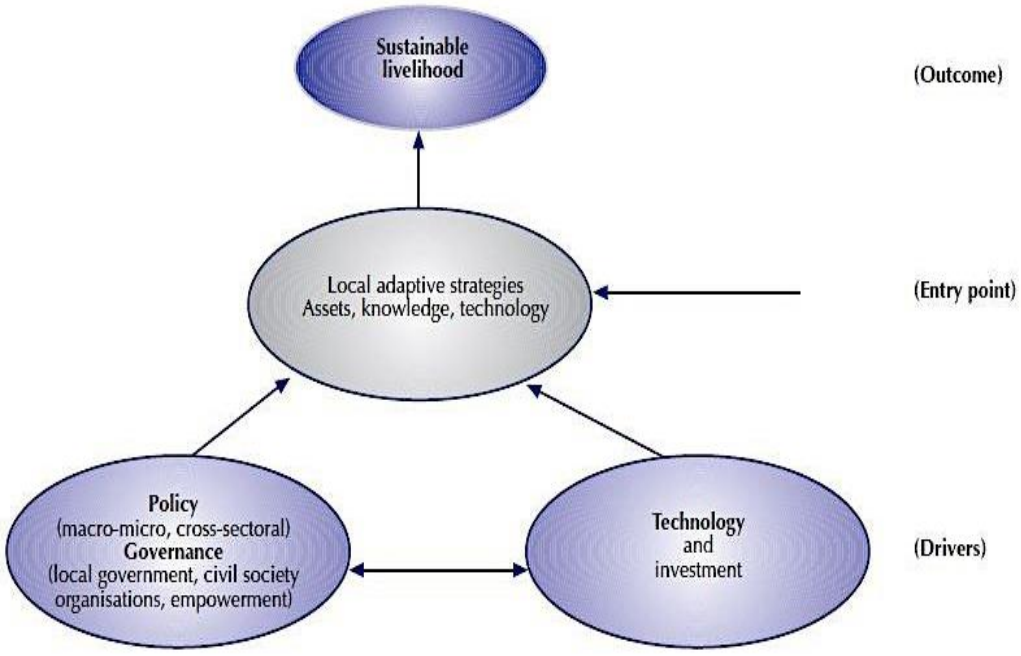


Figure 2.7: UNDP Livelihood Approach

Source: Carney *et al*., (1999).

2.12. Conceptual framework for analyzing the level of vulnerability in the study

This research adapted this livelihood approach and framework to clarify the impact of climate change on the livelihoods of fishers in Northern Ghana.

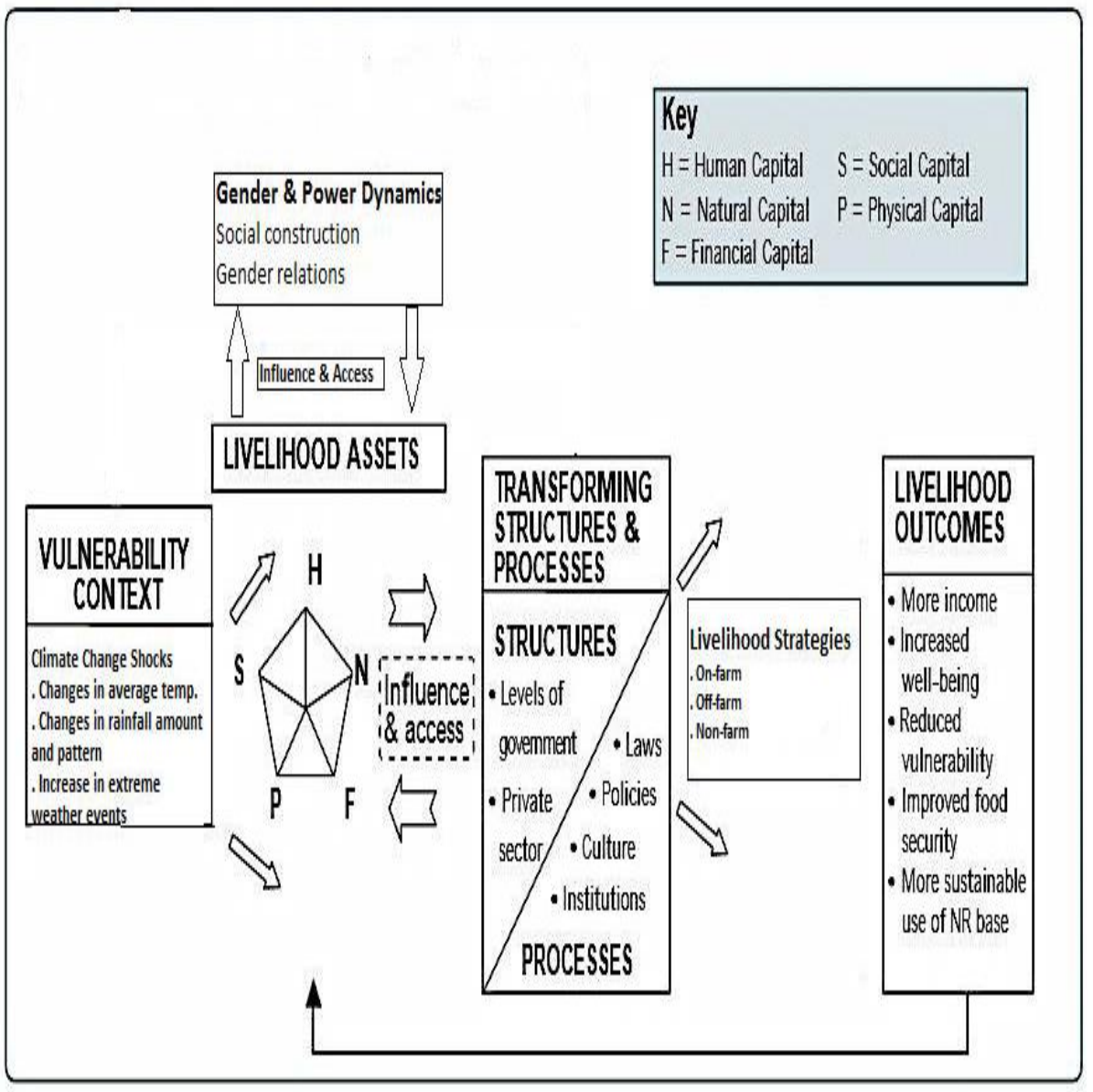


Figure 2.8.Conceptual framework for analyzing the level of vulnerability

Source: Adopted from DFID, (1999).

The main elements that affect the fishery-based livelihood and the interaction between these elements are presented in the framework figure 2.8. The framework depicts that fishery-based livelihoods are influenced by a variety of forces. These forces include vulnerability settings, fishery, transforming structures and processes, livelihood strategies and livelihood results.

However, the interaction of these forces is centered on climate change and fisheries (DFID, 1999).

People in riparian communities catch fish or are engaged in fishery-related activities and other livelihoods using assets(natural, social, financial, human and physical) to achieve their livelihood objectives or outcomes(more income, improve food security, reduce vulnerability, etc.). However, these assets or capitals are influenced by climate change as depicted in the vulnerability context. Therefore in order for people who depend on fisheries for their livelihood to achieve their livelihood outcomes, a variety of strategies (i.e. capture fish, fish farming and other fishery-related activities) must be adopted.

2.13. Conceptual Framework of the Study

According to the NASA (2011), climate change could be influenced by either internal or external factors. The internal factors are natural in nature which may include the thermohaline circulation. The external factors, on the other hand,goes beyond natural factors to include human actions for example, increased emissions of greenhouse gases and dust. These factors often lead to high temperature and erratic rainfall. Increasing temperature and rainfall may result in the redistribution of fish and reduction in the stock of fish as well as other marine mammals. This will lead to a decrease in catchability which is positively related to the quantity of fish available for consumption and low income of fishers and ultimately to low livelihoods among fisher.

As stated earlier in this chapter, livelihood is defined to encompass the capabilities, assets (social and natural) and activities that are essential for the survival of individuals and communities. Therefore low livelihood can be defined as a situation where the capabilities or assets or economic activities necessary for individual or communities survival are low. This means that when livelihood is low individuals and communities survival is not guaranteed or is not well supported.

This is illustrated in figure 2.9 below.

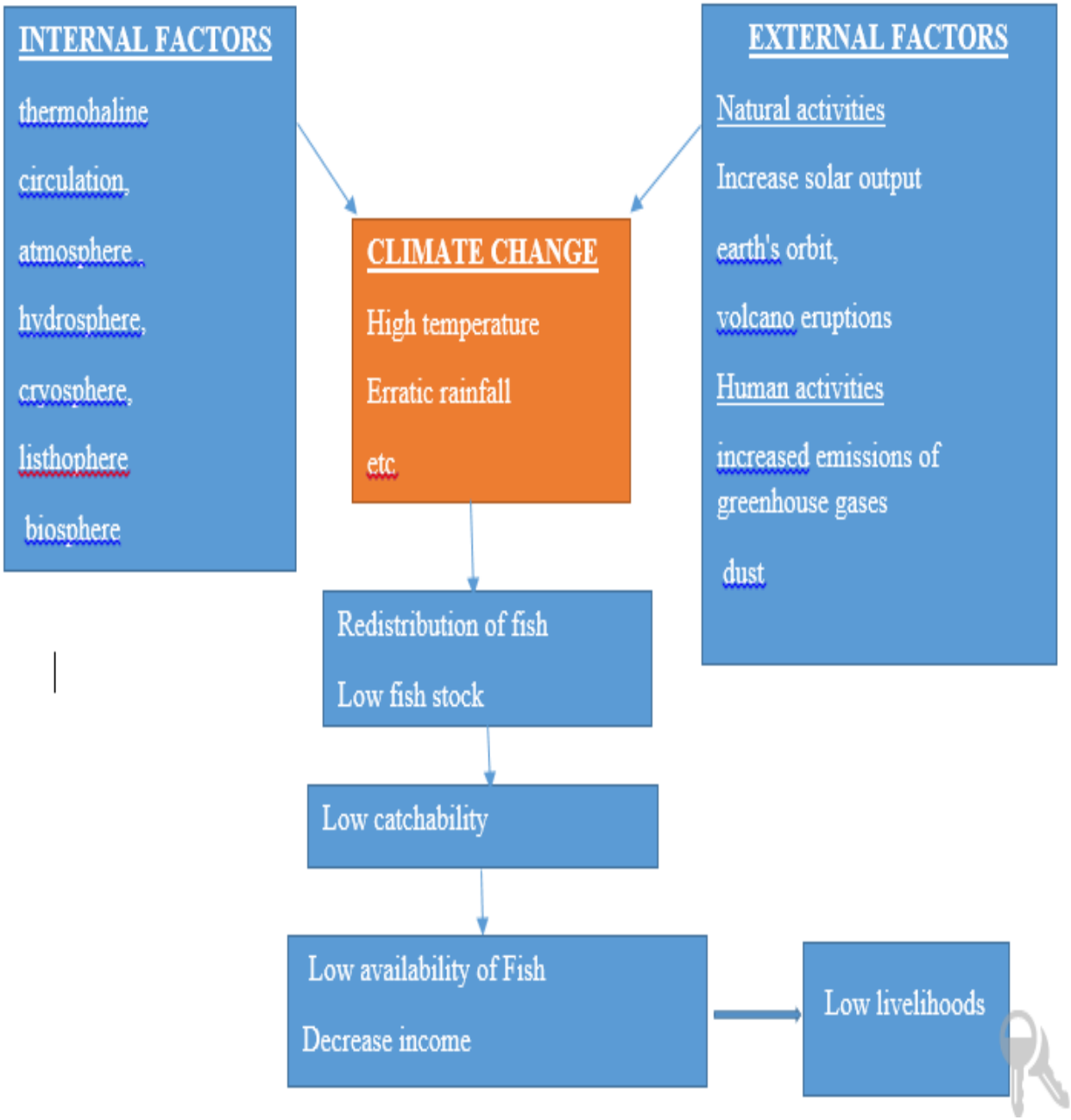


Figure 2.9.Conceptual Framework of the Study

Source: Modified from NASA, (2011)

2.14. Factors influencing Fishermen Decisions to Diversify

Diversification as a key livelihood strategy (Smith *et al*.,2005) has gained a lot of attention, particularly in climate change studies, as it helps to reduce the negative effects of seasonality by

utilizing labour and generating alternative money during bad climate change seasons (Smith et al., 2005). For instance, diversification can help decrease the hazards of losing all income generating avenues simultaneously, resulting from climatic or other shocks (Start, 2001).Thus, diversification helps to increase household wealth (Start, 2001). People may diversify because they want to survive or take advantage of new opportunities.

According to Smith *et al*., (2005), the major factors that influence people to diversify include; insufficient land (or fishing space), availability of family labor or capital, a decrease in income, high competition for resource use; decreased technological economies of scale, lack of purchasing power and poor market infrastructure, access and integration in remote areas which together affects effective demand; and equally poor access to credit(Smith et al., 2005).

CHAPTER THREE

METHODOLOGY

3.0 Chapter Outline

This chapter talks about the methodology of the study. The first subsection (3.1) contains the study area. The next two subsections talk about the type and source of data and sample size and sampling approach in 3.2 and 3.3, respectively. The method of data collection is contained in subsection 3.4. Finally, the method of data analysis is in subsection 3.5

3.1 Study Area

The research will be conducted in five districts in the Northern Region. These comprise, West Mamprusi, Kumbugu, Tolon, Central Gonja and Savulgu Districts.

The Northern Region is located in the southern part of the Upper West and Upper East regions. It has a total land areaof 70,384 km2 (27,175 sq mi) making it the largest region in terms of total land area, in Ghana. It has a total population size of 2,479,461 in 2010 and is made up of 20 districts with Tamale being its regional capital (Ghana statistical service, 2013). The map of Northen Region is below.

Figure 3.1.**Map of Northern Region**

Source: Wikipedia

3.2 Types and Source of Data

The research used both primary and secondary data. The primary data was data on the socioeconomic attributes and fishing activities of the targeted fishers in the Northern Region. Secondary data, on the other hand, was fish catch level obtained from the Department of Fishery; rainfall levels and temperature obtained from the Ghana Meteorological Department (GMet).

3.3 Sample size and sampling approach

Two hundred and seventy fishermen were interviewed for the study. This sample size is considered partly for statistical and logistical reasons. Statistically, the sample size is large enough for generalization purposes. Logistically, the research will be time constrained proportionally to the population under study.

A multistage sampling technique was used for the study. In stage one, a purposive sampling technique was used to choose five districts where they do fishing in the Northern Regions. In stage two, one/two fishing communities were purposively chosen from each of the five district selected districts. In the final stage, respondents were randomly sampled.

This is shown in the Table 3.1 below.

Table 3.1. A Table Showing the Sampling Procedure

Stage1-Purposively Sampled Districts	Stage 2 –Purposively Sampled Communities	Stage 3- Randomly Sampled Respondents
Central Gonja	Buipe	42
	Yapei	50
West Mamprusi	Nasia	50
Kumbungu	Nawuni	50
Tolon	Sheigbeni	43
Savulugu	Kuldanali	35
Total	270	

Source: Author's computation.

3.4 Method of data collection

The primary data was sourced from the sampled fisher households. This was done by administering a semi-structured questionnaire to fisher household heads. According to Saunders (2003), the use of a questionnaire helps to collect tailor-made data for the research questions and objectives and provide primary information on the topic under study.

The questionnaire for this study was divided into five sections. Broadly, the questionnaire sought for the socio-demographic and economic features of fisher households, their awareness of climate change, their fishing activities and some issues that border on the vulnerability of the fisher households.

With regard to the secondary data, the researcher presented letters to the Department of Fisheries and the Meteorological Department offices in Tamale and the required and available data was made available.

3.5 Method of Data Analysis

The data was analyzed using STATA Version 13 and Microsoft Office Excel Version 10. Descriptive statistics were used to present the awareness of climate change and its perceived effects on the quantity of fish catch.

To determine the impact of climate change on fish catchability, the study will use descriptive statistics and line graphs to establish the relationship.

Livelihood Vulnerability Index (LVI) and LVI-IPPC were employed in estimating the vulnerability level of Fishers to the changing climatic conditions. Specifically, the study has modified the LVI as used by Hahn *et al.*, (2009) which comprises seven major components ;Socio-Demographic Profile, Livelihood Strategies, Social Networks, Health, Food(fish), Water, and Natural Phenomena. The modification was necessary because the researcher could not measure all the sub-elements as used by Hahn *et al.,* (2009) and some of them were not necessary for the current study. Table 3.2 below shows the major components and the sub-components under each major component for this study.

Table 3.2.Major components and sub-component for LVI

Major components	Sub-component
Socio-demographic profile	Dependency ratio
	Percent of female-headed households
	Percent of illiterate household heads
Livelihood strategies	Percent of households who work outside the community
	Percent of households that depend solely on fishing as a source of income
Health	Average time to a health facility(minutes)
	Percent of households with a family member that has a chronic illness
	Percent of households where at least a member had to miss fishing in the last 2 weeks
	Average malaria exposure
Social network	Average receive: give ratio
	Average borrow: lend money ratio
Food	Percent of households that depend on family capture fish for food
	Average number of months households struggled to find fish
Water	Percent of families that noted water conflict in the last 12 months
	Percent of households that utilize a natural water source
	Average time to a water source(minutes)
	Percent of households that do not have a consistent water supply
Natural phenomena	Mean standard deviation of daily average maximum temperature by month
	Mean standard deviation of daily average maximum temperature by

	month
	Mean standard deviation of average precipitation by month

Source: modified from Hahn *et al* (2009).

Since most of the sub-components were estimated on a varying scale. It was therefore imperative to standardize each as an index (Hahn *et al.*, 2009). Equation (1) will be used to index each sub-component.

$$Index_{S_c} = \frac{S_c - S_{min}}{S_{max} - S_{min}} \quad \text{…….. (1)}$$

Where $S_c$the sub-component for community c, S_{min} is the minimum value for each sub-component and S_{max} is the maximum value for each sub-component. The data that was sourced from the communities was used to get the index.

After each subcomponent is standardized by indexing, the next step was to average the sub-component within a major component to determine its value. This was done using equation (2).

$$M_c = \frac{\sum_{i=1}^{n} Index_{S_{ci}}}{n} \quad \text{…….(2)}$$

Where, M_c is one of the seven major components for community c.

$Index_{S_c}$is the sub-component in each major component indexed by i.

N is the number of sub-components in each major component.

After this was done, the balanced weighted average was used to average each of the seven major components for community c. This was done using equation (3) and expanded in equation (4).

$$LVI_c = \frac{\sum_{i=1}^{7} W_{M_i} M_{di}}{\sum_{i=1}^{n} W_{M_i}} \quad \text{…….. (3)}$$

$$LVI_c = W_{SDP}SDP_C + W_{SL}SL_C + W_{SN}SN_c + W_H H_c + W_F F_d + W_W W_C + W_{NP}NP_c \quad \text{……. (4)}$$

Where: LVI_C is the livelihood vulnerability index for community c.

$W_{SDP}SDP_C$ is the weighted average of the socio-demographic profile of community c.

$W_{SL}SL_C$ is the weighted average of livelihoods strategies of community c

$W_{SN}SN_C$ is the weighted average of the social network of community c

$W_H H_c$ is the weighted average of the health of community c

$W_F F_C$ is the weighted average of food of community c

$W_W W_{C\,is}$ the weighted average of water of community c

$W_{NP}NP_C$ is the weighted average of natural phenomena

In this research, the scale of the LVI is from zero to zero point five. Where 0 means not/least vulnerable and 0.5 stand for the most vulnerable. From the scale it is obvious that the average vulnerability is 0.25.

Finally, to determine the factors influencing fishers' decision to diversify, the study will use the binary logit model where, the dependent variable (diversification) will be specified 0, if a fisherman diversifies, 1, otherwise. The study uses the binary logit because the dependent variable fishermen diversification has a logistical standard error and is binary (i.e. a fisherman either chooses to use diversification as an adaptation measure or not).The binary logit model is built on a latent regression in the same way as the binomial logit model (Greene, 2002).Where the utility of a choice consists of a deterministic component $\left(\beta' X_i\right)$ and an error term $\left(\varepsilon_i\right)$ which is independent of the deterministic components and follows a predetermined distribution. The binary logit model is given as $Y_i^* = \beta' X_i + \varepsilon_i$ Where X_i is are vectors of explanatoryvariables influencingfishermen decision to diversify, β' is a vector of parameters to

be determined, ε_i is the random error term that is assumed to form a standard normal distribution(Greene, 2002), Y^* is a vector of fishermen utilities derived from diversification which is unobserved.

The empirical model

$$DIVERSIFY = \beta_0 + \beta_1 ND + \beta_2 EXP + \beta_3 NPWSF + \beta_4 OC + \beta_5 SFS + \beta_6 \ AWC + \varepsilon_i$$

…….. (5)

The variables, used for the binary logit model are presented in Table 3.3.

Table 3.3. Names, measurement and *a prior* expectation of variables used for the logit model

Variables and Symbol	**Measurement**	***A prior* Expectation**
Decision to Diversify (DIVERSIFY)	0, if a fisherman diversify as an adaptation measure, 1, otherwise	
Number of dependence (ND)	Number people who depend on the respondent	+
Experience (EXP)	Number year spent in fishing	+/-
Number of people who support in fishing (NPWSF)	Number of people who support fishing.	+
Own canoe (OC)	Binary, 0 if a fisherman has his own canoe, 1 otherwise	-
Source of fish supply (SFS)	0, if capture, 1, if market	+/-
Awareness of climate change (AWC)	Binary, 0 if a respondent is aware of climate change product, 1 otherwise	+

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.0 Outline of Chapter

This chapter presents and analyses the results of both primary and secondary data gathered from the field, MOFA and GMet. The first section, 4.1 is made-up of the socioeconomic features of fishers in the study area. The second section, 4.2, describes the respondents' awareness of climate change. The next subsection (4.3) contains results on the impact of climate change on fish catchability (4.4). Moreover, the results of the Livelihood Vulnerability Index (LVI) of the various communities and the study zone at large are presented in subsection 4.5 as well as. Lastly, the results on the factors influencing fishers' decision to diversify are presented in subsection 4.6.

4.1 Socioeconomic characteristics of the sample households

It is very necessary to explain the socio-economic characteristics of the respondents, as these characteristics may have an influence on respondents' perceptions and responses (Phuong, 2012). Thus, describing, the socioeconomic characteristics of the respondent may help contextualize the main results of the study.

4.1.1 *Sex*

From Table 4.1 below, it can be deduced that the data was biased toward males as all (100%) the respondents in the study were males. This result makes sense as in Africa, some work is assumed to be meant for males. Besides, during the pilot study, it was revealed that women are not supposed to go fishing, but to only do household chores.

4.1.2 Age

The mean age of a fisher was about 44 years (Table 4.1). Talking about age categories, the highest percentage 51.9% of the study population were within the age category 36-64 years. This was followed by those within the age category 20-35 years being 36.2% while the least age 65 and above category being 11.9%. This finding reveals that the majority of the respondents were economically active. This means there is likely to be pressure on fisheries as more people will be out there fishing. This can reduce the fish catch level for individuals' fisher which has the tendency to affect their livelihoods.

4.1.3 Household size

Household size is another indicator that determines capabilities, choice and coping strategies available to household members (Rakodi, 2002). Therefore, it is essential to understand the household size and its composition in this research. The mean household size was about 10 persons (Table 4.1). This implies that the study area has a high household size. This could be an beneficial to the fishing industry as a household will demand more fish to feed on since the household size is assumed to have a direct association with the amount of food a household will demand. A possible reason for this result may be because, the majorities (90.7%) of the sampled population were married and these coupled with the prestige attach to child birth in some rural communities in Ghana, it may be assumed that different couples will produce children within the same household.

4.1.4 Ethnicity

It was interesting to find that ewes who are not indigenous in the study area were 61.85 percent of the respondents' representing the highest ethnic group. This was followed by the Gonjas and the Mamprusis representing 11.85 percent and 11.11 percent, respectively. Dagombas and

Mossis were the least ethnic groups, representing 4.1 percent of the sampled population. The finding that the Ewes were the majority ethnic group is not surprising, as they are known for fishing as their main source of livelihood. This could be because there is little or no extensive service that renders training on fishing except those for fish farmers. Therefore those who know how to fish acquired the skill from their family of orientation. Throughout the data collection, it was observed that almost all the canoes (including those used by the indigenes) were built by the ewe. My final observation of this finding is that there is no easy entry into the fishing industry.

4.1.5 Marital Status of Respondents

From Table 4.1 below, about 90.7 percent of the respondents were married, with 9.3% being single. This result is not surprising as it has been revealed by this study that, only about1.5% of the respondents were educated above the SHS level and thus the rest may marry very early.

Table 4.1.Socio-Economic Characteristics of Respondents

Variable	**Mean**	**Frequency (n=270)**	**Percentage (%)**
Sex:	-	-	-
Male	-	270	100
Female	-	0	0
Age:	43.6	-	-
20-35	-	97.7	36.2
36-64	-	140.2	51.9
65+	-	32.1	11.9
Household Size	9.9	-	-

Ethnicity:	-	-	-
Dagomba	-	11	4.1
Gonja	-	32	11.9
Mamprusi	-	30	11.1
Ewe	-	167	61.9
Hausa	-	19	7.0
Mossi	-	11	4.1
Marital status:		-	-
Married		243.8	90.7
Single		26.2	9.3
Education:	3.9	-	-
None	-	151	55.9
Primary	-	34	12.6
JHS	-	52	19.3
SHS	-	29	10.7
Tertiary	-	4	1.5
Experience	23.6	-	-

Source: Computed from field survey, (2017)

4.1.6 Educational level of respondents

The educational level of a respondent is a major factor that shapes how a person perceives his/her surroundings, including climatic variables (Maddison, 2007). As in Table 4.1 above, it

could be deduced that the average number of years a respondent has spent in school was about 3.9 years. It was further revealed that 55.9% of the respondents have no formal education with only 1.5 percent of the respondents having tertiary education. This study could, therefore, conclude that most of the sampled populations were not educated. This finding makes sense as it appears that most of the people in the agriculture sector in African countries, particularly Ghana are uneducated and besides, Ghana has not met the Sustainable Development Goals (SDGs) on universal education for all and also it could be because most of the fishers have to leave around water bodies where there may be few or no schools.

4.1.7 Experience

It was revealed that the average number of years a fisherman spent on fishing was 23.6 years (Table 4.1). This means that the sampled population was more experience in fishing. Therefore, a reduction in catch level cannot be attributed to a lack of fishing experience.

4.1.8 Fishing and Fishers Activities

All the sampled population does fishing because fishers were purposively sampled. As depicted in fig. 4.1 below almost all (90.4%) of the respondent revealed they do not do fish trading alongside, only 9.6% noting they do fish trading. Moreover, 17.5 % and 9.3% of the respondents revealed they do fish processing and net mending, respectively, with about 91.9% indicating they do other fishing activities that were not captured in the questionnaire.

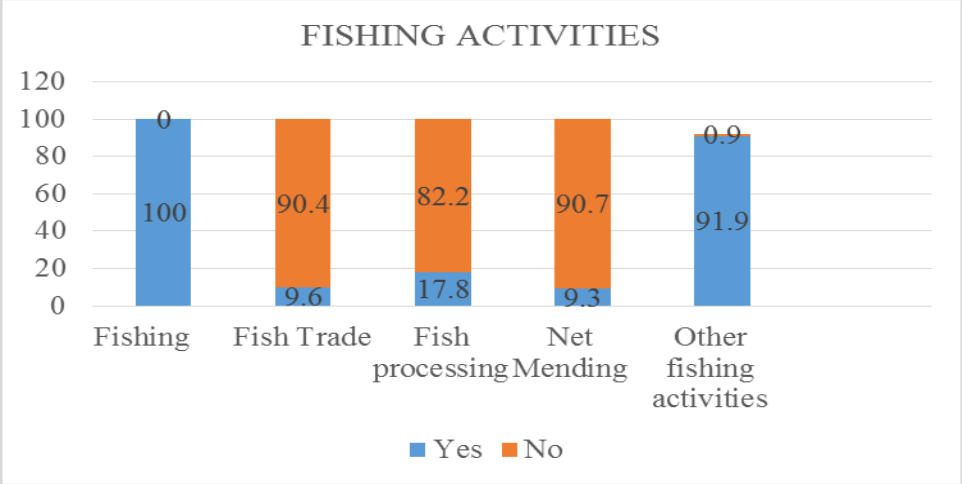


Figure. 4.1. Fishing and Fish-Related Activities Carried Out Respondents to Enhance Their Livelihood

Source: Estimates from field data, (2017)

When asked whether they have their own canoes, a higher percentage (91.1%) of the sampled population revealed they had their canoes with only 8.9% indicating they do not have their own canoes. 4.07% of the sampled population indicated they always beg a canoe from friends for fishing because they do not have their own. Also, others who do not also have their own canoes representing 2.96%, 1.11% and 0.74% of the respondents revealed that they always get the canoes for fishing from family members, through renting and other means, respectively.

In the researcher's quest to know whether there are some barriers to the fishers' access to the fishery, 82.6% of the sampled revealed that they are no constraints to accessing the fishery. The practice in most of the fisheries caused the "tragedy of the commons" a problem of overfishing or resource depletion due to lack of regulations guiding the fishery. On the contrary, the remaining 17.4% of the respondents revealed there were some barriers to fisheries. As they noted that some chiefs always sell certain parts of the water bodies to individual fishers, thereby barring other fishers from fishing in the water bodies until the contract elapses.

With their weekly percentage of fish consumed and sold, it came out that a household averagely consumed 29.4% of fish harvested per week whiles, selling 70.6% of the captured fish. This is not surprising as fishers may need other goods and services in order to survive and thus, they may have to sell a higher percentage in order to raise funds for the other needs and wants.

4.2 Climate Change Awareness

Fishers' awareness of climate change was assessed by seeking to know if they have ever heard someone mention or talk of the climate change. Respondents were also required to compare the rainfall levels and temperature now to that of a decade back and state a difference if there is any change and finally tell how that affects their catch levels.

It was revealed that 79.6% of the respondents said they have not heard of climate change whiles, 20.4% said they have heard of climate change. In a bid to know if the 20.4% of respondents who said they have heard of climate, know the meaning of climate change they were asked to tell what they know about climate change. The following were some of the responses received.

It is an increase in temperature and a decrease in rainfall

It is a change in the weather

It is the change in the weather by God

It means the end times

I do not know what it is

It is a situation where the surface of a water body is hot and the bottom is cool

The wrong handling of natural resources

The yearly change in the weather condition

Change in the nature of the water body

It is the situation where the fishing condition is different

It is human activities that lead to a negative weather condition

Changes in the world

It is the reduction in farm yield and fish catch

Changes in the weather due to pollution of the atmosphere

With regard to rainfall levels, 95.9% said that the rainfall levels of today (now) is not the same as the rainfall levels of a decade back. However, 4.1% said the rainfall levels have not changed when compared to 10 years ago. The 95.9% of the respondents who said the rainfall levels are not the same, went on to say that there is a lower rainfall level now compared to a decade back, with only 4.3% noting that there are higher rainfall levels now compared to a decade back. When asked whether the changes in rainfall affect fish catch about 92.2% reported that observed changes in rainfall levels affect the catch level of fish whiles 7.8% said that observed changes in rainfall donot affect levels of fish catch. When the fishers were further asked to indicate the nature of an effect on the fish catch, 96.8% said it decreased catch with 1.2% revealing rainfall patterns, increased catch whiles, 2% indicating that the nature of the effect is uncertain.

On changes in temperature, 90.8% said that there is a change in temperature when compared to 10 years back. From further probe, 93.1% reported that the difference is that there isa higher temperature now compared to a decade ago. And 6.94% said temperatures are now lower compared to the last decade. When asked, if the observed changes in temperature affect the catch levels of fish, 91.1% responded in the affirmative whiles 8.9% responded in the negative. For those who revealed that changes in rainfall affect fish catch 70.7% of them noted that higher temperature decreases fish catch, with only 2.0% said lower temperature increase fish catch levels and 27.3% revealing that the effects of higher temperature on fish catch level is uncertain.

Some fish species increase production in high-temperature whiles other species do well at low temperatures. Some fishers, however, said higher temperature does not affect the fish catch (quantity), but rather affect preservation. This is because the early catch of fish can get bad (rotten) when they fish until afternoon at higher temperature. This study, therefore, concluded that low rainfall and high temperature directly affect fish catch. This result is in harmony with a study by FAO (2005) which looks at the dynamics of global climatic indices and main commercial catches, concluded that there is a direct relationship between the commercial marine species, catch dynamics, and the patterns of various climatic indices. Moreover, Minta (2003) conducted a study titled an assessment of the vulnerability of Ghana's Coastal artisanal fishery to climate change(temperature and precipitation) and found that the lower fish population and catchability occurred in years of higher sea surface temperature and precipitation. Thus, the researcher concluded that climate directly affects the productivity of the ecosystem as well as its catchability and particularly, the fish population in water bodies.

4.3 Impact of Climate Change on Fish Catchability

This objective was basically analyzed using line graphs to depict the outcome of climate change on fish catchability. The study used both primary and secondary data collected from the meteorological and fishery departments of Northern Ghana. The research collected secondary data on fish catch in metric tonnes, the temperature in degrees Celcius and rainfall in millimeters.

After analyzing the primary data the researcher discovered the following responses from the respondents.

When fishers were asked whether the changes in rainfall they have observed affect fish catch about 92.2% reported that observed changes in rainfall levels affect the catch level of fish whiles 7.8% said that they have observed changes in rainfall doesnot affect levels of fish catch. When the fishers' were further asked to indicate the nature of the effect on the fish catch, 96.8% said it

decreased catch by 1.2% revealing rainfall patterns, increased catch whiles, 2% indicating that the nature of the effect is uncertain.

On changes in temperature, 90.8% said that there is a change in temperature when compared to 10 years back. From further probe, 93.1% reported that the difference is that there are higher temperatures now compared to a decade ago. And 6.94% said temperatures are now lower compared to the last decade. When asked, if the observed changes in temperature affect the catch level of fish, 91.1% responded in the affirmative whiles 8.9% responded in the negative. For those who revealed that changes in rainfall affect fish catch 70.7% of them noted that higher temperature decreases fish catch, with only 2.0% reporting that lower temperature increase fish catch levels and 27.3% revealing that the effects of higher temperature on fish catch level is uncertain.

Some fish species increase production in high-temperature whiles other species do well in low-temperature. Some fishers, however, said higher temperature does not affect the fish catch (quantity) but rather affect preservation as fish can get rotten at the field when the temperature is high.

Results from the secondary data collected from the meteorological and fishery departments in the Northern Region are also presented in figure 4.2 and figure 4.3 below.

The below charts were produced from annual averages of rainfall and temperature for the northern region from 2002 to 2016 and fish catch level in mt from the northern region for the same period of time.

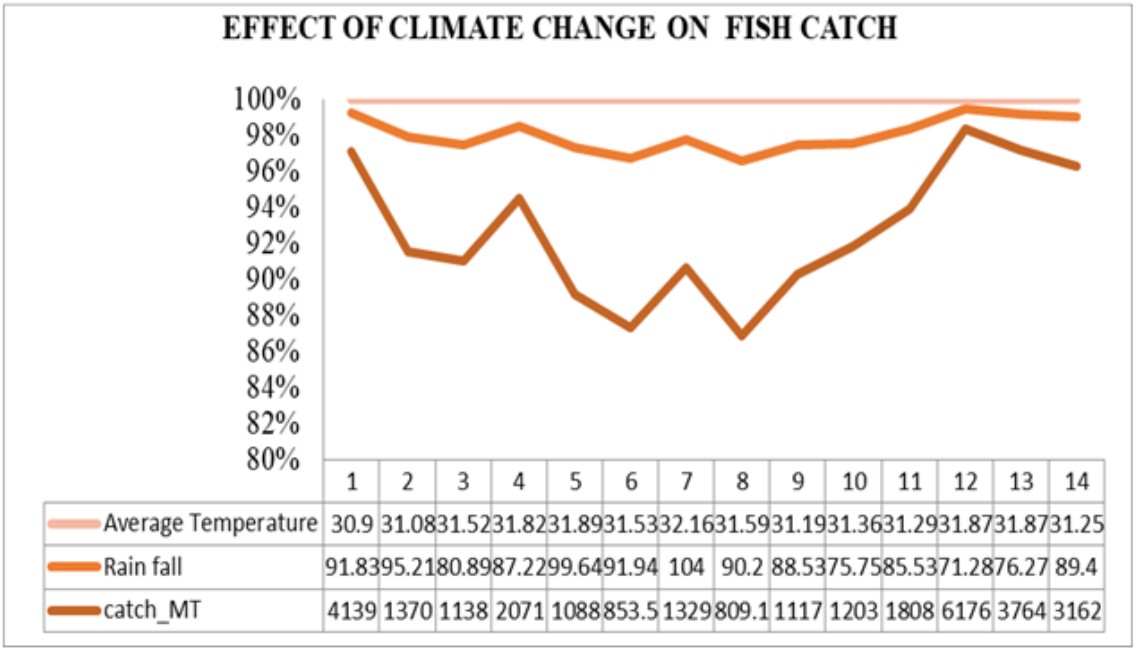
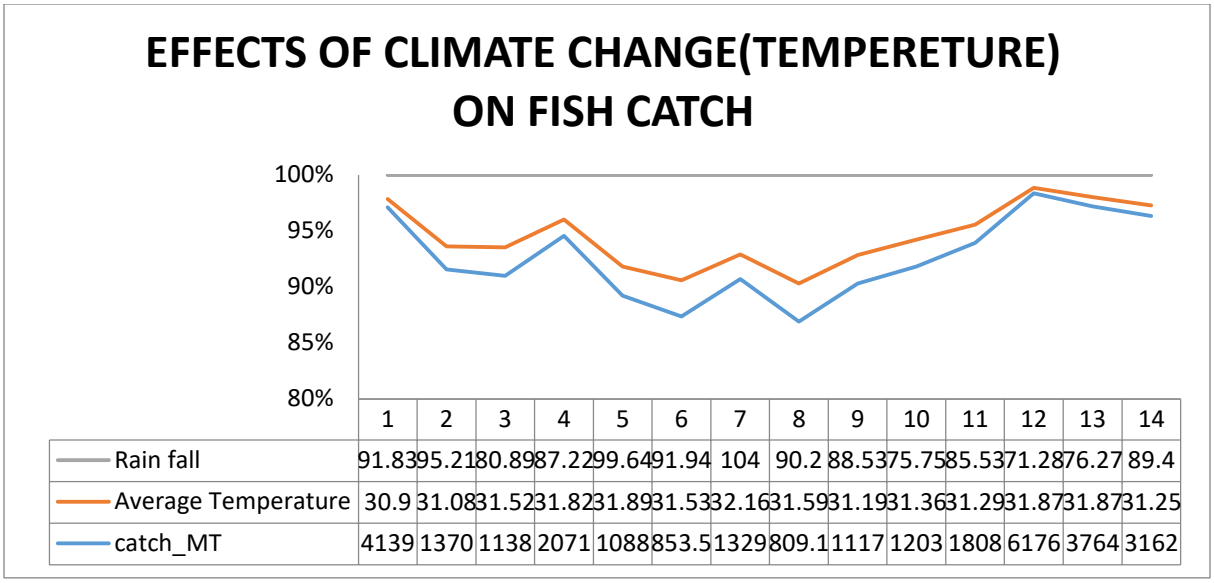


Figure 4.2: Effects of climate change (rainfall) on fish catch

Source: Drawn data from the meteorological and fishery departments (2017)

It can be deduced from the above graph (figure 4.2) that holding temperature constant and other factors constant, rainfall level affects the fish catch. For instance, from the above graph in 2002(1) the rainfall was 91.83mm and fish catch 4139mt but in exactly ten (10) years later (1-10) 2012(10) when the rainfall level reduced to 75.75mm and the catch level has also reduced to 1203mt.This is congruent to most fishers' observation, as they reported that at higher levels of water, the catch is mostly high. From the above results, we can conclude that rainfall positively affects fish catch, that is to say, an increase in rainfall will result in an increase in fish catch holding all other factors constant.



	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Rain fall	91.83	95.21	80.89	87.22	99.64	91.94	104	90.2	88.53	75.75	85.53	71.28	76.27	89.4
Average Temperature	30.9	31.08	31.52	31.82	31.89	31.53	32.16	31.59	31.19	31.36	31.29	31.87	31.87	31.25
catch_MT	4139	1370	1138	2071	1088	853.5	1329	809.1	1117	1203	1808	6176	3764	3162

Figure 4.3: Effects of climate change (average temperature) on fish catch.

Source: Drawn from meteorological and fishery department data (2017)

From figure 4.3, holding rainfall constant, the temperature record for 2002(1) is 30.9 degrees Celsius with a corresponding catch level is 4139 mt., however, in 2012(10) when the temperature increased to 31.36 degrees Celsius the corresponding catch level decreased to 1203 mt. This also denotes that holding rainfall and other factors constant, temperatures negatively affect fish catch. Thus, a rise in temperature will result in a decrease in fish catch and the vice versa, *ceteris parabus.*

This study, therefore, concluded that low rainfall and high temperature directly affect fish catch. This result is similar to findings by FAO (2005) a study which looks at the dynamics of global climatic indices and main commercial catches, concluded that there is a direct relationship between the commercials marine species, catch dynamics, and the patterns various climatic indices. Moreover, Minta (2003) conducted a study titled an assessment of the vulnerability of Ghana's coastal artisanal fishery to climate change(temperature and precipitation) and found that the lower fish population and catchability occurred in years of higher sea surface temperature and precipitation. Thus, the researcher concluded that climate, directly and

indirectly, affects the productivity of the ecosystem as well as its catchability and particularly, the population growth rate of the species in water bodies.

4.4 Assessing the Livelihood Vulnerability Index of the Study Area

The study further assessed the livelihood vulnerability index of fishermen in the Northern Region using the seven major components; sociodemographic profile, social network, livelihood/survival strategies, water, health, food and climate variability the results are presented in three separate tables. Table 4.2, presents the LVI sub-components and major components indexed values for each of the five districts. Finally, the major components and the composite LVI for each district are presented in Table 4.3.

4.4.1 Socio-demographic profile

Talking about the dependency ratio as a sub-component, it was revealed (Table 4.2) that the West Mamprusi District had the highest (0.128) dependency ratio, whiles the Savulugu District had the lowest (0.098) dependency ratio among the five Districts (West Mamprusi,Central Gonja,Tolon, Kumbungu and Savulugu). This implies that in terms of dependency ratio, West Mamprusi District was more vulnerable than the other four districts with the Savulugu district being better off compared to the other districts.

Similarly, for household heads with no formal education index, West Mamprusi recorded the highest (0.700) and Kumbungu recorded the lowest (0.400) (Table 4.2).

Table 4.2: Livelihood Vulnerability Index (LVI) Sub-Components Index

MAJOR COMPONENT	SUB-COMPONENTS	WEST MAMPRUSI	CENTRAL GONJA	TOLON	KUMBUNGU	SAVULUGU
Socio-demographic profile	Dependency ratio	0.128	0.112	0.102	0.113	0.098
	Percent of HH heads with no Edu	0.700	0.554	0.674	0.400	0.457
Livelihood strategies	% HH who work outside comm.	0.180	0.120	0.256	0.100	0.143
	% HH who diversify	0.010	0.015	0.017	0.012	0.012
Social networks	Average receive : give ratio	0.952	0.817	1	1	0.833
	Average borrow: lend ratio	0.478	0.373	0.280	0.524	0.889
Health	Average time to health facility	0.098	0.084	0.231	0.248	0.017
	% HH chronically ill	0.300	0.294	0.209	0.280	0.229
	% HH sick 2wks	0.740	0.565	0.814	0.700	0.829
Food	% of captured fish	0.880	0.859	0.977	0.940	0.971
	Average moths struggle for fish	0.254	0.304	0.345	0.283	0.368
Water	% water conflict	0.340	0.185	0.209	0.280	0.343
	% natural water	0.700	0.880	0.791	0.020	1.00
	Time to water source	0.068	0.141	0.079	0.039	0.057
	Water everyday	0.200	0.196	0.698	0.060	0.029
Natural disasters and climatic variability	Mean maximum temperature	0.330	0.330	0.330	0.330	0.330
	Minimum temperature	0.250	0.250	0.250	0.250	0.250
	Mean monthly precipitation	0.253	0.253	0.253	0.253	0.253

Source: Computed from Field Data, 2017

In terms of the overall vulnerability index (major component index), on the socio-demographic characteristics, the results were just like the sub-components, West Mamprusi recorded the highest (0.414) with Kumbugu being the lowest (0.257) (Table 4.3). This implies that West Mamprusi is more vulnerable in the socio-demographic component, unlikethe other district. This result is similar to Hahn *et al.,(*2008), who conduct a study titled, the Livelihood Vulnerability Index: A pragmatic approach to assessing risks from climate variability and change—A case study in Mozambique and concluded that Moma was more vulnerable in terms of water resources while Mabote on the other hand, was more vulnerable in terms of socio-demographic structure.

4.4.2 Livelihood strategies

Talking about the sub-components such as, the percentage of households who ply other trades in Table 4.2, the Tolon District recorded the highest (0.0167) percentage with the lowest being (0.0102) which was scored by the West Mamprusi District. However, for a rate of households with members who work outside the district, Kumbungu recorded the smallest (0.1) number of household members who work outside the district and the high (0.256) was recorded by Tolon. Finally, in terms of the overall major component vulnerability on livelihoodstrategies, it could be deduced that Tolondistrict was the most vulnerable (0.136) on this component than the rest of the districts with the lowest among the rest been Kumbungu with an index of 0.056 (Table 4.3)**.**

4.4.3 Social network

The social connection's major component index was the highest index recorded in each of the five districts when compared to the other major components. Savulugu was found to be most vulnerable (0.861) in terms of social networking (Table 4.3). In terms of the sub-major components, households in Tolon and Kumbungu reported receiving an equal proportion of help they gave. However,households in the West Mamprusi (0.92), Central Gonja (0.817) and Savulugu (0.833) reported giving more help than they receive from others (Table 4.2). From

Table 4.2, it was only Savulugu (0.889) and Tolon (0.92) who reported borrowing less than they lend. Therefore the lowest average borrows: lend ratio was recorded by Savulugu (0.889) and the highest was recorded by Kumbungu (1.286). The very high social network vulnerability in the index in districts in the Northern Region is consistent with findings by Stanturf *et al.,* (2011) who reported that the Upper East, Upper West and Northern Region have the highest overall social vulnerability to climate change in Ghana.

4.4.4 Health component

In measuring the districts' vulnerability in relation to health, it comprises three sub-components (average time to a health facility, percentage of household members chronically ill and percentage of household members sick in the last two weeks). It was found that Kumbungu, West Mamprusi and Salvulugu were more vulnerable in thissub-components with indexes of 0.248, 0.300 and 0.829, respectively (Table 4.2). Now talking about the major component (health), it was revealed that Kumbungu district was much poorer in accessing good health with an index of 0.614, with the central Gonja being better off among the five districts with an as low as 0.314.The remaining indexes were 0.379, 0.418 and 0.358, for the West Mamprusi district, Tolon and the Savulugu district, respectively, (Table 4.3). This implies that Kumbungu was more vulnerable to accessing quality health compared to the other districts in the study area.

4.4.5 Water component

In this study, the water major component had the highest number of sub-components, a total of four sub-components. For the percentage of households who use natural water for domestic purposes, including drinking, the fisher households in Savulugu reported that they all use the Volta River that is 100% and the average time to the water source according to the fishermen is 11.229 minutes. Interestingly, only 2% of the fisher households in Kumbungu reported using natural water for domestic purposes. In fact, most of the households had pipe-borne water

flowing into their houses. They also reported the lowest average time to a water source (8.057) with the highest being 26.32 minutes reported by fisher households in Central Gonja. Fishers in Kumbungu again recorded the second-lowest (6%) of the availability of water every day for domestic purposes at the source. For water major component, Kumbungu was found to be least vulnerable (0.1) and Tolon was found to be the most vulnerable (0.444).

Table 4.3: LVI Major Components Average Values and Overall LVI for each District

MAJOR COMPONENT	WEST MAMPRUSI	CENTRAL GONJA	TOLON	KUMBUNGU	SAVULUGU
Socio demographic profile	0.414	0.333	0.388	0.257	0.278
Livelihoods strategies	0.095	0.067	0.136	0.056	0.078
Social network	0.715	0.595	0.640	0.762	0.861
Health	0.379	0.314	0.418	0.614	0.358
Food	0.567	0.582	0.661	0.612	0.670
Water	0.327	0.351	0.444	0.100	0.357
Climatic variability	0.278	0.278	0.278	0.278	0.278
Livelihood Vulnerability index(LVI)	0.381	0.352	0.417	0.358	0.395
Average Northern Region livelihood vulnerability index(LVI)	0.380				

Source: Computed from Field Data, (2017).

4.4.6 Food component

In determining the level of vulnerability in terms of food, it was revealed that the Savulugu district was more vulnerable with an index of 0.670 (Table 4.3). The Tolon district came second with an index of 0.661. The other three districts (Kumbungu, central Gonja and West Mamprusi) recorded 0.612, 0.582 and 0.567 indexes, respectively (Table 4.3).

4.4.7 Climate Variability

The climatic variability major component had three sub-components. The data used here, which was secondary, actually were averaged for the northern region and not for specific districts. Hence, this major component which is the exposure component of the LVI-IPCC was the same in all districts. According to the IPPC, LVI has three major components, which are exposure (in this study climatic variability), adaptation (socio-demographics, livelihood strategies and social connection) and sensitivity (health, water and fish). These components are connected by the formula LVI-IPCC= $(E_d - A_d) \times S_d$ where E_d is exposure of a district climatic impacts, A_d is the adaptive capacity of a district to climatic impacts and S_d is the sensitivity of a district to climatic change. As stated early on, the exposure component is the same for all the districts studied with an index of 0.278(Table 4.3). Therefore, the difference in their LVIs is due to the differences in the adaptive capacity and sensitivity components.

In summary, the overall results of the LVI for the five districts as shown in Table 4.3 indicated that the Tolon district (0.417) was the most vulnerable district; this was followed by the Savulugu district with an LVI of 0.395. The West Mamprusi and Kumbugu districts came third and fourth, with LVI of 0.3812 and 0.358, respectively, with the least vulnerable district being the Central Gonja district (0.352) as shown in Table 4.3 above. In generalizing the results the overall average LVI for the districts 0.381 recorded, indicating that the vulnerability of fishers in Northern Ghana is above the average vulnerability (0.25). Therefore fishers in Northern Ghana are highly vulnerable to climate change impacts. The relatively high average LVI recorded in this study in districts in the Northern Region is consistent with findings by Stanturf *et al.*, (2011) who reported that the Upper East, Upper West And Northern Region have the highest overall social vulnerability to climate change in Ghana. This results sync Etwire *et al.*, (2013), which also analyzed the extent of smallholder farmers vulnerability to climate change and variability in Northern Ghana using a sample size of 320 farm households and with data on rainfall and

temperature and employing the Livelihood Vulnerability Index and revealed that the Northern Region was more vulnerable than Upper East Region and Upper East Region was also more vulnerable than Upper West regions in terms of the overall livelihood vulnerability index.

4.5 Fishers Diversification Decisions

In determining the factors influencing fishers' decision to diversify or not, the study used the logit model.

The results are presented in Table 4.4 below. The model has a pseudo-R-square of 0.09. This implies that the independent variables explain the dependent variable by 9%. The probability Chi-square was 0.003. Three variables out of the six variables were significant as shown in Table 4.4.

The number of dependence was a continuous variable and was significant at 1% and a negative marginal effect and the implication is that holding all other factors stable, a percentage increase in the number of dependenceof afisherman will lead to a 2.9 percent decreases in his probability to diversify. A possible reason for this finding may be that the fisher may not have enough resources to do other activities as such households tend to have high expenditures as well as many wants couple with limited resources.

The experience was measured as a continuous variable and was significant at 10% and has a negative marginal effect. The interpretation is that a percentage increase in the number of years of a fisherman will result in about a 0.6 percentage decrease in his willingness to diversify, *"ceteris parabus".*This makes sense as it is always said that "experience is the best teacher". Thus, fishermen who are experienced may have a high level of skills in fishing and thus may apply different methods in harvesting some fish notwithstanding the bad climatic condition.

Table 4.4: Factors influencing fishers' decision to diversify into other economic activities

Variable	Coefficient	Marginal effect
Number dependence	-0.073*** (.022)	-0.029*** (.009)
Experience in years	-0.014** (.008)	-0.006* (.003)
Number of people who support in fishing	0.179*** (.066)	0.071*** (.026)
Own canoe	-.300 (.492)	-.114 (.178)
Source fish supply	-.185 (.394)	-.072 (.149)
Heard climate change	.204 (.268)	.079 (.102)
Model fitness		
Pseudo R-Square	0.09	
Probability Chi-square	0.0032	
Log likelihood	-99.255	

Note: ***, **, * represent significant at 1%, 5% and 10%, respectively. Values in brackets are standard errors.

Source: Computed from Field Data, (2017)

The number of people in a household who are into fishing was also significant at 1% and positively correlated with fishermen's probability to diversify. The implication is that holding all other factors constant, a percentage increase in the number of people of a household in fishing will result in a 7.1 percent increase in the fisherman probability of diversifying.

This could be because the people are many, and households may tend to employ division of labour in order to ensure increase productivity and sustainability. Another reason could because, climate change has already reduced the catchability rate, and thus in order to be safe, a household

may tend to venture into other prominent vocations. This is similar to a research by Smith *et al.* (2005), who concluded that one of the major factors influencing diversification is the availability of family labour or capital.

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.0 Chapter Outline

This chapter comprises summary of the study (5.1), the other subsection 5.2 and 5.3 draw conclusions and make recommendations to policy, respectively.

5.1. Summary of the Study

The researcher sought to examine climate change awareness and perception in riparian communities in the Northern Region as well as establish the impact of climate change on fish catchability in the study area. Finally, researchers assess fishers' vulnerability to climate change using livelihood vulnerability index, and also analyze the factors that influence fishers' decision to diversify. The researcher sampled 270 fishermen for the study. Afterward, the study graphically plotted the data to depict the impact of climate change on fish catchability and the Livelihood Vulnerability Index (LVI) and the logit model to determine the level of vulnerability and the factors influencing fishermen decision to diversify respectively.

The findings revealed that 79.6% of the respondents had not heard of the term "climate change" whiles, 20.4% had heard of the term.

Furthermore, when asked whether the changes in rainfall affect fish catch about 92.2% reported that observed changes in rainfall levels affect the catch level of fish while 91.1% responded in the affirmative for temperature. It was further noted that the average temperature was 30.9 degrees celsius and average rainfall was 91mm, the average fish catch was 4139 tones, but when temperature increases to 31.87 degrees celsius, and average rainfall decrease to 76.27mm, the average fish catch has reduced to 200tones(Figure 4.1). Thus, it was revealed climate change affects fish catchability.

It was further revealed that the overall livelihood vulnerability index (LVI) for each of the five districts was; 0.417 for the Tolon district as the most vulnerable district. This was followed by the Savulugu district with an LVI of 0.395. The West Mamprusi and Kumbugu districts came third and fourth, with LVI of 0.3812 and 0.358, respectively, with the least vulnerable district being the Central Gonja district (0.352). In generalizing the results the overall average LVI for the districts 0.381 recorded (higher than the average LVI for the study (0.25), indicating that fishers in Northern Ghana were highly vulnerable to climate change impacts. Finally, the factors influencing fishermen's decision to diversify were the number of dependence, experience in fishing, number of household labour who support in fishing.

5.2 Conclusions of the Study

It is concluded that fishermen have low knowledge of climate change.

It was further concluded that climate change affects fish catchability and since the sampled population were largely ignorant of the changing climate, they are more vulnerable to climate change. This is because it is said that “knowing your problem is half way to solving it”.

In general, fishermen were vulnerable, but, fishermen who have a high dependency ratio, less experience and many household members to support them in fishing were more likely to diversify into other activities than their counterparts.

5.3 Policy Recommendations

It is recommended that policymakers and other stakeholders (such as the Ministry of Fishery, the Ministry of Food and Agriculture, Ministry of Science Environment and Natural Resources and people in the fish value chain) should put in measures to educate fishermen on climate change. Moreover, fishermen should be educated on some adaptation measures in order to assist them to protect our water bodies.

Since it has been revealed that climate change affects fish catchability, it is recommended that government and non-governmental organizations should help construct fish ponds for the fishermen in the study area since this may go a long way to support them to help reduce their level of vulnerability.

Measures should be put in place to educate fishermen on other trade and income generation activities. This may again help to reduce the high level of vulnerability the districts, particularly, the Tolon district is facing in the study area.

It is, finally, recommended that measures should be put on board to help promote/mitigate the factors that positively/negatively influence fisher decision to diversify in the study.

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APPENDICE

APPENDIX 1: SURVEY QUESTIONNAIRE

UNIVERSITY FOR DEVELOPMENT STUDIES, TAMALE, GHANA

DEPARTMENT OF AGRICULTURAL AND RESOURCE ECONOMICS

NYANKPALA CAMPUS

QUESTIONNAIRE

This questionnaire is to solicit information on the**impact of climate change on fishery-based livelihood in Northern Ghana**.All information provided will be treated confidential and will be used primarily for academic purposes.

Interviewer_____ Date of interview_____ /_____/2017.

District_____ Community_____

Questionnaire Number_____ Telephone number_____

SECTION A. SOCIO- DEMOGRAPHIC AND ECONOMICS CHARACTERISTICS OF FISHERMEN

1. Indicate your gender. Male[ ] Female [ ]
2. What is your age (in year)? ----------
3. What is your marital status? Single [ ] married [ ]
4. What is your level of education (in year)? ----------
5. What is your highest educational level completed? None [ ]

   Primary (class 1 – 6) [ ] Junior High School (JHS1 – JHS3) [ ]

Secondary (SHS1-SHS3, Vocational or Technical School) [ ] Tertiary (Training college, university, polytechnic) [ ]

6. Which ethnic group do you belong? Dagbeni [ ] Frafra [ ] Dagaari [ ] others [ ], specify……..
7. Which religious denomination do you belong? Christianity [ ] Islamic [ ] Traditionalist [ ]
8. What is your household size? ……
9. Please indicate the composition of your household [use the table below]

Household category	Total number of household members
Age	
0-15years(children)	
16-64 years	
65 and above	
Level of Education	
None	
Primary	
JHS	
SHS	
Tertiary	

10. How many of those referred above dependent solely on you for their livelihood? .....
11. How many people in your household earning cash income……

SECTION B. FISHERMEN AWARENESS OF CLIMATE CHANGE

1. Have you heard of the conceptclimate change? 1=Yes [ ] 2=No [ ]

2. If yes, what is climate change?

.....

.....

.....

.....

3. Is the rainfall level/pattern today the same as 10 years back? 1=Yes [ ] 2= No [ ]
4. If no, what is the difference?

……

……

……

5. Do observed changes in rainfall levels affect the catch level of fish?1=Yes [ ] 2= No [ ]
6. If yes, what is the nature of this effect on your catch? 1=increase [ ] 2= decrease [ ] 3= uncertain
7. Is temperature today the same as ten years back? 1=Yes [ ] 2=No [ ]
8. If no, what is the difference?

……

……

……

9. Do observed changes in temperature affect the catch level of fish? 1=Yes [ ] 2=No[ ]
10. If yes, how is it affecting catch? 1=Increase [ ] 2=decrease [ ] 3=uncertain

SECTION C: FISHERIES AND FISHERY-RELATED ACTIVITIES

1. Experience/Number of years in fishing……..
2. Which of the following fishery related activities do you engage in? (Multiple responses are allowed) 1=Fishing [ ] 2= Fish Trading [ ] 3=Fish processing [ ]

4=Net making/mending [ ] 5=others (Please specify)……

3. Do you own a boat? 1=Yes [ ] 2=No [ ]
4. If no, how do you get a boat for fishing? 1=From a friend [ ] 2=Family [ ] 3=Rent [ ] 4=Other(s) Please specify……
5. If rent, how much do you pay? ……..
6. Do you easily have access to the fishery? 1= Yes [ ] 2= No [ ]
7. Do you depend on fishery all year round? 1=Yes [ ] 2= No [ ]
8. If no, do you diversify into other activities? 1=Yes [ ] 2= No [ ]
9. What is your average catch per day in kg……....
10. What quantity of your fish (per week) is kept for household consumption and what quantity is sold? Specify as shown in the Table below

Quantity for household consumption (% or kg)	Quantity Sold (% or kg)

11. How many meals with fish are you able to serve in a day?

    One [ ] Two [ ] Three [ ] others [ ], please specify……

12. What are some of the adaptation measures that can be used to mitigate the effects of climate change on your fishery activities?

    ……

    ……

    ……

SECTION D: FISHER LIVELIHOOD VULNERABILITY TO CLIMATE CHANGE

1. How many people in your house hold work outside the community? .....

2. How many persons in the household engages in fishing as a source of income?.....
3. How long does it take you to get to a health facility? .....
4. Is anybody in your family chronically ill? 1=Yes [ ] 2=No [ ]
5. Has anyone in the household been sick in the last 2 weeks? 1=Yes [ ] 2=No [ ]
6. Which months of the year is malaria prevalent?

   ……
7. How many mosquito nets do you use to protect yourselves against mosquito bites…….
8. Did you borrow money from friends or relatives in the past 12 months?

   1=Yes [ ] 2=No [ ]
9. Did you lend money to friends or relatives in the past month? 1=Yes [ ] 2=No [ ]
10. Did relatives or friends help you or your family in the past month?

    1=Yes [ ] 2=No [ ]
11. Did you or your family help relatives or friends in the past month?

    1=Yes [ ] 2=No [ ]
12. Where does your family get most of its fish supply from?

    1=Capture [ ] 2= Market [ ]
13. Does your family have adequate fish all year round? 1=Yes [ ] 2=No [ ]
14. If no, how many months in a year is there trouble getting fish? ……
15. In the past year; have there been any conflict over water in your community?

    1=Yes [ ] 2=No [ ]
16. Where do you collect water from? 1=Pipe[ ] 2=creek [ ] 3= river[ ] 4=lake 5=pool [ ] 6= hole [ ]
17. How long does it take to get to your water source? …….

18. Is there water every day? ……

19. Do you have any question in relation to climate change……

SECTION E: FISHER DIVERSIFICATION DECISION

1. Do you easily have access to the fishery
2. Do you have any other possible occupation apart from fishing? 1=yes [ ] 2= no[ ]
3. If your answer to (2) above is yes, please specify……
4. Do you have people helping you inyour fishing activities? 1=yes [ ] 2= no[ ]
5. If yes, how many people? ……
6. Do you have access to credit? 1=yes [ ] 2= no[ ]
7. If yes, where do you get credit from? 1=Fish middlemen [ ] 2=family/friends [ ]
   3=bank and other financial institutions [ ] 4=co-operative 5=susu collectors
   6=others specify……
8. Do you easily have access to the market? 1=yes [ ] 2= no[ ]
9. If no, how do you market your fish?.....
10. Do you depend on fishing all year round? 1=yes [ ] 2= no[ ]
11. If no, what is your alternative source of livelihood?.....

THANK YOU VERY MUCH FOR YOUR TIME AND CO-OPERATION

APPENDIX 2: LIVELIHOOD VULNERABILITY INDEX (LVI) SUB-COMPONENT VALUES AND MAXIMUM AND MINIMUM VALUES OF SUB-COMPONENTS

MAJOR COMPONENT	SUB-COMPONENTS	UNITS	WEST MAMPRUSI	CENTRAL GONJA	TOLON	KUMBUNGU	SAVULUGU	MAXIMUM	MINIMUM
Socio-demographic profile	Dependency ratio	Ratio	1.0255	0.8923	0.8170	0.9013	0.7814	8	0
	Percent of HH heads with no Edu	Percent	70	55.43	67.44	40	45.71	100	0
Livelihood strategies	% HH who work outside comm	Percent	18	11.96		10	14.29	100	0
	% HH who diversify	Percent	0.0122	0.0167	0.0187	0.0139	0.0140	1	0.002
Social networks	Average receive : give ratio	Ratio	0.9523	0.8167	1	1	0.8333	1	0
	Average borrow:lend ratio	Ratio	1.2174	1.0588	0.92	1.2857	0.8889	2	0.5
Health	Average time to health facility	Minutes	30.4	26.2174	70.3023	75.2	6.2	300	1
	% HH chronically ill	Percent	30	29.35	20.93	28	22.86	100	0
	% HH sick 2wks	Percent	74	56.52	81.40	70	82.86	100	0
Food	% of captured fish	Percent	88	85.87	97.67	94	97.14	100	0
	Average moths struggle for fish	Months	3.0435	3.6444	4.1429	3.4	4.4167	12	0
Water	% water conflict	Percent	34	18.48	20.93	28	34.29	100	0
	% natural water	Percent	70	88.04	79.07	2	100	100	0
	Time to water source	minutes	13.14	26.3152	14.9535	8.0567	11.2286	100	0
	Water everyday	percent	20	19.57	6.98	6	2.86	100	0
Natural disasters and climatic variability	Mean maximum temperature		2.979668	2.979668	2.979668	2.979668	2.979668	6.8	1.1
	Minimum temperature		2.34933	2.34933	2.34933	2.34933	2.34933	7.0	0.8
	Mean monthly precipitation		86.14734	86.14734	86.14734	86.14734	86.14734	340.2	0

Source: Author computed from field work