Building Local Resilience to Climate Vulnerability In Small-scale Fishery Communities of Lake Volta, Ghana.

By
Rosina Amoah Agyapong

A thesis
presented to the University of Waterloo
in the fulfillment of the
Master of Environmental Studies
in
Sustainability Management

Waterloo, Ontario, Canada, 2021

Author's Declaration

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that the thesis may be made electronically available to the public.

Abstract

Climate change affects fishing globally, and the world's 100 million small-scale fisheries (SSF) are no exception. Despite the high number of SSFs worldwide and their significant economic contributions, SSFs often go understudied. The SSF sector continues to suffer from rapid depletion of fish resources due to climate change, affecting livelihoods and increasing their vulnerability worldwide. This study aims to understand the climate vulnerabilities experienced by SSFs communities, the challenges to building resilience, and the nature of governance responses needed to address impacts in Lake Volta, Ghana. A qualitative research method was used in gathering information for this research. Secondary data collection methods were used instead of primary data collection due to the Covid-19 pandemic. A systematic literature review was used with the help of a reference management tool known as the Zotero to collect, analyze, and organize existing literature using search engines. Also, the pragmatic worldview and I-ADApT framework are adopted to understand the various variations of adaptations, governing systems, vulnerabilities, and resilience strategies in SSFs communities affected by climate change. The study found that communities adapt to climate change impacts by diversifying their livelihoods and migrating to cities for alternative employment. However, their strategies are not integrated into policymaking and adaptation policies. The results of this study support designing policies fostering community adaptation and resilience and exceptional attention to local knowledge and participation in decision-making. The study recommends that policymakers embrace the essence of enhancing alternative livelihood strategies for the fishing communities in Lake Volta to help combat the effects of climate change. To this end, this study identifies the following as strategies to enhance adaptation and resilience through policymaking: facilitating the transition to alternative livelihoods, strengthening and building local capacities to reduce risk and vulnerability, responding to income uncertainty and fish stocks variations by countering climate change effects.

Keywords: Small-Scale Fisheries, Resilience, Vulnerability, Viability, Climate Change, Community Adaptation.

Acknowledgement

First and foremost, I would express my profound gratitude to God Almighty for successfully seeing me through this research. His grace kept me through it all.

Again, my most resounding words of appreciation go to my advisor, mentor, lecturer and supervisor, Prof. Prateep Kumar Nayak (Associate Professor and Associate Director of Graduate Studies, School of Environment, Enterprise and Development, University of Waterloo), for supporting me financially, physically, mentally, psychologically and emotionally when everything became tough during my research. I appreciate your constant check-ups, advice, patience, enthusiasm, motivation, immense knowledge, and guidance that helped me write the research paper. I could not have imagined having a better supervisor and mentor for my Masters' study.

I would also like to acknowledge my committee members- Prof. Nayak (Supervisor), Prof. Jeremy Pittman (Assistant Professor, University of Waterloo) and Dr. Ana Carolina Esteves Dias (University of Waterloo), each of whom has provided patient advice and guidance throughout the research process.

Special thanks go to the V2V Global Partnership Group for their support through a series of webinars, conferences, newsletters, journals, articles about the vulnerabilities and vulnerabilities of SSF communities, which gave me in-depth knowledge of my research paper and to the Social Sciences and Humanities Research Council Canada (SSHRCC) for funding this research.

My sincere appreciation goes to the University of Waterloo, Faculty of Environment and School of Environment, Enterprise, and Development (SEED), for affording me the incredible opportunity to complete my study here, despite all challenges that frustrated all my efforts.

Other thanks go to everyone who played a vital role in my academic accomplishments, especially my friends (Reynolds Addo-Labi, Saira Naeem and Raphael Ayambire-PhD), for their knowledge and support to make this research a success. In addition, I would like to thank all the researchers on whose work I was able to build. Finally, to my family, who supported me with love, prayers, encouragement and understanding. Without you, I could never have reached this current level of success. Thank you all for your unwavering support.

Dedication

This research is dedicated to my parents for believing in me despite all the challenges I went through in life. Most importantly, to my dear mum, who passed during the writing of my research paper. It hurts that you couldn't live long to enjoy the fruits of your labor, but God knows best. Continue to rest well in the bosom of God Almighty till we meet again with lots of love. Amen!

I also want to dedicate it to all the vulnerable SSF communities worldwide who go through challenges caused by environmental changes and finally to all the students and Faculty members of SEED and V2V Global Partnership Group.

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List of Acronyms

CARIAA - Collaborative Adaptation Research Initiative in Africa and Asia

CBOs - Community-Based Organizations

CBFMC - Community-Based Fisheries Management Committee

CCA - Climate Change Adaptation

DRR - Disaster Risk Reduction

EPA - Environmental Protection Agency

ENSO - El Nino Southern Oscillation

FAO- Food and Agricultural Organization

GNAP - Ghana National Adaptation Plan

GNCCP - Ghana National Climate Change Policy

I-ADApT - Assessment based on Description and responses and Appraisal for a Typology

IPCC - Intergovernmental Panel on Climate Change

MDAs - Ministries, Departments and Agencies

MESTI - Ministry of Environment, Science, Technology and Innovative

NADMO - National Disaster and Management Organization

NAP - National Adaptation Plan

NCCP - National Climate Change Policy

NCCAS - National Climate Change Adaptation Strategy

NDPC - National Development Planning Commission

NGOs - Non-Governmental Organizations

SSFs - Small-Scale Fisheries

UNFCCC -United Nations Framework Convention on Climate Change

V2V - Vulnerability to Viability

WMO- World Meteorological Organization

Chapter 1

1.1 Introduction

Fishing is an essential food source for humankind and a source of employment and financial benefits (Béné et al., 2016). Fisheries support the livelihoods and food security of more than half a billion people globally (Samieri et al., 2018). Cochrane et al. (2019) and Mohammed and Uraguchi (2013) argue that fisheries play a significant role in the food supply, nutrition and income generation at all levels. More than 2 billion people gain at least 20% of their animal protein from fish (Lowitt and Society, 2014, Iglesias et al., 2011). Sustainable Development Goal number two (SDG 2) describe that the world should go all-out to end hunger, achieve food security, improve nutrition and promote sustainable agriculture by 2030. SSFs have been identified as sectors that could enhance food security and reduce poverty to attain SDG 2 (Nthane, 2015), though; fisheries are climate-sensitive. Therefore, their production processes are likely to be affected by climate change (FAO, 2016).

Climate change is one of the main challenges to the global biophysical and socio-economic environment. Tiyo et al. (2015) showed that climate change is an essential environmental threat and an obstacle to development. Ghana is a developing country, and vulnerability to climate change occurs in most tropical regions due to their more significant economic and nutritional dependence on fish. Additionally, most developing countries also face enhanced barriers to resources that would support their resilience against climate change (Samieri et al., 2018). As Rice and Garcia (2011) have identified, changes in temperature and rainfall are the main factors contributing to a decline in food production systems, including fisheries. Given that the Small-Scale Fishery (SSF) sector will be affected by climate change through fluctuating water levels and flooding events (Brander, 2007), SSFs are highly vulnerable to climate change.

SSFs are vital to supporting the livelihoods of vulnerable and marginalized populations as they contribute to food security by making fish available to low-income people (Wiebe et al., 2019). Most SSFs in developing countries, particularly in Africa and Asia, are in remote rural areas and are characterized by limited alternative sources of income and employment (Béné et al., 2007). For this reason, fisheries are a substantial source of employment, income and food, contributing to

food security. Food security is defined as a condition that exists when all people always have the physical or economic right to use sufficient, safe and nutritious food to meet their nutritional needs and food preferences for an active and healthy life (FAO, 2013). Fish caught can be used for household consumption, which directly contributes to food security; however, fish catch can indirectly contribute to food security through income generation for SSF communities (Ngema et al., 2018).

In Ghana, climate change will aggravate people's livelihoods by presenting further food insecurity challenges, which are already a problem in agriculture-dependent communities where poverty and hunger are widespread (Shava and Gunhidzirai, 2017). Figure 1 shows a map of Ghana with Lake Volta. Fishing in Lake Volta contributes about 90% of the total inland fishery production in Ghana. About 40 years ago, Lake Volta was the largest human-made Lake in Africa and the second largest in the world. It is estimated that 300,000 people depend on the Lake for their livelihood, 80,000 are fishers and 20,000 are fish processors and traders (Braimah and Paper, 1995).

Figure 1.1 Map of Ghana with Lake Volta

The fishery is solely artisanal, with about 17,500 canoes actively working on the Lake operating from approximately 2,000 fishing villages (Bene, 2007). Fishing is the main livelihood activity; however, according to Ferdouse et al. (2018), since the 1990s, fish production in Lake Volta has declined. Because of its high vulnerability to climate change and its dependence on fishing, Ghana is among the most vulnerable countries to climate change based on the discussions above. Climate change modifies freshwater species' distribution and productivity, affects fishes' biological processes, and alters food webs (Yazdi et al., 2010). Over the years, there has been an increased interest in understanding factors affecting SSF. However, most studies are site-specific, frequently focusing on a much-localized area (Kronen et al., 2010; Cinner and McClanahan, 2006). There is little research on climate change impacts on SSFs, and for that matter, there is little research on the state of SSFs in Lake Volta (Allison et al., 2009), a gap that this study seeks to fill. To that end, this chapter highlights the impact of climate change on SSFs by examining the extent to which climate change affects small-scale fishers. First, this chapter will explain the study's background, followed by the problem statement that generated the study's desire to undertake the study. Further, the chapter outlines the study's aim, research objectives, and research questions and concludes with an outline of the dissertation's remainder.

1.2 Problem Statement

Climate change and variability continue to cause vulnerabilities in small-scale fishing communities affecting fishes' biophysical systems and the socio-economic lives of fishers and people that depend on fishing for survival (Mensah, 2019). This current study is crucial for three reasons:

i) First, the study attempts to understand how small-scale fishing communities in Lake Volta continue to lose their livelihood to climate change impacts (e.g., diminishing fish production) (Iwasaki et al., 2009).

There is compelling evidence to suggest that the changing climate results in climate variability and the frequency, intensity, spatial extent, duration, and timing of extreme weather and climate events across the globe (IPCC, 2012). Changes in water temperature, sea/water level rise, extreme weather events like storms, cyclones, heavy rainfall causing floods, ocean acidification are climate change components that cause vulnerabilities in marine and inland fishing sectors (McCarthy et al., 2001). These changes are expected to drive fish production meaningfully, and the cascading

effects on livelihood strategies of fisherfolks in the Lake Volta environs resulting in loss of livelihoods in fishing communities (e.g., diminishing fish production) (Iwasaki et al., 2009).

In Ghana's Lake Volta, a set of studies have already discovered a steady decline in fish catch which establish the fact that annihilation of freshwater fish species is caused by increases in habitat modification, changes in stream temperature, and changes to the flow of streams (Braimah 1995; De Graaf & Ofori-Danso 1997). According to the Ministry of Environment, Science, Technology and Innovation (MESTI, 2013), changes in climatological variables such as rain patterns are expected to affect the production and catch of inland wild fish and aquaculture fish in Ghana (Mensah, 2019). Previous studies have suggested that climatic effects on fish also have social and economic impacts on SSF communities and individuals in Lake Volta whose livelihoods depend on fisheries and aquaculture (Asante & Amuakwa-Mensah, 2015).

ii) Secondly, the study will examine the vulnerabilities SSFs in Lake Volta face and the economic, cultural, and political barriers that hinder their efforts to adapt to the adverse effects of climate change (Islam et al., 2014; Kalikoski et al., 2010).

Several gaps relate to climate change impacts and adaptation studies due to limited knowledge of climate change-induced implications on the local fisheries' livelihoods. This is because most of the available literature has focused on the national level of vulnerability of fisheries production systems (Allison et al., 2009). Research into the ecosystem's response to climate change is fundamental to build resilience and adaptation strategies at the local level. However, limited studies about the nexus between climate change, ecosystems, the fish stock, and the people exist in Lake Volta (Mensah, 2019). It is undeniable that freshwater fisheries are susceptible to a wide range of climate change impacts because the ecological systems that support fisheries are already sensitive to climate change (Daw et al., 2009). Limited studies and literature exist on climate change adaptation at the local level of SSF in Lake Volta and Africa as a whole; further, according to the United Nations Economic Commission for Africa (UNECA) (2011), climate change studies in Africa should focus on assessment of impacts and adaptation to climate change in several regions and sectors (including the fisheries sector) (Mensah, 2019).

iii) Thirdly, the study will examine existing national policies on adaptation, mitigation, resilience, and the associated challenges to increase local level resilience (Islam et al., 2014).

There is a significant struggle to mainstream climate change mitigation and adaptation into Ghana's district assembly planning system. Thus, climate change policies are primarily prepared at the national level. Establishing them at the local level has been a challenge in Ghana, especially SSF communities in Lake Volta (MESTI, 2013). This affects the effectiveness of climate change for resilience policies in most small-scale fishing communities. This research output seeks to determine further how the impacts of climate change are likely to influence the coping and adaptive strategies of fisheries-dependent individuals and their households in Lake Volta.

1.3 Aim of the study

In many cases, these challenges have placed the livelihoods, economy, food security, values, identity, and the viability of fishing communities at risk due to climate change's impact on SSF communities. These issues call for further research on enhancing community resilience in fishing societies to climate change (Iwasaki et al., 2009). Similarly, these issues demand policies to help small-scale fishing communities mitigate and adapt to climate change. Therefore, the study's overarching purpose is to explore the fishing communities' perspective on building local resilience to climate change by critically examining the achievement of viability in SSF communities of Lake Volta, Ghana.

1.4 Research Questions and Objectives

This research will explore local resilience to climate vulnerability in SSF in Lake Volta. More specifically, it will help to understand the areas of vulnerabilities due to climate change in SSF in Lake Volta through the following sub-questions and objectives:

1. To identify the range of vulnerabilities of fishing communities linked to climate change.

RQ a. What are the changes observed in the fishing area due to climatic factors?

RQ b. How do such changes influence the fishing practice and livelihoods in SSF communities in Lake Volta?

RQ c. What are the most important trends seen in recent years due to changes in climatic conditions?

2. To examine constraints and opportunities for viable fisher communities in the Lake Volta region.

RQ a. How does the SSF community cope with extreme weather events?

RQ b. What strategies or mechanisms do the fishing communities adapt to minimize the impacts concerning loss in life and livelihoods?

RQ c. What are the emerging support systems to avoid stress emanating from climate issues in the SSF community?

3. To assess community governance strategies to address climate change vulnerability concerning Ghana's climate action policies.

RQ a. What are the communities response mechanisms reflected in climate policy at the national level?

RQ b. What government policy implementation and financial mechanisms are in place to support SSF vulnerabilities to climate change?

RQ c. How do governance strategies attune towards local responses and behavior in terms of a governing system?

1.5 Literature Review

This research will draw its findings from a comprehensive literature set; the study's literature review will be composed of three parts.

First, it will present an overview of small-scale fishing, highlighting its importance in both the global and local context while also examining the impacts of climate change. Secondly, the link between climate change and vulnerability within small-scale fisheries will be reviewed. Thirdly, both governmental and adaptive community responses to climate change vulnerability will be examined.

1.6 Research Area and Methodology

The research methodology and the methods used are qualitative research. However, the primary data collection method was not used due to the Covid-19 pandemic; instead, the researcher adopted the secondary data collection method to gather information. A systematic literature review and a Zotero application were used to collect, analyze, and organize existing literature using search engines. Also, the pragmatic worldview and I-ADApT framework are adopted as a thinking tool

to understand the various variations of adaptations, governing systems, vulnerabilities and resilience strategies in small-scale fishing communities affected by climate change.

1.7 Overview of Thesis Structure

The below figure describes the structure of the thesis, from the introduction to its ending with recommendations. The introduction chapter will discuss different points: an overview of the subject matter, the study background, research objectives, research questions, and summation of thesis structure. The second chapter will review the literature on the effects of climate change on SSFs, proposed transitions from vulnerability to viability, community adaptive governance responses, and conceptual framework. The research methodology chapter will discuss the study area, a protocol for literature review, and Research methods and materials. The fourth chapter on results will discuss SSFs vulnerabilities in Lake Volta SSF due to climate change. Determining governance strategies in addressing communities' vulnerability to climate in Lake Volta will be discussed in the last chapter, a summary, recommendations, and limitations will be listed.

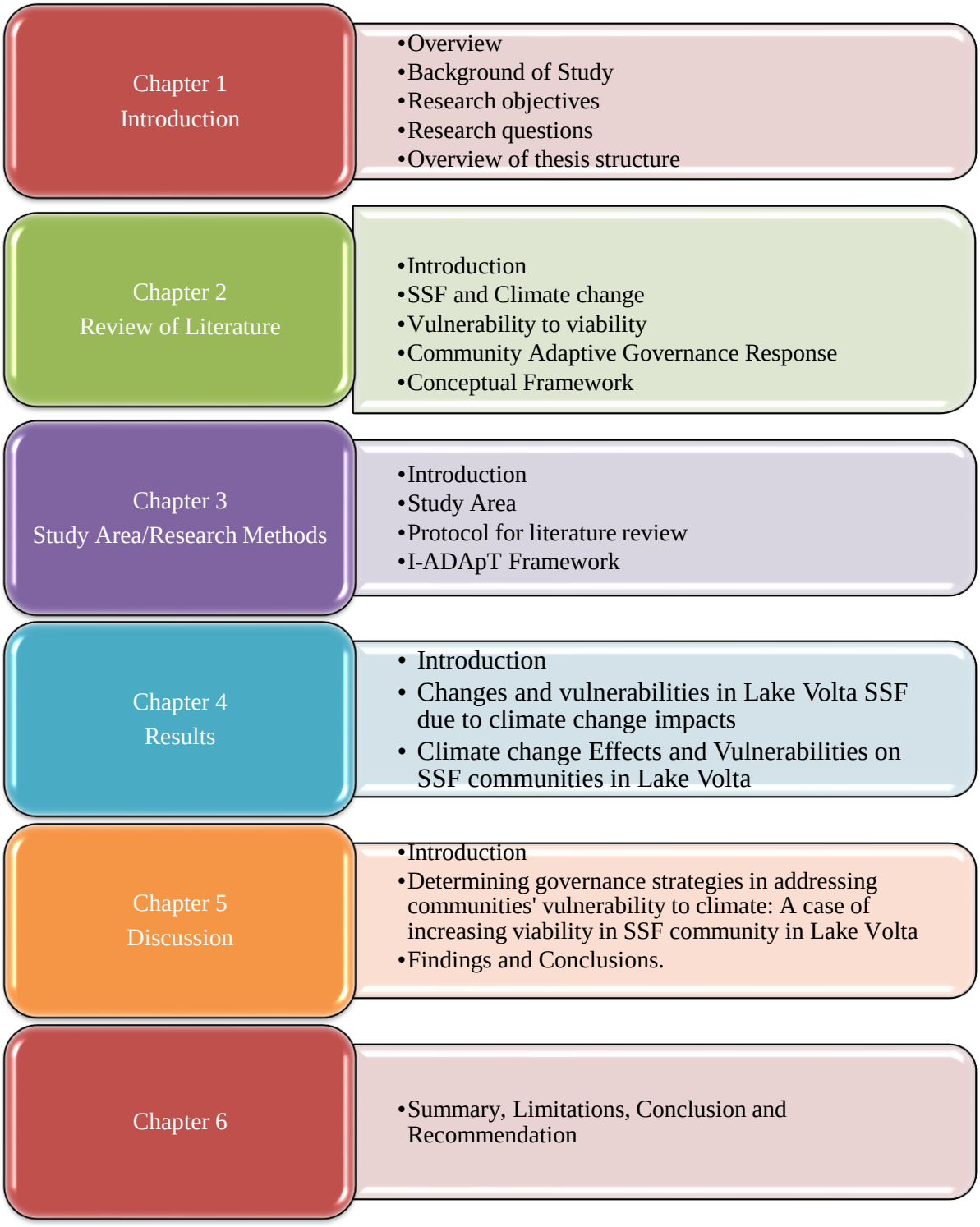

Figure 1.2 Overview of Thesis Structure

Chapter 2

A Review on SSF, Vulnerability to Viability and Community Adaptive Governance Response

2.1 Introduction

This literature aims to help address the study's objectives: small-scale understanding of fishing, climate change impacts on SSFs and how SSF communities deal with the vulnerabilities created by climate change. This research will draw heavily from a set of literature. This chapter will be in three parts; first, the study presents an overview of small-scale fishing and its importance in the global and the local context; then, it will examine the impacts of climate change on SSFs. The second part will emphasize the link between climate change and vulnerability within small-scale fisheries. Again, this review will draw knowledge from a large body of published research, outlining how different scholars understand Vulnerability to Viability (V2V). Thirdly, community adaptive responses and governance to climate change vulnerability will be reviewed. Also, local resilience to climate change vulnerability within the SSF would be explored by critically examining how to achieve viability.

2.2 Definitions of Key terms (Vulnerability, Resilience, Adaptive Capacity, Adaptation, Wellbeing, Governance and Viability)

Vulnerability, Resilience, Adaptive Capacity, Adaptation, Wellbeing, Governance and Viability are vital terms and concepts discussed for this research. Table 2.1 below outlines the various definitions of terms and their sources.

Table 2.1 Definition of terms

Key terms	***Sources***
Vulnerability	
"The likelihood that an individual or group will be exposed to and adversely affected by a hazard. It is the interaction of the hazards place with the social profile of communities."	Cutter (1996, p. 532)
Resilience	
Resilience is popularly understood as the degree of elasticity in a system, its ability to rebound or bounce back after experiencing some stress or shock	(Kais & Islam, 2016)

Resilience is defined as the capacity to absorb disturbance and reorganize while changing to retain the same function, structure, identity, and feedback.	(Walker et al. 2004)
Resilience is defined as the ability of a system to bounce back or return to equilibrium following disturbance.	(Holling, 1973)
Wellbeing	
Wellbeing is a state of being with others, where human needs are met, where one can act meaningfully to pursue one's goals and where one enjoys a satisfactory quality of life	(McGregor 2008)
Adaptation	
Adaptation is the adjustments in ecological-socio-economic systems in response to actual or expected climatic stimuli and their effects.	Smit et al. (2000, p. 225)
Adaptation is the adjustments in a system's behaviour and characteristics that enhance its ability to cope with external stress.	Brooks (2003, p. 8)
Adaptation refers to a process, action or outcome in a system to better cope with, manage or adjust to some changing condition, stress, hazard, risk or opportunity	(Smit & Wandel, 2006).
Adaptive Capacity	
The forces that influence the ability of the system to adapt are the drivers or determinants of adaptive capacity	(Adger, 2003; Walker et al., 2002)
Governance	
Governance is the broader decision-making network that can be seen as comprised of government and private actors, including the market and civil society.	(Keohane & Nye 2000).
Viability	
Viability has the higher social capital, networks, trust relationships, and increased adaptive capacity to build stronger fishing communities.	(Jentoft 2000; Berkes 2015).

2.3 An Overview on Small-Scale Fishing

SSF definitions may vary depending on the geographical location because, in reality, what may be considered small in one place might not be small in other areas (Chuenpagdee, 2012). There is no universal definition for SSF, but as the name suggests, small-scale fishing is done on a small non-industrial scale (FAO, 2019). However, the reports provided by the world's coastal nations on SSF depict that about 70% of the descriptions were characterized by boat size (small), horsepower, gear type, and distance from shore (Chuenpagdee, 2012). Generally, catching fish on a small scale for consumption and processing is termed small-scale fishing. It also involves boat building, nets repairing, fish processing and selling seafood (FAO, 2018).

The FAO (2012) defines small-scale fishing as fishing households (as opposed to commercial companies), using moderately small amounts of capital and energy, relatively small fishing containers (if any), making short fishing trips close to the coast. Therefore, the most common families with an incomplete operation range, dependency on local resources, and low capital investment. The FAO (2005) characterized small-scale fishing as a dynamic and evolving sub-sector of the fisheries industry that uses labour-intensive techniques to harvest fish in marine and inland water resources. Explaining further, SSF is conducted full-time, part-time or seasonal, primarily aimed for consumption and supplying to local and domestic markets (Chuenpagdee, 2012).

According to FAO (2012), about 660-820 million people globally depend on fisheries and supply 16.6% of the world's animal protein (Islam, 2013). Globally, approximately 120 million are involved in fish capture. Out of this, 90% are full-time or part-time fishers estimated to derive their livelihood from the SSF sector (Perry et al., 2011). 97% of SSFs are located in developing countries, with 47% of the total workforce represented by women who process and distribute the fish simultaneously; men are primarily engaged in fishing (FAO, 2018). The global workforce in the SSF sector is from developing countries, with 73% living in Asia. Small-scale fishing contributes over half of the total fish catch in developing countries, with 90-95% local consumption (FAO, 2018). Predictably, there are 1.2 million artisanal fishers in the Caribbean and America, 0.98 million small-scale fishers in Africa, and 6.1 million in Asia (FAO, 2012). According to FAO (2012), the fishing sector continues to grow in employment creation compared to agriculture, and it has an export value of US$102 billion (in value terms), contributing significantly to gross domestic product (GDP), food security and poverty alleviation (Islam, 2013).

In Africa, SSF accounts for the most fish catch. It is estimated that 10 million Africans depend on SSF as their primary source of livelihood, and 90 million African farmers and resourced poor depend on fishing as part of a diversified livelihood strategy (AU-IBAR, 2012). As a result, fish caught by SSF likely contribute a quarter of the total protein intake in Africa, and SSF communities play a vital role in nutrition, trade, and economic activity (Marquette et al., 2002). The commonly used fishing gears in Africa are purse seines, beach seiners, set nets, draft gill nets and hook and line (Tvedten and Hersoug, 1992). SSF is an essential contributor to African countries' fish production. West African countries are the largest fish producers, accounting for around 44% of

the total landed catches, 48% of the total landed value, and the highest small-scale fisheries producer with regional yields exceeding 1800,000 tons generating over 2000 million USD (TBTI report, 2013).

Just like most places in the world, Africa's SSF is done mainly by people and communities closer to the shore of marine or inland water bodies that are substantially dependent on, or substantially engaged in, the harvesting or processing of fish resources to meet social and economic needs (Islam, 2013). SSF communities include people directly involved in fishing, such as boat captains and crews called ''fisherfolk'' or ''fisher" and those who contribute indirectly to pre and post-harvest activities, such as gear and boat-making processing and trading (Islam, 2013).
Similar to other West African countries, the fishing sector in Ghana uses essential technologies. Commonly used fishing gears are purse seines, beach seiners, set nets, draft gill nets, and hook and line, with an identified 17,500 canoes operating in the inland sector (Failler and Ayoubi, 2012). Generally, small-scale fishers in Ghana use wooden dugout canoes, smaller boats and gear, and land smaller fish in their operations.

In Ghana, SSF takes place in marine and inland waters. Marine fishing occurs in the coastal areas, whiles inland fishing occurs predominantly on the Lake/River Volta (Marquette et al., 2002). In Ghana, the SSF sector is the most important in terms of fish output; it contributes to 68-70% of annual total fish catch, with about 10,000 marine small-scale canoes and 123,000 fishers operating from 304 landing centers in 189 fishing villages located along the coast (Failler and Ayoubi, 2012). Also, Lake Volta contributes about 90% of the country's total inland fish production and covers a surface area of 8,480 km² and 5,200 km of shoreline employing about 80,000 fishers and 20,000 fish processors.

Ghana's fisheries sector contributes 4.5% to GDP, accounts for 12% of the agricultural GDP and 10% of the labour force. About 2.4 million people, or 10 percent of the country's population, are dependent mainly on fisheries resources for their livelihood. Approximately 500,000 individuals are estimated to be fish workers engage in processing and distribution (Failler and Ayoubi, 2012). Domestically, the major inland fish trading centers are rich in fish, and about 140 species of fish could be identified in Lake Volta. Landings are dominated by tilapia species (38.1%), Chrysichtys spp. (34.4%), synodrantis sp. (11.4%), Labes (3.4%), Mormyrids (2.0%) Heterotis (1.5%) Clarias sp. (1.5%), Clarias spp. (1.5%), schilbeide (1.4%), odaxothrissa mento (1.4%), Bagrus spp. (1.35)

and Citharinus spp. (1.2%) and the rest which are less than 1% include Alestes sp., Brycinas sp. Distichodus spp., Gymnarchus spp.; Hydrocynus spp.; and Lates niloticus (Failler and Ayoubi, 2012). Small-scale fishing in Ghana and other African countries is likely to share the same sociocultural, geographic, demographic, and institutional characteristics with little variance. Figure 2.1 below shows some of these common characteristics (Marquette et al., 2002).

Table 1. Characteristics of small-scale fisheries and fishing communities in Africa. Sources: (7, 17, 45–52).

Criteria	Characteristics
Technological	Use of mixed types of fishing technologies combining low- and high technology crafts and gear Use of motorized and non-motorized craft capable of beach landings (canoes, rafts, smaller boats)
Sociocultural	Use of traditional fishing practices and techniques, e.g. dugout canoes in West Africa Fishing units often involve family kin groups Fishing units usually involve smaller numbers of people than commercial operations
Economic	Small-scale catches Labor as opposed to capital intensive activity Owner of boat and/or fishing capital personally involved in fishing operation Clear sexual division of labor, e.g. fishers are men, and processors and traders frequently are women Dependence on external inputs (general credit, boats, sails, motors, motor oil, petrol, spare parts), middlemen, and markets Fluctuating production and incomes linked to variations in natural fish stocks as well as man-made factors (markets and prices, availability of inputs) Combination of commercial production for sale and production for home consumption Diversified economic survival strategy combining fishing and agricultural activity Lower general standards of living in fishing communities than in other rural areas
Geographic and Demographic	Work out of scattered decentralized settlements along coastal and inland water areas Geographic mobility to follow seasonal migration of fish Higher fertility and population growth
Resource Access and Institutions	Fishery resources generally treated as common property Rarely open-access. Some type of regulation of access through informal rules and institutions

Figure 2.1 Characteristics of SSF and fishing communities in Africa

Retrieved from Marquette et al., 2002 as adapted by (Groeneworld, 1994; Hviding & Jul-Larsen, 1995; Overa, 1998; Chaboud & Charles-Dominique, 1991; Satia, 1993; Smith, 1997)

2.4 Importance of Small-Scale Fishing

2.4.1 Economic growth at the National Level

SSFs serve as foreign exchange for many countries involved in the sector, and their contribution to domestic economies cannot be underestimated. International trade from fishery has snowballed, and export values have risen from US$ 15 billion in 1980 to US$ 56 billion in 2001(FAO, 2007). Developing countries exports of fish increased by 40% to 50% during the same period from US$

4 billion to almost US$ 18 billion (FAO, 2007) with imports concentrated United States, Europe and Japan, with developed countries absorbing 80% of total world imports and these earnings increase economic growth (FAO, 2007). In Ghana, the SSF sector contributes about 3% to the national GDP and generates $341 million annually (USAID). SSF has multiplier and GDP effects on national economies by generating taxes and income for social and infrastructure development (FAO, 2007). SSF can make national-level contributions to economic growth by developing a wide range of taxes such as income tax and employment tax (e.g., social employment taxes, an excise tax on imports and exports, value-added tax, among others) (FAO, 2007).

2.4.2 Provision of Employment and Income to Millions

The SSF sector is a crucial element of the livelihood of the poor, and it contributes to poverty alleviation through the generation of wealth and income. According to the FAO report in 2015, about 120 million people, around 12% of the world's population, depend on fishery for survival. However, 90% are into SSF, where half are women who engage in processing and trading activities providing employment and income for households (Béné, 2006). SSFs' contributions to the household economy are much more modest, and the revenue generated may be sufficient to maintain the home at their current standard of living (Béné, 2006). In most developing countries, SSF is a welfare function where access to water resources is free or at a low entry cost, allowing household members to engage in the activity.

Many millions of people are also involved in temporary fishing activities where fishing is part of multi-activity livelihood strategies developed either at the individual or family level. Most West African villages on the coast or in the vicinity of inland rivers (e.g. Cameroon, Burkina Faso) or lagoons (e.g. Benin, Ivory Coast) do fishing occasionally but combine other activities such as farming, household or agricultural commitments occupying (Béné, 2006). In Africa, men are engaged in seasonal fishing along inland lakes and rivers, alternating this activity with other agricultural jobs. For example, In the Tonle Sap Lake area in the Mekong Basin, hundreds of thousands of households share their time between fishing activity, operated on the open water of the lake and the fringing floodplains during the rainy season, and the cultivation of rice paddy and other subsistence and cash crops during the rest of the year (Béné, 2006). It is practically impossible to find any article, report or document discussing SSFs that do not start by re-asserting how many of the world's SSFs are. FAO (1997) projected that during the two decades 1970 – 1990,

the total number of fishers with those involved in marine and inland capture fisheries and aquaculture- more than doubled, increasing from 12.5 to 29 million. Another approximation for the same period is Pomeroy and Williams (1994), who projected that 14– 20 million people were liable on SSFs for their livelihoods during the 1990s. The difference between the two estimates may prove that fish farmers were included in the FAO estimation. More recently, the FAO bent another estimate. It was specified that worldwide, about 35 million persons are involved in catching and fish processing, 75–80 percent of which are related to artisanal and small-scale capture fisheries (FAO, 2001). Over the years, employment in the SSF sector has increased tremendously based on the projections made in the last two decades since 1970-1990, /fishers in the marine and inland sector have risen from 12.5 to 29 million. This projection shows how millions of people rely on the SSF sector for their livelihood support. This estimate grows faster from the narrative than the world's population (Pomeroy and Williams, 1994).

In Ghana, the SSF sector employs 80% of fishers, and most fishers are men. Still, women play an essential role in the industry through fish preservation and marketing. As a whole, the fisheries sector of Ghana employs about 2.4 million individuals or 10% of the population (USAID). According to McGoodwin (2001), nearly 95 percent of the world's fishers are SSFs. There are more than 20 million primary producers globally plus another 20 million small-scale processors, marketers and distributors, adding approximately 40 million people wide-reaching who are directly employed in the small-scale sector (Béné, 2006).

As shown, figure 2.2 below demonstrates the number of fishing starting from 1995 to 2018. It shows that the number of fisheries around the world has risen every year and that from 1995 to 2018, there is a gradual increase in fisheries. It seems that fishing is playing a significant role worldwide.

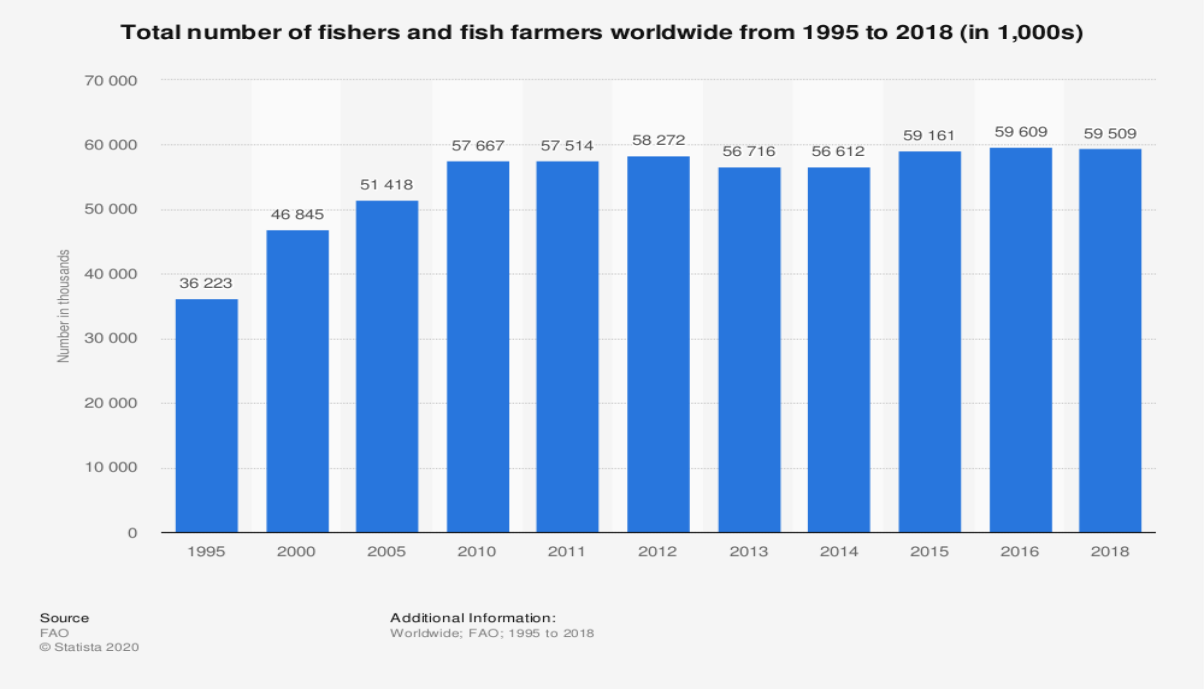

Figure 2.1 Total number of fishers and fish farmers worldwide from 1995-2018

2.4.3 Food Security and Poverty Alleviation

Worldwide, more than 1 billion people rely on fish as an essential source of animal proteins, especially where other animal protein sources are scarce or expensive. In East Asia and Africa, fish is vital. It supplies more than 50% of the animal protein intake in the diet of the 400 million living in some of the poorest countries of the world (Gambia, Ghana, Equatorial Guinea, Indonesia, Sierra Leone, Togo, Guinea, Bangladesh, the Republic of Congo and Cambodia) (Béné, 2006). At the global level, fish consumption has doubled since 1973, and the developing world has been responsible for over 90% of this growth, with small-scale fishing been a significant contributor.

According to Béné (2006), nutritionally, fish is the primary source of animal protein globally and in Ghana. More than half the human population (56%) derives at least 20% of its animal protein intake from fish. It provides various vitamins and minerals, including phosphorus, magnesium, selenium and iodine (Béné, 2006). FAO (2002) estimated that fish provides about 19% of the protein intake in developing countries. Fish consumption as an animal protein consumption can exceed 25% in many emerging countries and reach 90% in small island states and isolated parts of coastal or inland areas (FAO, 2012).

The growth of fish consumption in poorer countries has increased rapidly in recent decades (FAO, 2012). The contribution of SSFs to national food security is enormous because it directly contributes to household food security while also contributing to domestic local and national markets and has significant impacts on good global security (Béné, 2006). The most direct contribution of fishing activity to food security is through the consumption of household's catch which is primarily for subsistence, especially for poor people who cannot afford to buy food who depend on their catch, and this makes the difference between food security and starvation (Béné, 2006).

SSF contributes to national food security, and micro and macro mechanisms primarily determine this. Very little research exists concerning the link between SSFs and national self-sufficiency. Mainly, the capacity of a country to exploit its fish resources does not determine the nation's food security. For example, Cambodia, Peru, Vietnam, and Senegal have fish in abundance but have many undernourished adults and children (Béné, 2006). This situation is mainly a result of fish tradeoffs by nations for foreign exchange and then puts their nation's food security at risk, which is most detrimental to poor communities (FAO, 2012).

In terms of poverty alleviation, SSF has contributed to reducing poverty by providing a source of livelihood to people directly and indirectly, especially at the household level. Experience suggests that fishing and related activities have not generated high economic returns for most households involved in fishing activities (full-time, temporary or occasional fishers) in developing countries. Instead, they have helped them sustain daily livelihood preventing starvation (FAO, 2012). In areas where poor people cannot afford land acquisition for farming, inland fishing sites are relatively easy and free to access by poor people to sustain their livelihoods or gain access to paid employment (FAO, 2012). SSF can also provide a critical safety net for vulnerable households when they face a sudden decline in income or other unemployment, failed crop yield, natural disasters, wars and conflict displacing people (Béné, 2006).

2.4.4 Fish trade

The worldwide exchange of fish and fishery items has developed quickly throughout the most recent twenty years. Indeed, fish is the most vigorously exchanged food item globally and the quickest developing agricultural trade commodity on the international markets. In value terms, international trade in fishery products proceeded from US$ 6.1 billion in 1980 to US$ 56 billion

in 2001. In 1980, developing countries reported 39% of the value of exports. By 2001, they represented a large portion of the exports. Somewhere in the range of 1980 and 2001, the net receipts from fish trade by developing countries improved from US$ 3.4 billion to US$ 17.4 billion. This was a higher development rate than the increase in other agricultural commodities' net exports, for example, coffee, bananas, rice, and tea (FAO, 2002).In 2000, the equivalent of 50% of the low-income food-deficit countries' import bill for food was paid by receipts from fish exports (Delgado et al., 2003). In history, the direction of net trade by the quantity of total food fish has transformed intensely from the mid-1980s to the late 1990s. Overall, developing countries went from being net importers from developed countries (over 1.2 metric tons of food fish in 1985) to net exporters to developed countries (around four metric tons in 1997). From a macro-economic perspective, the continued significance of international trade in fishery products is quite evident. Since roughly 95% of the world fishers are engaged with limited-scope fisheries in non-industrial nations and produce 50% of the worldwide fish gets (FAO, 2002).

2.5 Climate Change and Small-Scale Fishing

The United Nations Framework Convention on Climate Change (1994) defines climate change as a change of climate which is attributed, directly or indirectly, to human activities that alter the composition of the global atmosphere and which are in addition to natural climate variability observed over comparable periods (Magawata et al., 2013). Climate change is associated with the effects of global warming, which is predicted to impact natural and human systems in various ways such as an increase in temperature, changes in precipitation, increase in flooding, changes in cyclones, increase in drought, rise in sea level and changes (Islam, 2013).

Climate change threats to human society and natural ecosystems have been a top priority since the release of the fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) in 2007. Given the fundamental role of fishing for human survival, the implications of climate change on fisheries and aquaculture are hard to ignore (FAO, 2009). It is anticipated that this will continue to be so in the decades ahead (Magawata et al., 2013)

Predictions are that an increase in precipitation is likely to cause more flooding, and those areas where precipitation decreases will cause drought. Also, sea-level may rise 18 – 59cm (IPCC,2007b) or even higher (29 – 84cm) (Bamber and Aspinall, 2013) by 2100 (Magawata et al.,

2013). Projections are that global average sea-level rise for 2090-2099 may increase or decrease. A 2mm increase in sea level is difficult to perceive unless one mainly watches for it (Salagrama, 2012). In 2019, the global mean sea level was 3.4 inches (87.6 millimeters) above the 1993 average, the highest annual average in the satellite record (1993-present). From 2018 to 2019, the global sea level rose 0.24 inches (6.1mm) (Lindsey, 2021). Sea-level rise affects fishing communities' especially coastal areas eroding shorelines and also contributes to coastal flooding. In Ghana, it is estimated that the risk of inundation based on coastal erosion estimates 2.6, 4.5 and 8.5 by the year 2050 (Prosper et al., 2017). The Average coastal erosion and shoreline loss is 0.38m per year (5, 12, 13, 14, 15, and 17) against 1.13m per year in the past 30years (USAID, 2016). Also, the rising sea level over the past 30 years is 63mm. Sea-level rise is estimated at 75–190 mm by 2100 (USAID, 2017).

Rising sea-surface temperature changes fish composition in their catches because pelagic species have descended to the lower layers from the surface due to variation in surface-water temperature (Salagrama, 2012). In the past 30 years, Ghana has had no precise data on increased sea surface temperatures; however, recent data shows an increase in sea surface temperatures by approximately 2–4°C (USAID, 2016).

According to the World Meteorological Organization (WMO) (2019), El Niño Southern Oscillation (ENSO) is one of the significant drivers of seasonal variability in both global weather and climate patterns and temperature. In Ghana, historical rainfall studies have established a link between ENSO events and the amount of rainfall received across the Volta River Basin (Mensah, 2019). The changing rainfall pattern is an essential indicator of climate change, and it has been observed that there is a decline in rainfall patterns across West Africa over the past five decades. Total annual precipitation has decreased in Ghana for the past 40 years, and the yearly reduction in yearly mean rainfall is projected at 10% (Mensah, 2019). Extreme rainfall causes floods which implies that less rainfall also leads to drought. In Ghana, excessive rain has caused flooding in 2007, 2008 and 2009 in parts of Accra, Upper East, Upper West and Northern regions, while rising temperatures have led to the drying up of some rivers in the dry season (Mensah, 2019). Generally, the impacts of climate change on small-scale fishing are manifested through various pathways, including flooding, drought, sea-level rise, change in the recurrence rate and distribution of rainfall, the drying-up of rivers and receding of water bodies (Mensah, 2019). Climate change is

projected to broadly impact ecosystems, societies and economies, increasing pressure on all livelihoods and food supplies, including those in the fisheries sector.

Table 2.1 below indicates climate change stressors and risks on SSFs in Ghana. According to USAID (2016), The SSF sector comprises marine fisheries inland, freshwater fishing in Lake Volta, Lake Bosomtwi and other reservoirs. Rising sea surface temperatures alter critical species' migratory patterns and reproductive cycles such as anchovies, sardines, tilapia, and catfish USAID (2017).

Table 2.2 Climate change stressors and risk in SSF

Stressors	Risk
Increased sea surface temperatures	A decline in the number and diversity of fish and shrimp species. Reduced freshwater fish stocks due to reduced river flows
Diminished rainfall	Loss of income and livelihoods
Rising sea level	Reduced protein intake and nutrition deficits for the human population

Source: Climate Change Risk Profile, Ghana USAID (2017).

Table 2.3 below outlines the main drivers of climate change on coastal systems and their main physical and ecosystem effects in the context of climate change (adapted from Nicholls et al., 2007). Ocean acidification, sea-level rise, sea surface temperature, waves, and currents are climate drivers that cause physical and ecosystem changes in aquatic systems.

Table 2.3 Climate change drivers and their effects on the ecosystem

Climate driver	***Main physical and ecosystem effects on coastal systems***
Ocean acidification/CO2 concentration	Increased CO2 fertilization and decreased seawater pH (or ocean acidification) negatively impacting coral reefs and other pH sensitive organisms

Sea level	Inundation, flood and storm damage, erosion, saltwater intrusion, rising water tables/impeded drainage, and wetland loss (and change)
Sea surface temperature	Increased stratification/changed circulation, reduced incidence of sea ice at higher latitudes, increased coral bleaching and mortality, pole-ward species migration, and increased algal blooms
Waves and currents	Altered wave conditions including swell, altered patterns of erosion and accretion, and re-orientation of beach plan form
Cyclone frequency	Altered surges and cyclone waves, and hence the risk of cyclone damage and flooding
Cyclone intensity	Increased extreme water levels and wave heights, episodic erosion, cyclone damage, risk of flooding and defense failure
Run-off	Altered flood risk in coastal lowlands, water quality/salinity, fluvial sediment supply, circulation and nutrient supply

Source: Vulnerability and Adaptation of Fishing Communities to the Impacts of Climate Variability and Change: Insights from Coastal Bangladesh (Islam, 2013)

2.6 Impacts of Climate change on Small-Scale Fishing

As shown so far, fisheries are a fundamental component of Ghana's economic health. However, climate change heavily endangers the flourishing of this financial sector. What follows is an in-depth explanation of the impacts of climate change on SSFs.

2.6.1 Ecosystem Impacts

Climate change has physical and biological impacts by modifying the distribution of marine and freshwater species. Ecosystem productivity is reduced, habitats are destroyed, and species are

displaced (FAO, 2009). Most often, mangroves that shelter fishes got from getting crushed or changed, including fish breeding and nursery grounds (Salagrama, 2012). There is a significant impact on coral reefs, wetlands, rivers, lakes and estuaries due to sea-level rise, glacier melting, ocean acidification and changes in precipitation, groundwater and river flows. Studies on climate change impacts report severe bleaching and mortality caused by ENSO (and extreme weather events such as floods, droughts and storms). According to Graham et al. (2006), the coral population dropped from 27% to a staggering 3%, leading to the extinction of coral-feeding fish species (Mensah, 2019).

Climate change affects the seasonality of particular biological processes, altering marine and freshwater food webs, with unpredictable consequences for fish production. Increased risks of species invasions and the spreading of vector-borne diseases provide additional concerns (FAO, 2009). High temperatures result in losses of about 15-59% of cool and cold water bodies (fish habitat), which is likely to cause fish habitat loss, annihilation, and extinction of aquatic organisms (Mensah, 2019). In the case of Ghana, historical record of the climate of Lake Volta showed that the mean temperature of 29.8°C and averaged between 31.0°C at the top and 29.3°C near the bottom with a rise in sea surface temperature leading to a 50% fluctuation in the biomass of zooplankton in the Gulf of Guinea (Mensah, 2019).

2.6.2 **Impacts on livelihoods/Livelihood Assets**

Climate change impacts are felt in the natural, physical, financial, social and human capitals, forming the basis of SSF communities' livelihoods. Without these capitals, SSF communities have no livelihood/livelihood asset. Climate change alters fish distribution, species composition and habitats, which require changes in fishing practices and aquaculture operations.

2.6.3 **Impacts on natural capital**

Fish ecosystems and water resources form the natural asset and capital of SSF communities globally because these biological systems produce the fish that sustain their lives and livelihoods. An alteration in the natural capital by climate change impacts makes SSF communities vulnerable. Climate change has already extended from aquatic ecosystems to dependent people in some areas, and that the effect on ecosystems affects fish to catch and livelihoods (Magawata et al., 2013). Significant ecological and biological changes to aquatic ecosystems and fish populations happen following changes in water temperature, precipitation, wind velocity, wave action, sea level,

dissolved oxygen concentration, and pH levels (IPCC, 2007). Changes in the environmental conditions of fishes in oceans, estuaries, coral reefs, mangroves, and seagrass beds generate complex and inter-related impacts on fish distribution, productivity, and species composition (Islam, 2013). Water temperatures, acidification, and sea-level rise threaten fish productivity and effects Mangroves and seagrass, breeding and nursery grounds for aquatic species (Islam, 2013). Patz et al. (1994) indicated in their research that an increase in sea surface temperature could trigger toxic marine algal blooms (such as dinoflagellates) that can cause red tides (Islam, 2013). Increases in extreme weather (and climatic) events, such as floods, may raise fish yields because seasonal flooding is a significant driver/determinant of biotic (fish) productivity. In contrast, drought dry-up of lakes induces low production and decreases fish catch rates (Mensah, 2019).

2.6.4 **Impacts on physical capital**

The physical capital of SSF communities includes houses, fish landing sites, boats and gears, public infrastructure and services. Sea-level rise, cyclones, and floods impact fish ecosystems leading to low harvest and destroy the physical assets and capitals of SSF poor communities (Islam, 2013). Extreme climate events can disrupt transport, market centers and fish processing centers, problematic for SSFs in developing countries with limited market power. For example, 90% of traps and 5% of Jamaican fishers' boats were destroyed by Hurricane Gilbert in 1998, resulting in a loss of revenue and a high repair cost. In 1998, Peruvian rural fishing communities could not access their usual markets due to disruption of road communications by heavy rain. In Akateng, an SSF community in Lake Volta, Ghana, extreme storm and ocean current rise destroys fishing boats and gears of many fishers' communities, including physical assets like school buildings, marketplace, and eroding shorelines (Mensah, 2019). This type of impact may ultimately result in a displacement of peoples, creating a need for many families' resettlement (Islam, 2013).

2.6.5 **Impacts on social capital**

SSF communities are bound by social norms, social institutions and beliefs which they cherish. An alteration in these social systems will impede their way of life and their relationship with each other (Magawata et al., 2013). Conflict is bound to happen when climate change leaves SSF communities with little fish stock, which may harm the relationships, cohesion, trust, solidarity and informal institutions in fishing communities (Islam, 2013). Revered laws and institutional beliefs relating to fishing in small-scale fishing communities are bound to be broken by the fish scarcity that sustains these communities' livelihoods (Failler and Ayoubi, 2012). People will

disrespect laws because they have to survive. Also, increased extreme weather events may disrupt social networks and lead to losing lives and properties. For example, in 2020, 5 people lost their lives in Jemeni in Lake Volta due to harsh weather conditions, which caused the vessel to overturn (A report by Jonathan Ofori, Daily Mail GH, 2020)**.** Several deaths have occurred across SSF communities in Lake Volta due to extreme climate conditions (A report by Starrfm Gh, Ghanaweb, 2020). Also, in 1991 the cyclone Gorki killed 150,000 people across coastal Bangladesh, resulting in the deaths of relatives and friends of many households across the Bay (Islam, 2013).

2.6.6 **Impacts on financial and Human Capital**

Ultimately, any impacts of climate change on other capital assets have financial consequences. Climate change is frequently cited as a cause of declining stock abundance and catches and subsequent reductions to net revenue of SSF households deepening the poverty level (Islam, 2013). SSF communities lose financial capital as they incur costs due to damage to physical capital such as infrastructure, fishing boats and gear. Also, in extreme cases of migration and resettlement, SSF communities will incur extra costs (FAO, 2010). In addition, fishing cost increases when fishers travel far offshore to catch fish because of low catch due to climate change. Finally, closure or reduction of fisheries-related activities during adverse weather conditions may incur a loss of revenues (FAO, 2010).

In terms of impacts on human capital, loss of life can be the most dangerous impact of increased extreme events that can affect other household members' economic and social activities (Islam, 2013). Climate change can cause physical injuries, disability due to shocks and stress, which reduces the physical ability of fishers to pursue their livelihoods. Climate change impacts can result in malaria and diarrhea due to drought or exposure to polluted environmental conditions. Shellfish poisoning can cause diarrhea due to the rise in sea temperatures. Also, Sea-level rise and higher levels of land erosion, cyclones and flooding can damage educational institutions and health facilities, limiting access and reducing the Capacity of SSF community members to pursue livelihood activities (Islam, 2013).

The impacts of climate change on small-scale fishing assets, strategies, institutions, policies, and outcomes can make fishing communities vulnerable by affecting their adaptive capacity, adaptation, and resilience.

For example, as demonstrated in figure 2.3 below, the projections of the impacts of climate change on the human and financial capitals are that in Africa, by 2020, between 75 and 250 million people are likely to be exposed to increased water stresses due to climate change. Financially the cost of adaptation could amount to 5% to 10% of GDP in Africa.

Table SPM.2. Examples of some projected regional impacts. {3.3.2}

Africa	• By 2020, between 75 and 250 million of people are projected to be exposed to increased water stress due to climate change. • By 2020, in some countries, yields from rain-fed agriculture could be reduced by up to 50%. Agricultural production, including access to food, in many African countries is projected to be severely compromised. This would further adversely affect food security and exacerbate malnutrition. • Towards the end of the 21st century, projected sea level rise will affect low-lying coastal areas with large populations. The cost of adaptation could amount to at least 5 to 10% of Gross Domestic Product (GDP). • By 2080, an increase of 5 to 8% of arid and semi-arid land in Africa is projected under a range of climate scenarios (TS).
Asia	• By the 2050s, freshwater availability in Central, South, East and South-East Asia, particularly in large river basins, is projected to decrease. • Coastal areas, especially heavily populated megadelta regions in South, East and South-East Asia, will be at greatest risk due to increased flooding from the sea and, in some megadeltas, flooding from the rivers. • Climate change is projected to compound the pressures on natural resources and the environment associated with rapid urbanisation, industrialisation and economic development. • Endemic morbidity and mortality due to diarrhoeal disease primarily associated with floods and droughts are expected to rise in East, South and South-East Asia due to projected changes in the hydrological cycle.
Australia and New Zealand	• By 2020, significant loss of biodiversity is projected to occur in some ecologically rich sites, including the Great Barrier Reef and Queensland Wet Tropics. • By 2030, water security problems are projected to intensify in southern and eastern Australia and, in New Zealand, in Northland and some eastern regions. • By 2030, production from agriculture and forestry is projected to decline over much of southern and eastern Australia, and over parts of eastern New Zealand, due to increased drought and fire. However, in New Zealand, initial benefits are projected in some other regions. • By 2050, ongoing coastal development and population growth in some areas of Australia and New Zealand are projected to exacerbate risks from sea level rise and increases in the severity and frequency of storms and coastal flooding.
Europe	• Climate change is expected to magnify regional differences in Europe's natural resources and assets. Negative impacts will include increased risk of inland flash floods and more frequent coastal flooding and increased erosion (due to storminess and sea level rise). • Mountainous areas will face glacier retreat, reduced snow cover and winter tourism, and extensive species losses (in some areas up to 60% under high emissions scenarios by 2080). • In southern Europe, climate change is projected to worsen conditions (high temperatures and drought) in a region already vulnerable to climate variability, and to reduce water availability, hydropower potential, summer tourism and, in general, crop productivity. • Climate change is also projected to increase the health risks due to heat waves and the frequency of wildfires.
Latin America	• By mid-century, increases in temperature and associated decreases in soil water are projected to lead to gradual replacement of tropical forest by savanna in eastern Amazonia. Semi-arid vegetation will tend to be replaced by arid-land vegetation. • There is a risk of significant biodiversity loss through species extinction in many areas of tropical Latin America. • Productivity of some important crops is projected to decrease and livestock productivity to decline, with adverse consequences for food security. In temperate zones, soybean yields are projected to increase. Overall, the number of people at risk of hunger is projected to increase (TS; *medium confidence*). • Changes in precipitation patterns and the disappearance of glaciers are projected to significantly affect water availability for human consumption, agriculture and energy generation.
North America	• Warming in western mountains is projected to cause decreased snowpack, more winter flooding and reduced summer flows, exacerbating competition for over-allocated water resources. • In the early decades of the century, moderate climate change is projected to increase aggregate yields of rain-fed agriculture by 5 to 20%, but with important variability among regions. Major challenges are projected for crops that are near the warm end of their suitable range or which depend on highly utilised water resources. • Cities that currently experience heat waves are expected to be further challenged by an increased number, intensity and duration of heat waves during the course of the century, with potential for adverse health impacts. • Coastal communities and habitats will be increasingly stressed by climate change impacts interacting with development and pollution.

Figure 2.3 Examples of global impacts for climate changes

Source: Climate Change 2007 Synthesis Report, IPCC.

2.7 Vulnerability to Viability (V2V)

2.7.1 2.6.1 Vulnerabilities of Small-Scale Fisheries

The impacts of climate change are predicted to create several vulnerabilities for SSFs. The concept of vulnerability has its roots in studying natural hazards and poverty (Janssen and Ostrom, 2006). Today, the idea of vulnerability is included in ecology, public health, and disaster management, which causes variations in vulnerability. In the environmental change literature, vulnerability is defined in different ways. Table 2.4 demonstrates various definitions of vulnerability by scholars.

Table 1.4 Definitions of Vulnerability

Definitions	***Sources***
"The likelihood that an individual or group will be exposed to and adversely affected by a hazard. It is the interaction of the hazards place with the social profile of communities."	Cutter (1996, p. 532)
"The exposure of individuals or collective groups to livelihood stress as a result of the impacts of such environmental change."	Adger (1999, p. 249)
"The ability or inability of individuals and social groupings to respond to, in the sense of cope with, recover from or adapt to, any external stress placed on their livelihoods and well-being."	Kelly and Adger (2000, p. 328)
"The characteristics of a person or group and their situation that influence their capacity to anticipate, cope with, resist and recover from the impact of natural hazards."	Wisner et al. (2004, p. 11)
"The exposure of groups or individuals to stress as a result of climate variability and change."	Allison et al. (2005, p. 3)
"The degree to which a system is susceptible to and unable to cope with, adverse effects of climate change, including climate variability and extremes."	IPCC (2007a, p. 883)
"The propensity or predisposition to be adversely affected."	IPCC (IPCC, 2012, p. 5)

Vulnerability can be attributed to somebody or something (e.g., the small-scale fishers/fisheries) as an object, and the definitions are focus mainly on vulnerability's social and social-ecological dimensions. Global climate change research views vulnerability as an integrative measure of

threats to natural and social science systems. Combining the natural and social science perspectives, IPCC (2007) defines vulnerability to climate change as the degree to which a system is susceptible to and unable to cope with adverse effects of climate change, including climate variability and extremes (Islam, 2013).

McGregor (2008) defines vulnerability as the absence of well-being. Its three aspects typically characterize well-being: material, relational, and subjective which can influence vulnerability within a specific context like SSF (Berkes & Nayak, 2019).

Bebbington (1997, 1999) says vulnerability can be seen as resulting from a lack of access to capital assets (human, physical, natural, social, and financial). Vulnerable people can cope and navigate vulnerability and access capital or resources (Berkes and Nayak, 2019).

On the other hand, IPCC (2007) sees vulnerability as a function of the character. Thus, the magnitude and rate of climate change to which a system is exposed, its sensitivity, and adaptive capacity are shown in figure 2.4 (Islam, 2013). In this definition, the more a system is exposed and sensitive to climate change components, the more vulnerable the system whiles adaptive capacity decreases vulnerability (IPCC, 2007). Thus (+) sign means an increased level of vulnerability, and the (-) sign means a reduced level of vulnerability.

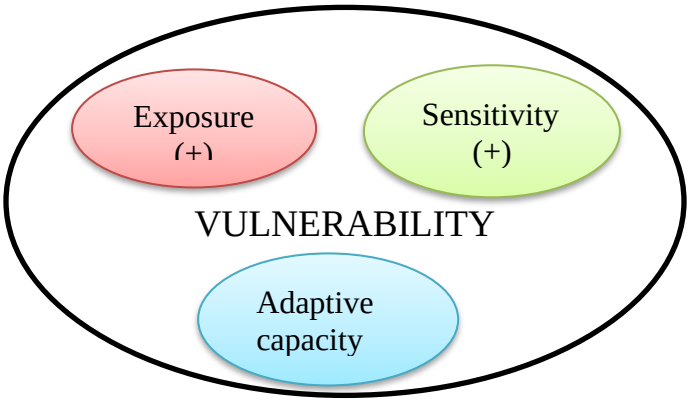

Figure 2.4 The Concept of Vulnerability

According to Adger (2006), vulnerability derives from stress with changes in all aspects of ambition and social and adaptive capacity (Dessai and Hulme 2004). According to Chambers (1989), vulnerability refers to "exposure to contingencies and stress, and difficulty in coping with

them" (Béné, 2006). On the other hand, vulnerability comes from a loss of resilience, and a reduced resilience increases the vulnerability of a system (small-scale fishing) (Berkes & Nayak, 2019).

In the context of SSF, fishing is, by nature, an unpredictable activity because there are fewer guarantees that fishers will catch more fish, and its vulnerability is seen as multi-dimensional, complex, highly active, and relative. For this reason, to capture its complexity, the study of SSF's vulnerability needs to be highly interdisciplinary and trans-disciplinary (Berke & Nayak, 2019). According to these authors, SSF communities are vulnerable because they are exposed to various climate change components. That vulnerability can be analyzed as an everlasting problem. The IPCC (2001) defines exposure as the "nature and degree to which a system is exposed to significant climatic variations" (Islam, 2013). SSF communities' exposure to different shocks and stresses such as rise in temperature and sea level, cyclones, floods, land erosion and droughts makes them vulnerable because repeated exposure can result in the loss or destruction of SSF communities' resources or capitals (Islam, 2013). Also, high exposure to changes in macro-economic factors (e.g. fuel and input price, fish price) and increased exposure to conflicts with other users makes SSF communities vulnerable, affecting their livelihoods and leading to poverty.

Furthermore, Williams et al., 2002 disclose that women in the fisheries sector may be more disadvantaged and vulnerable than men, and certain forms of social marginalization (Béné, 2006). The vulnerabilities of SSF communities come in several states.

Berkes & Nayak (2019) identified the dimensions of vulnerability and their resulting vulnerabilities of SSF in table 2.5 below. From the table, ecological problems result in shrinkage in lagoon fishing areas and fish diversity, economic crises result in loss of primary income, increased indebtedness, and social turmoil resulting in a breakdown of family ties and migration.

Table 2.5 Dimensions of the vulnerability of SSFs

Areas of vulnerability	***Resulting vulnerabilities***
Ecological Problems **Economic crisis** **Physical resources**	• Loss of primary income and increased indebtedness • Lack of asset holding • Decline in quality and quantity of food - food insecurity • Pollution and adverse ecological changes • Shrinkage in lagoon fishing area and fish diversity

	• Protracted court cases, extraordinary financial implications • Fishing is capital intensive, therefore, unaffordable • Migration – income is not financially rewarding
Social crisis **Economic dependence** **Political issues**	• Breakdown of joint family/family support system • Increased dependence on external market • Increase in inter-village conflicts • Competitive fishing practices – unsustainable fishery • Encroachment – lack of access to fish stock and fishing grounds • Migration – family members forced to live separately • Migration – long absence weakens fishing rights • Loss of political voice
Individual and **community level**	• Loss of customary skill sets and knowledge • High dropout from school and low enrolment • Fishers turned wage laborer's from entrepreneurs • Non-fishing activities disconnect fishers • Fishers find it challenging to return to fishing after migration • Adverse mental and physical health conditions

In dealing with vulnerability, concepts would be drawn from research on V2V. V2V has three dimensions well-being, capital, and resilience. Paying attention to resilience, livelihood capital, and well-being leads to the long-term viability of SSF.

2.8 Dimensions of Vulnerability

2.8.1 Resilience

According to (Walker et al. 2004), resilience is defined as the capacity of a system to absorb disturbance and reorganize while changing to retain essentially still the same function, structure, identity, and feedback. Resilience provides the ability to absorb shocks while maintaining integrity. When change occurs, resilience provides renewal and reorganization (Gunderson and

Holling 2002, Berkes et al. 2002). Vulnerability is the opposite of resilience: when a social or ecological system loses resilience, it becomes vulnerable to change that could be absorbed (Kasperson and Kasperson 2001a). Gunderson and Holling (2002) argue that resilience is not defined as the amount of time a system takes to return to an initial stable state but rather as the capacity of a system to absorb changes without shifting into an alternate form (Blythe, 2014). Working for resilience enhances the likelihood of sustainable development in changing environments where the future is unpredictable and surprise is likely. In a resilient system, change can create an opportunity for growth, novelty and innovation (Levin et al. 1998, Holling 2001). Resilience provides a valuable framework for understanding the climate change vulnerabilities experienced by fishing communities, the challenges to building resilience, and the nature of adaptive governance responses needed to address the concept.

Resilience theory emerged as a new form of thinking that challenges the earlier view of systems as orderly, static, and can obtain a state of equilibrium (Botkin 1990). Resilience theorists like Gunderson and Holling (2002) argued that methods are not fixed but undergo a complex change process through chaos and order (Blythe, 2014). Building resilience is a method for managing vulnerability. The adaptive capacity to adapt and conform to stresses brought about by social, political, economic, and natural changes and the loss of fishing community resilience result from vulnerability (Berkes & Nayak, 2019). Diminished resistance expands a community's vulnerability to lesser unsettling influences that it could already adapt to (Walker et al., 2004).

Consequently, improving community resilience is viewed as necessary as fishing communities far and wide face different and new risks that change the idea of communities themselves (Berkes and Nayak, 2018). It is a matter that vulnerability cannot be disposed of or limited: this prompts the need to live with change and fragility. To this end, Berkes, 2007, underscores the methodology of diminishing vulnerability by building resilience. However, the significant concerns are the resources needed to build resilience through enhanced adaptive capacity and knowledge co-production (Nayak and Berkes, 2019).

2.8.2 Livelihood Capitals

The concept of livelihood has received much attention over the last few decades to conceptualize and analyze people's means of living. Chambers and Conway (1992) describes livelihood as comprising of the capabilities, assets (stores, resources, claims and access) and activities required

for a means of living: a livelihood is sustainable when it can cope with and recover from stress and shocks, maintain or enhance its capabilities and assets, and provide sustainable livelihood opportunities for the next generation; and which contributes net benefits to other livelihoods at the local and global levels and in the short- and long-term (Islam, 2013). The concept of a livelihood' seeks to bring together the critical factors that affect individual or family survival strategies' vulnerability or strength (Wunder, 2001).

In an SSF context, livelihood encompasses the individual or household assets, the activities and strategies they are engaged in, and the processes that mediate access to resources, activities, and systems to generate livelihood outcomes. The livelihood assets of SSF communities can be grouped into five categories known as five capital assets: Natural, physical, human, financial and social capital (See figure 2.5 below), and these form the fundamental basis of resilience (Islam, 2013).

2.8.2.1 **Natural Capital**

Satia and Townsley (2004) describe natural capital as the natural resources such as fisheries resources like fish stock and aquatic habitats, ecosystems, and non-fisheries resources like land and fresh water for drinking, which SSF communities depend on or can depend on (Islam, 2013).

2.8.2.2 **Physical Capital**

Physical capital includes physical infrastructure and tools or equipment used to support livelihoods. These include fisheries resources such as fish landing centers, gear stores, ice plants, boats, engines, nets, processing equipment; non-fisheries resources such as roads, dams, houses, schools, markets, hospitals, water supply systems and cyclone shelters (raised concrete structures that protect from wind and flood) (Allison and Ellis, 2001; Satia, 2004; Townsley, 2004). However, most SSF communities lack proper roads and health and educational services (Islam, 2013).

2.8.2.3 **Human Capital**

Human capital is essential to effectively using the other four types of capital. Human capital includes knowledge, skills and health. These have education levels, fishing skills and physical ability to work (Satia, 2004; Townsley, 2004).

2.8.2.4 **Financial Capital**

Financial capital includes available stocks such as cash, bank deposits or liquid assets (livestock and jewelry) and regular money inflows such as remittances. In short, this consists of all financial resources people in SSF communities utilize to make a living (DFID, 1999). Most SSF communities in developing countries are considered vulnerable due to their low-income levels, and access to credit and insurance is problematic (Mills et al., 2011).

2.8.2.5 **Social Capital**

DFID (1999) describes social capital as social resources such as networks and relationships to achieve livelihood objectives (Islam, 2013). Community-based organizations (CBOs), fishers associations, political parties are formal examples of social capitals. On the other hand, kinship and family ties are informal social capitals that enable SSF communities to build collective actions and act together more effectively to pursue shared objectives (Islam, 2013). Adger (2003) reveals that SSF communities use social capitals to respond and build resilience better to the impacts of climatic shocks and stresses (Islam, 2013).

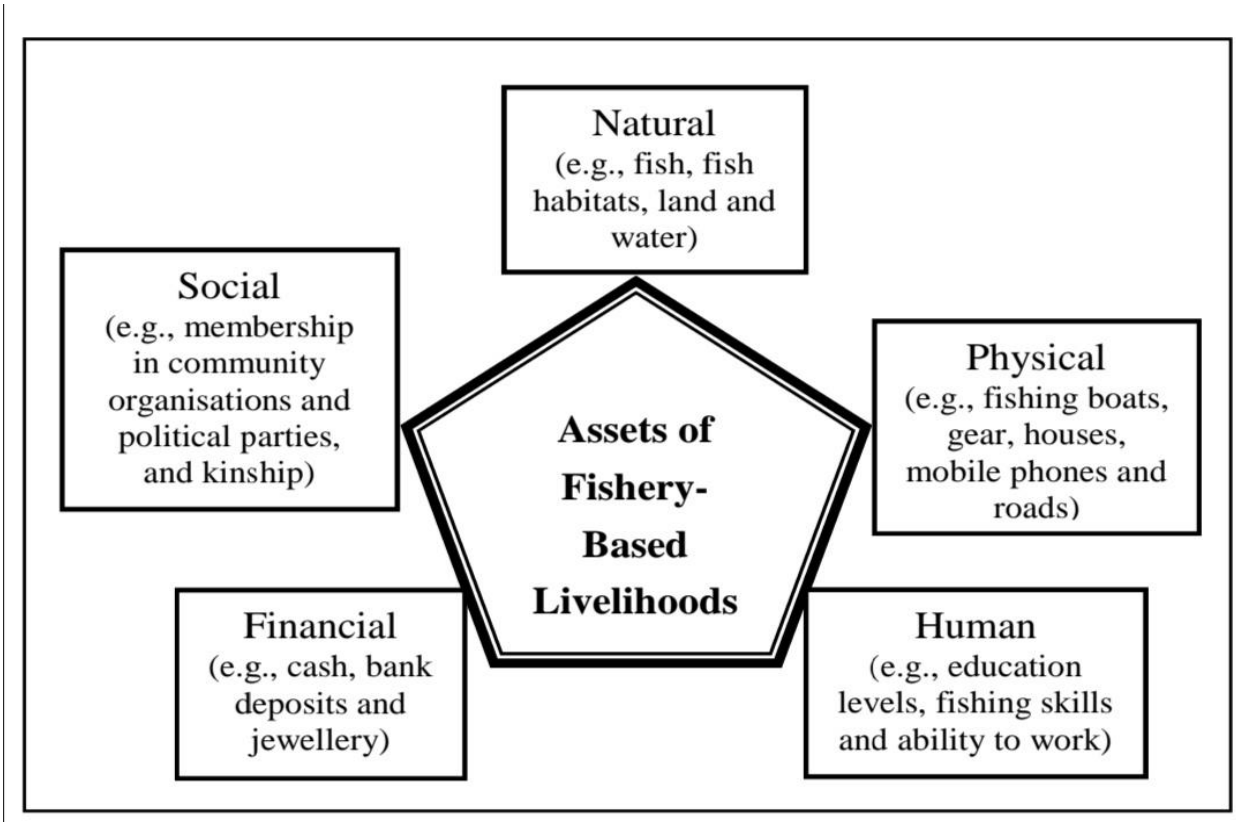

Figure 2.5 Livelihood capital assets of SSF community.

2.8.3 Wellbeing

The concept of well-being provides a comprehensive frame for understanding what is essential to people, communities and society. Figure 2.6 wellbeing describes how individuals think about what they possess, feel about what they can do and how admittance to assets is facilitated through social bonding and structures (modified from McGregor, 2008). Notably, the Research Group on Wellbeing in Developing Countries (WeD) defines social wellbeing as a three-dimensional view focusing on material, relational, and subjective components of well-being (Kahneman and Krueger 2006).

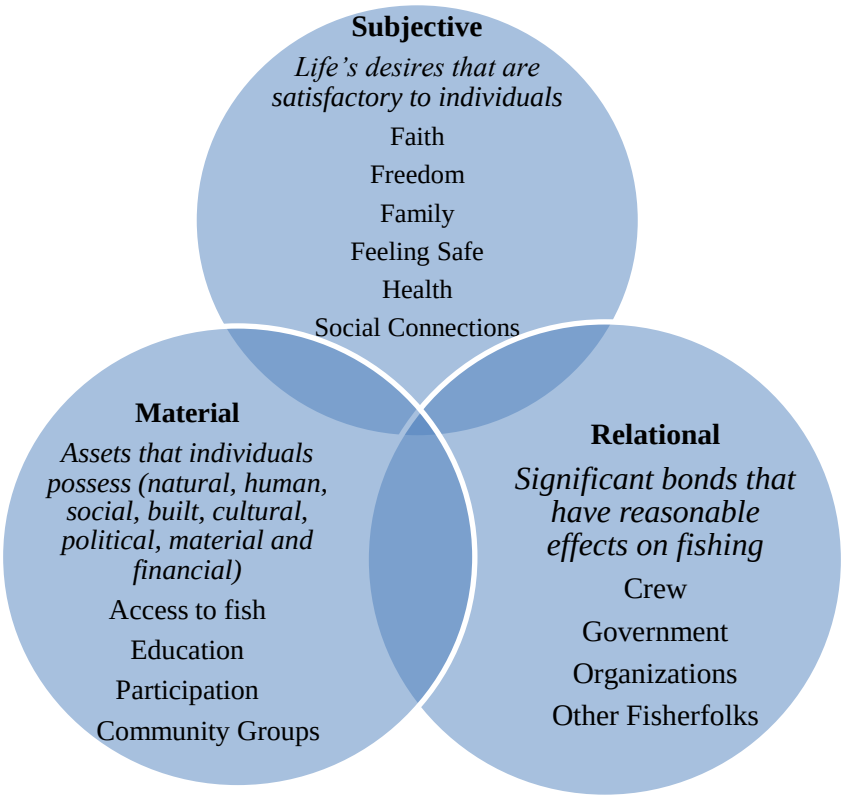

Figure 2.6 *Dimensions of wellbeing*

2.8.3.1 **Material**

Material wellbeing encompasses practical welfare and living standards such as income, wealth, assets, environmental quality and physical health. In the case of SSF communities, being materially poor does not necessarily mean an absence of wellbeing. SSF material well-being becomes a success story when there is an increase in financial capital. These are considered as the tangibles (and objectively verifiable) resources a person (SSF communities) has and the extent to

which their basic human needs are being met (see figure 2.6). Material wellbeing is what people have, or the objective outcomes of well-being, including material resources such as food, income, assets, shelter, employment, access to services and natural resources, and environmental quality (Coulthard et al., 2015).

2.8.3.2 **Relational**

Relational wellbeing includes human and social capital such as relations of love and care and networks of support and obligation. This concept also extends to social, political, and cultural identities, including links to the state's organs and formal structures, determining the scope for personal action and influencing the community. It encompasses what people do, how they interact with others, meet their needs, achieve a good quality of life, and how relationships can inhibit well-being.

SSF communities deal with how relationships affect the interaction between people and marine resources and social relations on fishing behaviour (McGregor, 2008). This focuses on interactions with others: relationships of affection, relations with the state, social institutions.

2.8.3.3 **Subjective**

Subjective wellbeing includes social and human capital. It spanned from notions of the self to individual and shared hopes, fears and aspirations, and expressed levels of satisfaction or dissatisfaction, trust and confidence (Russel, 2008). It concerns people’s subjective views and how they feel about their situation and pays attention to people’s values. White (2009) places the subjective at the apex of the wellbeing triangle because, as she argues, the meanings of the other dimensions (material and relational wellbeing) are derived through the values and interpretations of the people themselves and how they think about it (Coulthard et al., 2015).

Globally, SSF is being exposed to vulnerabilities such as access to capital, community wellbeing and reliance. A sharp decline in wellbeing will lead to an extraordinary increase in vulnerabilities (Nayak and Berkes, 2019).

Nonetheless, to achieve viability in SSF communities, there should be an increase in livelihood capitals, wellbeing, and resilience to counteract vulnerabilities. Figure 2.7 illustrates the concept of V2V. So, where there is no resilience and a decrease in wellbeing and livelihood capitals,

vulnerabilities persist. However, an increase in wellbeing, livelihood capital, and resilience ensures the viability of SSF.

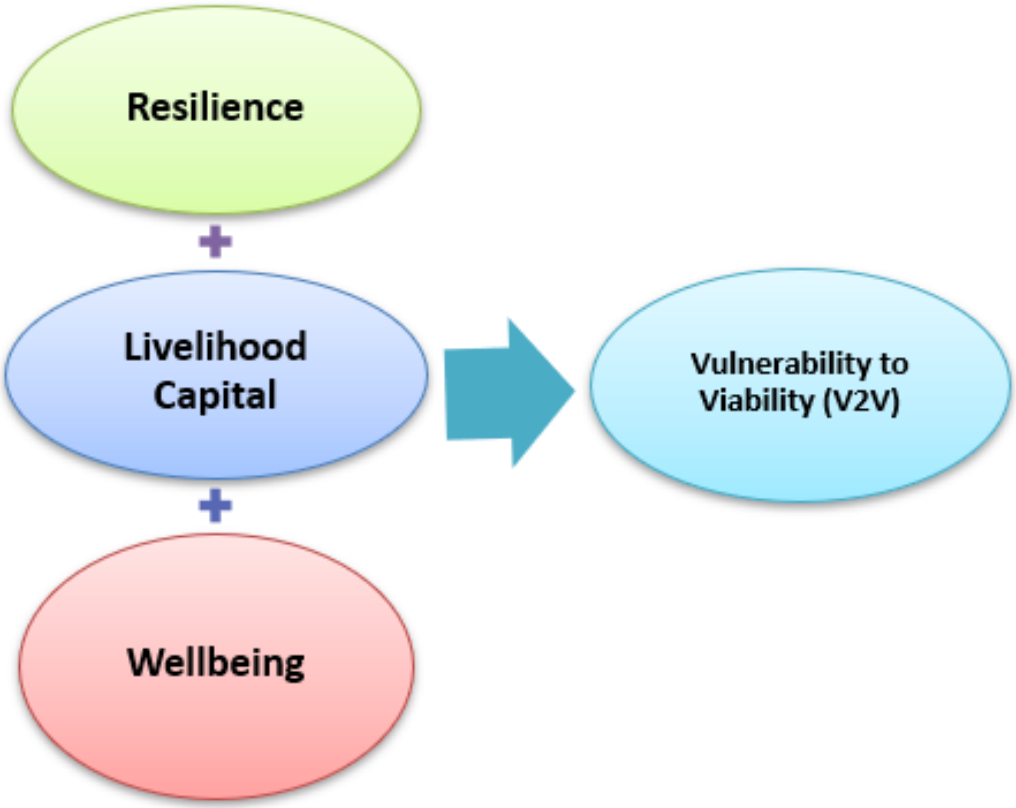

Figure 2.7 Components of Vulnerability

2.9 Community Adaptive Governance Response

The Stockholm Resilience Centre defined Adaptive governance as a developing examination system for breaking down the social, institutional, and environmental fundamentals of staggered governance, modes that effectively build resilience for the immense difficulties presented by global change and complex adaptive socio-ecological systems. According to Paul Onyango and Svein Jentoft in their research conducted in Lake Victoria, Tanzania, in 2010, the idea of interactive governance was initially brought about by Kooiman (2003) and later utilized to address fisheries issues (Kooiman et al. 2005). The term governance was customarily identified with what governments at the national level do. The government is seen as having the limit and assets to

address societal issues. In any case, the expanding acknowledgment that various social problems introduced themselves as excessively complicated for the government to manage without any help prompted social actors' consideration of governance, including stakeholders' representatives to the market and traditional society.

The theory of governance perceives two things; first, "that since governance is beyond government, it is possible to have more governance but less government, and that solutions to many societal 'wicked problems' require partnership arrangements between public and private actors" (Onyango and Jentoft, 2010, P 252); and second, perceiving that governance is larger than the administration. That is, governance includes more than the utilization of specialized instruments to address cultural issues. It likewise concerns the assurance of standards and qualities that underline how governors characterize their assignments and jobs. (Onyango & Jentoft, 2010). Individuals are increasing progressively, particularly considering climatic conditions because fisheries are transboundary assets. Hence, a multi-level method to deal with SSF viability is required. Because of the impacts of environmental change on SSF communities, there is an unquestionable requirement for robust adjustment procedures focusing on fishing communities to maximize viability.

Climate change impacts on SSF communities' exposes them to all kinds of vulnerabilities. Governments and civil society need to increase resilience to these hazards from the local to the global level. SSF communities have governance systems as part of their adaptive strategies to respond to vulnerabilities in building resilience. Historically, SSF communities have various forms of governance embedded in the fishing communities themselves (Kolding et al., 2014). Everyone who has ever lived in a village knows what it means to be part of a community. It provides a sense of security, belonging, and identity and a context of robust social control. For example, SSF communities can limit access to fishing grounds by defining who can fish and where (Kolding et al., 2014). These are traditional systems used by people to control, build capacity and resilience and govern human behaviour towards a particular ecological system towards climate change. This type of community interaction is called Community Adaptive Governance response. This involves traditional institutions, CBOs, policymakers, stakeholders, governments, Non-Governmental Organizations, representatives to the market and traditional society. Adaptive governance is a

multi-level system where broader decision-making networks comprise local, government, and private actors, including the market and civil society (Keskitalo & Kulyasova, 2009).

The concept of multi-level governance can be used to highlight the fact that decisions on resources and resource distribution, which may support adaptation and resilience, are not made at a single level only, such as the local level or the national level. Understanding governance as a multi-level phenomenon that may largely determine resources for adaptation locally may also have a considerable impact on work in community adaptation (Keskitalo & Kulyasova, 2009). Although much vulnerability assessment work has taken place at the community level to identify case-specific) determinants of vulnerability, the network and possibilities for adaptation may need to be seen explicitly in a broader perspective (see Næss et al. 2005).

A study conducted by Mohamed et al. in Malaysia, "Adapting Towards Climate Change Impacts: Strategies for Small-Scale Fishermen," in 2017 found that because climate change affects productivity, infrastructure, social lives, and health, adaptation strategies are needed to be for viability to increase. Their research argued that CBOs, policymakers, stakeholders, and governments could do the following: building up community connections; including fishers in environmental change adjustment plan; dealing with the fishing community's environmental change information; encouraging the community's learning of substitute skills, and upgrading the fishing community's access to credit. Building community connections will ensure robust security in the SSF vulnerable community when climate change occurs (Mohamed et al., 2017).

To adapt to the unending threat of climate change, SSF communities will need supporting infrastructure, increased resilience to erratic fishing seasons and extreme weather events, and, more so, access to coastal resources and different livelihoods (Allison et al., 2009). Reducing other impacts on coastal and freshwater ecosystems (pollution, habitat destruction) could also increase these resources' resilience to climate change effects.

2.10 Conceptual Framework

A system of ideas, concepts, theories, and expectations that informs and validates a research study can be termed a conceptual framework conceptual framework (Maxwell, 2005). The application of a conceptual framework is effective in any field of research and is generally employed to determine what will and will not be included in the study. This study's researcher will check the

impact of climate change on vulnerabilities of SSF communities in Lake Volta Ghana, therefore based on the above discussion following theoretical framework has been designed to conduct this study. The conceptual framework of this study is rooted in the following representation of knowledge shown in fig 2.8 below. Impacts of climate change on SSF communities result in vulnerability (loss of income, food insecurity, migration, conflict, loss of assets). However, access to resources or capitals, the wellbeing of the fishers, and resilience can potentially improve a community's adaptive responses such as social position, cultural identity, ecological security, and economic status, thereby increasing their viability. On the other hand, the absence or decline of capital or more of the three dimensions of wellbeing (material, relational, subjective) and loss of resilience triggers vulnerability which reduces the capacity of the communities to build strategies to move towards sustainability.

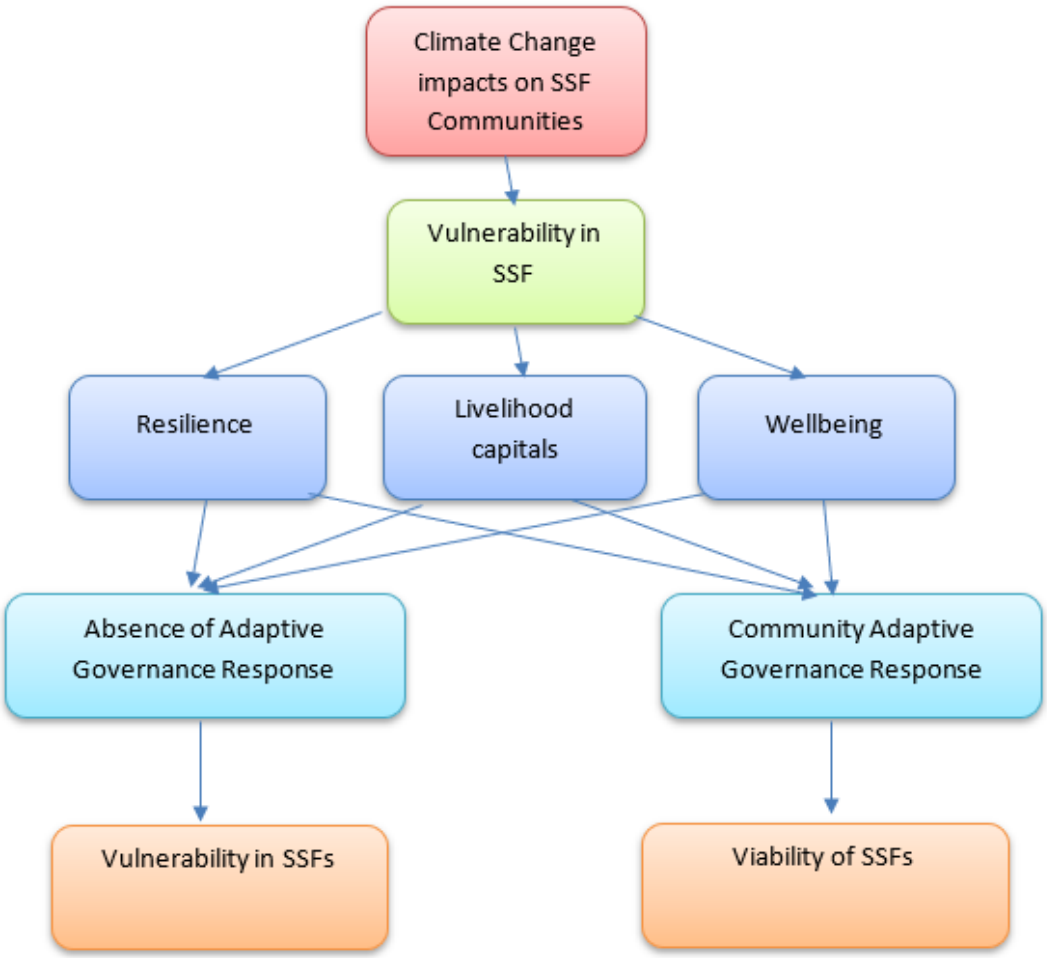

Figure 2.8 Conceptual Framework

Chapter 3

Study Area and Research Methodology

3.1 Introduction

This chapter describes Lake Volta's area under study by looking at the study profile and its social and ecological systems. The methodology follows by setting and justifying the suitability or relevance of the selected methods in connection to the research goals. The accompanying sections depict the justification for utilizing methodological strategies to design the investigation, gather and analyze the data. Additionally, the researcher will tend to the research philosophy, research approach, validity, reliability, and ethical considerations of the inquiry.

3.2 The study profile of Lake Volta, Ghana

The Volta River Basin covers an estimated 400,000 km^2 and is the ninth-largest basin in Sub-Saharan Africa (Béné, 2007). Several major rivers drain the Volta Basin: the Mouhoun (ex-Black Volta), the Nakambé (ex-White Volta), with the Nazinon (ex-Red Volta) as its tributary, the Oti River and the Lower Volta. Lake Volta is a dominant feature in the Volta Basin, covering about 4% of Ghana's total area. The Volta basin is spread over six West African countries: 43% in Burkina Faso, 42% in Ghana, and 15% in Togo, Benin, Cote d'Ivoire and Mali (Béné, 2007).

The Akosombo dam's (see fig 3.2) culmination on the Volta River in 1964 brought about making an immense reservoir (Lake Volta) with a length of 520 km and covering about 8500 km^2 or 3.2 percent of Ghana's total land zone (See figure 3.1). The reservoir is primarily used for hydro-energy production, the Akosombo dam and Kpong dam generating (1060MW) hydropower (Béné, 2007). The Akosombo hydropower dam construction led to the creation of the Volta Lake, the most significant human-made Lake globally; thus, Lake Volta is the largest human-made Lake in Africa second-largest in the world. The water level's total water supply is about 84.73m, approximately 150 billion m^3 (Béné, 2007).

About 80,000 people were resettled due to the dam's construction and several hundred villages to fifty newly built townships (more than 1% of Ghana's population at that time). In addition to the river communities' resettlement, damming affected local health, agriculture, fishing, and navigation. Aside from hydropower production, Volta Lake has other significant uses:

transportation, fishery, water supply (commercial and domestic purposes), tourism, and irrigation (Béné, 2007).

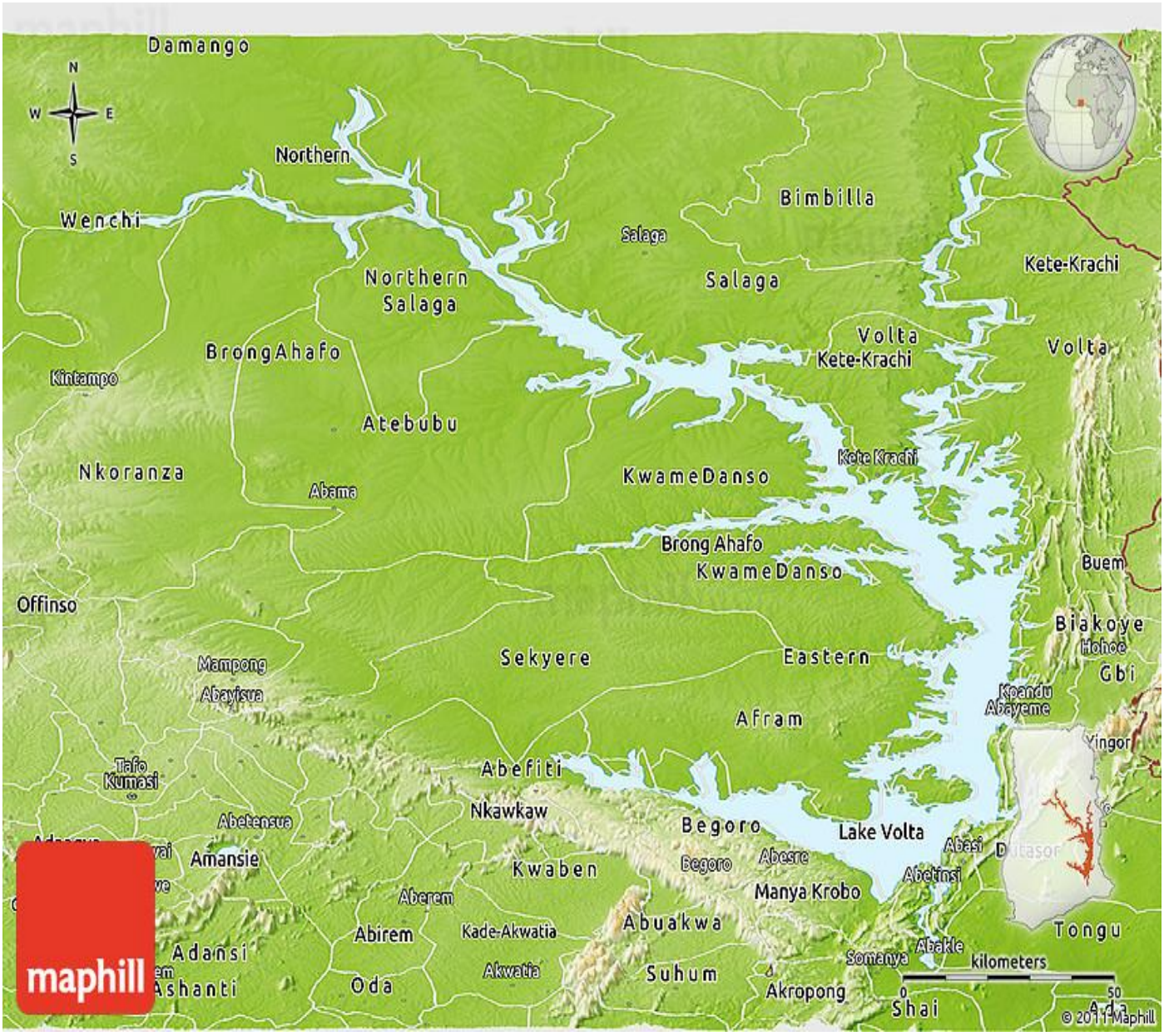

Figure 3.1 Map of Lake Volta and surrounding communities

Figure 3.2 Akosombo Dam on Lake Volta source: https://www.kulturstudier.no/blog/2013/10/11/ghana-field-trip-to-akosombo-dam-day-1/

3.2.1 Social Systems of Lake Volta.

According to Bene 2007, more than 90% of the inland freshwater fish are produced from Volta Lake. A tremendous fishing opportunity was offered by creating the Lake in 1960, and many fishers from various parts of Ghana moved into the lake area. Three hundred thousand people are estimated to depend on the Lake for their livelihood, 80,000 are fishers and 20,000 are fish processors and traders (Béné, 2007). Bene (2007) stated that fishing in the Lake is primarily artisanal, with about 17,500 canoes actively fishing in the Lake operating from approximately 2,000 fishing villages. A survey in 1970 and 1975 recorded 18,358 and 20,615 fishers and 12,074 and 13,815 canoes, respectively, in Lake Volta (Bazigos 1970, Coppola and Agadzi 1976). Landing sites in the Lake were seen to be on the rise in the early 1990s, reaching 80,000 in the late 1990s, and this increase is due to a surge in gears and for management purposes. According to

Bazigos, Coppola and Agadzi, in 1970 and 1975, the main fishing gears used in the Lake were gill nets, cast nets, lines and traps (Béné, 2007). According to Vanderpuye 1984, Fishers used gill nets ranging from 102 to 205 mm but nowadays, the most petite mesh sizes are reported to be below 25 mm (Béné, 2007). According to Braimah (1989, 1991), recently introduced gears in the past few years are primarily unauthorized and illegal on the Lake, such as and drive-in gear (locally known as Wangara), bamboo pipes (specifically for Chrysichthys spp.), combined gill nets and traps (nifa nifa), beach seines (adranyi), but currently purse seines (winch nets) contribute between 65 and 70% of the total fish landings from the Lake (Béné, 2007).

Fish is transported by boat, stuffed in boxes, to be sold later. The main weekly markets around the Lake Volta are at Buipe, Yeji, Makango, Dambai, Kwamekrom, Tapa-Abotoase, Kpandu-Tokor, Akateng, Dzemeni and Ampem. One recorder is accessible to monitor landings in any event at every one of these fundamental business sectors. A summary of arrivals from these nine business sectors was made yearly until 1977, when the project finished. Yet, no lake-wide summary has been made, and no checking of local recorders has occurred, which ultimately resulted in the data's quality deteriorating. Landing gauges generally depend on bin size and total amount. In Yeji, the project system was utilized until June 1990, after which the project system was also presented in light of bushel size and totality. At Kpandu-Tokor, the fish showing up at the market is weighed with a scale.

Yearly gauges of production from Lake Volta fisheries are founded on arrivals of prepared fish at the nine primary fish markets around the repository. Both overestimation and underestimation of all-out appearances occur. As all fish showing up at the business sectors are recorded, reusing is a wellspring of mistake as fish is introduced at the market, brought home and treated (for example, smoked), and in this way double tallied when gotten back to the market at the accompanying meeting.

Additionally, fish can be sold at an auxiliary market and introduced to be purchased again at a significant market. More extreme mistakes cause disparages. Landings in smaller markets are not considered, nor are landings at the impulsive temporary markets at landing places where transport vessels stop. Many fishers find ways of transporting their fish to the main markets in

Kumasi and Accra themselves. Consequently, not all fish passes through the central market places. Since the Lake's creation in 1964, there has been an increase in human population and anthropogenic activities such as pollution and habitat alteration, resulting in decreased fisheries resource availability and biodiversity reduction (Braimah, 1995; Ntow, 2003). Other external factors affecting the Lake Volta fishery productivity are demographic and socio-cultural transformation, industrial development, urbanization and tourism, forestry and reforestation, agricultural practices, etc.

3.2.2 Ecological Systems of Lake Volta

The Volta Lake is rich in fish fauna, and the most farmed species in the Lake is tilapia. Breeding in the Lake is perfect due to the rich diversity of flora and fauna (Agodzo, 2014). According to Robert (1967), the Lake has different fish species that, after the Lake was constructed, recorded 112 species during the pre-impoundment phase while 108 species were recorded during the filling stage; however, there are 121 species currently (Béné, 2007).

Fish species are likely to disappear due to the change from riverine to lacustrine conditions. According to Vanderpuye 1984, native fish species fill all the niches in the ecosystem, and it has not been necessary to introduce any exotic species. Changing the water from a river to a Lake changed the ecological environment, which resulted in substantial changes in the fish community structure leading to the death and depletion of fish species. This resulted in decreased fish catch, size of the fish caught, and overall scarcity of certain species (Agodzo, 2014). Species like Mormyridae almost completely disappeared during the first two years of the Lake's construction; however, thirty-six years on Tilapiine fish species has dominated commercial fishing in the Lake (Béné, 2007). It was recorded that before the Lake, the Tilapiine species were not dominant. Still, the Lake created a stabilized temperature and conditions for the new species of Tillapine to thrive in Lake.

The Ministry of Food and Agriculture (MOFA, 2003) indicated that the commercial catch composition (by weight) from 1991- 1998 comprises Chrysichthys spp. (34.4%), tilapias (28.1%), Synodontis spp. (11.4%) Labeo (3.4%) Mormyrids (2.0%), Heterotis spp. (1.5%), Clarias spp. (1.5%), Schilbeids (1.4%), Odaxothrissa mento (1.4%), Bragrus spp. (1.3%) and Citharinus spp. (1.2%). The remainders, which include Alestes spp., Brycinus spp. Distichodus spp., Gymnarchus spp. Hydrocynus spp. and Lates niloticus account for less than 1.0% of each commercial catch by

weight (Béné, 2007). According to Agodzo (2014), species like 'dzidzri' (electric fish), 'agada' (polypterus senegalus- gray bichir), 'lixe' (hepsetus odoe- kafue pike), 'eyor' (gymnarchus nilotius- aba), and 'agbogbo' (labeo senegalensis- West African carp) are challenging to come by in the Lake and that even current fish catch are smaller in size compared to those caught some decades ago (Agodzo, 2014).

3.3 **Research Methodology/Approach**

The research methodology and the methods used are based on the researcher's philosophy and worldview. The researcher adopted the pragmatic worldview as the research paradigm to gain knowledge and understanding of the research. Also, the I-ADApT framework was used as far this research is concerned to understand the various variations of adaptations, governing systems, vulnerabilities and resilience strategies that exist in small-scale fishing communities affected by climate change. A qualitative research approach was also used in gathering information for this research. A primary data collection method was not, rather, secondary data collection methods were employed due to the Covid-19 Pandemic. Under the secondary data collection method, the systematic literature review is used to collect and analyze existing literature using search engines on climate change impacts on SSF communities. The researcher used the Zotero application to organize relevant secondary data such as articles and academic research work on the topic.

3.3.1 Pragmatic Worldview and why?

In research, the approach employed is mainly determined by the researcher's worldview and the understanding of the various philosophical paradigms. As a research paradigm, pragmatism refuses to involve contentious metaphysical concepts such as truth and reality. Instead, it accepts that there can be single or multiple realities open to empirical inquiry (Creswell and Clark 2011). Pragmatist scholars have offered their particular opinion that there is an objective reality apart from human experience. However, this reality is grounded in the environment and can only be encountered through human experience (Goles and Hirschheim 2000; Morgan 2014a; Tashakkori and Teddlie 2008).

For pragmatists, the reality is accurate as it helps us get into satisfactory relations with other parts of our experiences (James 2000). Truth is whatever proves itself profitable or has stood the scrutiny of individual users over time (Baker and Schaltegger 2015; James 2000; Ray 2004). However,

there is a need to remember that pragmatism does not merely mean that "if it works, then it's true (James, 1995). Pragmatist researchers push aside philosophical arguments, particularly metaphysical ideas, and get their research done, concluding that broader philosophical views can never be solved.

As a research paradigm, pragmatism orients itself toward solving practical problems in the real world. It emerged as a method of inquiry for more practical-minded researchers (Creswell and Clark 2011; Maxcy 2003). For pragmatists, a quest—in social life and social work research—is worthwhile only if it achieves its purposes (Hothersall 2019). Pragmatists believe that we are free to believe anything we want, although some beliefs are more likely than others to meet our goals and needs (Morgan 2014a). Biesta (2010) reminds us not to merely understand pragmatism as a philosophical position but as a set of intellectual tools of value for addressing problems.

Pragmatism rejects the traditional philosophical dualism of objectivity and subjectivity (Biesta 2010). However, it allows the researcher to abandon the forced dichotomies, postpositivism and constructivism (Creswell and Clark 2011). In pragmatism, empirical is preferred over idealistic or rationalistic approaches (Frega, 2011). Rather than assigning postpositivism and constructivism in two different ontological and epistemological camps, pragmatism asks the researcher to focus on the two different approaches to inquiry (Morgan 2014b).

In this research, a pragmatic worldview is adopted because it combines both positivism and interpretivism. Reality exists and is not separate from the researcher, so the researcher needs to become a part of reality. That's why the constructivism research pattern was adopted by using a qualitative method to find the fact. In constructivism, each individual constructs their existence, so multiple interpretations are also referred to as interpretive.

The selection of pragmatism as an exploration paradigm empowers multi techniques or mixed strategies plans along these lines. A deliberate combination of qualitative and quantitative pragmatism and suggestion integrated strategies explore appropriate for investigating complex issues and matters. (Najmaei, 2016). Being a researcher, I believe that there is no single reality or truth, and therefore reality needs to be interpreted. Consequently, pragmatists are more likely to use qualitative methods to get those multiple realities, which come to light through individual interpretation.

In other words, the pragmatic worldview will help the researcher understand the vulnerabilities of climate change in SSF communities and how building resilience will increase viability.

3.3.2 I-ADApT framework

I-ADApT (Assessment based on Description and responses and Appraisal for a Typology) is a data collection tool developed by the Integrated Marine Biosphere Research (IMBeR) Human Dimensions Working Group (HDWG) (and V2V partner). Of note, seven V2V co-applicants have contributed members to understand the changes marine and fisher group systems face and how they respond to these changes to develop long-term solutions that can be applied in other jurisdictions. The design of the I-ADApT tool was based on various case studies that examined how climate change affects the social, natural, governing systems of marine systems and how marine systems respond to the effects of climate change. I-ADApT enables SSF managers, researchers and local stakeholders to (1) make decisions efficiently by capturing a full range of vulnerability dimensions, (2) improve their response promptly by engaging critical actors, and (3) evaluate where to most effectively allocate resources to reduce vulnerability, build strength and develop the capacity to enhance the viability of SSF communities.

I-ADApT framework provides for: (1) a 'descriptive' component to capture critical dimensions of vulnerability and viability (ecological, social and economic, etc.); (2) an 'appraisal' component to reflect on various responses to change and their outcomes; (3) an 'interactive' element to engage with SSF communities, deepen understanding and develop capacity; and (4) a 'typology' dimension to enable comparative assessment, learning and guidance for governance.

The I-ADApT framework was adopted for this study because of its interdisciplinary nature encompassing social and ecological systems related to fisheries and aquaculture concerning global change. As indicated in figure 3.3 below describing the process, I-ADApt helped identify relevant literature corresponding to Natural, Social, Governance systems and the type of vulnerability and response related to the case study (Lake Volta). The framework guided in selecting literature on the geographical location, ecosystem type and the main issues provided a good starting point for determining data. Also, the I-ADApT aided in gathering literature on the various forms of vulnerabilities in SSF communities and helped in its investigations.

Based on the framework, various case studies were examined with respect to governance and governability. It aided in investigating the multiple governance systems at different socio-economic levels among multiple case studies and how they apply to the case study (Lake Volta). I-ADApT ensured that literature on the socio-economic component of the case study was adequately captured since climate change impacted the capital systems of various SSF case studies. Lastly, the I-ADApT framework helped measure how responses to changes in selected study areas successfully dealt with climate change. Existing literature was analyzed to see the success of their adaptive responses to livelihood impacts caused by environmental changes. I-ADApT tool helped in the development of the typology based on the finding and results.

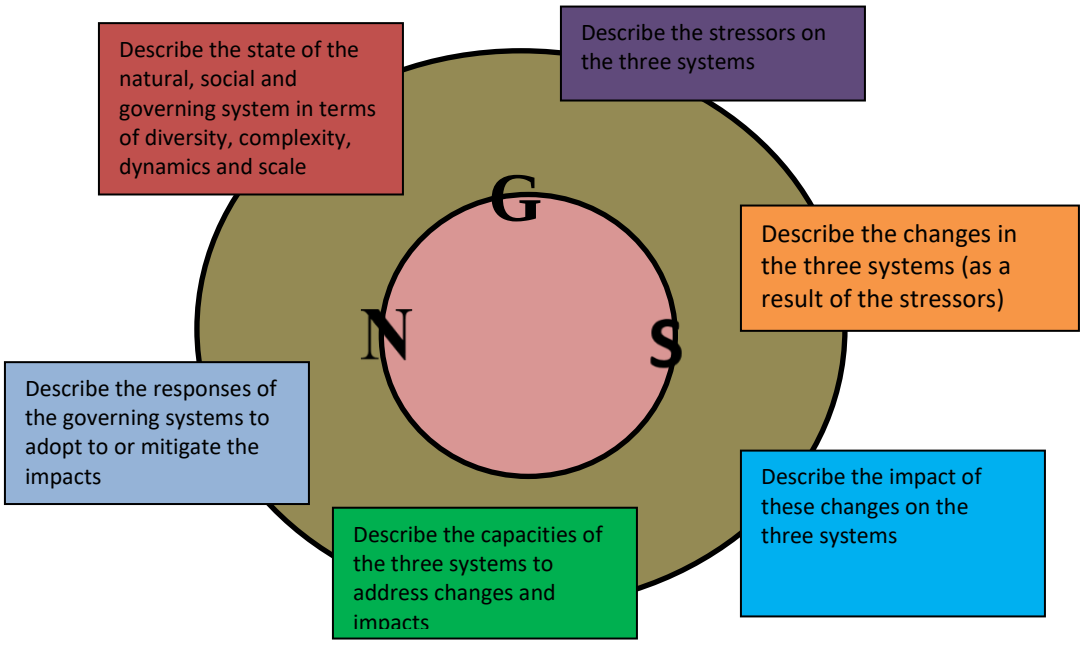

Figure 3.3 Description of I-ADApt Process

3.4 Qualitative Research Design

The qualitative data collection and data analysis process show how data is collected and how consumers of SSF gather information through surveys, semi-structured interviews and focus group discussions. But unfortunately, due to the COVID-19 Pandemic, the researcher was unable to do primary interviews. Hence, this study is moved towards a secondary approach and data was collected online using existing literature.

In this method, the researcher analyzes the respondents' beliefs through sentences in a typical environment and refers to the empirical investigation of social phenomena (Cameron, 2009). According to Creswell and Clark (2007), a qualitative approach is a particularly interview-based case study, which is valuable for exploring how to model, measure, and disclose intangibles by getting into the real-life situation where the phenomenon is developed.

The study will perform a systematic review to understand climate change and its impacts on the vulnerabilities of small-scale fishery communities of Lake Volta and explain the research's outcomes. A systematic review is a research method used to discern and plot the findings of several examinations. It is an approach to distinguish the general impact of the composition and which components differentiate the outcomes (Geyskens et al., 2009).

Moreover, it has been considered a review of reviews and can modify the upshots of different studies into one general result. The study will employ this approach to thoroughly examine the impact of climate change and the literature to date. As Naeem *et al*. (2019), suggested a systematic review is a systematic and explicit procedure of gathering a lot of information in an organized way.

According to Petticrew and Roberts (2006), a systematic review comprehensively recognizes, evaluates and synthesizes all relevant research studies on a selected topic. Petticrew and Roberts (2006) discussed the seven most important steps to conduct a meta-analysis:

1. Research questions must be distinctly described.
2. Select the type of studies required to conduct the research.
3. Make all-inclusive writing to investigate the process.
4. Observe the research studies located and analyze if they meet the inclusionary standard.
5. Critically review the relevant studies that will be a part of the meta-analysis process.
6. Arrange the research studies and evaluate for homogeneity.
7. Circulate the critical findings of the systematic review

3.5 Data Collection Method

3.5.1 Systematic Review

Due to the Pandemic, primary data could not be collected by the researcher. Thus, secondary research resorted. The routine analysis procedure for this study will give a consolidated outlook

on how climate change impacts SSF communities' vulnerabilities. Further, a systematic literature review is performed to analyze the extent to which the literature on the impact of climate change has been developed and what else is required from an academic perspective. The study will draw practicable guidance and marketing strategies for marketers, producers and food retailers, which will hopefully upgrade their livelihoods despite the obstacles posed by climate change.

Further, this study performed an audit of all available research work on climate and then empirically investigating that to what extent most of the literary work has been developed and what else is required. An electronic search app known as Zotero is managed using all available related studies and an electronic database of leading research journals. This study performed a meta-analytic review of published research studies. The systematic review helps research scholars to reach more valid conclusions by synthesizing results from several studies on the same concept into a single estimate (Hunter and Schmidt, 2004, Geyskens et al., 2009.

This study contributes to the field of fisheries in three significant ways. Firstly, this is the first study in small-scale fisheries communities to apply systematic review methodology for developing a collective understanding of existing literature on the fisheries community. Secondly, it identifies different factors affecting the SSF communities and gives a consolidated view of those factors. Thirdly, it identifies potential research gaps, providing recommendations and future research directions.

Table 3.1 shows the study's objectives, and it describes the method used to achieve each; and to achieve those objectives, different procedures were used by the researcher. For instance, to gain the first objective, i.e., identifying the range of fishing communities' vulnerabilities linked to climate change, a secondary source was used to find the relevant data using a systematic review.

To achieve the second objective, the I-ADApT framework was used to assess what strategies or mechanisms the fishing community adapts? What are the emerging support systems to avoid stress? To achieve the third objective, again literature review was adopted to check the community response mechanisms reflected in climate policy at the national level and government policy to support SSF vulnerabilities to climate change.

Table 3.1 Data collection

Objectives	Key Research Questions	Data Collection Method(s)
1. To identify the range of vulnerabilities of fishing communities linked to climate change	a. What are the changes observed in the fishing area due to climatic factors? b. How do such changes influence the fishing practice and livelihoods in SSF communities in Lake Volta? c. What are the most important trends seen in recent years due to changes in climatic conditions?	Systematic Literature review using Zotero
2. To examine constraints and opportunities for viable fisher communities in the Lake Volta region.	a. How does the SSF community cope with extreme weather events? b. What strategies or mechanisms do the fishing communities adapt to minimize the impacts concerning loss in life and livelihoods? c. What are the emerging support systems to avoid stress emanating from climate issues in the SSF community?	I-ADApT Framework
3. To assess community governance strategies to address climate change vulnerability concerning Ghana's climate action policies	a. What are the communities' response mechanisms reflected in climate policy at the national level? b. What government policy implementation and financial mechanisms are in place to support SSF vulnerabilities to climate change? c. How do governance strategies adapt towards local responses and behaviour in terms of a governing system?	Systematic Literature review using Zotero

3.6 Data Collection Source

As mentioned, this study was conducted using a systematic literature review approach using the Zotero method. This study has followed the following protocol for searching the relevant literature, as given below in the table. Numerous articles on small-scale fishery communities were analyzed. The following table shows keywords used to search relevant papers by using different databases, i.e., Google Scholar, Science Direct, JSTOR, Emerald Insight and ProQuest.

I selected keywords that are frequently used in the literature to describe the phenomena I was investigating. Given the research objectives, these keywords were chosen, considering all concepts associated with vulnerability and viability in SSFs.

The main objectives were to identify the range of vulnerabilities of fishing communities linked to climate change, examine constraints and opportunities for viable fisher communities in the Lake Volta region, and assess community governance strategies to address the vulnerability to climate change with Ghana's climate action policies. So, to achieve those objectives, the keywords listed in Table 3.2 have been combined using the following search indicators ("OR," "AND"). For instance, climate change" OR drought OR flood OR rainfall OR temperature) AND ("Lake Volta" or "Volta lake" OR Ghana) AND "Small-scale fish. Impacts of climate change on livelihood fishing communities in coastal Ghana and sea-level rise and its impact on coastal zones etc. Following table 3.3 shows the total number of papers find out by using different search terms.

A total of 338 relevant research papers, reviews, and conference proceedings were searched to conduct this study, but only 130 research articles were selected to complete this study. The tables below show the search combinations, the search engines used, the number of articles found, and the date of searching those articles. Most of the articles were found out using Google scholar, JStor, and Scopus by using keywords like CC & Livelihood & SSF, CC & SSF & Multi-level Governance, SSF & CC/Drought/Flood/Rainfall & Governance/Policies etc. Minimum Articles were found out by using ProQuest.

Table 3.2 Keywords based on objectives

Keywords	**Databases**
Climate change	Google Scholar, Science Direct, JSTOR, Emerald Insight and ProQuest
Lake Volta/Volta Lake	
Climatic factors/Extreme weather events (heavy rainfall, flood, rise in temperature, drought)	
Small-scale fisheries/Fisheries	
Community response/climate change	
Vulnerability	
Ghana	
Resilience	
Viability	
Adaptive capacity	

Table 3.3 Zotero application general

Search Terms	**No. of papers**	**Database**
("climate change" OR drought OR flood OR rainfall OR temperature) AND ("Lake Volta" or "Volta lake" OR Ghana) AND "Small-scale fish*."	5	Google Scholar
("climate change" OR drought OR flood OR rainfall OR temperature) AND (Livelihood OR employment OR fishing OR wellbeing OR "livelihood capital") AND "Small-Scale fish*"-	129	Science Direct, Google Scholar, JSTOR
"Small-scale fish*" AND ("climate change" OR drought OR flood OR rainfall OR temperature) AND (vulnerability OR viability OR resilience)-	48	Emerald Insight, Google Scholar
Small-scale fish*" AND ("climate change" OR drought OR flood OR rainfall OR temperature) AND ("community response" OR "local response" OR	10	Science Direct

"adaptive mechanism" OR "adaptive strategy*" OR "coping strategies")-		
Small-scale fish*" AND ("climate change" OR drought OR flood OR rainfall OR temperature) AND (governance OR policy OR management OR co-management)	115	Google Scholar, ProQuest
("climate change" OR drought OR flood OR rainfall) AND (Community response) AND "Small-scale fisheries."	5	Science Direct
Impacts of climate change on livelihood fishing communities	8	JSTOR
Impacts of climate change on livelihood fishing communities in coastal Ghana	7	Google Scholar
Drought and its impact on fishing in Ghana	2	JSTOR
high inland water temperature and its impact on fishing	3	Science Direct
Sea-level rise and its impact on coastal zones	8	JSTOR
Total number of papers	338	

Table 3.4 Zotero application selected articles

Search combination	**Search engines used**	**Number of articles found**	**Date of search**
Capitals & SSF & CC	Scopus	20	03/08/2020
CC & SSF & Lake Volta/Ghana	Google Scholar	7	17/07/2020
CC & SSF & Multi-level Governance	JSTOR	32	18/08/2020
Other articles	Scopus/Google Scholar	22	03/08/2020
CC & Lake Volta/Ghana & SSF	ProQuest	4	13/07/2020
CC & Livelihood & SSF	JSTOR	101	06/07/2020
CC & Community Responses & SSF	Google Scholar	17	22/06/2020

CC & SSF	Scopus/Google Scholar	20	09/06/2020
SSF & CC/Drought/Flood/Rainfall & Governance/Policies	Google Scholar/Science Direct	100	23/06/2020
SSF & CC/Drought/Flood/Rainfall & Governance/Policies	Google Scholar/Science Direct	100	23/06/2020
SSF & CC/Drought/Rainfall/Temperature & Community Responses/Adaptive Strategies	Scopus	10	29/07/2020
Final Document selection	130		30/08/2020-15/03/2021

After identifying the search combinations to get all the relevant papers (see table 3.4), Zotero-a reference management software was applied to gather, organize, and analyze relevant sources and share the research results differently (see fig 3.4). In addition to in-text citations and bibliographies, the integration of word processors and web browsers is one of Zotero's used features. As stated above, the research organization employed 338 materials based on three research areas and the methods used. However, 130 papers were obtained after taking out all duplicate and irrelevant documents to the research. All 130 articles were reviewed based on their titles, citation information, and abstracts. As a researcher using a systematic literature review, I intended to examine the impacts of climate change and its vulnerabilities in the SSF communities of Lake Volta, Ghana, and I discovered 26 articles relating to the research in Lake Volta and Ghana (see table 3.5).

However, due to limited access to relevant information in the study area, I didn't limit my data collection to that area (Lake Volta) alone. Thus, I reviewed literature from similar communities across developing countries (shown in table 3.6) and based on the findings, I reflected on their implications for the communities in the Lake Volta fishing area.

The review criteria were: i) papers must be English-written; ii) papers published no more than 40 years ago. iii) papers must be peer-reviewed, and iv) relevant to adaptive responses concerning climate change and SSF communities.

Table 3.5 Articles on Lake Volta used for research

Title of the Article	**Author(s)**
Sustainability of climate change adaptation strategies: experiences from Eastern Ghana. Development, 5(2).	Agyei, 2016
Adaptation opportunities and maladaptive outcomes in climate vulnerability hotspots of northern Ghana. Climate Risk Management, 19, 83-93.	Antwi-Agyei et al., 2018
Changes in the ecosystem services of the Volta Lake and their impacts on local livelihoods along its catchment areas in Ghana (Master's thesis, Norwegian University of Life Sciences, Ås).	Agodzo, 2014
National Climate Change Adaptation Strategy. In a workshop on National Adaptation Strategy Development. Akosombo	Agyeman-Bonsu, 2007
Geochemical contamination in the Densu Estuary, Gulf of Guinea, Ghana. 27(34), 42530-42555.	Akita et al., 2020
A review of Ghana's aquaculture industry. J Aquac Res Development, 9(545), 2.	Amenyogbe, 2018
Climate change and variability in Ghana: Stocktaking. Climate, 3(1), 78-99.	Asante & Amuakwa-Mensah, 2015
Using traditional knowledge to cope with climate change in rural Ghana. Unasylva, 60(281/232), 70-74.	Gyampoh et al., 2009
Orange-fleshed sweet potato (ofsp)–cassava composite gari: effects of processing variables and storage on beta-carotene and sensory qualities (Doctoral dissertation, University of CapeCoast).	Attobrah, 2020
Yield indices in inland fisheries with special reference to Volta Lake. Volta Lake Research and Development Project, Statistical Studies. Report No FAO/SF/GHA/10/St. S./3. FAO, Rome. 25p. Diagnostic study of the Volta Basin fisheries: Part 1 overview of the fisheries resources.	Bazigos, 1970 Bene, 2007

Recent developments in the fisheries of Volta Lake (Ghana). Current status of fisheries and fish stocks of four largest African resources. CIFA Technical Paper, 30, 111-134.	Braimah, 1995
Volta lake research and development project,[Ghana]. Evolution of the fishing industry over time at Volta lake 1970-1976.	Coppola, 1977
Vulnerability and adaptation assessment for Climate Change impacts on fisheries. The Netherlands Climate Assistance Programme (NCAP): Accra, Ghana.	Dontwi et al., 2008
Ghana national climate change policy. Ministry of Environment, Science, Technology and Innovation.	MESTI, 2013
Aquaculture and food security, poverty alleviation and nutrition in Ghana: Case study prepared for the aquaculture for food security, poverty alleviation and nutrition project. WorldFish	Kassam, 2014
Small-scale fisheries, population dynamics, and resource use in Africa: the case of Moree, Ghana. AMBIO: A Journal of the Human Environment, 31(4), 324-336.	Marquette et al., 2002
The Impacts of Climate Variability on Livelihoods of Fisher Folk at Yeji (Doctoral dissertation, University Of Ghana).	Mensah, 2019
Seasonal changes in fish catch and environmental variables in a large Tropical Lake, Volta, Ghana. African Journal of Ecology, 57(1), 66-75.	Mensah et al., 2019
The limnochemical conditions of the northern portion (Yeji area) of the Volta lake thirty years after impoundment. Tropical ecology, 44(2), 263-266.	Ntow, 2003
Population parameter estimates for Chrysichthys auratus and C. nigrodigitatus (Pisces: Claroteidae) in Lake Volta, Ghana. Fisheries Research, 54(2), 267-277.	Ofori-Danson et al., 2002
Trophic relationships and spawning habits of post-impoundment fish stocks of Lake Volta in Ghana. Ghana Journal of Science, 42, 61-70.	Ofori-Danson, 2002

Fishery Dependent Communities in Coastal Ghana: Nutritional Security, Gender, and Resilience.	Russel, 2017
Political economy of climate compatible development: artisanal fisheries and climate change in Ghana. IDS Working Papers, 2014(446), 1-30.	Tanner et al., 2014
The Importance of Wild Fisheries for Local Food Security: GHANA.	USAID, 2016
Fisheries and limnology of Volta Lake. Status of African reservoir fisheries., Eds., Kapetsky, JM and T. Petr. CIFA Technical Paper, 10, 261-320.	Vanderpuye, 1984

Table 3.6 Articles used outside Lake Volta for research

Title of the Article	**Author(s)**
Climate change and other external drivers in small-scale fisheries: Practical steps for responding. Small-Scale Fisheries Management: Frameworks and Approaches for the Developing World. CABI, Cambridge, 132–159	Hall, 2011
Sea level rise and its coastal impacts. Earth's Future, 2(2), 15–34. https://doi.org/10.1002/2013EF000188	Cazenave & Cozannet, 2014
Climate change: Mitigation and adaptation strategies in fisheries and aquaculture in Nigeria.	Magawata & Ipinjolu, 2013
Interplay between local and global: Change processes and small-scale fisheries. In Transdisciplinarity for Small-Scale Fisheries Governance (pp. 203-220). Springer, Cham.	Nayak & Berkes, 2019
The ACP Group of States and the challenge of Developing Aquaculture. Fisheries and Aquaculture Journal, 9(4), 1-4.	Failler & Ayoubi, 2015
Impacts of climate change on fisheries and aquaculture. United Nations' Food and Agriculture Organization	Barange et al., 2018
National Climate Adaptation Science Center; North Carolina Cooperative Fish and Wildlife Research Unit,	Myers, 2018

Department of Applied Ecology, North Carolina State University.	
Vulnerability and adaptation of fishing communities to the impacts of climate variability and change: insights from coastal Bangladesh. University of Leeds.	Islam, 2013
Impacts of flood control schemes on inland fisheries in Bangladesh: guidelines for mitigation. Hydrobiologia, 609(1), 45-58.	Halls et al., 2008
Case study on sea-level rise impacts. In OECD Workshop on the benefits of climate policy: improving information for policy makers (Vol. 9, pp. 69-86).	Nicholls, 2003
Impacts of climate variability and change on fishery-based livelihoods. Marine policy, 34(3), 375-383.	Badject et al., 2010
Impact of climate change on the fishermen's livelihood development: a case study of village in Coromandel Coast. Journal of Humanities and Social Science, 12(6), 49-54.	Srikhantan, 2013
The state of world fisheries and aquaculture 2014. Food and Agriculture Organization of the United Nations, Rome, Italy	FAO, 2014
Community-based adaptation to climate change. Environment: science and policy for sustainable development, 51(4), 22-31.	Ayers & Forsyth, 2009
Review of current and planned adaptation action in Ghana.	Daze & Echeverria, 2016
Adaptation of fisheries and fishing communities to the impacts of climate change in the CARICOM region. Mainstreaming Adaptation to Climate Change (MACC), 33.	Mahon, 2002

Zotero Application Data Collection details

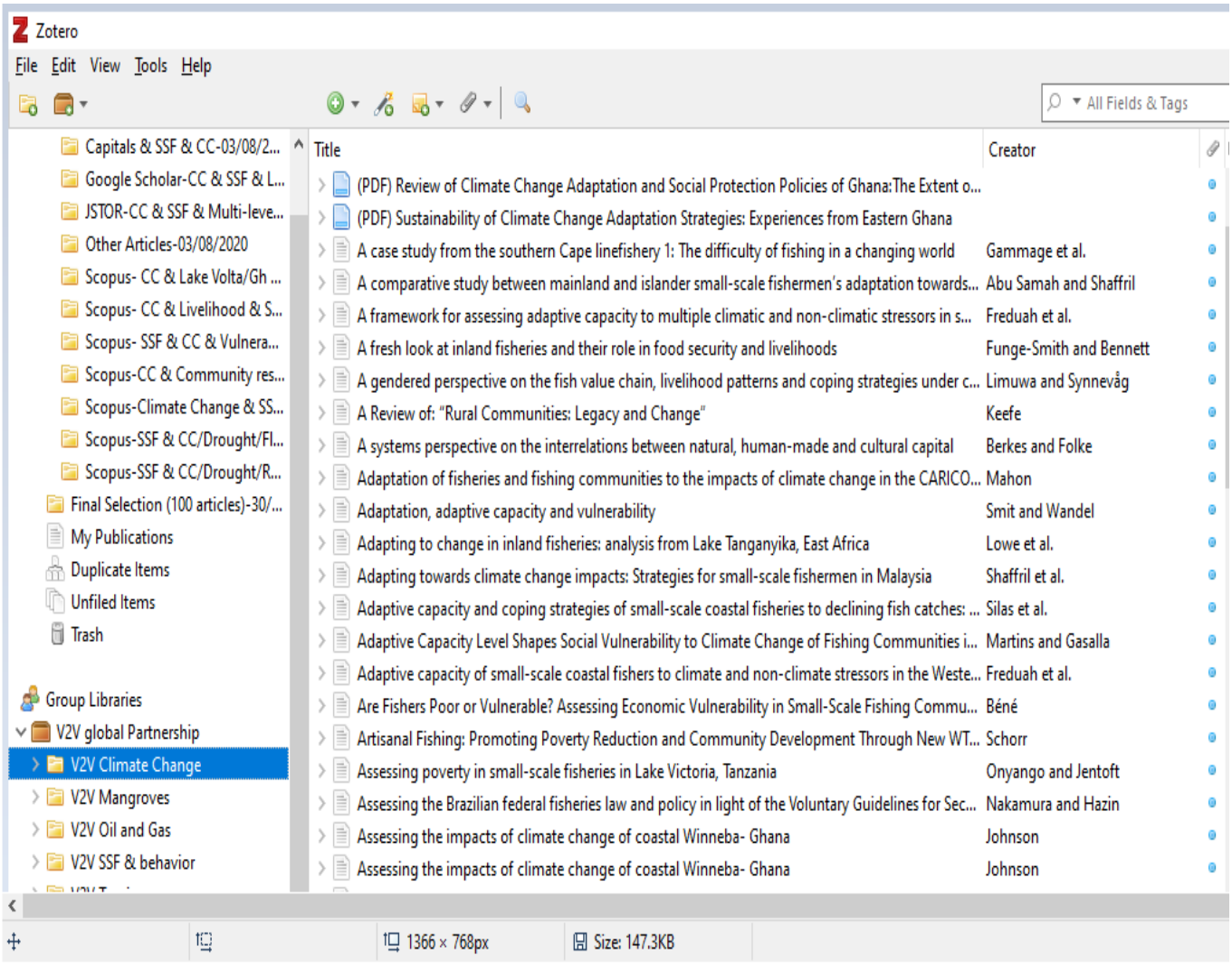

Figure 3.4 Zotero Reference Management Software for secondary data collection

3.7 **Personal Reflections**

Conducting secondary data collection instead of primary data collection was new to the researcher. Though there was a wide range of information on climate change, finding information that specifically addressed the researcher's focus was not easy. The secondary data the researcher came across did not have much information on Lake Volta, did not address the population the researcher was interested in studying or was very outdated. Since the researcher did not collect the data, the researcher had little control over the data set. This limited the analysis leading to some level of

alterations of questions the researcher sought to answer. Overall, there was insufficient literature which ultimately poses a challenge to the quality and reliability of the study's dataset

With all these challenges, the researcher has learned how to search for high-quality data, synthesize the data, and conclude based on the findings. The researcher's exposure to secondary world data has been a great experience in her academic life. Indeed, through selecting, assessing and drawing conclusions on secondary data, the researcher has expanded her knowledge on the use of secondary data and how to do the best quality research without primary data.

Chapter 4

Climate Change Impacts And Its Vulnerabilities On SSF Communities Of Lake Volta, Ghana.

4.1 Introduction

This chapter aims to assess the nature of climate change and its impacts on Lake Volta's SSFs. This will bear the vulnerabilities associated with climate change on Lake Volta's SSFs and the implications on livelihood capital and well-being. The physical, biophysical, ecological, and socio-economic effects of climate change in Lake Volta will be discussed using relevant cases to explain the nature and level of vulnerabilities in the study area and understand its threats to livelihoods and wellbeing.

4.2 Nature/Components of Climate change and its impacts on the biophysical and socio-economic aspects of SSF communities in Lake Volta.

The components of Climate change affect both biophysical and socio-economic features of SSF communities in Lake Volta. Climate Change components in Lake Volta are discussed below:

i. Water/Sea-Level Rise

Water level rise has biophysical effects on SSF communities leading to a significant land loss (see table 4.1). In Ghana, a rise in seawater levels erodes landing beaches, destroying coastal lands due to increased flooding of coastal and beach land and mangrove woodlands and the saltwater intrusion of surface waters (FAO, 2010). Longer-term effects also occur as the coast adjusts to the new conditions, including increased erosion and saltwater intrusion into groundwater and estuary system changes (Cazenave & Cozannet, 2014). The physical impacts have direct and indirect socio-economic effects, making SSF communities vulnerable, which overwhelmingly impacts communities' livelihood, wellbeing, and capital (Dontwi et al., 2008). Physical and financial assets like markets, boats, gears, nets may get damaged, causing economic crises for inhabitants. These results decrease income, increase debts, and loss of access to fishing grounds and occupational displacement leading to migration and resettlement (Berkes & Nayak, 2019).

ii. Higher inland water temperatures

SSF communities along the Lake Volta experience higher inland water temperatures affecting fishing and fish catch. The warming and heating of the Lake have already affected some fish species. As the water warms, fish need more oxygen to perform daily activities, like feeding. Therefore, temperature changes will change fish body size, breeding, and fish distributions (FAO, 2020). High temperatures and stratification diminishes water blending in lakes, lessens essential efficiency, and eventually, food supplies for fish species in lakes, decreasing fish stocks (as shown in table 4.1) in Lake Volta (Hall, 2011).

Higher temperatures affect plants and animals that live in freshwater lakes and rivers, altering and destroying their habitat and bringing life-threatening stress and disease. This means that freshwater fish species adapted to cold waters are most vulnerable to warming, as they experience unfavourably high temperatures, resulting in the possible loss of species and modification of species creation for Catch fisheries (Hall, 2011).

Since cold water holds more oxygen than warm water, the water quality declines as the temperature increases. As temperatures rise, the oxygen concentration of water declines and this change is evident in Lake Volta, which reduces the abundance and distribution of wild fish stocks (Hall, 2011). There is a potential loss of species or change in structure for catch fisheries due to the introduction of new predators and pathogens (Magawata et al., 2013). The socio-economic impacts are that SSF communities catch fewer fish, resulting in decreased income levels and increased fishing operations costs since they have to travel far from shore to catch fish (Salagrama, 2012).

iii. Changes in precipitation and water availability

The Changing rainfall patterns and water scarcity in Ghana and around Lake Volta impact the river and lake fisheries and aquaculture production (Mensah, 2019). There is less rain during the primary raining season and more showers during the dry season in recent years. These usual patterns affect the volume of water needed for temperature and acidity checks required for fish survival (Mensah, 2019). As a result, fish production's distribution, productivity, and species composition are changing, generating complex and inter-related impacts on coral reefs, mangroves, and seagrass beds that provide habitats and nursery areas for fish (FAO, 2020). This trending rainfall pattern change is a threat to fish production, fish catch, fish stock, and distribution, affecting the livelihood of SSF communities in Lake Volta (see table 4.1). These lead to loss of income and livelihoods, a

decline in food insecurity and conflicts over resources. Also, the extra cost is incurred in fishing operations, such as the fuel cost (Failler and Ayoubi, 2012).

iv. Drought

Low water, rainfall, and drought are a significant threat to SSF communities in Lake Volta. Barange et al., 2018 predicted that a decrease in mean precipitation would lead to an increased risk of drought, while an increase in mean rainfall would lead to increased flooding. Drought causes changes in salinity, and river level flows reduce, resulting in loss of wild and cultured stock, cost of production increases (see table 4.1) (FAO, 2010). There is limited production due to a loss of opportunities, reduced wild fish stock, increased alignment for fish in regions, and more fishers' movement. Droughts dissolve the oxygen found in freshwater, an element necessary for sustaining fish and invertebrate populations (Myers, 2018).

v. Increase in frequency or intensity of storms

Storms increase flooding, which creates room for predators to get into aquaculture structures during flooding. Additionally, storms destroy fishing equipment and gears used for their fishing activities, resulting in a loss in assets, cost, and expenditure, affecting the local communities' survival and livelihood. Storms threaten fishermen's safety, productivity, assets, jobs, food security, and the health of SSF communities. Lake Volta SSF communities are also vulnerable to increases in the power of storm surge and heavy precipitation. Storm surges low-lying flood areas, damages property, disrupt transport services, destroy habitat, and threaten human health and safety (Mensah, 2019). Overall, storms make fishing more dangerous, displace fish from the original habitat, and interfere with fish' breeding ability (As shown in table 4.1).

Table 4.1 Components of climate change and its biophysical and socioeconomic impacts on SSF communities in Lake Volta

Components of climate change	Biophysical effects	Implications for SSF aquaculture species and socio-economic impacts	References
Changes in water/sea surface temperature	• Increased frequency of illnesses and parasites modified biological systems change contenders, predators, and intrusive species. • Changes in timing and achievement of relocations, bringing forth as well as sex proportions. • Changes in the area and size of an appropriate range for animal categories. • Damage to coral reefs that fill in as reproducing environments may help shield the shore from wave activity (exposure to which may arise along with sea levels).	• It deteriorated invasions of entangling living beings, pests, annoyance species, and predators. • To catch fisheries impacts on the plenty of species structure of the fish stock. • The potential loss of species in catch fisheries impacts seed accessibility for aquaculture. • Possible species damage and changed species structure for a catch. • Reduced enrolment of fishery species. • More extreme wave harm to infrastructure or flooding from storm outpourings. • Loss of income and livelihoods • Food insecurity.	(Land Trust Alliance, 2020)

Drought	• Lower water quality and accessibility of aquaculture. • Changes in salinity. • Changes in lake water levels and river flows.	• Loss of wild and cultured stock. • Cost of production increases. • Limited production as a result of a loss of opportunities. • Reduced wild fish stock, increased alignment for fishing regions, and more movement for fishers.	(Barange et al., 2018). (*Bonnie Myers, 2018).*
Water/Sea level rise	• Loss of land • Estuary system changes. • Dissemination of saltwater into groundwater. • Loss of coastal environments, for example, mangrove woodlands.	• Freshwater species are lost. • Damage to freshwater catch fisheries. • It reduced enrolment and stocks for catch fisheries and seed for aquaculture. • Erosion of fishing shorelands • Conflict among inter villages on fishing resources	(Cazenave & Cozannet, 2014), (Dontwi et al., 2008) Nicholls, 2003)
Higher inland water temperatures	• High stratification and diminished water blending in lakes, lessening essential efficiency, and eventually food supplies for fish species. • Change in area and size of the expected range for a given species. • Time changes and accomplishment of relocations, generating, and peak abundance.	• A decrease in fish stocks • Possible loss of species and modification of species creation for catch fisheries. • The potential loss of species or change in structure for catch fisheries. • Increase cost of fishing operations • Loss of livelihood and income	(FAO, 2020) (Hall,2011)

Increase in frequency or intensity of storms	• Excessive waves and tempest floods. • Inland flooding from extreme rainfall. • Overview of illnesses or predators into aquaculture structures during flooding.	• Effects on wild fish stocks. • Destruction of fishing boats and gears • Loss of life and infrastructure. • Reduced income due to halt in fishing activities	(United States EPA, 2016) (University of Exeter, 2018) (Srikanthan, 2013)
Changes in precipitation and water availability	• Recruitment patterns and the movement of fish changes, and thus in recruitment success • The quality of water is low, triggering more diseases • Altered and decreased freshwater supplies with more danger of drought. • Changes in lake and stream levels and the overall degree and development patterns of surface water.	• Altered abundance and structure of a wild stock • Effects on seed accessibility for aquaculture. • Cultural species changes. • Altered distribution, composition, and abundance of fish stocks. • Low fish productivity and fish catch. • Food insecurity	(FAO, 2020)

4.3 Impacts of Climate Change on SSF communities in Lake Volta

Globally, fisheries support the livelihoods of over half a billion people who are exposed to multiple climatic stresses and shocks, including SSF communities in Lake Volta (Islam, 2013). Yet limited research exists on the vulnerability of fishery-based livelihood systems to climate change in Lake Volta. In general, the impacts of climate change and vulnerabilities between the SSF communities and those of other parts of the world may be similar as the nature of these fisheries systems varies little across the globe (discussed in section 2.5) (Islam, 2013).

Climate change usually refers to the rising ocean acidity, mainly due to the rise in carbon dioxide levels in the atmosphere leading to a decrease in the pH (FAO, 2020). The nature of climate change, such as high-temperature rise, a significant decline in precipitation, and sea-level rise, creates a substantial impact on Lake Volta SSF communities, causing different forms of vulnerabilities on their livelihoods, capital, and wellbeing (FAO, 2020). Mensah (2019) stated in his research in Lake Volta that 50% of respondents admitted that the quantity of fish catch had decreased substantially due to climate change impacts.

Rising sea/water levels

Extreme rainfall increases the Lake's water level destroying mangroves that shelter fishes and changed the ecological systems of fishes, leading to the loss of fish breeding and nursery grounds. A reduction in total rainfall has resulted in a general decline in the volume of fish caught in Lake Volta (Béné, 2007). Studies suggest that fish production can be 50% lower inside flood control schemes than outside, primarily due to reduced recruitment of high-value migratory whitefish species (Halls et al. 2008).

Mensah (2019) reveals that 75% of fishers affirmed that low rainfall has been widespread over the past ten years, 17.6% claimed that low rainfall has been less prevalent, whereas 7.4% did not observe low rainfall and that respondents asserted that extreme rainfall has been prevalent. According to Mensah (2019), generally, rainfall figures correlate with increases in fish catch figures and vice versa. For example, initial high annual rainfall totals of 21.3mm matched fish catch level 9861.18 tons in the 1991 fishing season. Also, a substantial reduction in rainfall of 0.8mm in 2010 coupled with a considerable decrease in fish catch 2801.2 tons was observed. Generally, a rain decrease affects fish catch figures because fish catch rates change as rainfall inputs change (Mensah, 2019).

Rising temperatures

Lake Volta continues to experience a temperature rise, especially around SSF communities with the mean temperature of 29.8°C; an average of 31.0°C at the water's surface and 29.3°C near the bottom also observed (Mensah, 2019). Climate studies in Lake Volta (1986 to 2012) demonstrate potential rising temperature and a warming trend. Records indicate that 2013 recorded a high temperature of 27.658°C and a low temperature of -20.271°C.

Again, 2020 recorded the highest temperature of about 30.794°C and low temperature of 10.151°C around SSF communities like Yeji, Jaklai, Edamrakra, Kapua, and Langasilanga. In contrast, regions that experienced low temperatures are mostly areas farther away from Volta Lake, including Beposo, resulting in a decline in the production of fish (Mensah, 2019). Lake Volta SSF communities continue to experience a decrease in the number and diversity of fish and shrimp species due to a rise in water temperatures.

In some cases, fish mortality due to hotter temperatures impact the fish stock, migration, and increase in death of wild fish stocks (Dontwi et al., 2008). Mensah (2019) reveals in his research that high fishing season temperatures have been prevalent over the past ten years. About 8.3% accepted that they observed lower temperatures, whereas 3.7% claimed that high temperatures were not dominant. Generally, low water temperatures may result in high fish catch and vice versa, but it's not always the case; however, changes in water temperatures commonly affect fish production and harvest (Mensah, 2019).

Changes in precipitations

Fishers in Lake Volta experience water level rise and lows due to fluctuations in rainfall patterns affecting waves, currents and bottom pressure in the nearshore areas. This results in severe exposure to waves and tempest floods and danger that Lake Volta fishers become overwhelmed (Nicholls, 2003). The impacts are that freshwater species are lost, reducing circulation and enrollment of fish stocks (Dontwi et al., 2008). Water level rise causes land erosion may and erosion of some islands in Lake Volta, which is likely to result in the displacement of people or may leave them in a more vulnerable situation.

Flooding and storms

In Lake Volta, there are several occurrences of floodings and storms that affect SSF communities. Storms associated with floods may exert tremendous impacts on fishing assets, infrastructure and ultimately on the livelihoods of fishing communities.

Research conducted by Mensah (2019) on the impacts of climate variability on livelihoods of fisherfolk at Yeji, Lake Volta, reveals that with the most significant number of fishers, 88.9% admitted they observed associated rainfall storms. Furthermore, the majority, 71.3% of the people surveyed, hinted that floodings had been prevalent. Around 14.8% stated that flood events have

been less prevalent in terms of annual occurrence, while 13.9% of fishers indicated that floods have not been rampant. The majority of fishers, 96.3%, agreed that rainfall associated with storms poses potential threats to fishers and fishing materials (fishing nets and boats), which may undeniably decrease fish catch quantity (Mensah, 2019).

The figure below demonstrates climate change impacts and effects on SSF communities of Lake Volta. From the formation, climate change drivers affect the ecosystem that impacts fish production and species composition. Communities' livelihoods are affected due to climate change, which results in the loss of capital and assets, ultimately impacting the broader economy.

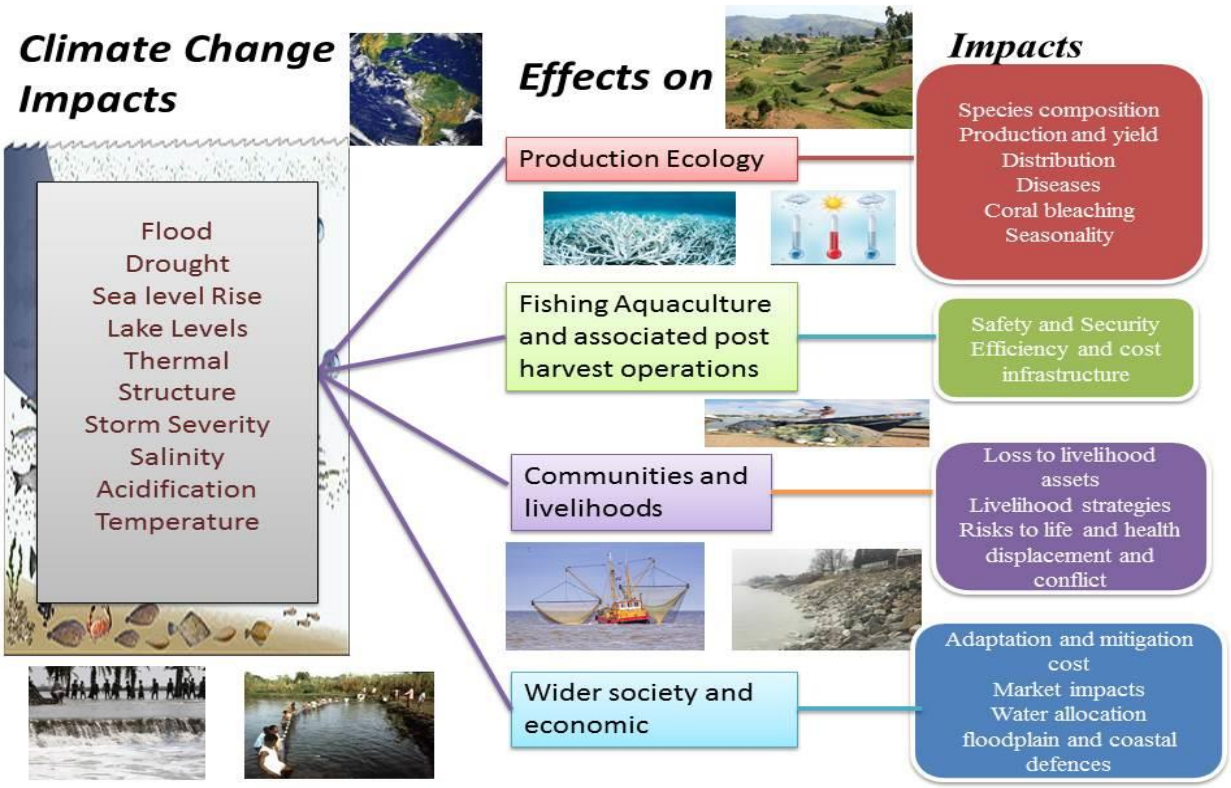

Figure 4.1 Climate change effect on fishing resources in SSF communities in Lake Volta

4.4 Climate Change Vulnerabilities of SSF communities in Lake Volta.

As stated by Berkes & Nayak (2019) in table 4.2 below, the vulnerabilities associated with climate change in SSF communities globally are no different from that of Lake Volta. As such, there are many similarities in vulnerabilities. The vulnerabilities experienced in the small-scale fishery

sector of Lake Volta encompass the material, relational, and subjective aspects of fishers' lives (Berkes & Nayak, 2019).

Material

Material vulnerabilities in Lake Volta include the natural, financial, and physical capitals of their lives.

Natural

Their natural capitals involve the ecological and aquaculture systems that house the fish species. Climate change impacts the natural capital, leading to changes in fish composition, pollution, adverse environmental and biological problems to aquatic ecosystems and fish populations, affecting fish productivity.

Financial

When this happens, SSF communities in Lake Volta face economic crises such as loss of income from fishing, debt, food insecurity, and increased fishing operations costs. SSF communities also lose their physical capitals such as fishing infrastructure, fish landing sites, boats and gear, houses (buildings), markets, etc., leading to a decline in fish stock. Furthermore, the inability to retain assets, the breakdown of fishery infrastructure, loss of access to fishing grounds, occupational and resettlement leads to migration (Nayak & Berkes, 2019).

Physical

Damages and loss of fishing equipment have a severe financial effect on well-being, leading to Psycho-social problems. Erosion and inundation of shorelines due to rise in water level leads to loss of infrastructure and threatens assets, increasing the cost of operations, reducing their fishing capacity. Unpredictable storms and rainfalls, drought, and high water levels lead to low fish catch and over the use of capital, primarily financial, which have adverse effects on the well-being of people due to the high cost of living (Srikanthan, 2013).

Relational

Relational vulnerabilities encompass the human and social capitals of SSF communities in Lake Volta. Human and social relationships between people may be bound to break because climate change may bring up conflict and increase violence between resource users which may harm the social relationship, cohesion, trust, solidarity and informal institutions among households both

within and between fishing communities. Climate change impact may break down the connections, networking and governance systems in Lake Volta SSF communities (Srikanthan, 2013).

Human capital like skills and knowledge used for fishing and community resilience may be affected due to the loss of lives during storms and flooding. In extreme events where communities' have to migrate, it breaks down family ties and social relations (Dontwi et al., 2008). Extreme climatic events can cause deaths, loss of income and breakdown of the family systems, social insecurity, and institutions and governance collapse (Nayak & Berkes, 2019).

Subjective

Subjective vulnerabilities encompass the social and human capitals of SSF communities in Lake Volta. Due to impacts on aquaculture, it causes vulnerabilities at individual and community levels. For example, fishers in Lake Volta may gradually lose their customary fishing skill sets and knowledge, lack of capacity to fish, fear and loss of hopes and aspirations, stress and deteriorating mental and physical health (Berkes & Nayak, 2019).

Climate change extremes diminish the hopes and aspirations of SSF communities, significantly alleviating poverty and vulnerabilities. However, losing one's primary source of livelihood to climate change without the capacity to engage in alternative livelihoods due to lack of credit or education subject to the wellbeing of people in SSF communities into vulnerabilities altering their wellbeing in Lake Volta (Barange et al., 2018).

Generally, Climate change impacts fishery communities' wellbeing in terms of psycho-social problems, squeezing fish markets and trade, reducing resources for fisheries to catch fish, and reducing their income and earnings. Damages and loss of fishing equipment is a severe problem made by climate change. The impact of climate change makes such derogatory consequences on the fishermen's livelihood and leads to multi-dimensional poverty (Dontwi et al., 2008).

The table below shows the dimensions of vulnerabilities, the various capitals (natural, financial, human and physical capitals) and the resulting vulnerabilities in Lake Volta.

Table 4.2 Key dimensions of the vulnerability of SSF communities to climate change in Lake Volta

Dimension of vulnerabilities	Lack of access to Capitals	Areas of vulnerability In Lake Volta SSF communities	Resulting vulnerabilities in In Lake Volta SSF communities
Material	Natural Financial Physical	Ecological Problems Economic crisis Physical resources	• Loss of primary income and increased indebtedness • Lack of asset holding • Decline in quality and quantity of food - food insecurity • Pollution and adverse ecological changes • Shrinkage in the fishing area and fish diversity • Protracted court cases, extraordinary financial implications • Fishing is capital intensive, therefore, unaffordable • Migration – income is not financially rewarding.
Relational	Human Social	Social crisis Economic dependence Political issues	• Breakdown of joint family/family support system • Increased dependence on external market • Increase in inter-village conflicts • Competitive fishing practices – unsustainable fishery • Encroachment – lack of access to fish stock and fishing grounds • Migration – family members forced to live separately • Migration – long absence weakens fishing rights • Loss of political voice
Subjective	Human Social	Individual and community level	• Loss of customary skill sets and knowledge • High dropout from school and low enrolment • Fishers turned wage labourers from entrepreneurs • Non-fishing activities disconnect fishers • Fishers find it challenging to return to fishing after migration • Adverse mental and physical health conditions

Source: Interplay Between Local and Global: Change Processes and Small-Scale Fisheries: Analysis and Practice (Berkes & Nayak, 2019).

4.5 Conclusion

This chapter of the study sought to present the results from the data reviewed using objective one, identifying the range of fishing communities' vulnerabilities linked to climate change. First and foremost, the nature and components of climate change were described. This chapter presented evidence between climate change drivers and the quantity of fish catch amount in SSF communities. The chapter also examined the impacts of climatic change constraints on livelihoods and wellbeing and resulting vulnerabilities in SSF communities of Lake Volta.

Chapter 5

An Adaptive Community Response Towards Achieving Viability To Climate Change Vulnerability In SSF Communities Of Lake Volta.

5.1 **Introduction**

This chapter seeks to assess community governance strategies and adaptive community response to address the vulnerabilities to climate change concerning Ghana's climate action policies and relate to SSF communities in Lake Volta. Governance response to climate change determines climate change adaptation. This governmental effort calls for individuals' and stakeholders' collective input to design an adaptive strategy. Ghana's Governance and coordination of climate change lie at the heart of the National Climate Change Policy (NCCP). It aimed to create a more significant constituency extending beyond government to include the private sector, non-governmental organizations, Parliamentarians, communities, and other key stakeholders (MESTI, 2013).

In Ghana, large fish landing sites are found along Lake Volta's coast, which serves as industrial, inshore, and artisanal vessels (FAO, 2014). Along the long stretch of Lake Volta, there are about 310 landing beaches. Among these, Yeji is the most important. Others include Kwamekrom, Tapa Abotoase, Kpando Torkor, Dzemeni, Torkurroano, Dambai Brumben, Ekye Amenfrom, Nyuinyui Nos. 1 & 2, Akateng and Akokoma Sisi all involved in SSF (FAO, 2014). The management of the fishing sector of Ghana involves some institutions, which include the Fisheries Commission, Department of fisheries, Community-Based Fisheries Management Committee (CBFMC), and other institutions such as the Volta River Authority, NGOs like the Adventist Development and Relief Agency, and Fishermen Associations (FAO, 2014).

However, people living in fishing communities have been managing climate change impacts for years. This is where community vulnerability first saw resilience and local adaptive capacity (a community-based approach prioritizing local efforts) (Ayers & Forsyth, 2009). In Ghana, SSF communities use their local and traditional governance system to manage climate change with their knowledge, resources and skill. In Lake Volta, the governance systems existing for adaptive response to climate change involve the Traditional Authorities (Chiefs), Town/Area Councils and Unit Committees, CBFMCs, Small-Scale Fishermen Associations, Chiefs, Faith-Based Organizations, Volta River Authority with assistance from government agencies and NGOs. These

local institutions have used their power and knowledge to mitigate climate change impacts using models to provide early warning signs for climate forecasting (Antwi-Agyei et al., 2018).

Over the years, the Ghana National Adaptation Plan (GNAP) has learned to harness Ghana's traditional and local authority structure. This promotes climate change adaptation and response because local communities are at the centre of adaptation and response to empower local people in building resilience and adaptive capacity (Antwi-Agyei et al., 2018).

Ghana recognizes Community response to climate change as crucial because of the impacts on poor communities' livelihoods. Ghana's economic stability depends on communities' responsive capacity and resilience to cope with climate change (MESTI, 2013). Community response to climate change is the main focus because the local people are the most vulnerable and victims of climate change (Ayers & Forsyth, 2009).

Community response to climate change is a significant concern in dealing with the events of extreme weather that can damage the habitats of fishing communities such as Akateng and Akokoma Sisi, Yeji, Kwamekrom, Tapa Abotoase in Lake Volta, including mangroves that are important for fish breeding and shelter, disruption of landing sites and fishing patterns (MESTI, 2013).

5.2 **Determining governance strategies in addressing communities' vulnerability to climate: A case of increasing viability in SSF community in Lake Volta.**

5.2.1 Climate change policy in Ghana and adaptive response strategies to help communities

Ghana's economy is highly vulnerable to climate change due to its impact on critical sectors such as health, energy, agriculture, infrastructure, water resource, land, fisheries and forestry. The Government of Ghana recognizes that climate change must be mainstreamed into national policies and sectoral activities to achieve sustainable growth (MESTI, 2013).

Ghana National Climate Change Policy (GNCCP) (2013)

The National Climate Change Policy (NCCP) was developed in 2013 as Ghana's integrated response to climate change through extensive consultations (Terry et al., 2014). It provides the pathway to respond to climate change challenges within the socio-economic context of Ghana. The NCCP vision ensures a climate-resilient and climate-compatible economy while achieving

sustainable development through equitable low-carbon economic growth for Ghana (MESTI, 2013). However, in terms of institutional structure for climate governance, the Ministry of Environment, Science, Technology and Innovation (MESTI) through the Environment Protection Agency (EPA) is responsible for leading climate change policy development and facilitating the implementation of actions to address the causes and effects of climate change in Ghana. The EPA works with the National Disaster Management Organization (NADMO) and the National Development Planning Commission (NDPC) to facilitate the integration of Climate Change Adaptation and Disaster Risk Reduction (DRR) into development initiatives and sectors at all national and sub-national levels down to the district level (Dazé and Echeverría, 2016).

The NCCP prioritized five (5) main areas: Agriculture and Food Security, Disaster Preparedness and Response, Natural Resource Management, Equitable Social Development and Energy, Industrial and Infrastructural Development (MESTI, 2013). However, the NCCP prioritized Area 1 and 3, as shown in Table 5.1, referenced adaptation support programs and their implications for community adaptive response for SSF in Ghana. Though the overall aim of the policy is to increase the resilience of communities to climate change adaptation, improve food security and environmental management practices, it does not highlight specific detailed policies and strategies for the fishing sector on its own geared towards SSF in Lake Volta (Dazé and Echeverría, 2016).

Table 5.1 below shows the priority areas of the NCCP adaptation support programs referenced SSFs.

Table 5.1 Priority areas, adaptation programs and their implications for community adaptive response

Priority Area	Adaptation Programs	Implication for community adaptive response.
Priority Area 1	• Building and strengthening the capacity of extension officers in climate-smart agriculture to enhance support to farmers and fishers. • Promoting capacity-building for farmers and fisherfolk and	• Creates awareness on climate change and adaptation strategies • Increased food security • identifying and enhancing early warning systems

	building awareness on climate change issues. •Designing and implementing programs on fisheries management and disease control, which integrate climatic and hydrological parameters.	• Strengthen the relationship between scientific knowledge and traditional or indigenous knowledge • Develop alternative livelihood strategies for fishers • increase in social and human capital, and social resilience
Priority Area 3	• To protect mangroves with programme areas focusing on improved marine and coastal ecosystem management and ecosystem-based adaptation	Sustaining livelihoods through enhanced fisheries resource management

Source: Ghana National Climate Change Policy. Ministry of Environment, Science, Technology, and Innovation (2013).

National Climate Change Adaptation Strategy (NCCAS)

The NCCAS was developed in Ghana parallel with the NCCP released in 2012 to cover ten years, thus 2010 to 2020 to ensure a consistent, comprehensive and a targeted approach to increasing climate resilience and decreasing the vulnerability of the populace (Antwi-Agyei, 2018). Although the two documents align, the NCCAS goal was to protect Ghana's current and future development from climate change impacts by strengthening its adaptive capacity and building resilience of the society and ecosystems (Dazé and Echeverría 2016). The NCCP aims to integrate climate resilience, climate-compatible development, and low-carbon strategies into all ministries, departments and agencies (MDAs) and ensure effective adaptation in Ghana (Antwi-Agyei et al., 2018). NCCAS goal was to be achieved through five key objectives:

- to improve society's awareness of climate change and preparedness for the future;
- to Mainstream climate change into national development to reduce climate risks;
- to increase robust infrastructure development and long-term investments.
- to increase the flexibility and resilience of vulnerable ecological and social systems to enhance their adaptive capacity; and
- to foster competitiveness and promote technological innovation.

These objectives were to be achieved through energy, livelihoods, fisheries management, agriculture, land use, health and water. A series of implementation programs were designed for urgent adaptation, including strengthening early warnings around floods/storms, supporting the poor and vulnerable, supporting alternative livelihoods, and enhancing fisheries resource management (Dazé and Echeverría, 2016). However, the critical adaptation actions by sector identified in Ghana's NCCAS have little priority on fishing, not to talk of SSF communities and Lake Volta. This does not give specific strategies and policies to address SSF climate change response and resilience building (NCCAS, 2010). It is also unclear how and when the NCCAS will transform into a formal National Adaptation Plan (NAP) (Dazé & Echeverría, 2016).

National Adaptation Plan Framework (NAP)

In 2013, Ghana's NAP was initiated under the United Nations Framework Convention on Climate Change (UNFCCC) to address medium and long-term climate adaptation needs with the vulnerability's objective by building adaptive capacity and resilience (Antwi-Agyei et al., 2018). The NAP process seeks to provide the enabling framework for the planning and implementing adaptation actions as stated in the NCCP. The National Climate Change Adaptation Strategy (NCCAS, 2012) will help build local resilience and adaptive capacity to climate change (Antwi-Agyei et al., 2018). NAP's approach, processes and strategy included mainstreaming climate change adaptation into district-level plans and engaging the private sector, community-based adaptation, ecosystem-based adaptation, horizontal and vertical integration and gender responsiveness (Antwi-Agyei et al., 2018).

A summary of the key areas and goals of Ghana's Climate Change policy from 2010 to 2020 is to promote capacity building and support vulnerable communities by providing alternative livelihoods is depicted in Table 5.2 below.

Table 5.2 Ghana's climate change policy goals and timelines

Climate change Policy	Key areas and goals	Timelines
National Climate Change Policy (NCCP)	•Building and strengthening the capacity of extension officers in climate-smart agriculture to enhance support to farmers and fishers, • Promoting capacity-building for farmers and fisherfolk and building awareness on climate change issues and • Designing and implementing programmes on fisheries management and disease control, which integrate climatic and hydrological parameters.	2010-2020 (Released in 2012)
National Climate Change Adaptation Strategy (NCCAS)	• Strengthening early warnings around floods/storms. • supporting the poor and vulnerable and supporting alternative livelihoods, • Enhancing fisheries resource management.	2013
National Adaptation Plan Framework (NAP)	To address medium- and long-term climate adaptation needs with the objective of reducing the vulnerability to the adverse impacts of climate change by building adaptive capacity and resilience and to help climate change policies, programs and activities	2010

Source: Ghana National Climate Change Policy. Ministry of Environment, Science, Technology and Innovation (2013)

5.2.2 Ghana's Climate Change Policy's Challenges and Implications to Adaptive Response in Relation to SSF Communities in Lake Volta.

The climate change policies of Ghana (NAP, NCCP, NCCAS) acknowledge the need to focus on community adaptation and response to climate change and, by their guiding principles, ensures participatory decision-making processes involving relevant stakeholders at the local level (Antwi-Agyei et al., 2018). The policies incorporated local indigenous knowledge to ensure effective adaptation. The NAP's strategies tap into household and communities' traditional or indigenous knowledge to cope with climate change's adverse impacts. The NCCP recognizes that over the years, traditional understanding of SSF communities has been critical in climate change adaptation by conserving natural resources, protecting the environment, making farming decisions, predicting the weather, managing health and coping with extreme climate variability (Antwi-Agyei, 2018). Despite existing adaptation strategies outlined in the NCCP, community response to climate change rests in local people, traditional leaders, and CBFMC. In extreme floods, storms, and disasters in Lake Volta's SSF communities, the National Disaster Management Organization (NADMO) assists in disaster preparedness and response (MESTI, 2013). The NADMO aims to build a climate-resilient society by communicating early signs of disaster warnings to SSF communities before the worse disaster happens.

The implementation of Ghana's climate change policies remains a problem. Adaptive response to climate change in SSF communities is yet to be manifested due to some challenges (See table 5.3). In 2016, a document by Collaborative Adaptation Research Initiative in Africa and Asia (CARIAA) on the "Review of Current and Planned Adaptation Action in Ghana" reveals that climate change was recognized as an issue in the energy sector and to that effect, the fishing sector. For that matter, SSF communities along the Lake Volta were not considered vulnerable to climate change, thereby making SSF communities' capacity in Lake Volta to respond to climate change uncertain and unprepared (Dazé and Echeverría, 2016). The table below identifies the challenges in the policies and the implications to Adaptive response.

Table 5.3 Ghana's climate change policy challenges and implications

Challenges in Policy	Implications to Adaptive response
Inadequate institutional capacity	• Weak coordination and the continuation of several reactive approaches between institutions. • Poor institutional structures and poor adaptive Governance
Low public awareness	• Inadequate relevant information on adaptation and resilience • Increase vulnerability and incapacity
Financial constraints	No operational climate change fund or adaptation fund to finance the policies. No ongoing climate change adaptation projects
Policy deficit in fisheries	Little strategy, initiatives, and plan to deal with climate response and adaptation in the fishing sector (SSF in Lake Volta).

Source: Review of Current and Planned Adaptation Action in Ghana (Dazé and Echeverría, 2016).

5.3 **SSF Community's Adaptive Response to Climate Change**

Lake Volta SSFs remain vulnerable to multiple challenges; however, they also have specific strengths that help them become viable. SSF communities over the years have been adapting to climate change on their own using their strengths and capabilities; otherwise, they might have disappeared a long time ago. SSF communities in Lake Volta have found varied coping and responding to climate changes and their vulnerabilities. These include:

- Traditional knowledge and practices such as conventional taboos forbid people from fishing on specific weekdays or months to protect fish species and regulate fishing (observing fishing holidays) **(**Gyampoh et al., 2007**).**
- NADMO provides early warning information on incoming storms and public education and awareness. Together with NGOs, they provide relief services in times of floods and storms to affected communities.

- The traditional and local authorities, including CBOs and fishers, play central capacity building through community participation to respond to extreme vulnerabilities and regulate overfishing and deforestation **(**Gyampoh et al., 2007**).**
- Fisherfolks engage in alternative livelihoods to cope with the stress and impacts of climate change on fishing, such as crop farming, which is mostly subsistence farming, rearing of domestic animals on a small scale for providing food for their household and engaging in other forms of trade and production such as "gari," bread, buying and selling. Also, fisher folks migrate to nearby communities to fish when the impact of climate change becomes severe (Mensah, 2019).

As discussed earlier on the vulnerabilities of SSF in Lake Volta (Chapter 4), an adaptive response will take a similar form in terms of material, relational and subjective responses to SSF vulnerabilities. In response to material vulnerabilities in Lake Volta that deal with natural, financial, and physical capitals, SSF communities have adopted ways to increase their financial capitals (Berkes & Nayak, 2019).

Some fishers belong to community money collecting groups called "SUSU" Groups, where group members make contributions to support each other overcome stressors of climate change vulnerabilities. "SUSU" groups can easily access loans from microfinance institutions because their model is lucrative and reliable (Mensah, 2019). SSF communities in Lake Volta have built a capital base, and access to credit has been flexible. This has helped them purchase physical assets like gears, nets, and boats to maintain their livelihood (MESTI, 2013).

Fishermen associations, NGOs also assist their members by supporting their members to get new equipment. Also, through the traditional authorities and fisher associations, the natural capitals are protected against over-fishing and exploitation. Fines are charged on fishers who flaunt laws on fishing breaks and other related rules associated with fishing.

Relational response in SSF in Lake Volta involves responses dealing with human and social vulnerabilities. SSF communities continue to strengthen community support systems and increase human and social capital to enhance social resilience to deal with family and community problems (Berkes & Nayak, 2019). They do this through religious organizations such as church activities, festivals, funerals and community-based activities to build solidarity and create a sense of

community, cherishing each other and helping each other cope with vulnerabilities (Mensah, 2019).

Finally, coping with subjective stress denotes that SSFs in Lake Volta are often intimately familiar with their resources and hold local knowledge about the aquatic environment and the fish they harvest, making them natural partners in ecosystem management and conservation. Through the improvements in education, health, and economic well-being, SSF communities become proud and dignified in their lives, coping with human and social vulnerabilities.

The table below shows the Adaptive response of SSF communities to vulnerabilities (natural, financial, human and physical capitals) associated with climate change in Lake Volta.

Table 5.4 Key dimensions and areas of strength of SSF communities in response to climate change in Lake Volta

Dimension of vulnerabilities	**Better access to Capitals**	**Areas of strength In Lake Volta SSF communities**	**Resulting viability in Lake Volta SSF communities**
Material	Natural	Ecological sustainability	• increase of primary income • asset holding increases • Food security • Increase species and fish diversity
	Financial	Economic stability	• Affordability of fishing equipment
	Physical	Physical resources	
Relational	Human	Social harmony	• Strengthening of joint family/family support system • Decreased dependence on external market
		Economic independence	• Absence of inter-village conflicts access to fish stock and fishing grounds
	Social		• Family bond and ties
		Political stability	• Increase participation

Subjective	Human Social	Individual and community level	• sustainability of customary skill sets and knowledge • increase school enrolment • Regulated fishing activities for all • Decreased Migration

Source: Interplay Between Local and Global: Change Processes and Small-Scale Fisheries: Analysis and Practice (Nayak & Berkes, 2019).

5.4 **Governance Strategies Towards the Responses and Adaptation Process of SSF Communities in Lake Volta.**

Climate change issues should be fully integrated into regional and national decision-making and planning for the fisheries sector (Mahon, 2002). As part of Ghana's strategy to climate change response in the NCCP, institutional governance structures incorporate all the relevant stakeholders from the national to the local level. The government recognizes the need to collaborate with other institutions to effectively implement the strategies in the NCCP (Dazé and Echeverría, 2016). At the national level, the fishery sector needs attention by developing key policies and procedures to tackle climate change in the industry.

There are little attention and programs designed for the fishing sector in the NCCP. The central bodies responsible for development planning and implementation at the sub-national level are municipalities and district assemblies; that is, the primary actors in implementing government-led climate change initiatives at the local communities through their environmental committees (Dazé and Echeverría, 2016).

Sectoral Ministries, NGOs, CBOs, Traditional Authorities and the private sector are all expected to collaborate with District Assemblies to ensure decentralized planning and implementation of CCA and risk management by incorporating community-level adaptation action plans. Although these decentralization processes create the opportunity for a locally driven adaptation, the missing link to ensure a successful policy implementation is capacity building and resource challenges.

As shown in Figure 5.1, to ensure a resilient response to climate change in SSF communities moving forward, there is the need to:

i. Strengthen and Build local capacities to reduce risk and vulnerability.

National, regional and local communities are all under-capacitated due to poor institutional structures and poor governance. Building their capacity involves giving extreme attention to policies by improving technical and institutional capacity through research support and training, especially at the local level for SSF communities (MESTI, 2013). Also, a need to promote capacity-building fisherfolks is made out; a need for more awareness of climate change is created. It may be addressed through public education using the media, churches, CBOs, and similar venues. The government must invest and promote appropriate indigenous knowledge and best practices to build community-level weather data collection and disseminating information (MESTI, 2013). Finally, new policies would ideally include monitoring the impact of climate change, for example, by systematically collecting and analyzing data to track the socio-economic and ecological changes in SSF communities in Lake Volta (Mahon, 2002).

ii. Public Education and Primary Stakeholder Awareness

This time moving forward, education and awareness on climate change response and adaptation must assume a much more prominent role (Mahon, 2002). Communication is critical to engage all stakeholders on climate change. However, communication "business as usual" is not enough (MESTI, 2013). Climate change is everybody's business, and good communication and awareness-raising around climate change are essential to adaptation in SSF communities to be resilient to its impacts. Traditional Authorities, CBOs, Fisherfolks, NGOs must be well vested in CCA issues to know what to do, what they need to go and what they need to do to get there (Mahon, 2002).

iii. Enhancing the work of Non-Governmental /Civil Society Organizations (NGOs/CBOs)

NGOs/CSOs are involved directly and indirectly in Ghana's climate and development debate, implementing specific climate change initiatives at the community level and engaging in policy advocacy at national and international levels (MESTI, 2013). NGOs and CSOs are involved in climate change activities, including community education, delivery of environmental services, research and vulnerability analysis, facilitating models for community-based climate change adaptation, emergency response and relief, mobilizing CSOs, engaging government in climate change policy monitoring and implementation and more. Recognizing their role is essential, and

the need to enhance their work is crucial. The government needs to dedicate funding to capacity building of civil societies, implementation of policies, participation and design, information and knowledge-sharing to enhance these institutions' role in climate change (MESTI, 2013).

iv. Promote alternative sources of livelihoods and social development in SSF communities along Lake Volta.

SSF communities' capability to respond to climate change depends on physical, socio-economic, and technological factors. Improved essential public social services such as access to health centers, roads, markets, schools and other social amenities will help SSF communities build resilience to climate change. Social support systems include Livelihood Empowerment Programs, health and climate change impact insurance, access to microfinance is necessary to be resilient to climate change in SSF communities (MESTI, 2013). Again livelihood diversification such as crop farming, livestock rearing, trading, and dressmaking will help offset vulnerabilities faced by SSF communities. Access to technology such as early warning equipment will aid SSF communities in building resilience towards upcoming climate change events.

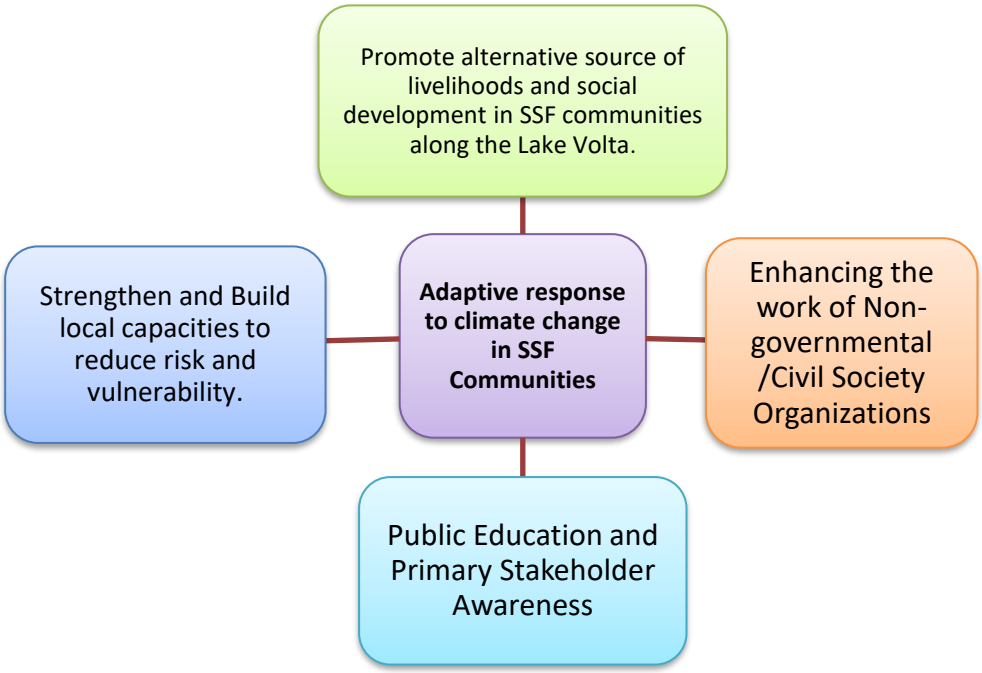

Figure 5.1 Four governance strategies that help adaptive responses in SSF in Lake Volta

5.4.1 How Adaptation Response help moves SSF Communities from Vulnerabilities to Viability in Lake Volta.

The literature shows that SSF communities' adaptation strategies to climate change are dominated by diversification or flexible livelihoods and migration. A diversified fishery-based livelihood can adapt to change better. Diversification of livelihoods provided fishers with several income-generating activities to build their financial capital base and mobilize resources for their physical needs. Diversification has also occurred to address the non-climatic stresses in small-scale fisheries, such as in the face of resource fluctuations. SSF communities' vulnerabilities are dynamic, but many small-scale fishery systems have survived in the long term, meaning they have been viable.

From the concept of vulnerability to viability (see fig. 5.2), the absence or decline of capital and wellbeing results in vulnerability. The ability to satisfy these two requirements results in a resilient community. SSFs with abundant livelihood capital can mobilize them to counteract vulnerabilities. Similarly, a resilient community will deal with shocks when the community has a higher standard of relational, material, and subjective wellbeing. For example, improved early warning and forecasting systems for severe weather events have built the human and financial resilience of SSF communities in Lake Volta to respond to severe storms and floods.

Community participation has been an effective tool used by NGOs and CBOs to make SSF communities viable in raising awareness and providing financial support to fisherfolks to become resilient to climate change vulnerabilities in Lake Volta. In Lake Volta, SSF communities' access to all capitals supports wellbeing and vice versa. Moving from vulnerability to viability stresses that well-being and capital build resilience, ensuring that movement from vulnerability to viability is achieved.

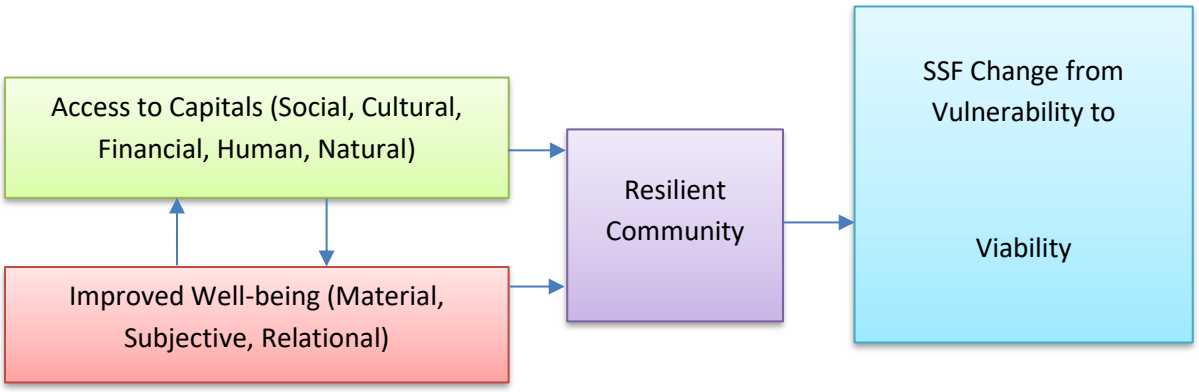

Figure 5.2 Change from vulnerability to viability in small-scale fisheries

5.5 Findings and Conclusions

Ghana recognizes the need to strengthen climate resilience with emerging national development strategies. The country is making strides toward increasing its people's adaptive capacity through improvements and integration in many crucial sectors. The NCCP, the leading climate change policy in Ghana, has identified ten Policy Focus Areas for addressing Ghana's climate change challenges and opportunities. The approach recognizes the vulnerability of local communities in the agriculture and fishing sector and the need to engage all stakeholders to plan climate change adaptation responses. The EPA is responsible for implementing the NCCP and provides technical assistance to regional governments and sectoral ministries on climate change planning and action and support for adaptation mainstreaming. Although the government recognizes the need to increase climate resilience in Ghana and, for that matter, SSF vulnerable communities, mitigation and disaster risk reduction measures tend to focus. The mainstreaming of adaptation appears to be lacking. Institutional capacity gaps exist, which remains a hindrance to the successful implementation of policies.

Moving forward, a multidisciplinary approach involving the public sector, the private sector, SSF communities, traditional authorities and NGOs should be enhanced to tackle the complex problems in managing climate change. The NCCP and NCCAS policies have a few projects centered on the agriculture sector, with few addressing the fisheries sector. To achieve an effective community response to climate change, capacity development and empowering stakeholders should be strengthened to help SSF communities in Lake Volta be resilient to climate change.

Chapter 6

Summary, Recommendations & Limitations

6.1 **Summary**

Chapter 1 highlighted the global sector known as 'small-scale fisheries' (SSFs) and investigated the impact of climate change on SSFs communities in Lake Volta. This chapter explained the study's background and the problem statement that generated the desire to undertake the research. This chapter concludes that climate change is a significant challenge SSFs in developing areas like Lake Volta. Overall, SSFs, directly and indirectly, contribute to food security in Ghana as they make fish accessible and available to needy populations.

Chapter 2 reviews the literature on climate change and its impacts on the vulnerabilities of SSFs communities. This chapter gave an overview of the nature of SSFs, looking at their significance and the effects of climate change. It then considered vulnerability to viability-resilience practices, livelihood capitals, wellbeing and community adaptive governance. SSFs are an essential but underrated source of employment, food security, and income in Ghana threatened by climate change every day.

Chapter 3 describes the study area and methodological approach. In this chapter, a systematic literature review is performed to know the impact of climate change on SSF. By using a pragmatic philosophical approach, qualitative research data was collected. The researcher analyzed numerous articles on SSFs communities using different key search engines and keywords derived from the three key objectives of the study. Furthermore, Zotero's reference management software was applied to gather, organize, and analyze relevant sources and share the research results differently.

Chapter 4 discusses the results and findings that climatic impacts on fish have social and financial implications for people whose employment relies on fishing. Further, climate change components, biophysical effects and their effects on fishing and aquaculture species were discussed. This chapter also highlights the impacts of climate change on livelihoods, capital and wellbeing of SSF communities in Lake Volta. Overall, this chapter finds that climate change impacts laborer’s at fisheries, fishing communities, and fish customers.

Chapter 5 discussed community governance strategies and adaptive community response to address vulnerability to viability. Specific policy plans, such as the NCCP and other support programs, have been explained.

In conclusion, the way ahead is not as straightforward as are the problems. To achieve a resilient and adaptive response to climate change in SSF communities, governance strategies must do the needful. The local people are the beneficiaries of all adaptive responses; building and strengthening their capacity empowers them. To reduce vulnerability risk, the government must provide training, incentives, training on other fishing techniques, and financial and social support to cushion people from vulnerabilities.

Building local capacities eases them temporarily; however, providing and promoting alternative livelihoods will sustain their household providing diverse sources of income, strengthening their resilient capacities. Engaging NGOs will contribute to education and public awareness adaptation options, capacity building, capital and infrastructure development, and support in alternative livelihoods, which will ensure an effective adaptation response. Knowledge is key to providing an effective adaptation strategy. Government institutions are responsible for collaborating with local institutions to educate SSF communities on climate change impacts, assist in public awareness, and provide infrastructure to help SSF communities become resilient to climate change impacts.

6.2 **Recommendations**

This study shows that fisheries play an important role in supporting livelihoods and food security through SSFs' diets and income. It can be determined that fishing is the primary livelihood in Lake Volta. The study reveals that the effects of climate change continue to impede SSFs communities' livelihoods at Lake Volta. The following suggestions are planned to promote livelihood growth in the fishing community.

- Maintaining fish species diversity should be at the top of the agenda. The sector Ministry and other departments with oversight responsibilities over the fisheries sector should invest in fishing equipment such as fishing nets that will not disturb the ecosystem. Fishers should be equipped with adequate resources necessary for fishing to aid in their fishing activity to ensure a sustainable livelihood. Also, fishers should adopt the best and responsible fishing practices.

- Capacity development is necessary through training, education, awareness creation, having an exchange of collaborative programs from research and academia should be strengthened to help vulnerable SSF communities to become viable.
- The government should have a change in policy towards enhancing local knowledge and increasing the participation of SSF community members in policy formulation and implementation.
- This study's results suggest that policymakers should embrace essence in enhancing alternative livelihood strategies for the fishing communities. Despite new efforts to address the effects of climate change on agriculture (crops, livestock and forestry), more research is required to identify possible justification and adaptation measures of SSFs in the study area.
- This study also recommends future research on large-scale fishing households' status at the national level with primary source developing opportunities for more income-generating activities and access to credit for SSFs. Fishers should be encouraged to partake in community activities, decision-making processes, and training held by the government or NGOs. This study also recommends that future research be conducted on small-scale fishing households' food security at the national level.

6.3 Limitations

Limitation to research is something that a researcher shouldn’t be afraid of when faced with such challenges. As I mentioned in chapter 3 concerning my reflections, utilizing secondary data for the fundamental research was new to the researcher. Therefore it wasn't easy to access reliable secondary data suitable for achieving the objectives. Due to that, the researcher encountered few challenges regarding the research study area and climate change effects on the fishery communities. Thus, access to relevant information, lack of prior research studies in the study area, the authenticity of documents, and the date of the research data became a problem in organizing this paper. Even though the initial plan was to use documents no more than 30 years, the researcher used articles more than the stipulated age. Notwithstanding these challenges, the researcher adapted studies from different communities in most developing countries that go through the exact effects of climate change. Based on the results, reflections were made on their implications in the fishery communities of the study location.

Amidst the challenges in gathering this information for this study, the researcher's exposure to secondary world data has been a great experience in her academic life. Indeed, by selecting, assessing, and drawing conclusions on secondary data, the researcher has expanded her knowledge on using secondary data and how to do the best quality research without primary data.

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